BEFORE THE HEARING PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by Tararua District Council to Horizons Regional Council for application **APP-2005011178.01** for resource consents associated with the operation of the Eketahuna Wastewater Treatment Plant, including a discharge into the Makakahi River, a discharge to air (principally odour), and a discharge to land via pond seepage, Bridge Street, Eketahuna.

REPORT TO THE COMMISSIONERS

DR BRENT COWIE (CHAIR), MR REGINALD PROFFIT AND MR PETER CALLANDER

SECTION 42A REPORT OF LOGAN ARTHUR BROWN – FRESHWATER AND PARTNERSHIPS MANAGER

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7 March 2017

A. INTRODUCTION

Qualification and Experience

1. My name is Logan Arthur Brown.

2. I am currently employed by the Manawatū-Wanganui Regional Council (MWRC) as the Freshwater and Partnerships Manager. I have held this role since July 2016, prior to this I was a Senior Scientist – Water Quality. I have been employed by MWRC since June 2010 and prior to this I was employed by the Department of Conservation as a Freshwater Technical Officer. I have a Masters in Science - Ecology and a Bachelor of Business Studies majoring in Economics and a Bachelor of Science majoring in Ecology from Massey University.

3. In my previous role as a senior scientist I oversaw the delivery of our coastal and estuary monitoring programmes, our State of the Environment monitoring programmes for biological parameters which include periphyton, macroinvertebrates and fish, our contact recreation, and our LakeSPI monitoring programme. In addition, I am still involved in a number of research programmes focused on freshwater systems.

4. I have reviewed the application by Tararua District Council (Applicant) dated the 31st March 2015, s92 response dated the 11th December 2015 (and associated attachments), and the s92 response dated 27 February. I have been involved in the water quality, periphyton, and macroinvertebrate monitoring that is required as part of the current resource consent conditions and am therefore familiar with the nature of receiving environment in the Makakahi catchment.

5. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. My evidence has been prepared in compliance with those codes. In particular, unless I state otherwise, the evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

B. SUMMARY

6. TDC have applied to allow for the discharge of treated wastewater from Eketahuna Township to the Makakahi River. The proposal involves the relocation of the discharge point and upgrades to the treatment process to improve the quality of the discharge to the receiving environment. While estimations of likely performance have been provided for some parameters, the final effluent quality is currently unknown.

7. The Makakahi River holds a number of reach specific and zone wide values that have been identified through the One Plan. Targets within the One Plan were developed at the time to provide protection to these values.

8. MWRC has two SOE monitoring sites on the Makakahi River which show degradation in water quality, periphyton, and macroinvertebrate communities as you move down the catchment.

9. The monitoring associated with the current discharge shows that there is an increase in the amount of periphyton that is seen in the Makakahi River downstream of the discharge. In addition the macroinvertebrate communities show a significant decline downstream of the discharge point into the Makakahi River.

10. In terms of improvements that will be seen as a result of the upgrades, it is difficult to comment without being provided clear effluent quality standards that apply to the discharge; and with the uncertainty associated with the proposed new discharge point. While likely effluent standards have been provided, these are of little value without discharge volumes with which to put them in to context. The application does provide a maximum volume that is not to be exceeded but the use of such a value creates a pessimist assessment as the maximum volumes are normally associated with large wet weather events and are not reflective of what is occurring the majority of the time.

C. SCOPE OF REPORT

11. This report covers the discharge to water components of the application made by the Applicant to allow for the continued operation of the Eketehuna Wastewater Treatment Plant (WWTP). This evidence specifically covers the discharge to the Makakahi River.

12. In particular I will address:

    a. Values and water quality overview;

    b. Water quality in the Makakahi River;

    c. Native Fish Communities and Migrations in the Makakahi River;

    d. Current effluent quality and effects;

    e. Proposed discharge location;

    f. Likely effluent standards;

    g. Submissions;

    h. Monitoring and Conditions; and

    i. Summary.

D. VALUES AND WATER QUALITY OVERVIEW

13. The application is for a continued direct discharge of the Eketahuna wastewater from the Eketahuna WWTP to the Makakahi River. Originally a term of 20 years was applied for with my understanding that this has now been reduced to a term of five years. In addition the application seeks to change the location of the discharge point and also undertake upgrades to the treatment plant that will improve the quality of the effluent that is discharged to the Makakahi Stream. The applicant provided a s92 response on 27th of February 2017. However, some key pieces of information were not included. These include the discharge volumes from the pond, and the finalised discharge point including the manner by which the discharge will occur (e.g. via a wetland or not). This limits some of the conclusions that can be drawn about the future effects of the activity. If greater clarity regarding these information gaps becomes available, most likely via the s41B applicant hearing reports, then it may be necessary for supplementary evidence to be tabled at the hearing. .

14. The Makakahi River in the vicinity of the discharge point has a number of values, and associated with these values are a number of water quality targets which have been identified in the One Plan. This is covered in more detail below.

15. The water management framework of the One Plan recognises the need to manage water bodies within the Region for the different environmental, social and economic values they hold. Water Management Zones (WMZs) are the underpinning geographical component of the integrated water management framework in the One Plan and are located in Schedule A. Forty-three water management zones have been identified and further divided into 124 water management Sub-zones.

16. Water body values are attached to each surface Water Management Zone and Sub-zone. These values embody the environmental, social, cultural and economic values of each sub-zone. They are defined as either reach or zone specific depending on whether the value is dependent on managing reach-specific effects, or zone-wide effects. The water body values are located in Schedule B of the One Plan.

17. The proposed discharge of treated sewage effluent from the Eketahuna WWTP to the Makakahi River occurs within the Makakahi (Mana_18d) sub-zone, which is a water management sub-zone of the Mangatainoka (Mana_8) water management zone (refer Map 1). The following values have been identified in the Makakahi River in the vicinity of the proposed discharge point (refer Maps 1 and 2 for reach specific values):

a. Life Supporting Capacity – Hill country mixed (HM) geology;

b. Water supply (Pahiatua water supply in Pahiatua)

c. Trout fishery (regionally significant);

d. Trout spawning;

e. Site of Significant – Aquatic (not at site but in the Makakahi River headwaters);

f. Flood control/drainage;

g. Aesthetics;

h. Mauri;

i. Contact Recreation;

j. Stockwater;

k. Industrial Abstraction;

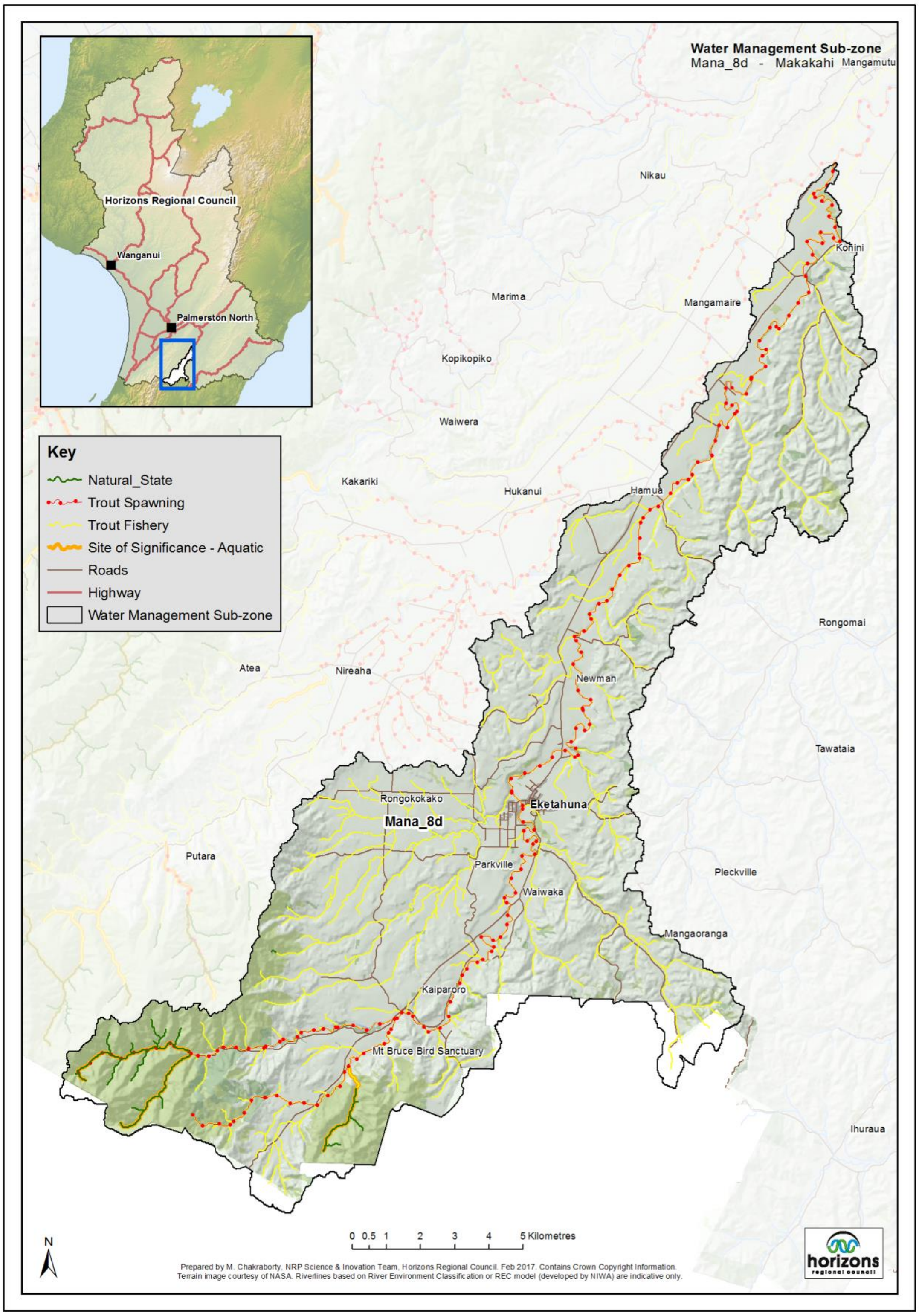
l. Existing infrastructure;

m. Irrigation; and

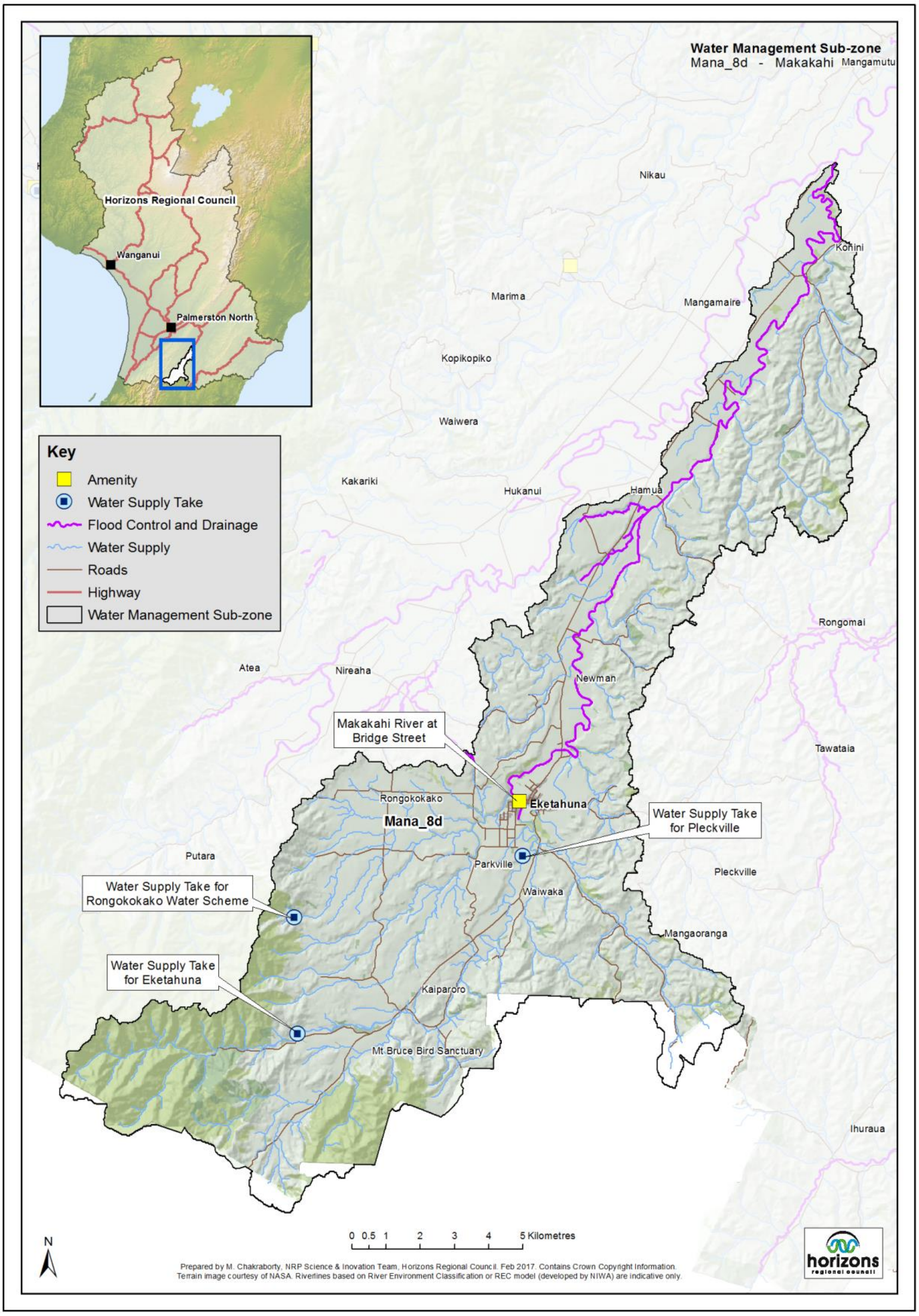
n. Capacity to Assimilate Pollution.

18. Schedule E of the One Plan (2014) sets out numerical targets to protect the majority of values identified in the Makakahi River [Tables 1 and 2, Appendix 1]. These targets have been established using the best available science and expert opinion at the time the One Plan was developed. The targets are designed to provide the best level of protection for the values within a water management Sub-zone (Ausseil and Clark, 2007). As such, if the targets set out in the One Plan are complied with, the effects of an activity on the receiving water body are likely to be no more than minor.

19. An assessment of the current state of the Makakahi River against some of the One Plan water quality targets is made later in this report.



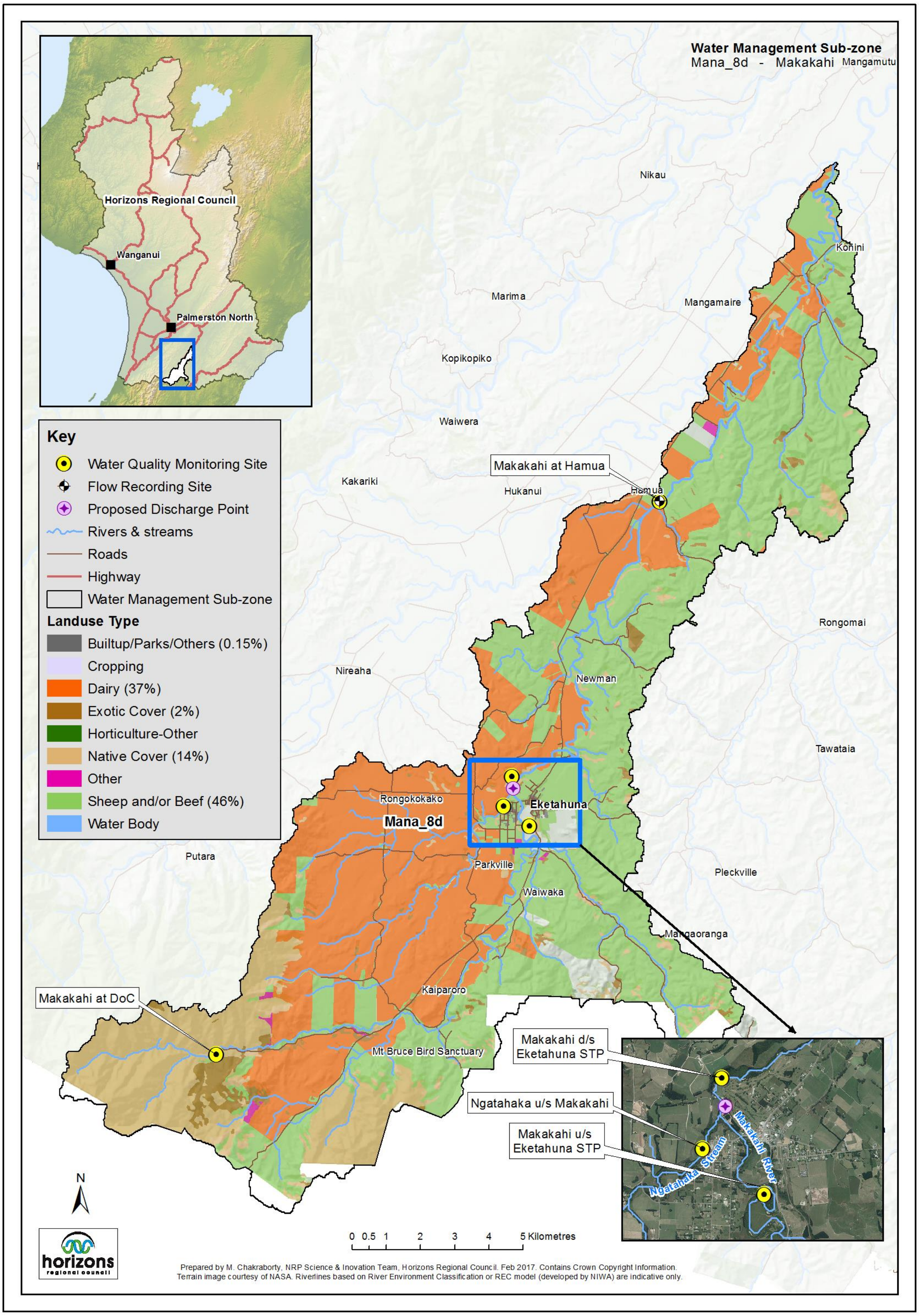
Map 1: Map showing the reaches of the river valued for Natural State, Trout spawning, Trout fishery, and Sites of Significance – Aquatic



Map 2: Map showing the reaches of the river valued for amenity, water supply take, flood control and drainage, and water supply.

E. MAKAKAHI CATCHMENT AND LANDUSE

20. Land use within the Makakahi catchment is shown in Map 3.



Map 3: Land use within the Makakahi catchment.

F. WATER QUALITY IN THE MAKAKAHI CATCHMENT

21. MWRC has two State of the Environment (SOE) monitoring sites in the Makakahi catchment. These being:

    a. Makakahi at DOC (reference site); and

    b. Makakahi at Hamua.

22. This monitoring involves the collection of monthly water quality samples, monthly periphyton samples, annual macroinvertebrate samples, and continuous flow at Makakahi at Hamua.

23. Monitoring has been undertaken on an annual basis since 2014 for macroinvertebrates at both of these sites. Macroinvertebrate monitoring has occurred annually at Makakahi at Hamua since 2006. The last time that a trend analysis was undertaken for the Makakahi at Hamua site the results showed that what appeared to be a negative trend in the graph was not statistically significant for MCI (Stark, 2016). Makakahi at DOC has not been monitored long enough to allow a trend analysis to be undertaken.

24. When undertaking macroinvertebrate monitoring the data that is collected can be shown in a number of different ways. Commonly the species and abundance data is used to form indices which are used to consider different aspects of the community composition.

25. The Macroinvertebrate Community Index (MCI) and its quantitative variant the Quantitative Macroinvertebrate Community Index (QMCI) are indices of macroinvertebrate community health that relate to the impact of organic enrichment developed by Stark (1985). The original indices were developed for stony bottomed streams on the Taranaki Ring Plain but since their development in the mid 1980s these indices have been widely applied as a useful resource management tool to describe the impact of enrichment on aquatic ecosystems (Boothroyd and Stark, 2000). The Macroinvertebrate Community Index works by allocating enrichment sensitivity scores to individual aquatic invertebrate taxa. A sample of the macroinvertebrates is collected and then the scores of the invertebrates present in the sample are summed and standardised to determine a score between 0 and 200 with a high score indicating a lesser degree of impact from enrichment.

26. The QMCI uses the same enrichment sensitivity scores for each taxa as the MCI, in addition to data on the abundance of taxa, rather than just the presence / absence resolution of the MCI. A QMCI score is determined from a formula using the sensitivity scores and abundance data to give a value in the range of 0 to 8, with a score of 8 indicating an unimpacted macroinvertebrate community. The QMCI is also a widely used index and there are standardised national protocols for collecting and enumerating macroinvertebrates to determine MCI or QMCI scores (Stark et al., 2001; Stark and Maxted, 2007). Additionally, a soft-bottom MCI and a semi-quantitative version (SQMCI) have been developed to incorporate different stream substrates and reduce sampling and enumeration effort respectively.

27. The MCI is widely considered to be the most appropriate index for SOE reporting of macroinvertebrate community impact with regard to organic enrichment. The QMCI is purported to be the most appropriate index for compliance monitoring of the impacts of specific activities such as the comparison between macroinvertebrate communities upstream and downstream of a wastewater discharge.

28. The MCI is the most suitable index for SOE monitoring as this monitoring is frequently undertaken over weeks to months each year. Variable weather patterns mean that rivers are likely to have high flow events or receding flows during this time. During these flow events, the species composition is unlikely to significantly change, however the relative abundance of taxa or densities will. The MCI does not take this change in relative abundance or densities into consideration. The QMCI is suitable for compliance monitoring as the reference (upstream) and impacted sites are monitored on the same day (after the same flow regime). The QMCI takes into consideration the community taxonomic and numerical composition of the samples. This allows the detection of subtle changes in community composition and is why the QMCI and SQMCI are the preferred method of compliance monitoring over the MCI (Stark, 2007).

29. Other indices also widely employed across the country for macroinvertebrate monitoring as indicators of water quality include %EPT taxa and %EPT individuals. These indices describe the proportion of Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddis flies) in a macroinvertebrate community hence EPT families. Generally speaking these are comprised of large, enrichment sensitive taxa. The higher the proportion of EPT taxa or individuals, the less impacted the sample meaning a less impacted waterbody.

30. From the calculation of MCI and QMCI indices you can then assign a water quality class to a site as seen in Table 1.

Table 1: Water quality classes for the MCI and QMCI.

Quality class	Stark (1998) descriptions	Stark & Maxted (2007a)	
		MCI	QMCI
Excellent	Clean water	>119	>6
Good	Doubtful quality or possible mild pollution	100 – 119	5.00 – 5.99
Fair	Probable moderate pollution	80 – 99	4.00 – 4.99
Poor	Probable severe pollution	<80	<4.00

31. In addition Death (2009) proposed thresholds of 10% and 60% for interpreting both the %EPT richness and %EPT abundance indices. Values <10% were considered to indicate severe pollution or impact, values from 10–60% mild to moderate pollution, and values >60% clean water.

32. In regards to the One Plan, a MCI target has been established for each of the management zone and sub-zones within the region. For the Makakahi sub-zone there is a target of a MCI value greater than 120.

33. Tables 2 through 4 provide the results of the monitoring undertaken from 2014 to 2016 at Makakahi at DOC and Makakahi at Hamua for macroinvertebrates.

Table 2: Macroinvertebrate monitoring result for Makakahi at DOC and Hamua in 2016. Colours aligning with the water quality classes in Table 1.

	MCI	QMCI	%EPT richness	%EPT abundance
DOC	140	8.45	69.23	81.82
Hamua	94	3.99	38.71	33.12

Table 3: Macroinvertebrate monitoring result for Makakahi at DOC and Hamua in 2015. Colours aligning with the water quality classes in Table 1.

	MCI	QMCI	%EPT richness	%EPT abundance
DOC	138	7.70	66.67	82.36
Hamua	91	3.93	40	22.80

Table 4: Macroinvertebrate monitoring result for Makakahi at DOC and Hamua in 2014. Colours aligning with the water quality classes in Table 1.

	MCI	QMCI	%EPT richness	%EPT abundance
DOC	133	8.08	62.50	88.29
Hamua	98	4.99	46.67	47.89

34. Using the MCI it can be seen that the Makakahi at DOC (reference) site meets the One Plan target and falls into the category of excellent (clean water) water quality. However, by the time you reach Makakahi at Hamua the One Plan target is no longer met and the water quality falls into fair (probable moderate pollution).

35. Using the QMCI it can be seen that the Makakahi at DOC (reference) site falls into the category of excellent (clean water) water quality and by the time you reach Makakahi at Hamua the water quality falls into poor (probable severe pollution) in 2016 and 2015 and fair (probable moderate pollution) in 2014.

36. Using both %EPT richness and abundance values it can be seen that the Makkahi at DOC (reference) site falls into the category of clean water quality and by the time you reach Makakahi at Hamua the water quality falls into mild to moderate pollution.

37. In addition to macroinvertebrate monitoring being undertaken at each of these sites, periphyton data has been collected on a monthly basis at Makakahi at DOC since August 2013 and at Makakahi at Hamua since December 2008.

38. HRC recently had a detailed analysis of the data collected via the periphyton monitoring programme in 2016 (Kilroy *et al*, 2016). In this report a number of categories were proposed that sites could be assigned to based on the levels that periphyton reached. These are reproduced in Table 5.

Table 5: Definitions of periphyton state in bands from very low to very high chlorophyll *a* and percent cover. Very low represents the best state (i.e. least periphyton) and very high represents the worst state (most periphyton). Taken from Kilroy *et al*, 2016.

	Range of values in coding category					Justification for bands
Periphyton metric	VLow	Low	Mod	High	VHigh	
Mean chlorophyll *a*	<5	5 - <15	15 - <50	50 - <120	>120	Vlow and Low thresholds in range for high quality invertebrates and dominant cover by film. Low – Mod threshold set at mean value to protect biodiversity (Biggs 2000a). VHigh set at One Plan middle range.
Median chlorophyll *a*	<3	3 - <15	15 - <50	50 - <120	>120	As above. VLow – Low threshold lower because mean tends to be higher than median if maximum is high.
92nd percentile, % mats	<5	5 - <15	15 - <30	30 - <60	>60	VLow starts at barely visible peak cover, approximately equivalent to 5 mg/m^2 if no other algae present. VHigh band uses threshold for protection of aesthetic/recreation values in Biggs (2000a).
92nd percentile, % filaments	<2.5	2.5 - <5	5 - <15	15 - <30	>30	As above for mats – range Vlow to Mod covers barely visible to easily visible cover. VHigh band uses threshold for protection of aesthetic/recreation and trout habitat/angling values in Biggs (2000a).
92nd percentile, % cyanobacteria	0	0-<2	2-<10	10-<20	>20	The VLow band is effectively extremely low or no occurrence of cyanobacteria; VHigh is exceedance of the "alert" level in the cyanobacteria guidelines.

39. To ensure that we are comparing like with like I have only reproduced the analysis that was undertaken from May 2012 to April 2015 so that we are using the same time periods. Using the categories above Makakahi at DOC falls into very low for all measures except for 92nd percentile, % cyanobacteria for which it falls into low. For Makakahi at Hamua the site is moderate for chl *a* median, and mats 92nd percentile, high for chl *a* mean, and 92nd percentile for cyanobacteria and very high for 92nd percentile filamentous algae.

40. The One Plan also contains a chlorophyll a target of less than 120 mg/m^2 for the Makakahi water management sub-zone.

41. In the technical document that supported the water quality targets in the One Plan compliance with the periphyton chlorophyll a target was recommended to be *"The 120*

and 200 mg chlorophyll a /m^2. Some *occasional breaches may be acceptable, and the recommended approach is to assess compliance at the 95th percentile level, ie. up to 1 sample every two years may not be compliant. This recommended methodology is based on monthly monitoring, as recommended in section* ***Error! Reference source not found.*** *of this report."* Page 140 (Ausseil & Clark, 2007).

42. In addition the Freshwater NPS contains bands for periphyton as measured through chlorophyll *a* biomass. Using the analysis undertaken from 2012 to 2015 for Makakahi at Hamua the site falls into Band C (Band B if using data from 2008 to 2015). At the time of the Kilroy *et al* report was produced Makakahi at DOC did not have a complete three years worth of data to complete the NPS assessment but based on monitoring data to date the site would fall into Band A.

43. Using the above method to assess compliance with the One Plan target for chlorophyll *a* for data from 2012 to 2015 the Makakahi at DOC site meets 100% of the time and Makakahi at Hamua 92% of the time. Therefore Makakahi at Hamua is not meeting the One Plan target.

44. As an overall summary the monitoring data shows there is a clear degradation of water quality as you move from the reference monitoring site (Makakahi at DOC) to the Makakahi at Hamua monitoring site.

G. NATIVE FISH COMMUNITIES AND MIGRATIONS IN THE MAKAKAHI CATCHMENT

45. New Zealand has a highly mobile native fish fauna consisting of a large number of diadromous (migratory) species. New Zealand's native fish communities also display a high degree of endemism (85% of New Zealand's native fish fauna are only found in New Zealand (Jowett & Richardson, 1996)). Many native fish species such as the Galaxiidae spawn within the riparian margins of rivers, streams and estuaries, and upon hatching the larvae migrate into the coastal marine waters to grow. These species return to freshwater as juvenile whitebait in the spring and migrate upriver into the habitats preferred by adult fish.

46. The juvenile fish, known collectively as whitebait, comprise six species of native fish: common smelt (Retropinna *retropinna*), inanga (Galaxias *maculatus*), koaro (*G. brevipinnis*), giant kokopu (*G. argenteus*), shortjaw kokopu (*G. postvectis*) and banded kokopu (*G. fasciatus*). All of these species have been found in the Manawatū catchment in fish surveys conducted within the last 5 years.

47. Other native migratory species which commonly inhabit freshwaters include redfin bully (*Gobiomorphus huttoni*), common bully (*G. cotidianus*), bluegill bully (*G. hubbsi*), giant bully (*G. gobioides*), torrentfish (*Cheimarrichthys fosteri*), longfin (*Anguilla dieffenbachii*) and shortfin eels (*A. australis*). All of these species except for bluegill bully have been found in the Manawatū catchment in fish surveys conducted within the last 5 years.

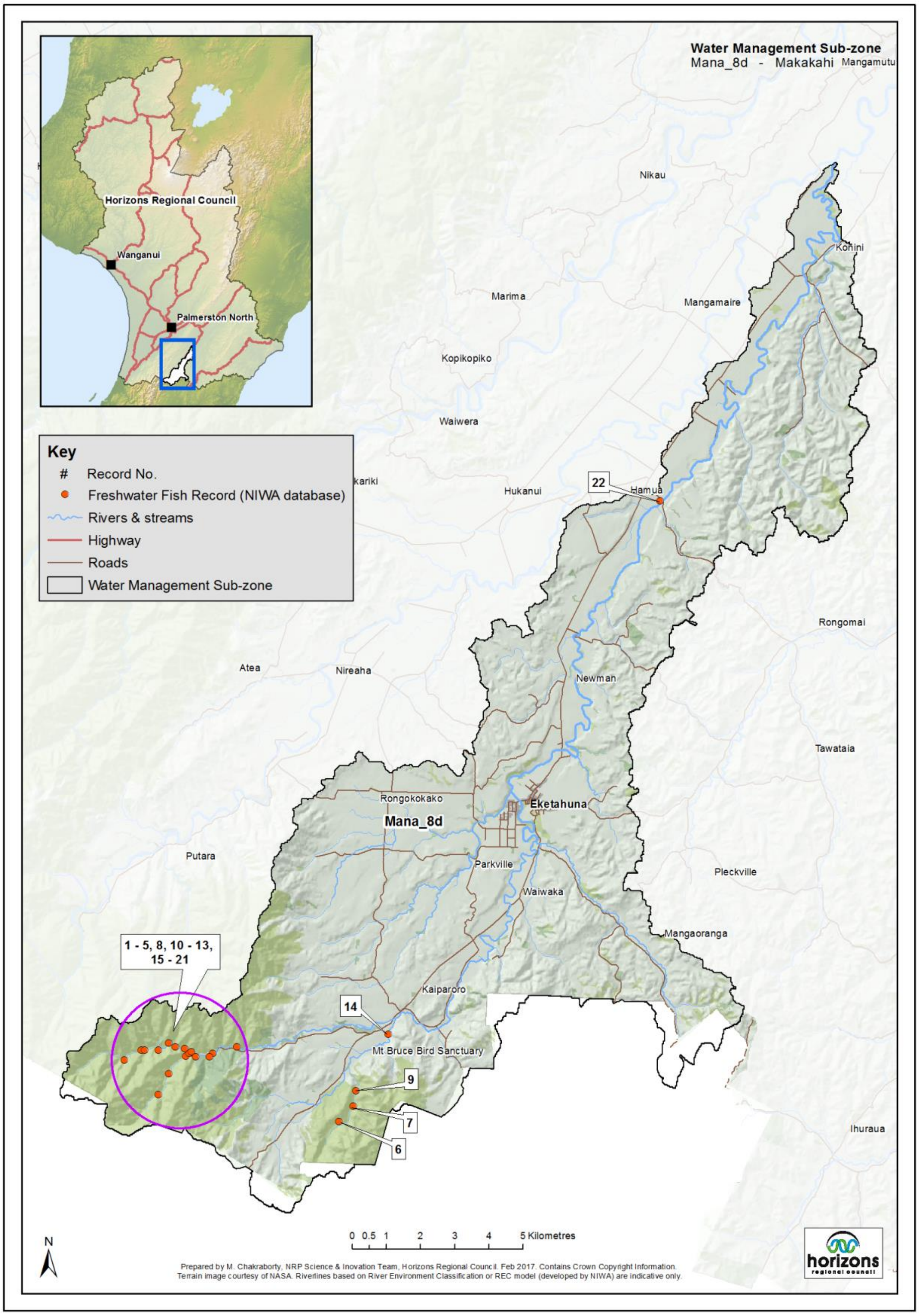
48. Brown trout (*Salmo trutta*), are common throughout the Manawatū River catchment, and can also be 'sea-run', spending time at sea and within the tidal reaches of the river, and migrating up river to spawn (McDowall, 1976 & 1990). Rainbow trout (*Oncorhynchus mykiss*) and perch (*Perca fluviatilis*) are also common introduced species within the Manawatū, but neither is known to migrate between fresh and coastal waters.

49. Some of the freshwater fish species found within the Makakahi catchment are considered to be threatened and are contained within the New Zealand threat classification system (refer Table 6 for the species found in the Makakahi catchment and Table 1, Appendix 2 for their threat classification) (Goodman *et al*., 2013*, and Grainger et al., 2014).

50. The sites that have been surveyed in the Makakahi catchment since 1991 and fish species that have been recorded at each of these sites are shown in Map 4 and Table 6. This information is taken from the NIWA Freshwater Fish database and therefore will not include surveys that have been undertaken but not submitted to the database administer. Further information is likely to exist but is currently not accessible.

51. Migratory pathways between rivers and the sea are extremely important components of healthy riverine ecosystems and aquatic biodiversity in New Zealand. The migration times of diadromous fish (requiring access to the sea at some stage during their life cycle) differ according to species, however, fish are migrating throughout the year in the Manawatū catchment (refer Table 1, Appendix 3).

52. Of particular importance in the Makakahi River is the migratory path for short jaw kokopu into the headwaters of the Bruce Stream, and the Makakahi River.



Map 4: Record of sites contained in the NIWA Freshwater Fish Database that have been monitored in the Makakahi catchment since 1991 to 2016. The numbers refer to Table 6 which contains the species and abundance found at each of the sites.

Table 6: Record of fish species and abundance found at each of the sites monitored in the Makakahi catchment between 1991 and 2016 and contained in the NIWA Freshwater Fish Database.

New Zealand Freshwater Fish Database records (NIWA) in Makakahi catchment, 1991 onwards															
Record No.	**Year**	**Waterways**	**NZREACH ID**	**Easting**	**Northing**	**shortjaw kokopu**	**shortfin eel**	**longfin eel**	**Unidentified eel**	**upland bully**	**common bully**	**Unidentified bully**	**koura**	**Unindentified trout**	**brown trout**
1	2012	Makakahi River	7048886	1818655	5489709	8		1					3	4	1
2	2014	Makakahi River Tributary	7048886	1818497	5489608	7		14							7
3	2011	Makakahi River	7048840	1818455	5489834	6		11							6
4	2001	Makakahi River Tributary	7048886	1818588	5489685	5		3							1
5	2001	Makakahi River	7048861	1817188	5489785	1		4					1		
6	2000	Bruce Stream	7049096	1822989	5487685	1		12					common		6
7	2013	Bruce Stream	7049032	1823394	5488139	1		80							
8	2012	Makakahi River	7048840	1818658	5489733	1		4							3
9	2000	Bruce Stream	7048934	1823489	5488585			7							10
10	2001	Makakahi River Tributary	7048886	1817988	5489085			6							
11	2001	Makakahi River	7048853	1817988	5489985			2					13		
12	2000	Makakahi River	7048841	1819988	5489885			4		44			3		18
13	2001	Makakahi River	7048840	1818188	5489885			3					5		
14	2011	Bruce Stream	7048766	1824425	5490256			13	2		5		11		
15	2001	Makakahi River	7048874	1819288	5489685			2							1
16	2001	Makakahi River	7048861	1817288	5489785			2					3		
17	2001	Makakahi River Tributary	7049014	1817688	5488485			2					3		
18	2001	Makakahi River	7048892	1818788	5489585			1					1		2
19	2001	Makakahi River	7048897	1819188	5489585								3		
20	2001	Makakahi River	7048882	1816688	5489485			8					2		
21	2001	Makakahi River	7048853	1817688	5489785			2					3		
22	2010	Makakahi River	7044946	1832392	5505889		2	4		20	14	3			2

H. CURRENT EFFLUENT QUALITY AND EFFECTS

53. To help inform the assessment of effects from the proposal I have first considered the current effluent quality, and current effects on the receiving environment. The discharge currently occurs into the Makakahi Stream through a pipe (refer Photo 1) just upstream of the confluence with the Ngatahaka Stream.

Photo 1: Current discharge structure from the Eketahuna WWTP into the Makakahi River.

54. The current resource consents require that regular monitoring is undertaken to look at the effects of the discharge on the Makakahi River. This monitoring includes:

   a. Monthly water quality monitoring of the discharge itself and also in the Makakahi upstream of the discharge point, the Ngatahaka upstream of the Makakahi confluence, and the Makakahi downstream of the WWTP discharge;

   b. Periphyton monitoring every two months in the Makakahi upstream of the discharge point, the Ngatahaka upstream of the Makakahi confluence, and the Makakahi downstream of the WWTP discharge;

   c. Macroinvertebrate monitoring on an annual basis in the Makakahi upstream of the discharge point, the Ngatahaka upstream of the Makakahi confluence, and the Makakahi downstream of the WWTP discharge.

55. The current effluent quality is summarised in Tables 7 to 9. Table 7 provides the median effluent quality for the last 5 years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017). Table 8 provides the average effluent quality for the last 5 years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017). Table 9 provides the 95th percentile effluent quality for the last 5 years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017).

Table 7: Median effluent quality for the last five years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017).

	E.coli	TSS	Ammonia	SIN	DRP	scBOD
2012 – 17	484.5	21	3.9	4.283	0.487	2.15
2016 - 17	195	9.5	4.28	4.504	0.5365	3

Table 8: Average effluent quality for the last five years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017).

	E.coli	TSS	Ammonia	SIN	DRP	scBOD
2012 – 17	1537	28.4	4.16	4.84	0.70	2.63
2016 - 17	909	19.2	5.86	6.30	0.88	4

Table 9: 95th percentile effluent quality for the last five years (January 2012 to January 2017) and the last 12 months (January 2016 to January 2017).

	E.coli	TSS	Ammonia	SIN	DRP	scBOD
2012 – 17	4705	26.45	10.16	10.31	1.972	6.05
2016 - 17	3790	20.03	13.85	13.96	2.254	10

56. To date the proposal includes a number of upgrades to the treatment plant that will result in improvements in the quality of the effluent that is discharged to the Makakahi River. My understanding of the upgrades is that they will be based on the upgrades that have been undertaken at the Pahiatua WWTP and the effluent will therefore be of similar quality to that seen from this discharge. To date I have been provided with some limited monitoring data that shows some of the results that they are getting from the Pahiatua WWTP. I have reproduced the range of quality that is seen in the monitoring data although this only covers from 20th September 2016 to 13th December 2016 (Table 10). However, to date the applicant has not provided what the end of pipe standards would be for the Eketahuna WWTP discharge.

57. As of the 27th February 2017 (s92 response) some possible effluent standards have been provided. These are based on preliminary results from the Pahiatua WWTP upgrades. For several of these parameters the standards are expected only and do not appear to reflect current actual results being seen at the Pahiatua WWTP (refer Table 10). The applicant has not provided any discharge volumes from the WWTP, although the s92 response states that volumes are expected to change as a result of reduced inflows into the plant.

58. Due to the above limitations it has made assessing the potential effects of the proposal extremely difficult. This is because the current monitoring data can provide certainty around the current effects but without certainty around the proposed effluent volumes and proposed quality I am limited in the ability to predict potential effects.

Table 10: Range in effluent quality parameters from monitoring undertaken on the Pahiatua WWTP discharge, the likely mean effluent standards provided by the applicant and the current mean effluent quality from the Eketahua WWTP discharge. Monitoring data from September 2016 to December 2016 for Pahiatua WWTP and January 2012 to January 2017 for Eketahuna WWTP.

	E.coli	**TSS**	**Ammonia**	**SIN**	**DRP**	**cBOD**
Range (Pahiatua)	11-3000	21-76	0.032-3.54	0.153-5.87	1.16-2.03	15-36
Likely Effluent Standards	<500 MPN/100ml	<30 mg/l	<5 mg/l	Stated under ammonia as unlikely to change	<1.3 mg/l	<3 mg/l
Current Eketahuna WWTP mean discharge results	1537 MPN/100ml	28.4 mg/l	4.16 mg/l	4.84 mg/l	0.70 mg/l	2.63 mg/l

59. From the monthly water quality data collected I have looked at the results of the in-river monitoring in order to undertake an assessment against the One Plan target for each of the sites that are monitored. This assessment is shown in Tables 11 to 13 below.

60. Table 11 shows an assessment for Makakahi at downstream of the Eketahuna WWTP discharge against the One Plan targets for SIN, DRP, and ammonia.

Table 11: An assessment of the Makakahi at downstream of the Eketahuna WWTP discharge against the One Plan targets. All analysis using annual averages but no adjustment made for flow above the 20th FEP. Red non-complies with the One Plan target, Green complies with the One Plan target.

	SIN (g/m^3)	**DRP (g/m^3)**	**Ammonia (g/m^3)**
2012	0.453	0.0068	0.016
2013	0.449	0.0086	0.019
2014	0.455	0.0075	0.012
2015	0.468	0.0090	0.0088
2016	0.518	0.0103	0.0192

61. The data showing that the Makakahi at downstream of the Eketahuna WWTP discharge doesn't met the One Plan targets for SIN, DRP, but does met it for ammonia.

62. Table 12 shows an assessment for Ngatahaka upstream of the Makakahi confluence against the One Plan targets for SIN, DRP, and ammonia.

Table 12: An assessment of the Ngatahaka upstream of the Makakahi confluence against the One Plan targets. All analysis using annual averages but no adjustment made for flow above the 20th FEP. Red non-complies with the One Plan target, Green complies with the One Plan target.

	SIN (g/m^3)	DRP (g/m^3)	Ammonia(g/m^3)
2012	0.850	0.0082	0.0123
2013	0.776	0.0079	0.0299
2014	0.973	0.0084	0.0221
2015	0.946	0.0091	0.0079
2016	0.966	0.0114	0.0104

63. The data showing that the Ngatahaka at upstream Makakahi confluence doesn't meet the One Plan targets for SIN, DRP, but does meet it for ammonia.

64. Table 13 shows an assessment for Makakahi at upstream of the Eketahuna WWTP discharge against the One Plan targets for SIN, DRP, and ammonia.

Table 13: An assessment of the Makakahi at upstream of the Eketahuna WWTP discharge against the One Plan targets. All analysis using annual averages but no adjustment made for flow above the 20th FEP. Red non-complies with the One Plan target, Green complies with the One Plan target.

	SIN (g/m^3)	DRP(g/m^3)	Ammonia (g/m^3)
2012	0.262	0.0043	0.0115
2013	0.246	0.005	0.0098
2014	0.222	0.006	0.0152
2015	0.259	0.004	0.005
2016	0.254	0.0065	0.005

65. The data showing that the Makakahi at upstream of the Eketahuna WWTP discharge meets the One Plan targets for SIN, DRP, and ammonia.

66. During the development of the One Plan a number of technical documents were produced to help inform the plan. The reports identified values within the regions waterways. Another report recommended targets/standards and the method of assessing compliance to ensure protection of the values that had been identified. In regards to *E.coli* concentrations, compliance was suggested to be assessed at the 95th percentile for the following reasoning:

> *"However, due to the nature of the microbiological results, where an unsatisfactory result can commonly be several orders of magnitude greater than a satisfactory sample, the 95th percentile may be misleadingly high when it is calculated on a small number of samples (ie. one very high sample out of 20 samples can lead to a high 95th percentile even if the 19 other results are satisfactory). The 95th percentile approach is suitable (and recommended) when the number of sample is sufficient (eg. 50 samples). When the number of samples is less than 50, the recommended approach is to compare the 90th percentile of the data to the standard. (page 140)"*

67. Using the information for the monitored sites we end up with a 95th percentile for the last 5 years of monitoring data as follows:

    67.1. Makakahi River upstream Eketahuna WWTP = 1210 mpn/100ml (8 samples out of 60 above 550 mpn/100ml)

    67.2. Ngatahaka River upstream confluence with Makakahi River = 3200 mpn/100ml (13 samples out of 65 above 550 mpn/100ml).

    67.3. Makakahi River downstream Eketahuna WWTP = 2908 (11 samples out of 61 above 550 mpn/100ml).

68. Compliance with the 95th percentile is therefore not achieved at any of these sites in relation to *E.coli* concentrations and the One Plan.

69. The SIN and DRP targets that are included in the One Plan do not directly relate to effects on river values, rather they are a sub-set of controlling factors to other factors (such as periphyton growth), which can directly affect river values. Specifically, from a technical point of view, in-stream nutrients (DRP and SIN) can be considered subordinate to the periphyton and macroinvertebrate targets.

70. With respect to life supporting capacity, the most relevant Schedule E targets are pH, temperature, dissolved oxygen (DO), periphyton cover, periphyton biomass (chlorophyll a), MCI, QMCI, ammoniacal nitrogen, toxicants.

71. As a requirement of the current resource consents macroinvertebrate monitoring has been undertaken on an annual basis since the last short term consent was issued. The monitoring results of this are summarised in Tables 14 to 17 below.

72. The monitoring in general terms shows a similar pattern across the years. This is that the macroinvertebrate communities are of lower quality downstream of the Eketahuna WWTP discharge into the Makakahi River. This reduction in the indices is seen regardless of whether you use the Makakahi upstream of the Eketahuna discharge as the control site or if you use the Ngatahaka upstream of the Makakahi confluence as the control site. In either case, there is a reduction in quality.

73. The One Plan has a target of a no greater than a 20% change in the QMCI around point source discharges. In addition we can also look at other indices to consider the effects on the macroinvertebrate communities. In general those that look at the quantities of macroinvertebrates (QMCI and %EPT abundance) are more informative as they allow changes in the communities to be detected at a earlier time rather the simple presence/absence of species/taxa (MCI)

74. If we look at the monitoring data collected for QMCI on the 2nd February 2013 we see that the change is a decline of 30.3 (%) and 25.1 (%) between the downstream point and the Ngatahaka and Makakahi control sites respectively. This decline is seen equally in the other indices that are used to look at the effects of point source discharges on macroinvertebrate communities.

Table 14: Results of monitoring undertaken in the Makakahi and Ngatahaka on the 2nd February 2013 associated with the Eketahuna WWTP discharge to the Makakahi River: The fill colours representing the water quality classes as shown in Table 1.

	Ngatahaka u/s Makakahi	**Makakahi u/s WWTP**	**Makakahi d/s WWTP**	**% change between Nga and d/s**	**% change between u/s and d/s**
MCI	108	105	97	- 10.2	- 7.6
QMCI	5.18	4.82	3.61	- 30.3	- 25.1
%EPT taxa[1]	45.23	42.62	34.56	- 23.6	- 18.9
%EPT abundance[2]	60.77	52.82	36.90	- 30.1	- 39.3

75. Looking at the monitoring data collected for the QMCI on the 1st March 2014 you can see that the change is a decline of 32.6 (%) and 43 (%) between the downstream point and the Ngatahaka and Makakahi control sites respectively. This decline is seen equally in the other indices that are used to look at the effects of point source discharges on macroinvertebrate communities.

[1] Excluding Hydroptilidae
[2] Excluding Hydroptilidae

Table 15: Results of monitoring undertaken in the Makakahi and Ngatahaka on the 1st March 2014 associated with the Eketahuna WWTP discharge to the Makakahi River. The fill colours representing the water quality classes as shown in Table 1.

	Ngatahaka u/s Makakahi	Makakahi u/s WWTP	Makakahi d/s WWTP	% change between Nga and d/s	% change between u/s and d/s
MCI	109	107	104	- 4.6	- 2.8
QMCI	5.55	6.56	3.74	- 32.6	- 43
%EPT taxa[3]	46.59	43.35	42.60	- 8.6	- 1.7
%EPT abundance[4]	53.85	75.37	33.45	- 37.9	- 55.6

76. Looking at the monitoring data collected for the QMCI on the 26th January 2015 you can see that the change is a decline of 19.86 (%) and 43.3 (%) between the downstream point and the Ngatahaka and Makakahi control sites respectively. This decline is seen equally in the other indices that are used to look at the effects of point source discharges on macroinvertebrate communities.

[3] Excluding Hydroptilidae
[4] Excluding Hydroptilidae

Table 16: Results of monitoring undertaken in the Makakahi and Ngatahaka on the 26th January 2015 associated with the Eketahuna WWTP discharge to the Makakahi River. The fill colours representing the water quality classes as shown in Table 1.

	Ngatahaka u/s Makakahi	Makakahi u/s WWTP	Makakahi d/s WWTP	% change between Nga and d/s	% change between u/s and d/s
MCI	102	103	100	- 1.96	- 2.91
QMCI	4.33	6.12	3.47	- 19.86	- 43.3
%EPT taxa[5]	49.70	41.87	40.05	- 15.8	- 19.4
%EPT abundance[6]	44.52	80.16	29.39	- 34	- 63.3

77. Looking at the monitoring data collected for the QMCI on the 17th March 2016 you can see that the change is a decline of 15.6 (%) and 18.6 (%) between the downstream point and the Ngatahaka and Makakahi control sites respectively. This decline is seen equally in the other indices that are used to look at the effects of point source discharges on macroinvertebrate communities.

[5] Excluding Hydroptilidae
[6] Excluding Hydroptilidae

Table 17: Results of monitoring undertaken in the Makakahi and Ngatahaka on the 17th March 2016 associated with the Eketahuna WWTP discharge to the Makakahi River. The fill colours representing the water quality classes as shown in Table 1.

	Ngatahaka u/s Makakahi	Makakahi u/s WWTP	Makakahi d/s WWTP	% change between Nga and d/s	% change between u/s and d/s
MCI	102	94	95	- 6.9	- 6.7
QMCI	4.42	4.58	3.73	- 15.6	- 18.6
%EPT taxa[7]	39.31	35.00	30.05	- 23.6	- 14.1
%EPT abundance[8]	33.78	28.95	37.45	+ 10.9	+ 29.4

78. While the Ngatahaka does add nutrients and other contaminants into the Makakahi River at this point, which likely reduces water quality in the Makakahi River, it is my opinion that the change in macroinvertebrate indices can not be attributed solely to this. This is because there is a significant reduction in macroinvertebrate indices values between the Ngatahaka site and the Makakahi downstream WWTP site that in my opinion is most likely attributable to the discharge. Therefore taking the macroinvertebrate indices at face value it is my opinion that the discharge currently causes significant adverse effects on the macroinvertebrate communities within the Makakahi River.

79. In addition to the collection of macroinvertebrate samples on an annual basis periphyton monitoring is undertaken once every two months.

[7] Excluding Hydroptilidae
[8] Excluding Hydroptilidae

80. From the periphyton data that has been collected we are able to assign each of the sites based on their periphyton metrics and associated values into the categories in Table 5. So for chlorophyll *a* I have looked at the median and mean to compare with the categories in the Kilroy *et al* 2016 report, the 92nd percentile as an assessment against the NPS, and the 95th percentile as a compliance assessment against the One Plan chlorophyll *a* target of 120 mg/m^2 for this water management sub-zone. The Freshwater NPS assessment is not technically correct as the assessment should be based on monthly data and with 36 data points but is useful to complete in terms of providing context.

Table 18: Results of the chlorophyll a data collected on a two monthly basis and assigned to each of the classes referred to in Kilroy *et al*, 2016 for mean and median chlorophyll a, the 92nd percentile and its associated NPS periphyton band (A through to D), and the 95th percentile as to whether the site meets the One Plan target (✓ = yes, × = no).

Chl a indices	**Sample size**	**Mean**	**Median**	**92nd %ile (NPS)**	**95th %ile (One Plan)**
Makakahi at u/s WWTP	24	22.2 (Mod)	30.5 (Mod)	69.4 (B)	90.1 (✓)
Ngatahaka u/s Makakahi	24	59.6 (High)	44.8 (Mod)	130.6 (C)	131.2 (×)
Makakahi at d/s WWTP	24	65.7 (High)	62.4 (High)	118.4 (C)	144.8 (×)

Table 19: Results of the periphyton coverage data collected on a two monthly basis and assigned to each of the classes referred to in Kilroy *et al*, 2016 for the 92nd percentile and whether the parameter meets the One Plan target(✓ = yes, × = no).

		Mats		Filamentous algae		Cyanobacteria	
	Sample size	**92nd %ile**	**Number of exceedances (One Plan)**	**92nd %ile**	**Number of exceedances**	**92nd %ile**	**Number of exceedances (One Plan)**
Makakahi at u/s WWTP	26	8.5 (Low)	0 (✓)	12.3 (Mod)	0 (✓)	2.5 (Mod)	0 (✓)
Ngatahaka u/s Makakahi	26	11.6 (Low)	0 (✓)	7.0 (Mod)	0 (✓)	1.0 (Low)	0 (✓)
Makakahi at d/s WWTP	26	20.3 (Mod)	0 (✓)	16.3 (High)	0 (✓)	10.0 (High)	0 (✓)

I. PROPOSED DISCHARGE LOCATION

81. The 27 February 2017 s92 further information response identified two potential locations for discharge points in order to remove the confounding effect of the Ngatahaka Stream on monitoring the effect of the Eketahuna WWTP. The first option (option 1) is to create a series of small bunded areas/wetlands in the shallow gully located immediately to the Northeast of the oxidation ponds. The second option (option 2) is to create a larger wetland area on a lower river terrace below the golf course.

82. Concern has been raised around how comparable the current monitoring sites (refer to photos 2 to 4 for photos of the sites) are in terms of looking at effects on both macroinvertebrate and periphyton communities around the point source discharge. It has been suggested by the applicant that it is the meeting of the Makakahi River and Ngatahaka Stream that causes the changes in the macroinvertebrate communities and therefore the shifting of the discharge point to downstream of the confluence will alleviate the effects that we currently see in the Makakahi River. I do not share the same opinion in regards to proposed discharge location option 1. In my opinion the shifting of the discharge to this location (option 1) will simply raise the same issues when the consent comes up for renewal (assuming it is granted). The reason for this are:

    a. The decline that you see between the control sites (Ngatahaka Stream and Makakahi upstream Eketahuna WWTP) and the downstream site remains regardless of which reference site you use;

    b. The new upstream monitoring point will fall into a gorge area which is likely to receive only mid day sun. Therefore periphyton growth is likely to be less pronounced regardless of the nutrient concentrations that are experienced at the site;

    c. The proposed placement of the new upstream monitoring site will mean that the ability to undertake monitoring will be restricted more than currently occurs due to the constrained nature of the stream between the cliffs. Therefore, the ability to get into the river and sample will be influenced more than it currently is; and

    d. The Ngatahaka Stream is very similar to the current downstream monitoring point in the Makakahi River in terms of characteristics, and therefore I would not normally expect to see such a large difference between the upstream and downstream sites.

83. In my opinion the movement of the discharge point to within the gorge (option 1) will simply raise more uncertainties around the effects at the expiry of any new consent that may be issued. The other concern I have would be the ability to undertake compliance action at a future date especially if there is uncertainty around the comparability of sites.

84. I do not hold the same concerns in regards to the proposed discharge location of Option 2. As the option 2 location was only presented in the s92 of 27 February 2017 I have not been able to undertake a site inspection of suitable monitoring locations. However from my existing knowledge of this site I am of the view that option 2 will be the more viable discharge site in respect of a monitoring and substrate comparability perspective.

85. In the case of both option 1 and option 2 there have been no suggested changes in water quality as a result of the wetlands (noting that there is uncertainty around the development of these too). Any additional treatment or 'polishing' of the discharge water provided by the wetlands is not assessed due to the lack of information regarding the wetland construction. At the time of finalising this report, it remains unclear if the applicant has a preferred discharge location.

Photo 2: Periphyton and macroinvertebrate monitoring site at Makakahi upstream Eketahuna WWTP discharge. Photo taken on the 1st March 2014.

Photo 3: Periphyton and macroinvertebrate monitoring site at Ngatahaka upstream Makakahi confluence. Photo taken on the 1st March 2014.

Photo 4: Periphyton and macroinvertebrate monitoring site at Makakahi downstream of Eketahuna WWTP. Photo taken on the 1st March 2014.

J. LIKELY EFFLUENT STANDARDS

86. The further information response (27th February 2017) outlined some 'Likely Effluent Standards' that could be applied to the final discharge. These are based on results that are being achieved at the Pahiatua WWTP, as similar treatment processes are expected to be employed at Eketahuna WWTP. It appears that several of these results are 'expected' results rather than reflecting what is currently occurring at Pahiatua WWTP. For example *E. coli* hasn't been measured at the appropriate place at the Pahiatua plant to inform the efficacy of treatment, and DRP treatment is currently causing little or no improvement. The likely effluent standards are displayed here and compared to current mean results for these parameters in the Eketahuna WWTP discharge with data from January 2012 until January 2017 (Table 20).

Table 20: Eketahuna WWTP mean discharge results January 2012 – January 2017; and proposed likely effluent standards.

	E.coli	**TSS**	**Ammonia**	**SIN**	**DRP**	**scBOD$_5$**
Eketahuna WWTP mean discharge results	1537 MPN/100ml	28.4 mg/l	4.16 mg/l	4.84 mg/l	0.70 mg/l	2.63 mg/l
Likely Effluent Standards	<500 MPN/100ml	<30 mg/l	<5 mg/l	Stated under ammonia as unlikely to change	<1.3 mg/l	<3 mg/l

87. The further information request response dated 27th February 2017 was lacking any information regarding outflow volumes from the plant. The applicant has stated that the inflows will reduce and that the hydraulic retention time in the pond will subsequently increase due to sewerage infrastructure upgrades reducing ingress. Although no prediction has been provided as to the reductions that may be seen as a result of this work. As such it is impossible to calculate in stream loads, and impossible to assess the effects that these may have on the receiving environment.

88. Assuming discharge volumes do not change a comparison could be made of current mean discharge values with the Likely Effluent Standards (Table 20). This would result in a reduction in *E. coli* and no reduction of any of the other parameters. It is important to note that the applicant has stated TSS could be reduced to <15 mg/l and DRP to <0.5mg/l if correctly tuned. This would result in a reduction for both of these parameters. However, with the current information provided by the applicant it is unclear as to whether this will be achieved or not. The effect on the receiving environment if these likely effluent standards were to be met is hard to quantify. There would be no expected impact upon the periphyton or macroinvertebrate communities as a result of a reduction in *E. coli*. Assuming the fine tuning of TSS and DRP treatment is successful, this would result in a reduction of biologically available phosphorus, which would be expected to result in a reduction in periphyton growth, and a potential flow on effect to macroinvertebrates. However, generally there is little to no difference with existing mean discharge results so a similar outcome is expected.

89. Given the uncertainty around these standards, and the lack of discharge volumes resulting in an inability to calculate loads, the Likely Effluent Standards have not been analysed any further in this technical assessment.

K. SUBMISSIONS

90. I have read the submissions that have been made on the applications that were publicly notified. Many of the submission cover topics that fall outside of my area of expertise and will be covered in the technical reports of other experts. From the submissions that did cover areas that were in my expertise the following general statements can be made.

91. Many of the submissions focused on the lack of information to make an informed opinion on the application. This limitation has followed through into this assessment.

92. In regards to water quality and cumulative effects the above assessment has given an outline of the current state of the catchment and the effects of the current discharge. At this stage I cannot go much further in terms of effects until the final effluent quality and discharge volumes are known. In terms of monitoring requirements I touch briefly on those below. Given the current uncertainty around potential effects and what the effluent quality will be like, I would suggest that continuing the current monitoring regime (with an increase for periphyton) would be appropriate.

L. MONITORING AND CONDITIONS

93. If the consent was deemed suitable to be granted the current monitoring regime would be the basis to base any future monitoring on. This monitoring should include:

    93.1. Continuous telemetered monitoring of the discharge volumes;

    93.2. Monthly monitoring of the effluent quality;

    93.3. Monthly monitoring of the receiving environment both upstream and downstream of the discharge point into the Makakahi River;

    93.4. Monthly monitoring of periphyton using the same protocols for the monitoring that is currently undertaken; and

    93.5. Annual monitoring of macroinvertebrate communities both upstream and downstream of the discharge point into the Makakahi River.

94. In terms of appropriate in-river standards the standards on the recently granted Feilding WWTP and AFFCO discharges would be a good starting basis with refinement to the values and targets for the Makakahi water management sub-zone.

M. SUMMARY

95. TDC have applied to allow for the discharge of treated wastewater from Eketahuna Township to the Makakahi River. The proposal involves the relocation of the discharge point and upgrades to the treatment process to improve the quality the discharge to the receiving environment. The final effluent quality and volume is currently unknown.

96. The Makakahi River holds a number of reach and zone wide values that have been identified through the One Plan. Targets within the One Plan we developed at the time to provide protection to these values.

97. MWRC has two SOE monitoring sites on the Makakahi Stream which show degradation in water quality, periphyton, and macroinvertebrate communities as you move down the catchment.

98. The monitoring associated with the current discharge shows that there is an increase in the amount of periphyton that is seen in the Makakahi River downstream of the discharge. In addition the macroinvertebrate communities show a significant decline downstream of the discharge point into the Makakahi River. In my opinion this decline is irrespective of the impact of the Ngatahaka Stream.

99. In terms of improvements that will be seen as a result of the upgrades it is difficult to comment without being provided with clear effluent quality standards and discharge volumes that are to apply to the discharge.

DATED this 7 day of March 2017

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Logan Arthur Brown

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Appendix 1:

Table 1: Water Quality targets for all rivers and streams in the Makakahi management Sub-zone

Abbreviations used in Tables D.1A to D.4A		Full Wording of the Target
pH	Range	The pH of the *water*^ must be within the range 7 to 8.5 unless natural levels are already outside this range.
	Δ	The pH of the *water*^ must not be changed by more than 0.5.
Temp (^{o}C)	<	The temperature of the *water*^ must not exceed 19 degrees Celsius.
	Δ	The temperature of the *water*^ must not be changed by more than 3 degrees Celsius.
DO (% SAT)	>	The concentration of dissolved oxygen (DO) must exceed 80 % of saturation.
$sCBOD_5$ (g/m^3)	<	The monthly average five-days filtered / soluble carbonaceous biochemical oxygen demand ($sCBOD_5$) when the *river*^ flow is at or below the 20th *flow exceedance percentile** must not exceed 1.5 grams per cubic metre.
POM (g/m^3)	<	The average concentration of particulate organic matter when the *river*^ flow is at or below the 50th *flow exceedance percentile** must not exceed 5 grams per cubic metre.
Periphyton (*rivers*^)	Chl *a* (mg/m^2)	The algal biomass on the *river*^ *bed*^ must not exceed 120 milligrams of chlorophyll *a* per square metre.
	% cover	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/m^3)	<	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.
SIN (g/m^3)	<	The annual average concentration of soluble inorganic nitrogen (SIN)[9] 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.
Despoiled Sediment Cover[10]	% cover	The maximum cover of visible 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).
MCI[11]	>	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 targets also apply.
QMCI	% Δ	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[12] (g/m^3) (*rivers*^)	<	The average concentration of ammoniacal nitrogen must not exceed 0.4 grams per cubic metre.
	Max	The maximum concentration of ammoniacal nitrogen must not exceed 2.1 grams per cubic metre.

9 Soluble inorganic nitrogen (SIN) concentration is measured as the sum of nitrate nitrogen, nitrite nitrogen, and ammoniacal nitrogen or the sum of total oxidised nitrogen and ammoniacal nitrogen.

10 The Deposited Sediment Cover (%) Water Quality Target (or standard where specified under conditions/standards/terms in a rule) only applies for State of the Environment monitoring purposes to determine if the percentage cover of deposited sediment on the bed of the river will provide for and maintain the values for each WMSZ. The effects of deposited sediment on the bed of rivers in relation to resource consent applications should be determined using the deposited sediment protocols of Clapcott et al. (2010).

11 The Macroinvertebrate Community Index (MCI) target applies only for State of the Environment monitoring purposes to determine if the aquatic macroinvertebrate communities are adequate to provide for and maintain the values in each WMSZ. This target is not appropriate for monitoring the effect of activities such as discharges to water on macroinvertebrate communities upstream and downstream of the activity.

12 Ammoniacal nitrogen is a component of SIN. SIN target should also be considered when assessing ammoniacal nitrogen concentrations against the targets.

Abbreviations used in Tables D.1A to D.4A		Full Wording of the Target
Tox. or 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 (m) (*rivers*^)	% Δ	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 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 50^{th} *flow exceedance percentile**.
E. coli / 100 ml (*rivers*^)	< m	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 50^{th} *flow exceedance percentile**.
	<20^{th} %ile	The concentration of *Escherichia coli* must not exceed 550 per 100 millilitres year round when the *river*^ flow is at or below the 20^{th} *flow exceedance percentile**.

Table 2: Specific water quality targets to protect the trout spawning value.

Management Zone	Sub-Zone	Temp (°C)		DO* (%SAT)	Sediment or POM	Toxicants (%)
		<	Δ	>		
All *Water Management Zones classified as being managed for Trout Spawning**	All *Water Management Sub-Zones** classified as being managed for Trout Spawning	11	2	80	No measurable increase of deposited sediment or particulate organic matter (POM) on the *bed*^ of the *river*^ or stream	99

Appendix 2:

Table 1: Summary of migration movement of native diadromous fish in the Manawatū River catchment. Arrows pointing to the left indicate downstream migration to estuaries or the sea, arrows pointing to the right indicate upstream migration into freshwaters.

Species	Winter	Spring	Summer	Autumn
Giant kokopu	←	→		←
Short jaw kokopu	←	→		←
Banded kokopu	← →	→		←
Koaro	← →	→		←
Redfin bully		← →	→	
Lamprey	← →	← →		
Torrentfish	→	→	←	←
Eels (Longfin and shortfin)	← →	←		→ ←
Giant bully	→	← →	← →	
Smelt		→	→	←
Inanga	→	→ ←		→ ←

Appendix 3:

Table 1: Threat classification of the freshwater species found in the Manawatū catchment. Freshwater fish threat classification based on 2013 publication* (Goodman et al, 2014) and koura and kakahi based on 2013 publication+ (Grainger et al, 2014).

Common name	**Scientific name**	**Threat ranking**
Koura	*Paranephrops planifrons*	Not threatened+
Koaro	*Galaxias brevipinnis*	Declining*
Giant kokopu	*Galaxias argenteus*	Declining*
Short jaw kokopu	*Galaxias postvectis*	Nationally vulnerable*
Banded kokopu	*Galaxias fasciatus*	Not threatened*
Lamprey	*Geotria australis*	Nationally vulnerable*
Brown mudfish	*Neochanna apoda*	Declining*
Inanga	*Galaxias maculatus*	Declining*
Giant bully	*Gobiomorphus gobioides*	Not threatened*
Redfin bully	*Gobiomorphus huttoni*	Declining*
Dwarf galaxias	*Galaxias divergens*	Declining*
Long fin eel	*Anguilla dieffenbachia*	Declining*
Torrentfish	*Cheimarrichthys fosteri*	Declining*
Kakahi	Echyridella menziesi	Declining+
Upland bully	*Gobiomorphus aff. breviceps*	Not threatened*
Crans bully	*Gobiomorphus basalis*	Not threatened*
Common bully	*Gobiomorphus cotidianus*	Not threatened*
Smelt	*Retropinna retropinna*	Not threatened*
Short fin eel	*Anguilla australis schmidtii*	Not threatened*
Brown trout	*Salmo trutta*	Introduced and naturalized*
Rainbow trout	*Oncorhynchus mykiss*	Introduced and naturalized*
Perch	*Perca fluviatilis*	Introduced and naturalized*