IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for consents (**APP-2005011178.01**) by the **TARARUA DISTRICT COUNCIL** to the **HORIZONS REGIONAL COUNCIL** for resource consents associated with the operation of the Ekatahuna Wastewater Treatment Plant, including a discharge into the Makahi River, a discharge to air, and a discharge to landvia pond seepage, Bridge St, Ekatahuna

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STATEMENT OF EVIDENCE OF DR OLIVIER MICHEL NICOLAS AUSSEIL (FRESHWATER QUALITY) ON BEHALF OF TARARUA DISTRICT COUNCIL

14 March 2017

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1. INTRODUCTION

1.1 My name is Olivier Michel Nicolas Ausseil (pronounced “O-Say”).

1.2 I am Principal Scientist – Water Quality at Aquanet Consulting Ltd, a water quality and ecology consultancy based in Palmerston North and Wellington.

1.3 My evidence is given in relation to the application for resource consents for the discharges from the Eketahuna Wastewater Treatment Plant (WWTP) lodged by Tararua District Council (TDC).

2. QUALIFICATIONS AND EXPERIENCE

2.1 I have the following qualifications and experience relevant to my evidence.

2.2 I hold a PhD of Environmental Biosciences, Chemistry and Health from the University of Provence, France. I also hold a Master of Science Degree of Agronomical Engineering from the National Higher Agronomical School of Montpellier, France, and a DEA (equivalent Masters Degree) in Freshwater Environmental Sciences from the University of Montpellier II, France.

2.3 I have over 14 years’ experience in New Zealand as a scientist working in local government and as a private consultant working for regional councils and local authorities, central government and government agencies, and the private sector. Prior to that, I worked as a Research Engineer between 1998 and 2001 for the French Atomic Energy Commissariat during my PhD studies.

2.4 Prior to forming Aquanet Consulting Ltd, I was employed by the Regional Planning Group of Horizons from July 2002 to June 2007, where I held the positions of Project Scientist, Environmental Scientist- Water Quality, and Senior Scientist - Water Quality.

2.5 My responsibilities at Horizons included leading the water quality and aquatic biodiversity monitoring and research programme, providing technical support to policy development and reporting on resource consent applications. I was the primary author of three technical reports underpinning the river classification, river values framework and water quality standards in the notified version of the Proposed One Plan for the Manawatu-Wanganui Region.

2.6 Since July 2007, I have been Principal Scientist at Aquanet Consulting Limited. In this position, I have been engaged by 17 different regional, district or city councils, the Ministry for the Environment, a number of iwi/hapū, the Department of Conservation, Fish and Game New Zealand, and various private companies/corporations to provide a variety of technical and scientific services in relation to water quality and aquatic ecology.

2.7 I am a certified Commissioner under the Ministry for the Environment "Making Good Decisions" programme. I was a Hearing Commissioner appointed by Horizons to hear New Zealand Defence Force's consent applications to discharge treated wastewater from the Waiouru wastewater treatment plant to the Waitangi Stream, in June 2011 and February 2012.

2.8 I have worked as a technical advisor on behalf of the consenting authority, the applicant and/or submitters on well over 150 resource consent applications, compliance assessments and/or prosecution cases for a wide range of activities.

2.9 My work routinely involves providing assessment of effects on water quality and/or aquatic ecology, recommending or assessing compliance with, resource consent conditions, and designing or implementing water quality/aquatic ecology monitoring programmes. I have designed and implemented a large number of monitoring programmes both at the scale of a specific activity and at a wider catchment or regional scale. As part of my previous role at Horizons I redesigned the state of the environment water quality monitoring programme. I also undertook a detailed review of Environment Southland's water quality monitoring programme in 2010 and of Environment Bay of Plenty's in 2012.

2.10 I am currently the Project Manager for the development of the National Environmental Monitoring Standards (NEMS) for discrete water quality monitoring. This particular Standard encompasses all sampling and field measurement procedures, laboratory methods as well as data management and quality control for water quality monitoring in rivers, lakes, groundwater and coastal waters.

2.11 I have authored or co-authored numerous catchment- or region-wide water quality reports for Greater Wellington Regional Council (whole region), Hawke's Bay Regional Council on 7 catchments (2008 and 2016), and for Environment Canterbury on the Hurunui catchment and Pegasus Bay.

2.12 I have authored various reports making recommendations for water quality limits for regional plan change processes, for Horizons Regional Council, Hawke's Bay Regional Council and Greater Wellington Regional Council. I am currently involved in the Gisborne District Freshwater Plan on behalf of the Mangatu/Wi Pere Trusts, and in the Waikato Regional Plan Change 1 on behalf of the Five Waikato River Iwi.

2.13 With regards to municipal wastewater treatment plants I have worked as a technical advisor on behalf of consenting authorities, applicants and submitters on over 35 resource consent applications for discharges of treated domestic wastewater to land and/or water, from both medium-sized towns and small communities.

2.14 I am a member of the New Zealand Freshwater Sciences Society and the Resource Management Act Law Association (RMLA).

2.15 I was the co-recipient of the New Zealand Resource Management Law Association 2016 Chapman Tripp Project Award for an ongoing consultation process associated with the re-consenting of wastewater treatment plant and community water supplies in the Ruapehu District.

2.16 I confirm that I have read the 'Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2014. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this 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.

BACKGROUND AND ROLE

2.17 I was engaged by Tararua District Council in December 2014 to provide an independent assessment of effects from the Eketahuna WWTP discharge on water quality and freshwater ecology.

2.18 In March 2015, I produced, with the assistance of my team, a technical report providing an assessment of the current effects of the discharge on water quality and ecology (dated 30 March 2015)[1]. I also contributed to the responses to the two S92 requests for further information provided in December 2015 and March 2017.

2.19 I have visited the Eketahuna WWTP on several occasions over the last three years, including looking at potential monitoring sites' characteristics and accessibility. Through my work in the region over the last 15 years, I am very familiar with Manawatu catchment and the Makakahi River and their recreational and ecological values.

2.20 I have read Mr Brown's S42A report and have responded at the end of my evidence to issues raised by Mr Brown. I have also read, and relied on, the evidence prepared by Mr John Crawford in relation to the WWTP treatment process and performance.

3. SCOPE OF EVIDENCE

3.1 My evidence addresses the following matters:

(a) River values and water quality targets

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[1] Eketahuna WWTP discharge to the Makakahi River: Summary of Current effects on freshwater quality and ecology, March 2015, Aquanet Consulting Ltd

(b) An analysis of the current effects of the discharge, based on existing water quality and ecological data;

(c) An assessment of the potential future effects of the discharge, on the basis of the proposed changes to the current discharge quality and location

(d) A response to Mr Brown's S42A report.

3.2 As indicated above, I have carefully read Mr Brown's s42A report and, where I substantively agree with his evidence, have directly referred to specific sections of his report to avoid duplication.

4. RIVER VALUES AND WATER QUALITY TARGETS

4.1 In paragraphs 13 to 20, Mr Brown provides a summary of the river values identified in the One Plan in relation to the Makakahi River. I agree with Mr Brown's assessment and I do not repeat it here.

4.2 Appendix 1 of Mr Brown's evidence presents the One Plan (Schedule E) water quality targets applicable to the Makakahi water management sub-zone, in which the discharge is located. Again, I agree with Mr Brown's assessment, and do not repeat it in my evidence.

4.3 It is important to note that, from a technical point of view different Schedule E targets were defined for different reasons. In particular:

(a) Some of the targets are only defined as "State of the Environment" targets and are not directly applicable to point source discharges. This is, for example, the case for MCI and deposited sediment;

(b) Some of the targets directly relate to (i.e. are a measure of) the state of a given river value. For example, visual water clarity and periphyton cover directly relates to the aesthetic and recreational values of the river. Likewise, MCI provides a direct measure of the river's life-supporting capacity, and the change in QMCI provides a direct measure of the degree of effects of a specific activity on life supporting capacity;

(c) By contrast, other targets, such as DRP, SIN, $ScBOD_5$ or POM targets 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 it means that, from a technical point of view, in-stream nutrient (DRP and SIN) can be considered subsidiary to the periphyton and macroinvertebrate targets.

4.4 The above comment has relevance to the decision to apply different targets in different contexts, including in resource consent conditions.

5. CURRENT EFFECTS

5.1 The Eketahuna Wastewater Treatment Plant (WWTP) currently discharges treated effluent to the surface water of the Makakahi River. The discharge point is located immediately upstream of the confluence with a major tributary of the Makakahi River, the Ngatahaka Creek. The Ngatahaka Creek flows represent approximately one third of the flow in the Makakahi River downstream of the discharge.

5.2 The in-stream water quality and ecology monitoring sites are located upstream and downstream of both the discharge from the WWTP and the Ngatahaka Creek confluence. As a result, any comparison between upstream and downstream monitoring results incorporates the inputs of both the discharge and the Ngatahaka Creek. Essentially, the monitoring results available provide a measure of the cumulative effects of inputs from the WWTP discharge plus those from the Ngatahaka Creek. This consideration is critically important in understanding the cause of any effects and developing an appropriate solution to any significant adverse effects.

5.3 The Aquanet report, dated March 2015 provides a summary of the water quality and ecological data available at the time. Appendix A to this evidence provides an update of the same analysis. It also incorporates an additional analysis of contaminant loads in the discharge, utilising discharge flow rate data (for the period January to December 2016) that has recently been provided to me. Discharge rate data has enabled a finer analysis of the contribution of contaminants (in particular SIN and DRP) from the discharge to the downstream water quality. This new analysis has led me to amend some of my 2015 conclusions, in particular regarding the discharge’s contribution to in-river DRP and SIN loads during low river flows.

5.4 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 effects in relation to these determinands (refer to Appendix 1, Section 1.2.6 for more detail). These contaminants are not considered in more detail in this evidence.

5.5 Statistically significant differences in *E. coli* concentrations were identified between upstream and downstream in most flow bins (all flows, at flows above the 20th FEP and at flows below half median), and the proportion of samples compliant with the One Plan targets decreased between upstream and downstream and the discharge (refer to Appendix 1, Section 1.2.5). The Ngatahaka Creek generally has higher *E.coli* concentrations than the Makakahi upstream site and may contribute to this increase, and so does the discharge.

5.6 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) occur in the Makakahi River between the upstream and downstream monitoring sites.

5.7 Increases in ammoniacal nitrogen are likely to be principally caused by the discharge, rather than inputs from the Ngatahaka Creek (where concentrations are generally very low). 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 toxic effects on aquatic life are expected downstream of the discharge (refer to Appendix 1, Section 1.2.1).

5.8 SIN[2]: The One Plan SIN target (i.e. an annual average concentration of 0.444 g/m^3 at flows below the 20th FEP) was met in the Makakahi River both upstream and downstream of the discharge, but largely exceeded in the Ngatahaka Creek (Appendix 1, Figure 7). I note that Mr Brown reaches (at paragraph 61) the conclusion that the SIN target is exceeded at the downstream site. This seems to be due to Mr Brown not having excluded data collected during flood flows (above 20th FEP), although the One Plan targets specifically exclude these flows.

5.9 Additional modelling of SIN loads and concentrations indicates that (Appendix 1, figure 9):

(a) The discharge contributes approximately 1% of the annual SIN load at the downstream site. The main contributors to the downstream annual SIN loads are the Ngatahaka Creek (approximately two thirds of the downstream load) and the Makakahi upstream (approximately one third)

(b) However, the proportion of SIN contributed by the discharge remains relatively constant year-round, whilst the contributions from the Ngatahaka and Makakahi upstream are highly flow dependent. Under low flow conditions, i.e. when he Makakahi River at Hamua was below half median flow, the discharge contributed approximately 37% of the SIN, and the Ngatahaka Creek approximately 60%.

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[2] Soluble Inorganic Nitrogen. This is the sum of nitrate-, nitrite- and ammoniacal nitrogen, and is generally considered as the nitrogen fraction directly available for plant/algae growth.

5.10 DRP: 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 (Appendix 1, Figure 10). Similarly to SIN, I note that Mr Brown reaches the conclusion that the DRP target is exceeded both in the Ngatahaka Creek and the Makakahi downstream. I believe Mr Brown's conclusion is incorrect, and due to using the wrong water quality target and not excluding data collected at high river flows.

5.11 Additional analysis indicates that (Appendix 1, Figure 12):

(a) The discharge contributes approximately 8% of the annual DRP load at the downstream site. The main contributors to the downstream annual SIN loads are the Makakahi upstream (approximately 52%) and the Ngatahaka Creek (approximately 40%);

(b) However, when considering low flow conditions, the discharge contributed 70% of the load, against 13% for the Ngatahaka Creek.

5.12 Analysis of the ecological data available indicates that, for Periphyton biomass:

(a) The dataset available spans a period of nearly 3 and a half years (February 2013 to September 2016); however, data was not collected monthly, and only 24 individual samples are available during that period;

(b) Periphyton biomass generally increased in the Makakahi River between the upstream and downstream sites. The Ngatahaka Creek also generally had periphyton biomass greater than those in the Makakahi River at the upstream site, and similar to, or greater than, the Makakahi downstream site (Appendix 1, Figure 19);

(c) The One Plan target was exceeded once (out of 24 samples, i.e. 4% of samples) at the upstream site, three times (12.5% of samples) at the Makakahi downstream site and twice (8% of samples) in the Ngatahaka Creek;

(d) The issue of how compliance with the One Plan biomass target should be assessed was the subject of extensive debate and expert caucusing during the Feilding WWTP council level and environment court hearings. The Court accepted that these targets were not applicable as absolute numbers, and, on the basis of consensus among technical experts, imposed a consent condition based on no more than 1 exceedance out of 12 consecutive monthly samples (roughly equivalent to 8% of samples);

(e) The dataset available does not allow a full assessment against the One Plan targets on the above basis (because monitoring was not undertaken monthly); however, on the basis of the data available, it seems likely that the Makakahi upstream site meets the One Plan target, the Ngatahaka Creek possibly meets the target, and the Makakahi downstream site possibly exceeds the target.

(f) Similarly, although insufficient data are available, a preliminary assessment indicates that the upstream site is likely to fall in the NPSFM (2014) ‘B’ grade for periphyton (Trophic state), whilst the downstream site and the Ngatahaka Creek may fall in either the ‘B’ or ‘C’ grades

5.13 With regards to periphyton cover, all three sites meet the One Plan targets for long filamentous algae and thick mats (Appendix 1, Figure 21).

5.14 With regards to macroinvertebrate communities, a number of indices are routinely used to provide a summary of the state or “health” of macroinvertebrate communities, as explained in paragraphs 24 to 32 of Mr Brown’s evidence.

5.15 Tables 14 to 17of Mr Brown’s evidence provide a summary of the data available in relation to 4 key indices (MCI, QMCI, %EPT taxa and %EPT individuals).

5.16 MCI: all three sites (including the Ngatahaka Creek) had MCI scores generally around 100, indicative of good water quality, but below the One Plan target (an MCI score of 120). Any differences between sites were generally small (Appendix 1, figure 24). It is noted that the One Plan target relative to MCI specifically relates to “state of the environment” monitoring situations. The One Plan defines a target relative to a change in QMCI specifically in relation to point source discharges.

5.17 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 2013, 2014 and 2015. An 18% decrease was observed in 2016.

5.18 While the Number of Individuals increases significantly between upstream and downstream sites, the percentage of EPT Individuals decreases. This is primarily a result of an increase in the numbers of the Chironimid, *Tanytarsus* sp., a non-EPT taxa, at the downstream site.

5.19 Overall, I am of the opinion that the changes in macroinvertebrate communities in the Makakahi River between the two monitoring sites are adverse and significant. I discuss the possible causes of these changes below.

5.20 Macroinvertebrate communities are known to change in response to a number of contaminants and/or mechanisms of effects, including:

(a) The deposition of organic matter on the bottom of the river; and/or

(b) The deposition of fine sediment;

(c) Toxic effects, for examples caused by ammonia

(d) The flow on-effects on macroinvertebrate communities arising from increased growth of periphyton at the downstream site compared with upstream.

5.21 Taking each of these mechanisms in turn:

(a) the One Plan defines water quality targets relative to Particulate Organic Matter (POM) specifically to manage the risk of effects on macroinvertebrate communities due to organic matter deposition downstream of point-source discharges. As explained in paragraph 5.4 the POM target was met at all three sites, and no significant increases were detected between the Makakahi upstream and downstream sites. This mechanism therefore seems unlikely to be the dominant cause of the changes in macroinvertebrate communities in this situation;

(b) Likewise, no increases in TSS concentrations were detected between the Makakahi upstream and downstream sites, making the deposition of fine sediment an unlikely mechanism of effect;

(c) Whilst ammoniacal nitrogen concentrations increased between upstream and downstream of the discharge, concentrations at the downstream site remained well below the One Plan targets for both chronic and acute ammonia toxicity. Again, it seems unlikely

(d) As noted in paragraph 5.12(b), periphyton biomass generally increased between the upstream and downstream sites. It seems possible that the increase in periphyton growth is a contributor to the measured changes in macroinvertebrate communities.

(e) Macroinvertebrate communities may also change in response to differences in physical habitat characteristics, such as substrate composition, embeddedness, etc.

(f) It is possible that more than one of the above mechanisms of effects may be the cause of the changes in macroinvertebrate communities measured in the Makakahi River.

5.22 As explained above in paragraph 4.3(c), nutrients such as SIN and DRP are controlling factors of periphyton. As noted in the 2015 Aquanet report[3], the growth of periphyton in the Makakahi River is likely to be primarily controlled by SIN during periods of low flow, and by DRP during periods of higher flow. The concentrations of both nutrient increase downstream of the discharge; it thus seems plausible that the increase in SIN and/or DRP concentrations measured between upstream and downstream of the

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[3] Section 3.1.5, p28-29

discharge are the driver of the increased periphyton growth measured at the downstream site.

5.23 The updated load calculations I have undertaken have led me to the conclusion that, whilst the discharge from the Eketahuna WWTP is a relatively minor contributor to the in-river annual loads of SIN and DRP, during periods of low flow it does contribute materially to the SIN loads and is the main source of DRP. The Ngatahaka Creek remains however the largest source of SIN under nearly all situations.

5.24 Given that SIN appears to be the main factor controlling periphyton growth in the Makakahi River during periods of low flows, the relative contribution of inputs from the Ngatahaka Creek vs. those from the discharge to the increased periphyton growth (and any flow-on effects on macroinvertebrate communities) need to be considered.

5.25 There are no modelling tool available by which the effects of a point-source discharge on macroinvertebrate communities can quantitatively or semi-quantitatively be predicted. Given the multiple potential mechanisms of effects and source of contaminants from both the discharge and the Ngatahaka Creek, no firm conclusion can, in my view, be drawn with regards to the direct effects of the discharge from the Eketahuna WWTP on periphyton or macroinvertebrate communities on the basis of available data.

5.26 In my view, only the physical separation of the discharge from the Ngatahaka Creek will enable a direct measure of the effects of the discharge.

6. EFFECTS OF THE FUTURE/PROPOSED DISCHARGE AND RECOMMENDATIONS

6.1 As noted in paragraph 5.5, there is currently a significant increase in *E. coli* concentrations in the Makakahi River between the upstream and downstream monitoring sites, and both the discharge and the Ngatahaka Creek are likely contributors to this increase. It is my understanding that the proposed upgrades at the Eketahuna WWTP include UV treatment of the wastewater. Mr Crawford has commented on the likely performance of the UV treatment, and concluded that *E. coli* concentrations in the 260 to 1,000 *E.coli*/100mL should be achieved. On that basis, I expect that any effects of the discharge on in-river *E. coli* concentrations will become relatively minor.

6.2 I also understand that the proposal will include dosing with a flocculant and/or coagulant before clarification and filtration, as well as a form of land passage and/or wetland. These upgrades will be expected to reduce the loads and concentrations of DRP and particulate organic matter in the discharge. I am not however aware of any upgrades that specifically aim at reducing the nitrogen concentrations or loads in the discharge.

6.3 It is difficult to predict the likely ecological effects of the discharges under the proposal with any degree of certainty, as it will depend on two key questions that are currently un-answered:

(a) What is the relative role of the Ngatahaka Creek vs. the discharge itself in the detrimental changes in periphyton biomass and macroinvertebrate communities measured in the Ngatahaka Creek?; and

(b) If the discharge in itself does cause significant adverse effects, what is/are the mechanism(s) of effect? In other words, what contaminant(s) (e.g. POM, ammonia, DRP, SIN?) are the primary cause of the effects?

6.4 It is my understanding that TDC are proposing to shift the discharge to a location further downstream, although the exact location of the discharge point and setup (land passage or wetland) is still to be confirmed.

6.5 Shifting the discharge point as proposed by TDC will not change the actual effects of the discharge, but will physically separate out the inputs from the Ngatahaka Creek vs. those of the discharge. Assuming adequate monitoring sites can be identified, it will provide the opportunity to monitor the actual effects of the discharge without the interference from the Ngatahaka Creek.

6.6 Depending on the key mechanism(s) of effect, the upgrades proposed at the Eketahuna WWTP may, or may not, address any significant adverse effects caused by the discharge itself. For example, if particulate organic matter and/or DRP from the discharge are the main cause of the ecological effects measured in the Makakahi River, then the upgrades are likely to improve the situation. If SIN from the discharge is the main contaminant in cause, then the upgrades appear unlikely to address the effects.

6.7 Given the source or cause of the ecological changes have not been identified I am not in a position to make a firm recommendation regarding the need for any specific changes to the effluent quality, such as for example additional phosphorus or nitrogen removal.

6.8 Once the discharge has been shifted to its new location, I recommend that a period of water quality and ecological monitoring follows to robustly assess the effects of the discharge itself (i.e. separately from the inputs from the Ngatahaka Creek). Monitoring sites should be, as much as practicable of similar physical characteristics (depth, velocity, substrate size, shading) to enable an upstream/downstream comparison of ecological monitoring results.

6.9 The monitoring period should be of sufficient duration to account for climatic variability (e.g. wet vs dry years), and, in my opinion, should be of at least three years in duration after which the significance of any effect can be assessed and a solution, if required, devised.

6.10 It is my understanding that TDC are currently investigating two options for the discharge location. Option 1 is an overland wetland passage immediately to the Northeast of the WWTP, and Option 2 is a larger constructed wetland on a lower river terrace on land owned by the Eketahuna golf course. In my opinion, Option 2 will provide adequately comparable and accessible upstream and downstream monitoring sites for both water quality and ecological monitoring. Option 1 would however constrain the location of the upstream monitoring site, and it is less likely that a well matched downstream monitoring site will be able to be identified. Under Option 1, water quality sampling should be able to be adequately undertaken, but the undertaking and interpretation of any ecological monitoring (periphyton and macroinvertebrates) is likely to be problematic.

7. RESPONSE TO S42A REPORT

7.1 Paragraphs 60 to 65 (Tables 11 to 13) of Mr Brown's S42A report present an assessment of water quality monitoring data against the One Plan targets for DRP and SIN. These are based on annual average concentrations of all the data. However, the One Plan DRP and SIN targets specifically exclude (i.e. do not apply) river flows above the 20th FEP (flood flows), and data collected above the 20th FEP must be excluded from the calculation. DRP and SIN concentrations in rivers are often flow related, and not excluding data collected at high river flows is likely to result in a higher calculated average concentration.

7.2 As a result, Mr Brown has concluded that the SIN target was exceeded both in the Ngatahaka Creek and the Makakahi downstream site. My assessment, which does exclude data collected at river flows above 20th FEP concludes that the One Plan SIN target is largely exceeded in the Ngatahaka Creek but met in the Makakahi at the downstream site (although by a small margin, and in spite of a significant increase compared with the upstream site, as illustrated in Appendix 1, Figure 7).

7.3 Further, it seems that the wrong DRP target has been used in Mr Brown's report. The One Plan target for the Makakahi Water Management sub-Zone is 0.010 g/m^3. Table 11 shows that the DRP concentration in the Makakahi downstream did not meet the One Plan target in any of the years, in spite of being between 0.007 and 0.009 g/m^3 in 2012 to 2015. In my assessment, all three sites do meet the One Plan target by some margin, as illustrated in Appendix 1 to my evidence (Figure 10).

7.4 In paragraph 78, Mr Brown says that while the Ngatahaka Creek adds nutrient to the Makakahi Creek, the changes in macroinvertebrate indices cannot be attributed solely to this. I fully agree with this statement, and repeat my opinion that what is being measured is the results of the combined inputs from the Ngatahaka Creek and the discharge. I note however that exactly the same reasoning should be made for the discharge, i.e. given that the Ngatahaka Creek is a significant contributor of the nutrient loads measured in the Makakahi at the downstream site, then the changes in macroinvertebrate indices cannot be solely attributed to the discharge.

7.5 In paragraph 82, Mr Brown says that the Applicant has suggested that shifting the discharge point will alleviate the effects currently seen in the Makakahi River. I did not make such a statement and do not believe it has been made by, on or behalf of, the Applicant. To be clear, merely shifting the discharge point will do nothing to alleviate any effects of the discharge itself. However, the Ngatahaka Creek flows into the Makakahi between the upstream and the downstream site and it is demonstrably a significant contributor to the increases in SIN and DRP concentrations measured at the downstream Makakahi site. We are therefore currently measuring the combined effects of the two sources of contaminants. Shifting the discharge point will simply separate the effects of the Ngatahaka Creek from those of the discharge.

7.6 In paragraphs 82 and 83, Mr Brown raises concern with regards to the ability to undertake monitoring upstream and downstream of the discharge point. In my opinion, water quality sampling will be able to be undertaken adequately (e.g. by use of a sampling pole). However, I do share Mr Brown's concerns with regards to ecological monitoring. I also agree that Option 2 will not give rise to the same concerns, and should provide for adequate water quality and ecological monitoring sites.

Dr Olivier Michel Nicolas Ausseil

14 March 2017

Appendix A: Update of the monitoring data analysis

Appendix A

Eketahuna WWTP discharge to the Makakahi River:

Summary of Current effects on freshwater quality and ecology, 2010-2016

1.1. Available data and data preparation

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 2010-2016.

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.

The data used for the assessment presented here are summarised in Table 1 below. River flow statistics used are summarised in Table 2.

Water quality, periphyton 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 Mangatainoka - Makakahi management sub-zone (Mana_8d) and those included in the current resource consent conditions (Discharge Consent N. 4367).

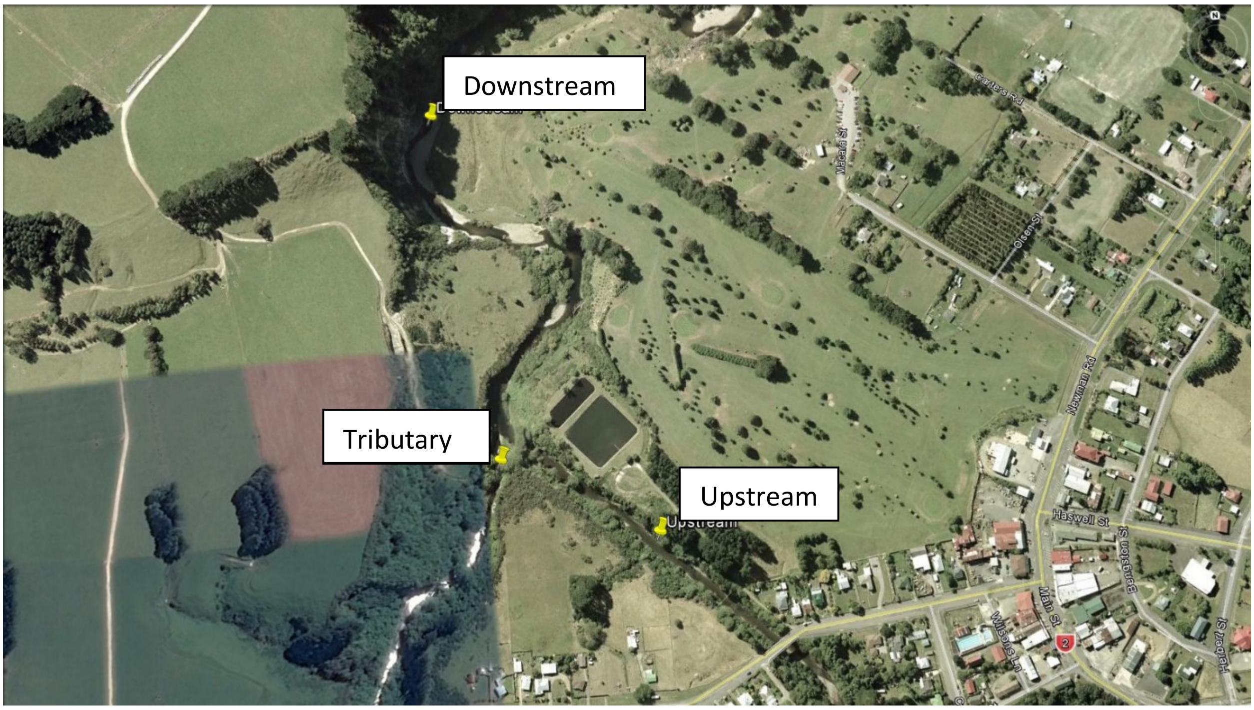

Figure 1: Locations of sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge point and within the Ngatahaka Creek tributary, 2010-2016.

Table 1: Summary of data used in this assessment

Site	Type	Parameters	Frequency	Period	Source
Eketahuna STP at Secondary oxpond	Effluent quality	DRP, TP, TN, NO_3-N, NO_2-N, TNH_3-N, SIN, *E. coli*, Enterococci, TSS, POM, Visual clarity (Black disc), $sCBOD_5$,	Monthly	Jan 2010 to Dec 2016	Horizons
	Effluent flow	Daily mean flow	Daily	January -November 2016	TDC
Makakahi River at Hamua	River flow	Daily mean flow	Daily	Jan 2010 to Dec 2016	Horizons
Makakahi River above confluence (Synthetic)				Dec 1979 to Jan 2017	OPUS
Makakahi River below confluence (Synthetic)					
Ngatahaka Creek (Synthetic)					
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), $sCBOD_5$, DOsat., pH, Temp	Monthly	Jan 2010 to Dec 2016	Horizons
Makakahi River downstream of Eketahuna WWTP discharge					
Tributary (Ngatahaka Creek)				Oct 2010 to Dec 2016	
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. March 2014 January 2015 and March 2016 Feb 2013 to Sept 2016	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

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/m^3)	BOD_5 concentration shall not exceed **1.5 g/m^3** (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/m^3)	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/m^2** (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/m^3)	DRP concentrations must not exceed **0.010 g/m^3** 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**.

1.2. 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 December 2016 have been summarised and are presented in the Figures below (mean concentrations with error bars representing the 95% confidence intervals).

NPSFM assessments were carried out on Total ammoniacal nitrogen (Figure 3), Nitrate nitrogen (Figure 6) and *E.coli* (Figure 14) data collected from the three sites for each twelve month period beginning in January 2010 and ending in January 2017.

In-stream loads were calculated over the 2010 to 2016 period. Discharge loads of SIN and DRP were calculated for 2016 only, due to the limited availability of effluent flow data (January to December 2016 only). In-stream loads presented in comparison to discharge loads were calculated over the same period for comparability. Low flow loads were calculated over the February to April 2016 period, as being the period of low river flow for which discharge and in-stream data were available. Contributions from each of the three sources (upstream, the discharge and the Ngatahaka Creek tributary) have been calculated as a ratio of each to the sum of the three.

1.2.1. Total Ammoniacal Nitrogen

- Total ammoniacal nitrogen concentrations were always well below the One Plan and Consent target, both upstream and downstream of the Eketahuna WWTP discharge (Figure 2, upper), 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 between median and 20th FEP and half median to median. When the influence of the tributary was removed from the downstream site, the significant differences remained the same (Figure 2, lower).
- 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 with respect to annual median concentrations both with and without the influence of the tributary (Figure 3, upper). Annual maximum concentrations of ammoniacal nitrogen are assigned to Attribute State A from June 2012 onwards 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.

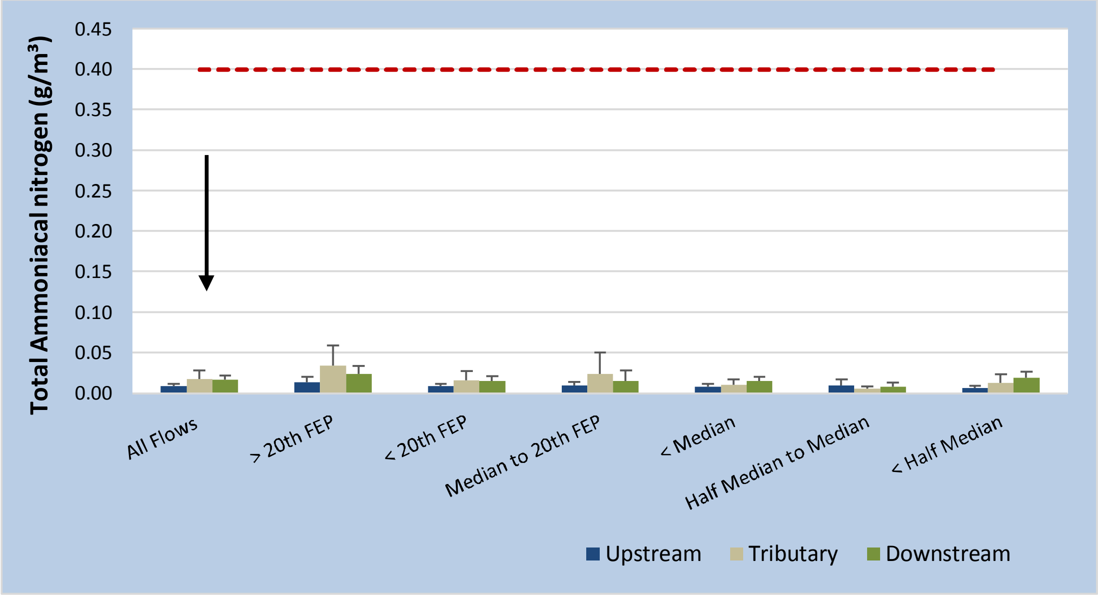

Figure 2: Mean Total Ammoniacal Nitrogen concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows. The One Plan target for Total Ammoniacal Nitrogen (chronic exposure) is represented as a dashed red line. The black arrow indicates the flow bin defined in the One Plan target.

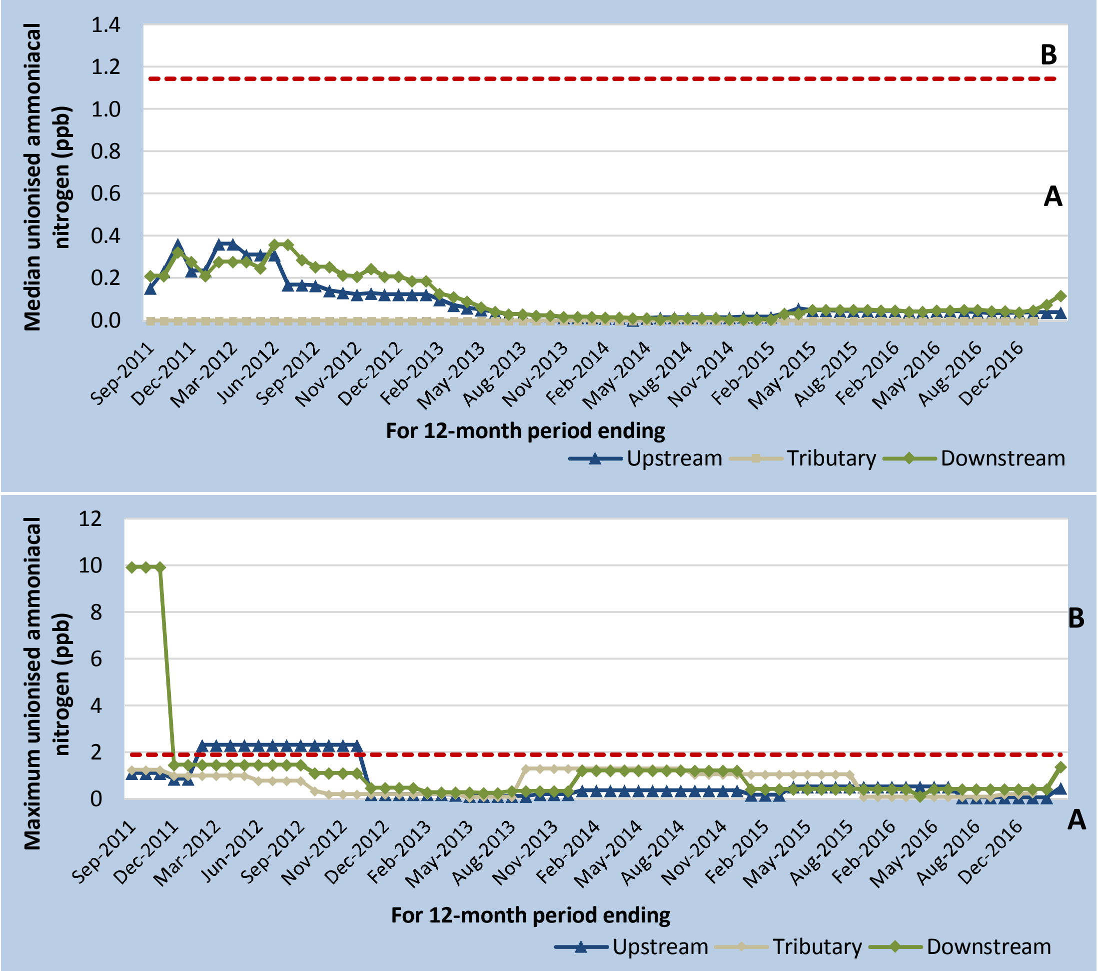

Figure 3: Rolling Annual Median (upper) and Rolling Annual Maximum (lower) unionised ammoniacal nitrogen concentrations for sites sampled on Makakahi River (January 2010 – January 2017) upstream and downstream of the Eketahuna WWTP. NPSFM 2014 Attribute States (A and B) are indicated by the red lines.

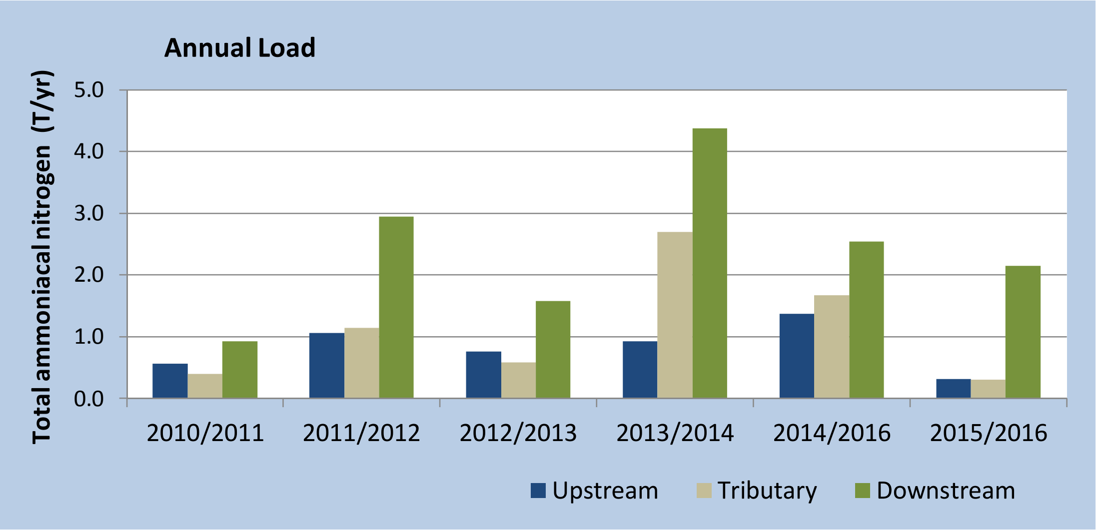

Figure 4: Total Ammoniacal Nitrogen annual loads for sites upstream and downstream of the Eketahuna WWTP discharge point as well as within the Ngatahaka Creek tributary, 2010 - 2016.

1.2.2. Nitrate Nitrogen

- Significant increases in nitrate nitrogen concentrations occurred between upstream and downstream of the discharge in all flow bins.
- Of all three sites, the Ngatahaka Creek presented the highest concentrations. Once the inputs from the Ngatahaka Creek were removed from the downstream site, significant differences still remained between upstream and downstream of the discharge in all flow bins (Figure 5, lower), indicating that the Ngatahaka Creek is the likely main source of the increase in nitrate-nitrogen concentrations between the Makakahi upstream and downstream sites.
- Assessment against the NPSFM (2014) for nitrate (Toxicity) concentrations 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 (Figure 6), while nitrate concentrations within the Ngatahaka Creek tributary are assigned mostly to Attribute State A up from September 2011 until March 2014 and then mostly to Attribute State B. This suggests a high conservation value system where any effects of nitrate toxicity are unlikely even on sensitive species at the upstream and downstream sites but some growth effect on up to 5 % of species is expected within the tributary in the 2014-2016 period.

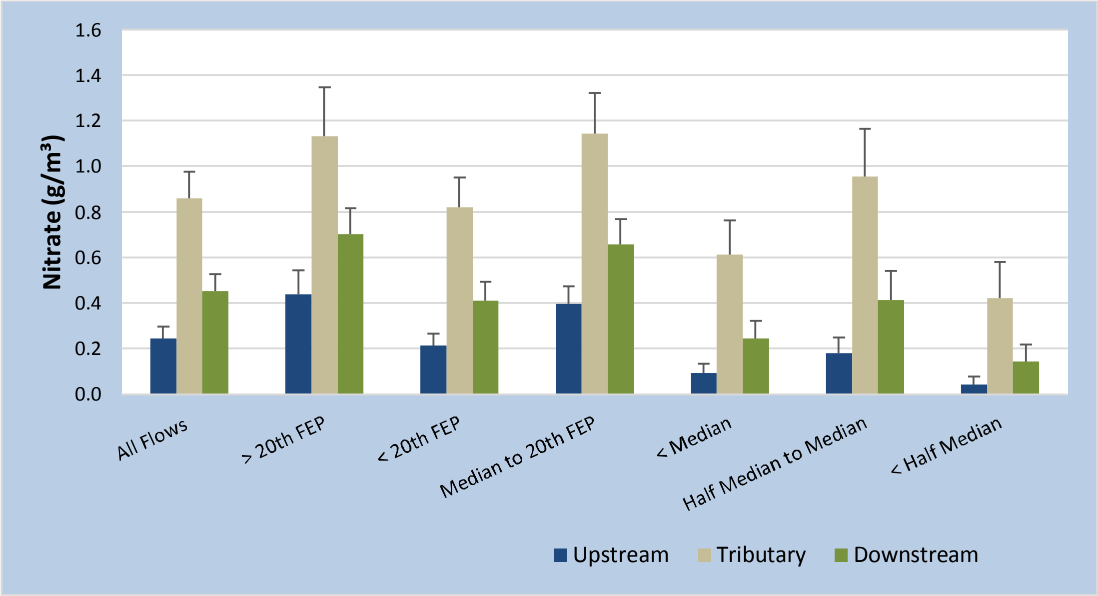

Figure 5: Mean Nitrate Nitrogen concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows.

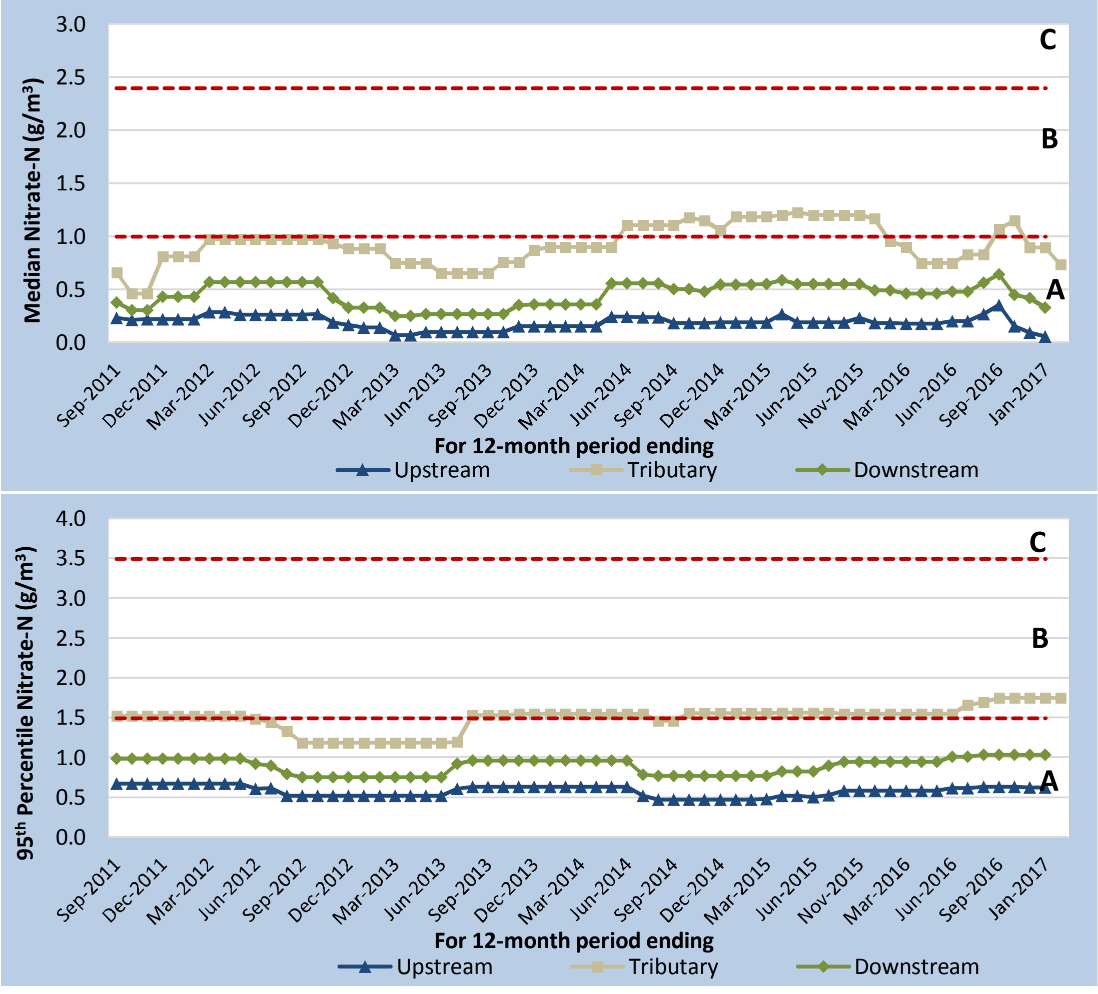

Figure 6: Rolling Annual Median (upper) and Rolling Annual 95th Percentile (lower) Nitrate nitrogen concentrations for sites sampled on Makakahi River upstream and downstream of the Eketahuna WWTP and in the Ngatahaka Creek tributary (January 2010 – January 2017. NPSFM 2014 Attribute States (A, B and C) are indicated by the red lines.

1.2.3. 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/m^3 at flows below the 20th FEP). The Ngatahaka Stream largely exceeded the SIN target (Figure 7).
- SIN concentrations were significantly higher at the Makakahi downstream site than at the Makakahi upstream site.
- When considering SIN load inputs, the is estimated to contribute approximately 1% to the downstream SIN load, while the tributary contributes 64%.
- During low flow periods the discharge contributes 37% to the downstream SIN load, while the tributary contributes 60% (Figure 8).

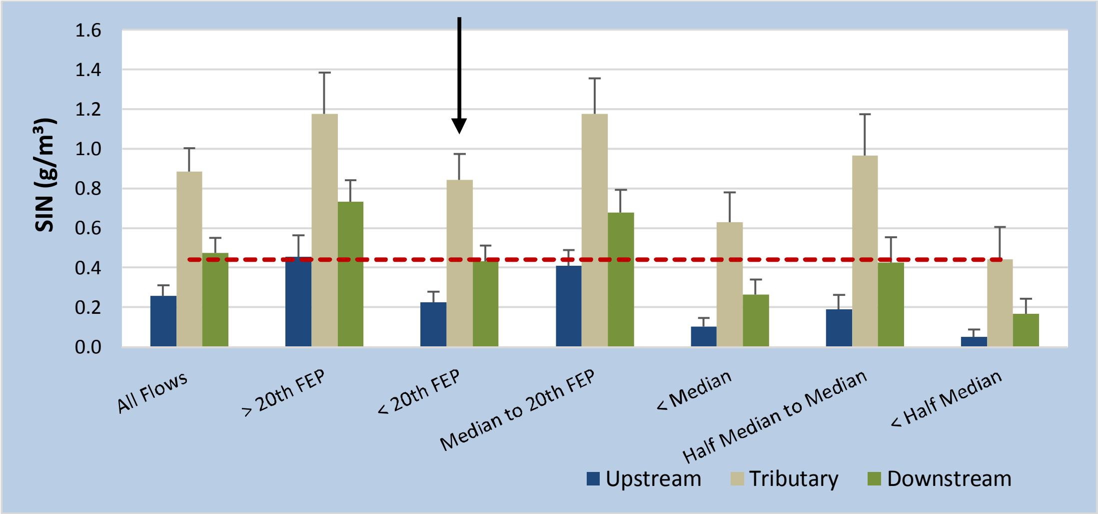

Figure 7: Mean Soluble Inorganic Nitrogen (SIN) concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows. Dashed red lines indicate the One Plan target. The black arrow indicates the flow bin defined in the One Plan target.

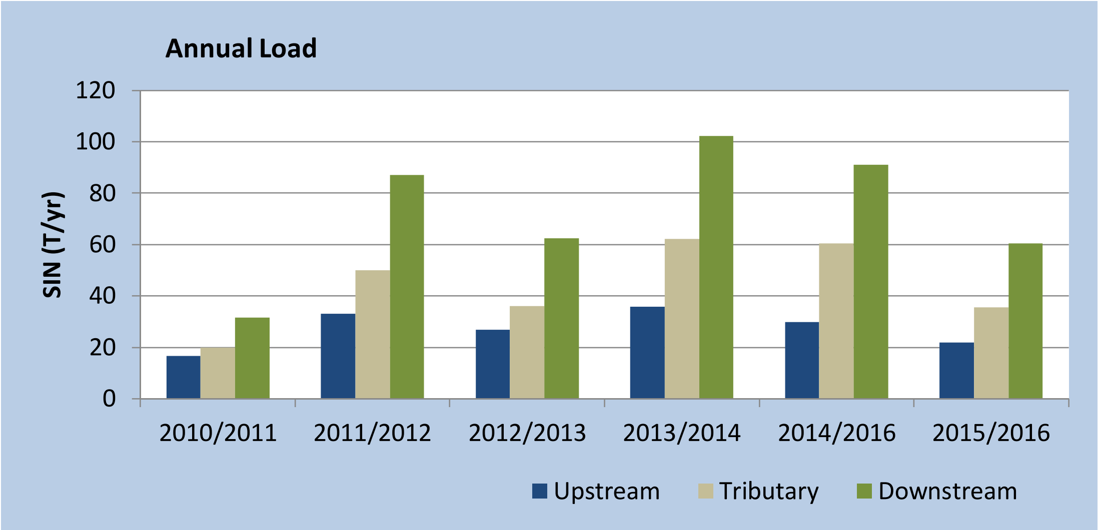

Figure 8: Soluble Inorganic Nitrogen (SIN) annual loads for sites upstream and downstream of the Eketahuna WWTP discharge point as well as within the Ngatahaka Creek, 2010 - 2016.

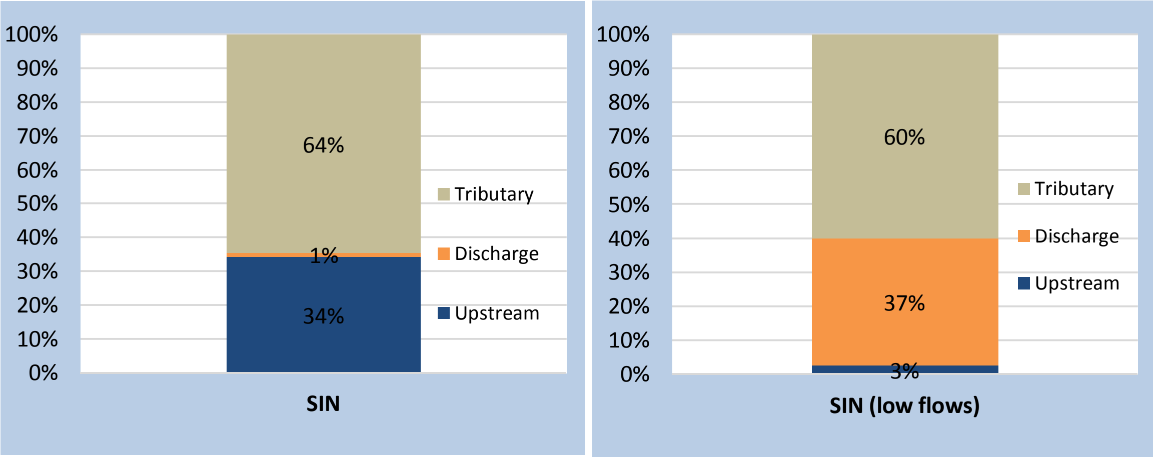

Figure 9: Contribution from various sources to the percentage of downstream Soluble Inorganic Nitrogen (SIN), for the whole of 2016 (left), and during low flows only (February to April 2016).

1.2.4. 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 20th FEP) was met at all three sites (Figure 10).
- Concentrations of DRP were significantly different between upstream and downstream of the discharge within all flow bins, except at flows between half median and median.
- When considering annual loads, the discharge is estimated to contribute approximately 8% of the inputs to the downstream 10% to the DRP load at the downstream Makakahi site, while the tributary contributes 40%.
- However, during the February to April 2016 low flow period the discharge contributed 70% to the downstream DRP load, while the tributary contributed 13% (Figure 12).

1.2.5. 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) at flows below median, met the One Plan limit of 260/100mL 66% of the time upstream and 56% of the time at the downstream (59% compliance in the tributary) (Figure 13, upper).
- *E. coli* concentrations year-round at flows below the 20th FEP complied with the One Plan target of 550/100mL 84%, 81% and 77% (upstream, downstream and in the tributary, respectively) during the sampling period (October 2010 – December 2016).
- There were significant differences between upstream and downstream sites at all flows, at flows above the 20th FEP and at flows below half median.
- Assessment against the NPSFM (2014) for *E.coli* concentrations in the Makakahi River upstream of the Eketahuna WWTP discharge assigns an Attribute State of A (when considering annual median) in all 12-month periods except that ending May 2015. These results imply a low risk of infection (< 0.1% risk) from contact during water activities.
- At the downstream site, annual median *E.coli* concentrations are assigned an Attribute State of B (< 1% risk) in the 12-month periods ending August 2014, October 2014, May 2015, November 2015 – February 2016 and May 2016; with an Attribute State of A in all other 12-month periods.
- When considering 95th percentile however, all three sites receive an overall D grading, indicative of a high risk of infection from contact during water activities.

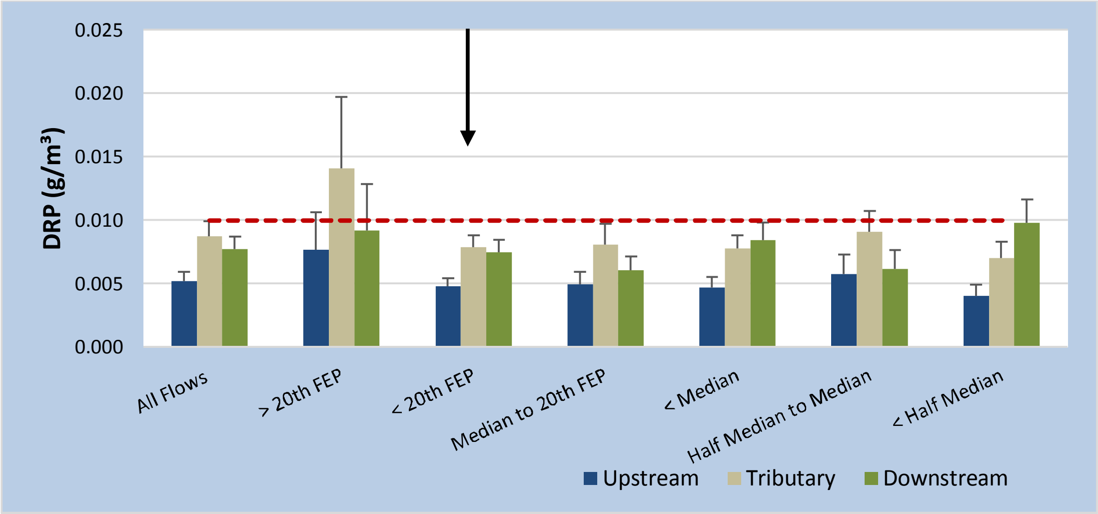

Figure 10: Mean Dissolved Reactive Phosphorus (DRP) concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows. The One Plan target is represented as a dashed red line. The black arrow indicates the flow bin defined in the One Plan target.

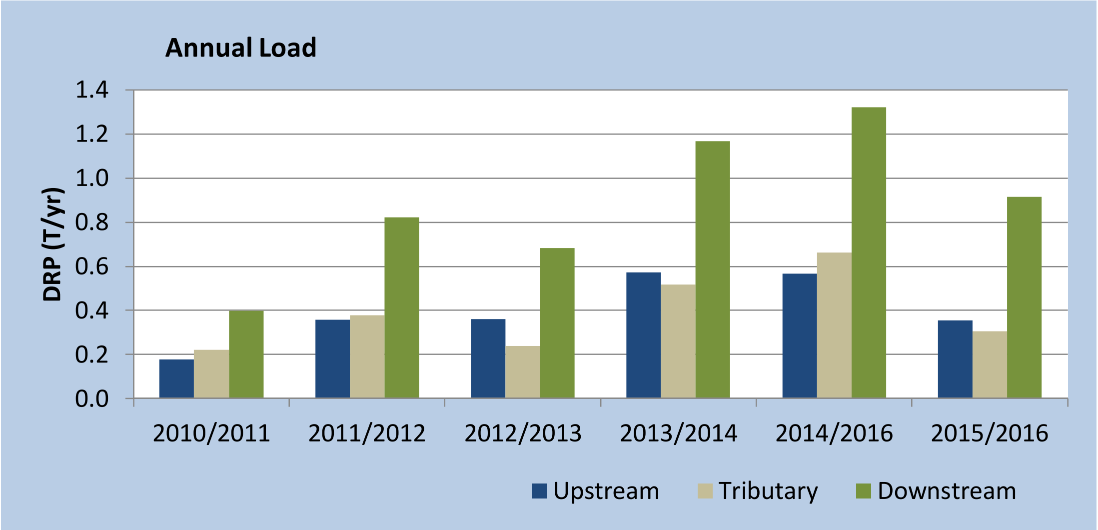

Figure 11: Dissolved Reactive Phosphorus (DRP) annual loads for sites upstream and downstream of the Eketahuna WWTP discharge point as well as within the Ngatahaka Creek tributary, 2010 - 2016.

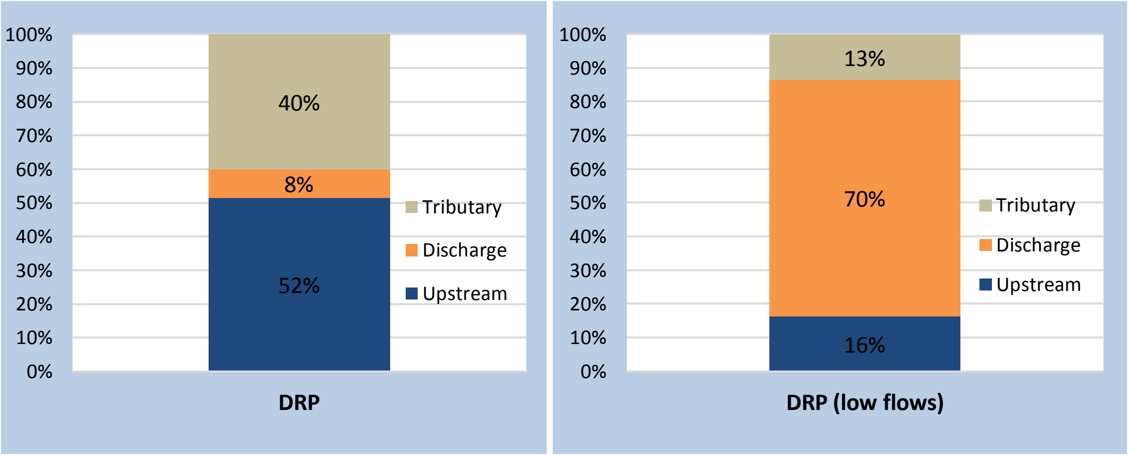

Figure 12: Contribution from various sources to the percentage of downstream Dissolved Reactive Phosphorus (DRP), for the whole of 2016 (left), and during low flows only (February to April 2016).

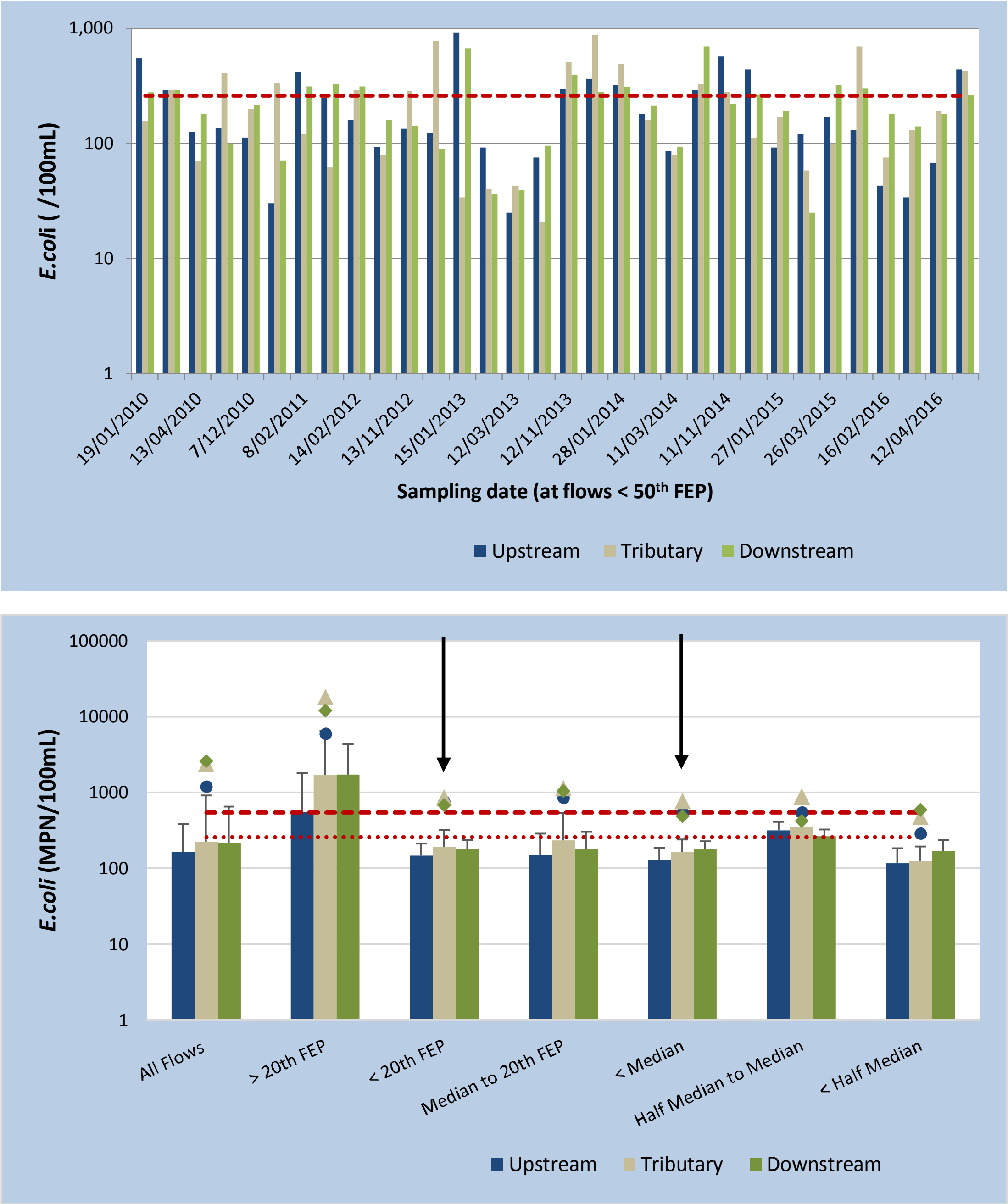

Figure 13: Daily *E.coli* concentrations at or below median flow during summer months (upper) and Median (bars) and 95th percentile (dots) *E.coli* concentrations (lower) at sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 –December 2016) at various flows. One Plan targets for *E. coli* are represented as dashed and dotted red lines. The black arrows indicate the flow bins defined in the One Plan target.

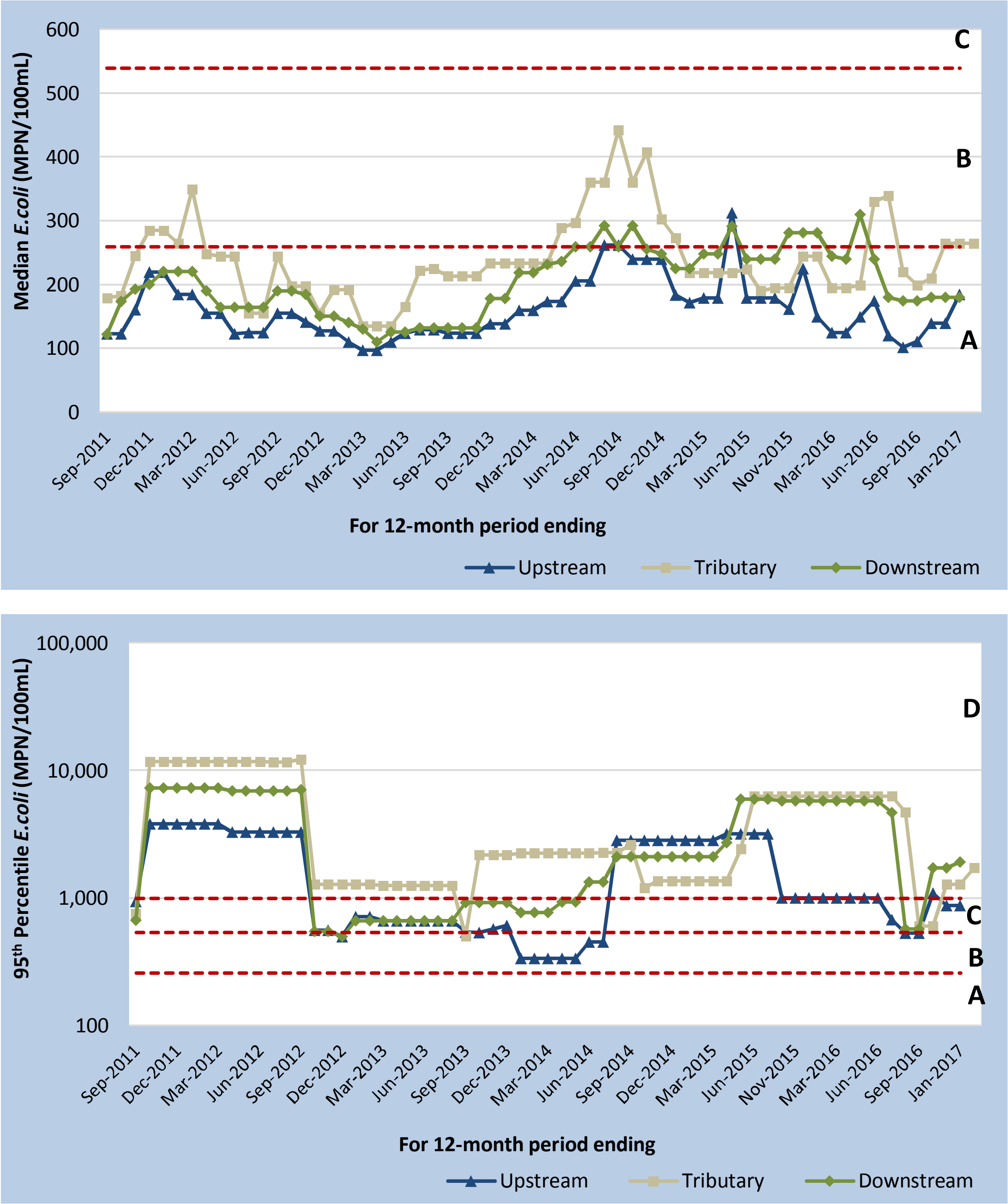

Figure 14: Rolling Annual Median (upper) and Rolling Annual 95th Percentile (log scale) (lower) *E.coli* concentrations for sites sampled on Makakahi River upstream and downstream of the Eketahuna WWTP and in the Ngatahaka Creek tributary (January 2010 – January 2017). NPSFM 2014 Attribute States (A, B, C and D) are indicated by the red lines.

1.2.6. Black Disk, Total suspended solids and Particulate organic matter

- Average black disc readings both upstream and downstream of the Eketahuna WWTP discharge were below the One Plan and Consent target of 3 m minimum visual clarity in all flow bins (Figure 15). 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 and Consent target of 20% between October 2010 and December 2016, there were just as many increases as decreases in visual clarity between upstream and downstream of the discharge (Figure 16).
- Concentrations of Total Suspended Solids (TSS) were higher upstream of the discharge compared with the downstream site for all flow bins except flows below the 20th FEP and between half median to median flows (Figure 17), with no significant differences in concentrations between sites.
- Comparisons of Particulate Organic Matter (POM) between upstream and downstream sites showed slightly higher concentrations upstream compared with downstream of the Eketahuna WWTP discharge, with concentrations well under the target required by both Consent conditions and the One Plan of 5 g/m³ at both sites (Figure 18). No significant differences were observed between sites.

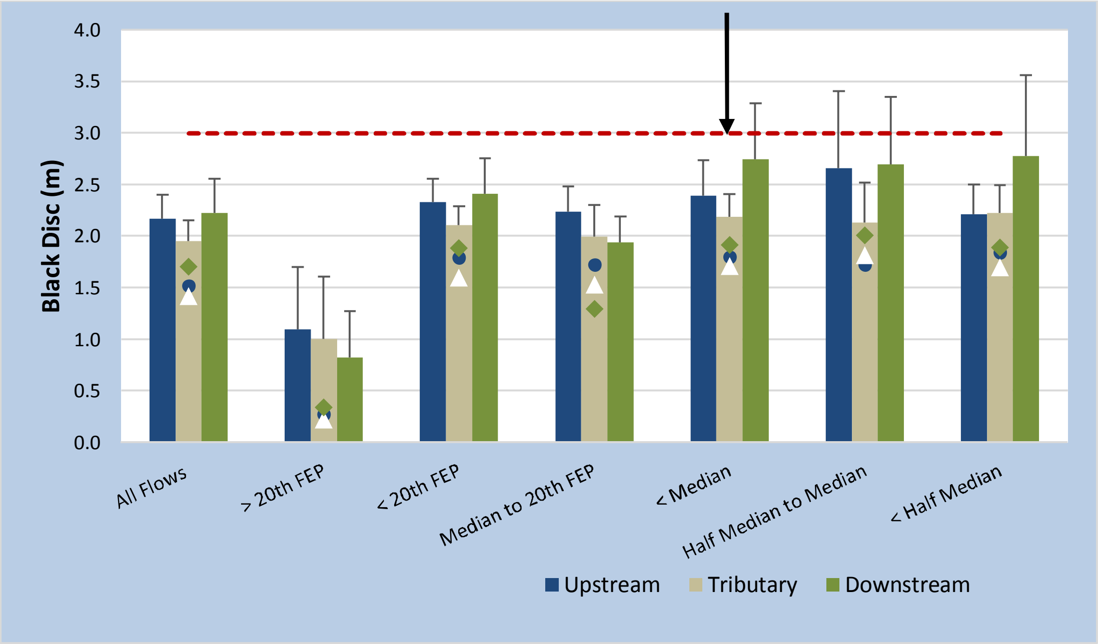

Figure 15: Mean (bars) and 20th percentile (dots) black disk readings for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows. The One Plan target for Black disk is represented as a dashed red line. The black arrow indicates the flow bin defined in the One Plan target.

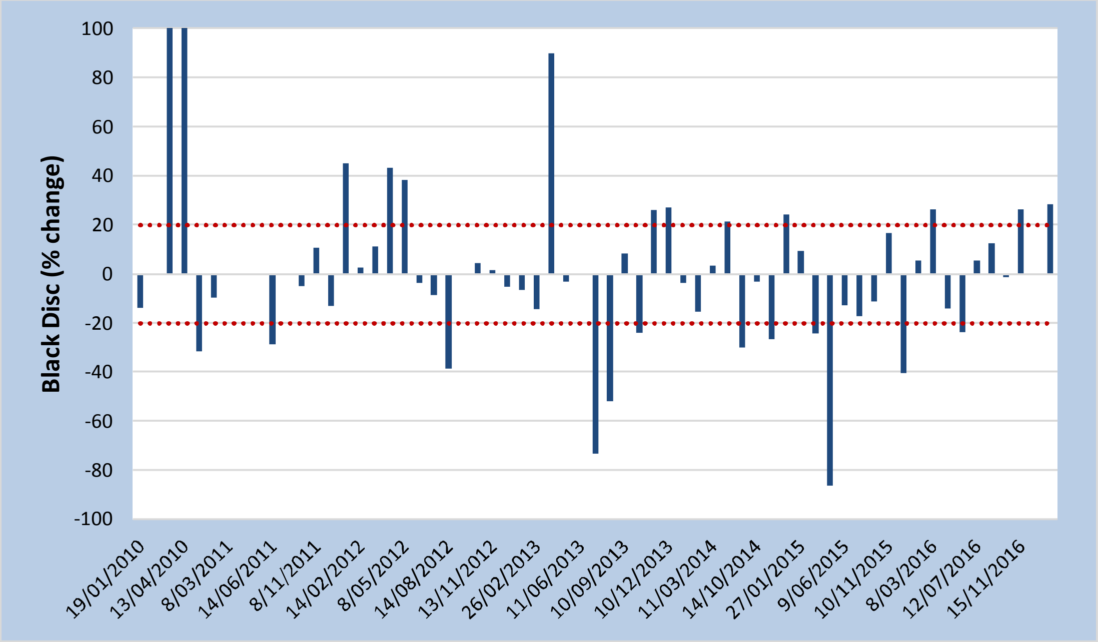

Figure 16: Percent change in visual clarity measured using a black disc, between upstream and downstream of the Eketahuna WWTP discharge into the Makakahi River, between October 2010 and December 2016. Dashed red lines indicate a change of 20 percent (One Plan & Consent limit).

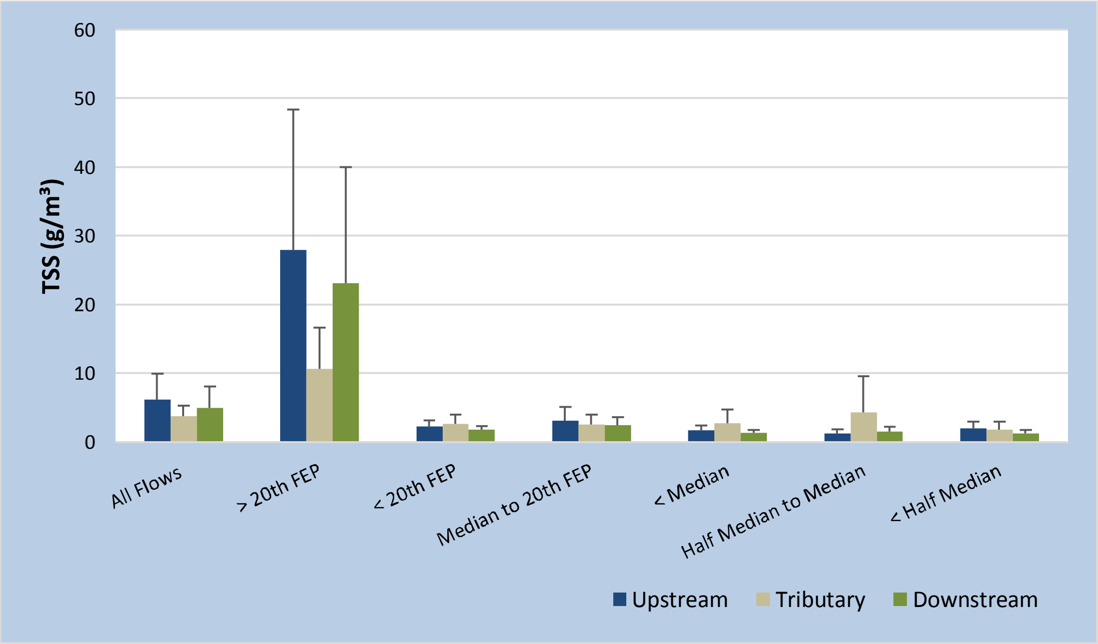

Figure 17: Mean Total Suspended Solid (TSS) concentrations for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows.

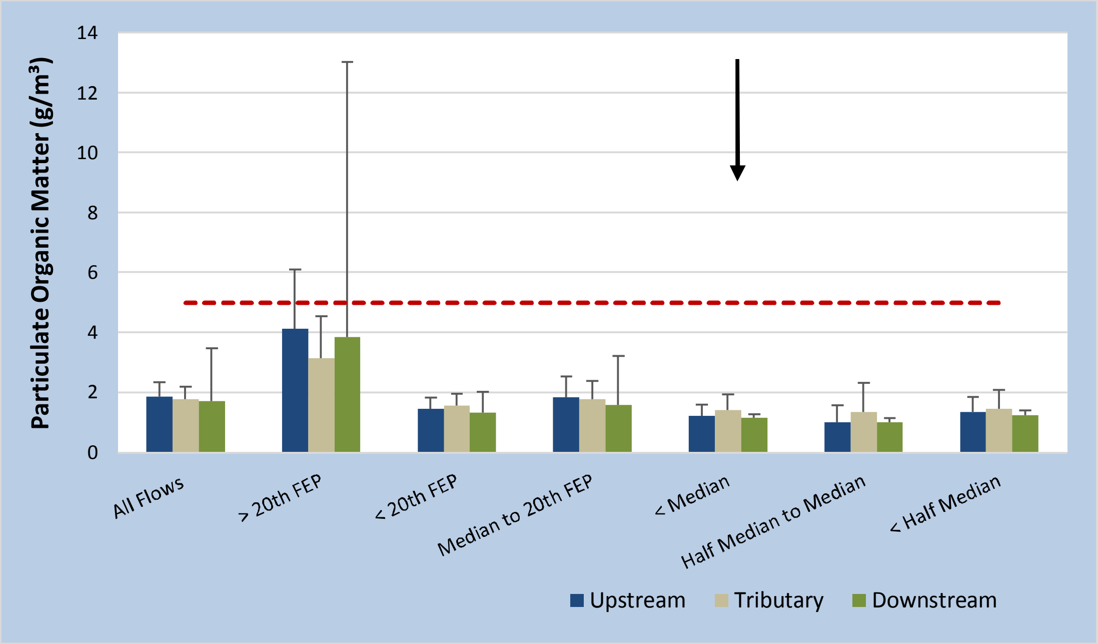

Figure 18: Mean Particulate Organic Matter (POM) concentrations at for sites on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary (October 2010 – December 2016) at various flows. The One Plan target and Consent limit for POM is represented as a dashed red line. The black arrow indicates the flow bin defined in the One Plan target.

1.3. Effects on river ecology

1.3.1. Periphyton Communities

Mean periphyton biomass, measured as Chlorophyll *a*, and visual estimates of periphyton cover were measured between 2013 and 2016.

Periphyton biomass increased between upstream and downstream sites on 16 out of 24 sampling occasions between February 2013 and September 2016 (Figure 19). Chlorophyll *a* concentrations were however, below the Consent and One Plan target (120 mg/m^2) on all sampling occasions at the upstream site except in July 2015, and exceeded the target at the downstream site on three occasions (131 mg/m^2 in July 2013, 130 mg/m^2 in May 2014 and 205 mg/m^2 in July 2015) and on two occasions within the Ngatahaka Creek (151 mg/m^2 in May 2014 and 215 mg/m^2 in July 2015).

While visual assessments of periphyton cover showed the percentage of substrate covered by long filamentous algae and diatom mats was higher at the downstream site over most of the monitoring period, the One Plan targets relative to periphyton cover by thick diatom mats (no more than 60% cover) and long filamentous algae (no more than 30% cover) were always met at all three sites (Figure 20).

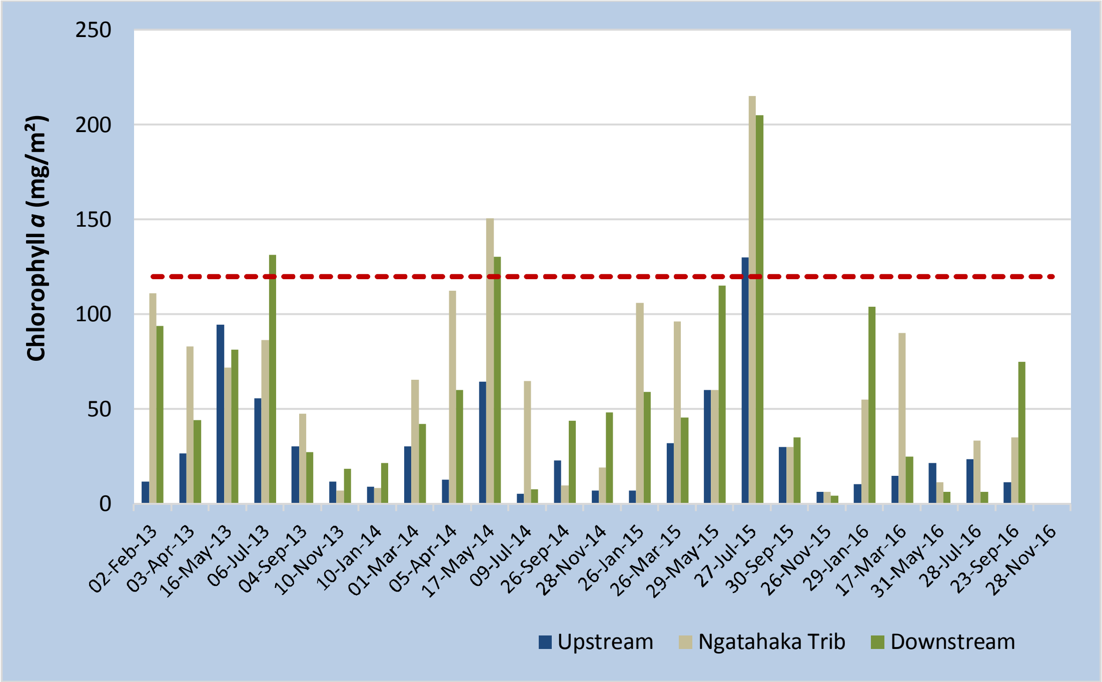

Figure 19: Mean periphyton biomass, measured as Chlorophyll a (mg/m^2), for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary between 2013 and 2016. The One Plan target of 120 mg /m^2 is represented as a dashed red line.

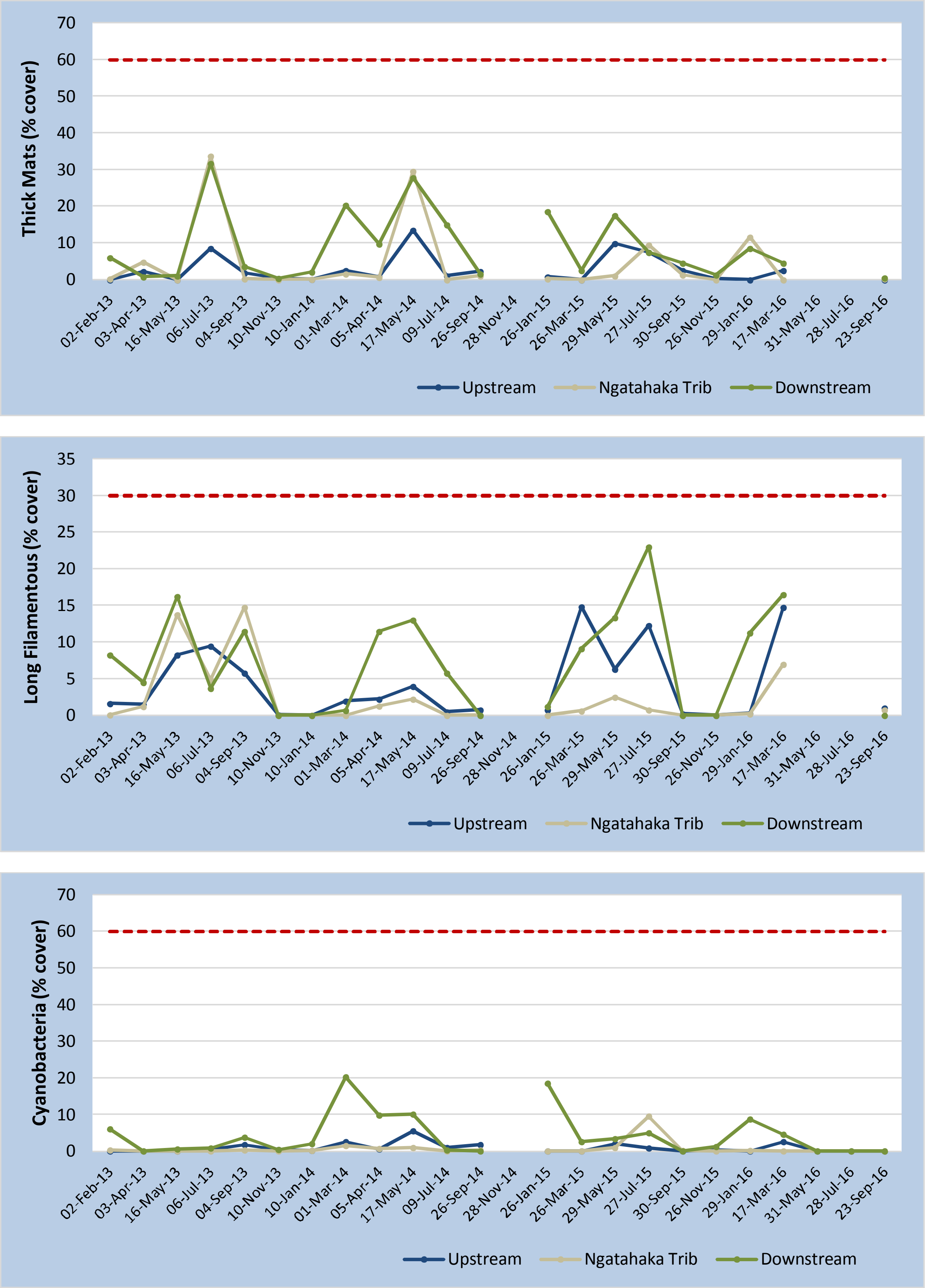

Figure 20: Percentage of substrate cover by Thick diatom mats (upper), Total filamentous algae (middle) and Cyanobacterial mats (lower) for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP and within the Ngatahaka Creek tributary between 2013 and 2016. The One Plan targets are presented as dashed red lines.

1.3.2. Macroinvertebrate Communities

Macroinvertebrate communities in the Makakahi River and Ngatahaka Creek appeared similar over the years with the caddisfly *Aoteapsyche* sp. and mayfly *Deleatidium* sp. dominating in 2013-2015 but much lower numbers of mayfly in 2016 (Figure 21).

Biotic index scores for sites sampled on the Makakahi River and in Ngatahaka Creek between 2013 and 2016 are presented in Figure 22 to 11. All biotic indices, except Number of taxa, differed significantly between sites and between years.

All three sites (including the Ngatahaka Creek) were below the One Plan target for MCI (120).

There were significant decreases in QMCI between the Makakahi upstream and downstream sites in 2013 to 2015, in excess of the One Plan target of no more than 20% reduction in QMCI, (2013: 25% decrease, 2014: 43% decrease and 2015: 44% decrease). The 18% decrease in QMCI in 2016 was within the required One Plan target.

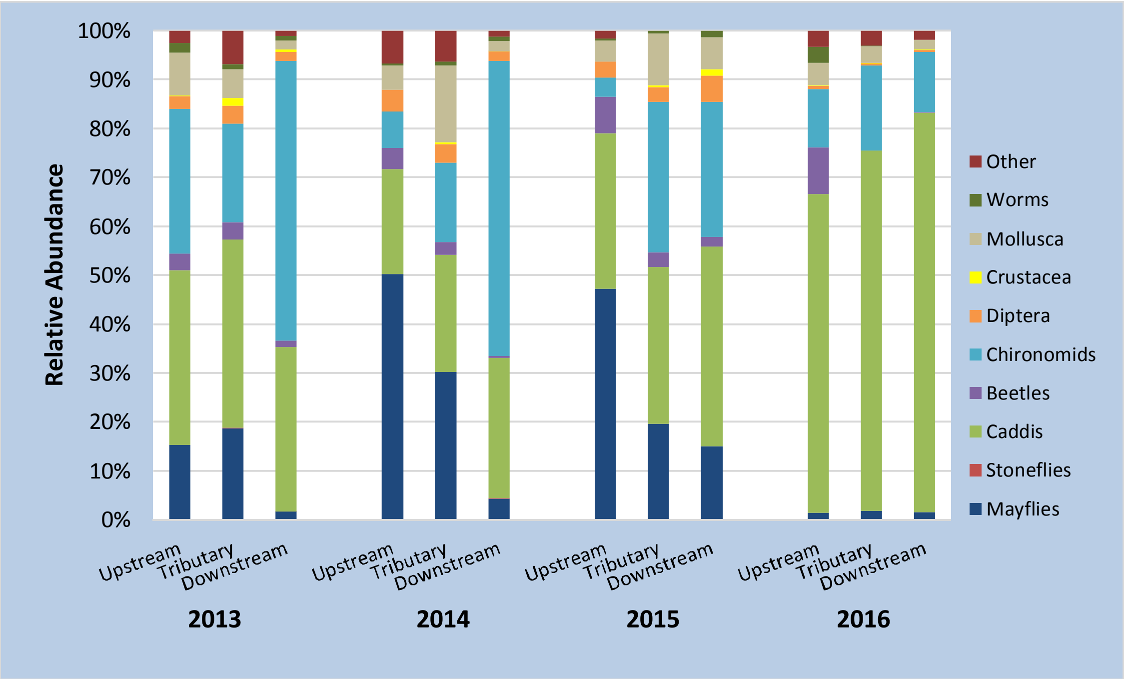

Figure 21: Relative abundance of the main taxonomic groups for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary, 2013-2016.

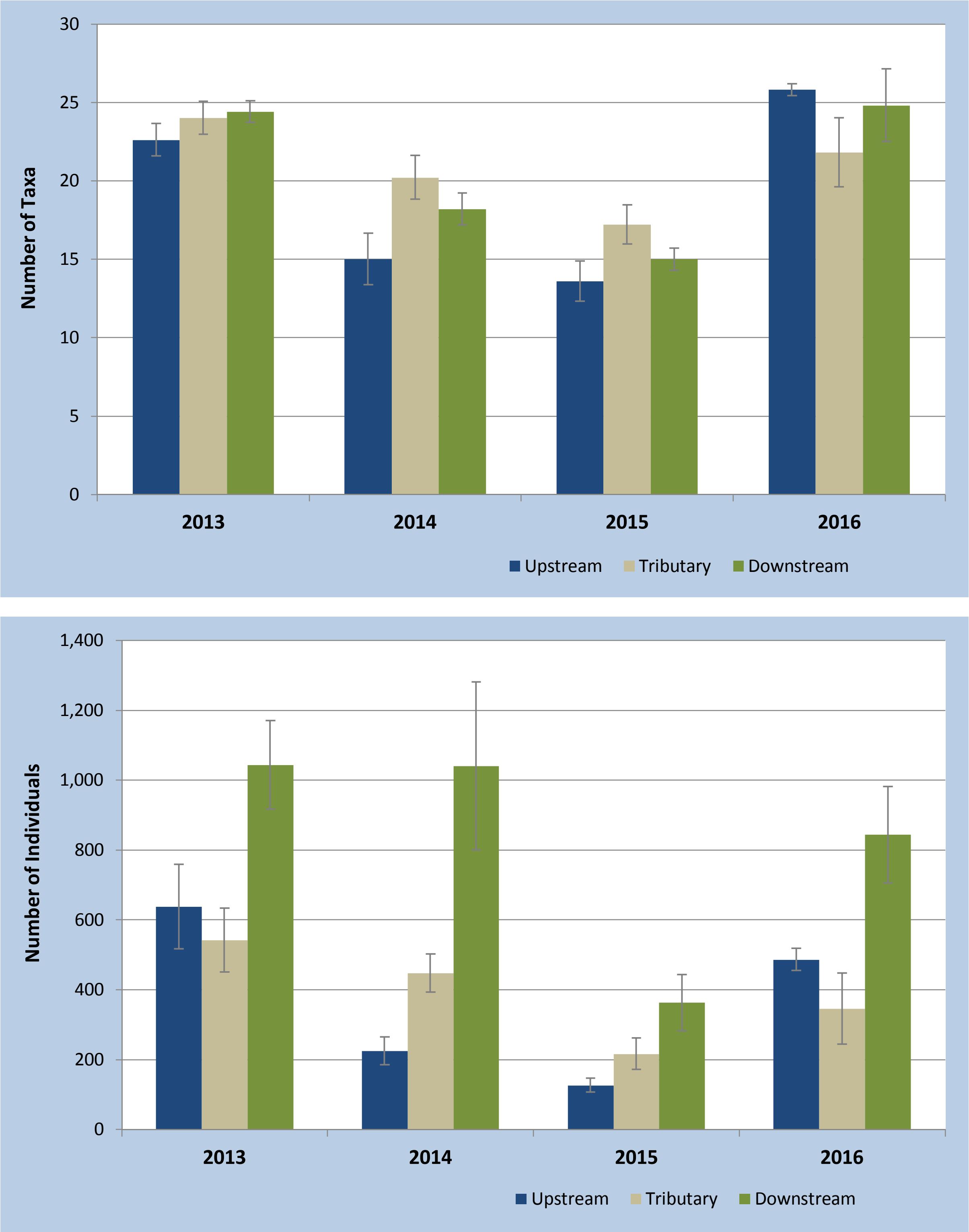

Figure 22: Mean (± 1 SE) A. Number of taxa and B. Number of individuals for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary, 2013-2016.

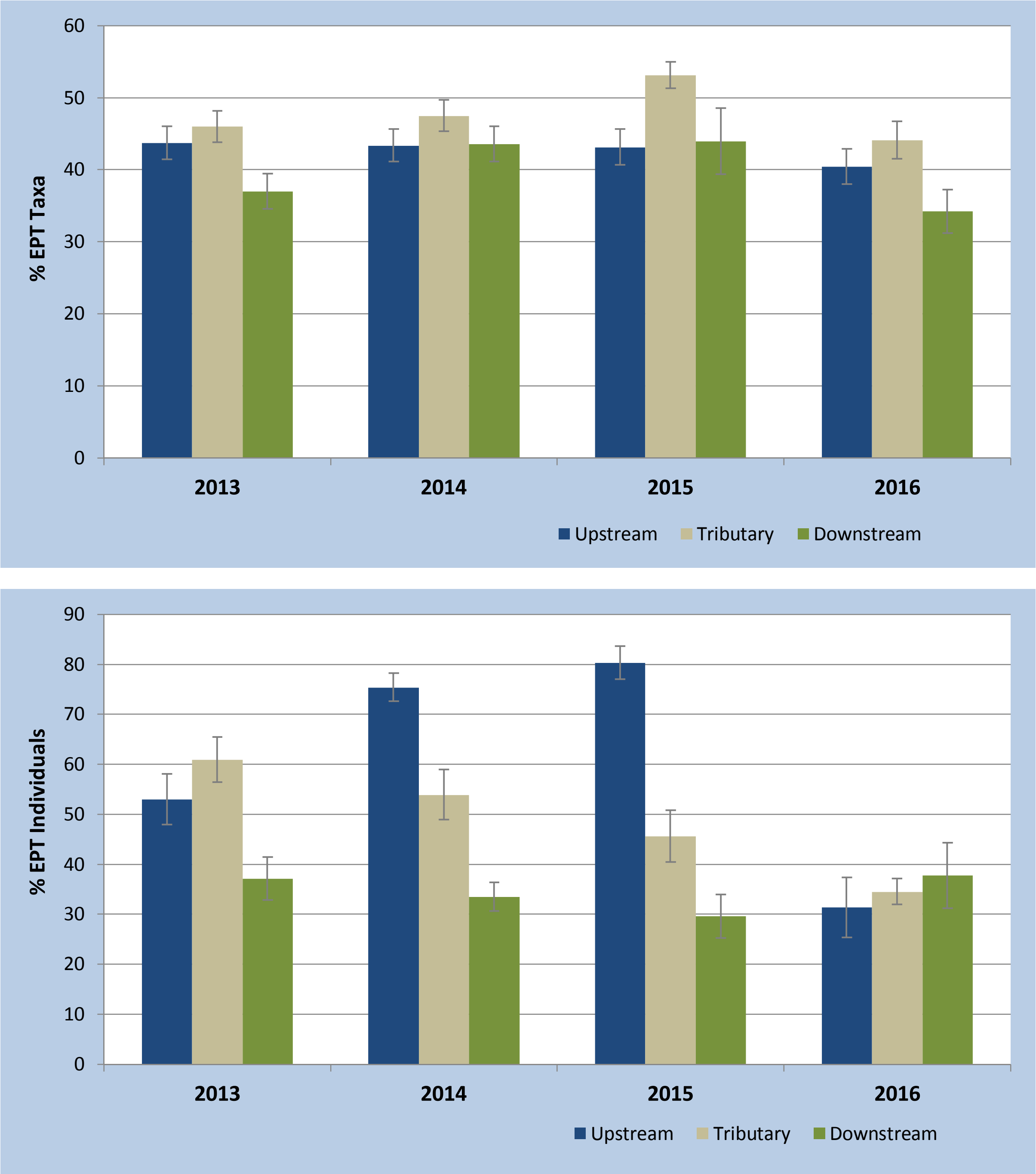

Figure 23: Mean (± 1 SE) A. %EPT Taxa and B. %EPT Individuals for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary, 2013-2016.

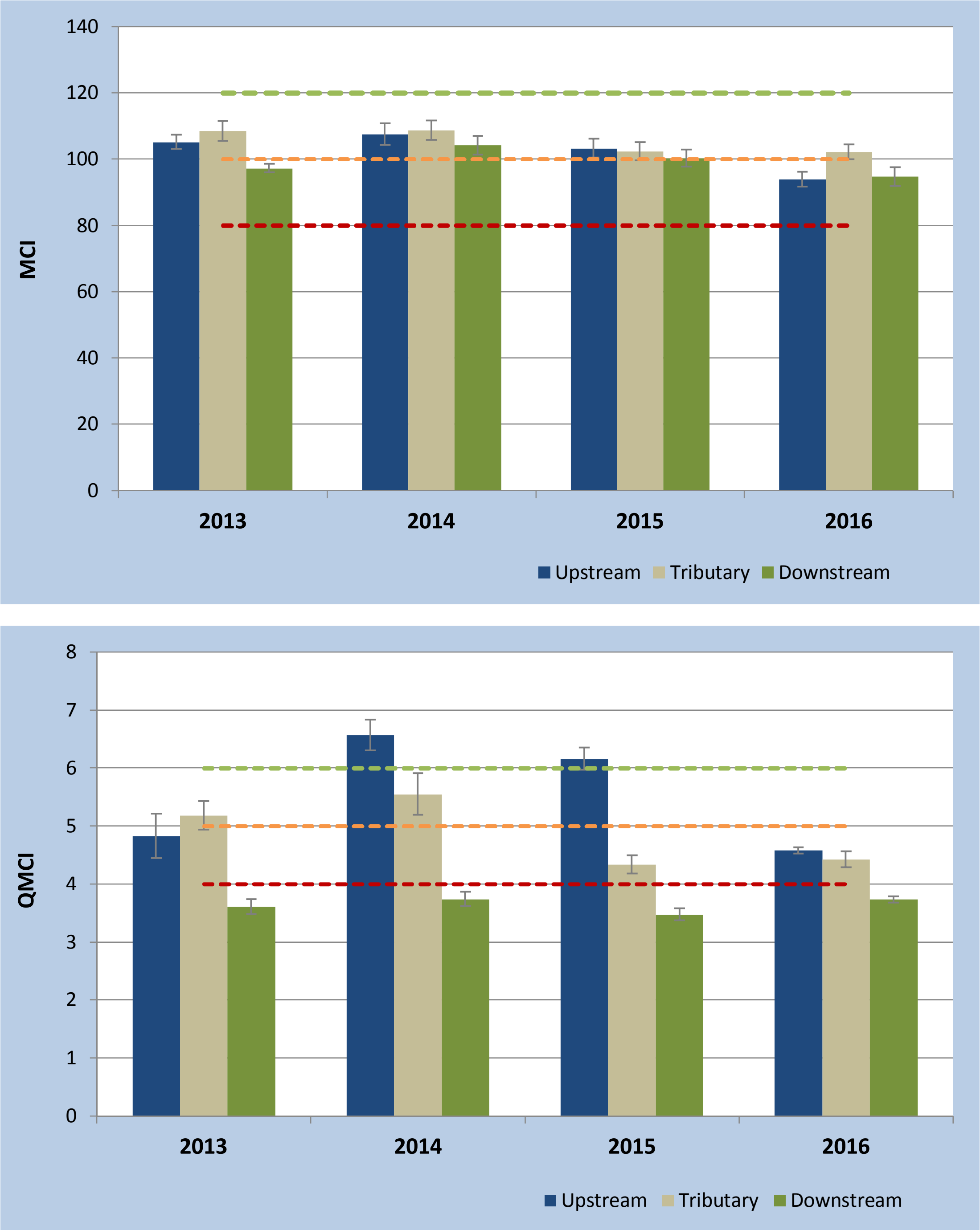

Figure 24: Mean (± 1 SE) A. MCI and B. QMCI for sites sampled on the Makakahi River upstream and downstream of the Eketahuna WWTP discharge and within the Ngatahaka Creek tributary, 2013-2016.