BEFORE THE HEAING 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 Mākakahi 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

STATEMENT OF SUPPLEMENTARY EVIDENCE OF

KATHRYN JANE MCARTHUR – FRESHWATER QUALITY

FOR KAHUNGUNU KI TAMAKI NUI-A-RUA TRUST

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7 April 2017

A Introduction

Qualifications and Experience

1. My name is Kathryn Jane McArthur. My qualifications and experience are as outlined in my evidence in chief dated 21 March 2017. I re-confirm my commitment to operate under the Environment Court's Code of Conduct for Expert Witnesses for the purposes of preparing this supplementary evidence.

Purpose and Scope of Evidence

2. This supplementary evidence has been prepared on behalf of Kahungunu ki Tamaki nui-a-rua Trust and is based on my oral presentation to the hearing commissioners on 6 April.

3. My supplementary evidence addresses the following matters:

    I. The context of water quality in the Mangatainoka Water Management Zone and Mākakahi Sub-Zone, including commentary on over-allocation

    II. The nature of cumulative effects on river ecology and water quality in the vicinity of the Eketahuna Waste Water Treatment Plant (EWWTP) discharge, including periphyton and macroinvertebrate relationships

    III. Exceptional circumstances in relation to point sourced discharges in the Manawatū catchment

    IV. Limiting nutrients to control periphyton growth

    V. Periphyton targets and annual maxima

    VI. Proposed shifts in location of the monitoring sites

    VII. Monitoring of dissolved oxygen (DO) and associated research findings in the Mangatainoka catchment

    VIII. I have attached the relevant published journal papers as Appendices for the hearing commissioners' information

B Cumulative Effects in the Mangatainoka and Mākakahi Catchments

4. The water quality experts agree there is a significant adverse effect on aquatic life occurring between the upstream and downstream monitoring sites on the Mākakahi River. Experts also agree that the effects are cumulative in nature, being associated with the combination of diffuse and point source inputs that affect the stream ecology between the upstream and downstream sites. When addressing the complexities of cumulative effects, it is important to look at the wider catchment context within which activities occur.

5. The Mākakahi River is a major contributing catchment to the wider Mangatainoka Water Management Zone. The Mangatainoka is a targeted water management zone defined in Table 14.1 of the One Plan for the purposes of contaminant management to improve water quality and ecological health. In my evidence in chief at paragraph 18 I state that in my opinion the Mākakahi Water Management Sub-zone is over-allocated with respect to the One Plan targets in Schedule E. It is my further opinion that the effects measured in the Mākakahi River also contribute to cumulative adverse effects and over-allocation at the wider scale of the Mangatainoka River, as measured at the SH2 site in the lower catchment.

6. In determining the Mangatainoka is over-allocated I draw the hearing commissioners' attention to a paper by Roygard *et al.*[1], which I have appended as Appendix 1. Roygard and colleagues undertook a study of nitrogen and phosphorus concentrations, river flows and loads in two sub-catchments of the Manawatū River, one of which was the Mangatainoka at SH2 site. A key aim of the research was to determine whether soluble nitrogen (SIN) and phosphorus (DRP) concentrations, when calculated as annual loads, would exceed the One Plan targets at flows less than the 20th flow exceedance percentile (FEP), also calculated as annual loads[2].

7. They found annual average loads (excluding all observations from flows greater than the 20th FEP) exceeded One Plan concentration targets converted to loads by 190% for SIN and 32% for DRP at the SH2 site near the bottom of the Mangatainoka zone for water years 1989 to 2005 (Roygard et al. 2012, Table 3). The inter-annual variability in load estimate ranged from -54% to +45% for SIN and -40% to +31% for DRP (Roygard et al. 2012, Table 1) and was largely driven by variability in river flow from year to year.

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[1] Roygard JKF, McArthur KJ, Clark ME 2012. Diffuse contributions dominate over point sources of soluble nutrients in two sub-catchments of the Manawatu River, New Zealand. *New Zealand Journal of Marine and Freshwater Research i-First, 2012*, 1-23.

[2] The reason for converting concentration effects and targets into loads is so that diffuse and point sourced contributions to over-allocation can be considered, relative to each other.

8. The over-allocation of nutrients in the Mākakahi and Mangatainoka is also reflected in the MCI scores for Mākakahi at Hamua and Mangatainoka at SH2, which reflect a 'fair' state of macroinvertebrate health, rather than the target 'good' state sought by Schedule E of the One Plan for these sites. Cyanobacteria blooms (*Phormidium autumnale*) are also common to both catchments.

9. Native fish in the Mangatainoka are only able to be considered at the broader regional or national scale. Catchment specific fish data has only recently been collected in a robust and nationally consistent manner and any trends in fish diversity or abundance are difficult to interpret when longer term data is included. Given that nationally, >75% of native fish species are 'threatened' or 'at risk' of extinction[3], the general state of native fish is poor. This pattern is also reflected in the wider Manawatū catchment[4]. Shortjaw kōkopu are a key species of interest for the Mākakahi and Mangatainoka catchment, given their high threat status. Notably, the naming of the Mākakahi River is associated with plentiful (mā) freshwater mussel resources (kakahi). This also indicates an historical association with abundant native fish, which are the host of the parasitic mussel larvae.

C Cumulative Effects in the Vicinity of the EWWTP Discharge

10. The significant adverse effect on aquatic life at the monitoring site downstream of the EWWTP is as a result of cumulative effects from diffuse sources (largely entering the Mākakahi from the Ngatahaka Creek with some background diffuse contamination from the upper Mākakahi catchment) and from the contribution of the EWWTP discharge. By their very nature, causative links between contributing sources and cumulative effects are difficult to unravel in order to determine the contribution of individual contaminants and ecological effects such as the large decrease in QMCI seen at the downstream monitoring site.

11. Adding to this complexity are issues associated with the potential landfill/dump site on the river terrace and any leachate that may be entering the river, and also leakage from the ponds, which is currently unquantified. Changes to the current monitoring sites are discussed further on in this supplementary statement.

[3] Goodman JM, Dunn NR, Ravenscroft PJ, Allibone RM, Boubee JAT, David BO, Griffiths M, Ling N, Hitchmough RA, Rolfe JR 2014. Conservation status of New Zealand freshwater fish, 2013. New Zealand Threat Classification Series 7, Department of Conservation, Wellington, 12p.

[4] McArthur KJ, Clark M, McGehan J 2007. Sites of significance for aquatic biodiversity in the Manawatu-Wanganui Region: Technical report to support policy development. Horizons Regional Council Report No: 2007/EXT/794.

12. Hearing commissioners asked why the One Plan targets set for the Mākakai sub-zone (i.e. SIN and DRP, and at times periphyton biomass expressed as Chlorophyll *a*) are resulting in a significant adverse effect on macroinvertebrate community health (QMCI), when this circumstance is what the targets are designed to avoid. To answer this question, some context of the nutrient target setting for the Mākakahi sub-zone is needed.

13. The Mākakahi River is a small, upland waterway, dominated by rural land use. Dr Ausseil stated during the hearing that the reference condition for SIN in the Mākakahi is likely to be somewhere between 0.02mg/l and 0.1mg/l. I agree with this statement. In the absence of diffuse or point sources of SIN the Mākakahi SIN concentration at the upstream monitoring site would be likely to fit within this range. The LAWA[5] website shows that the median DRP concentration at the upstream site is less than the level of detection at 0.005mg/l, in my opinion this is likely to be the same as reference conditions in this catchment. For similar elevation and sized rivers the One Plan SIN target has been set at 0.07 - 0.110mg/l (the upper Mangatainoka at Putara has a target SIN concentration of 0.07mg/l just downstream of the Tararua Forest Park, and a median measured SIN concentration of 0.015mg/l).

14. The median SIN concentration for the Mākakahi at Hamua, approximately 25 km downstream of the EWWTP, is 0.491mg/l, already exceeding the One Plan target, even before the Mākakahi reaches the Mangatainoka River. The Mangatainoka River median SIN concentration is 0.885mg/l at the SH2 site. These concentrations are far above those that are relevant to small, upland rivers in forest and extensive pastoral land use. Due to the degree of dairy farming in the Mākakahi and Mangatainoka catchments, a more achievable SIN target was set (0.444mg/l) in the One Plan to signal the need for a reducing trajectory of nitrogen contamination in the rivers from diffuse and point source contributors. This target was set as a pragmatic response to a cumulative catchment-wide water quality issue.

15. I understand a large number of consents for land use have been issued by Horizons Regional Council in the Mangatainoka water management zone that exceed the One Plan nitrogen leaching limits ([2017] NZENVC 37 Wellington Fish and Game Council and EDS Inc. vs. Manawatu-Whanganui Regional Council). Therefore, it is unclear whether the requirement for a reducing nitrogen trajectory is being implemented by diffuse contributors at this time.

[5] Land, Air, Water Aotearoa: www.lawa.org.nz

D QMCI and Periphyton Relationships

16. Dr Ausseil presented figures of periphyton biomass (Chlorophyll *a*) and where biomass exceeds One Plan targets in Figure 19 of his evidence in chief. At his presentation to the hearing, he added notation to the figure showing the coinciding periods when macroinvertebrate sampling was undertaken over the last four summers. Dr Ausseil noted he was "puzzled" by the results which showed large QMCI reductions between upstream and downstream were associated with periphyton biomass that was within the One Plan targets.

17. A plausible explanation for this pattern of poor macroinvertebrate community health coinciding with low periphyton biomass is the shift in community composition from a large number of EPT taxa to a high abundance of macroinvertebrates dominated by algal grazers (e.g. chironomid midge larvae). I have examined the raw macroinvertebrate data for the sites to test this hypothesis.

18. In every year, the downstream monitoring site on the Mākakahi River had a considerably greater abundance of invertebrates than the Ngatahaka Creek or upstream Mākakahi River sites (Figure 1). When taxa within the Chironomidae group were enumerated, the downstream Mākakahi River site had considerably more Chironomids than the upstream Mākakahi River or Ngatahaka Creek sites in every year (Figure 2).

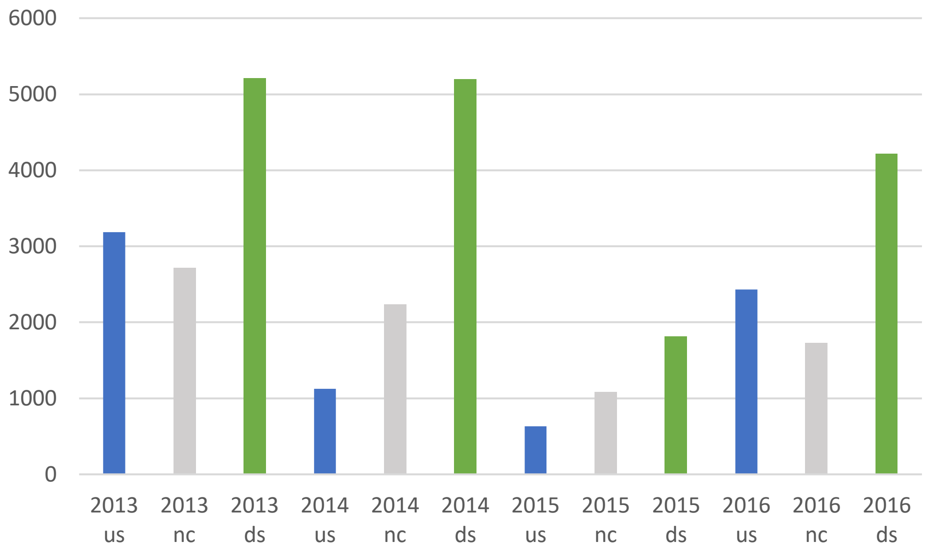

Figure 1: Total number of animals per sample (all five pseudo-replicates included) at three sites in the Mākakahi River sampled annually 2013 - 2016. us = upstream of the EWWTP, nc = Ngatahaka creek, ds = downstream on the Ngatahaka Creek confluence and EWWTP discharge.

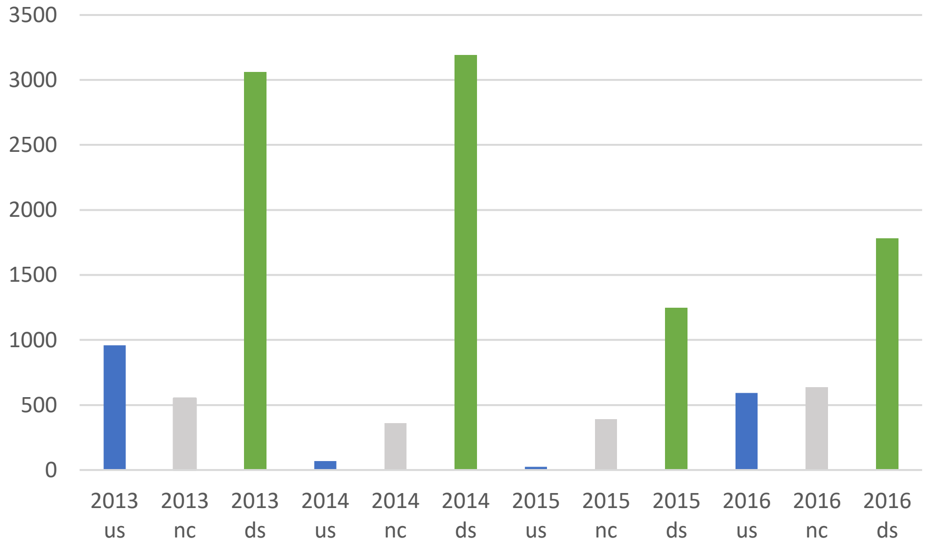

Figure 2: Total number of Chironomidae at three sites in the Mākakahi River sampled annually 2013 - 2016. us = upstream of the EWWTP, nc = Ngatahaka Creek, ds = downstream of the Ngatahaka Creek confluence and EWWTP discharge.

19. In examining relative abundance, the proportional shift in macroinvertebrate composition can be seen in Figures 3 and 4. The average %EPT abundance (excluding *Hydrotilidae* taxa, that are often associated with nutrient enrichment) was lowest at the downstream Mākakahi site in every year except 2016. The proportion of animals within the Chironomidae group was considerably greater at the downstream Mākakahi river site in every year.

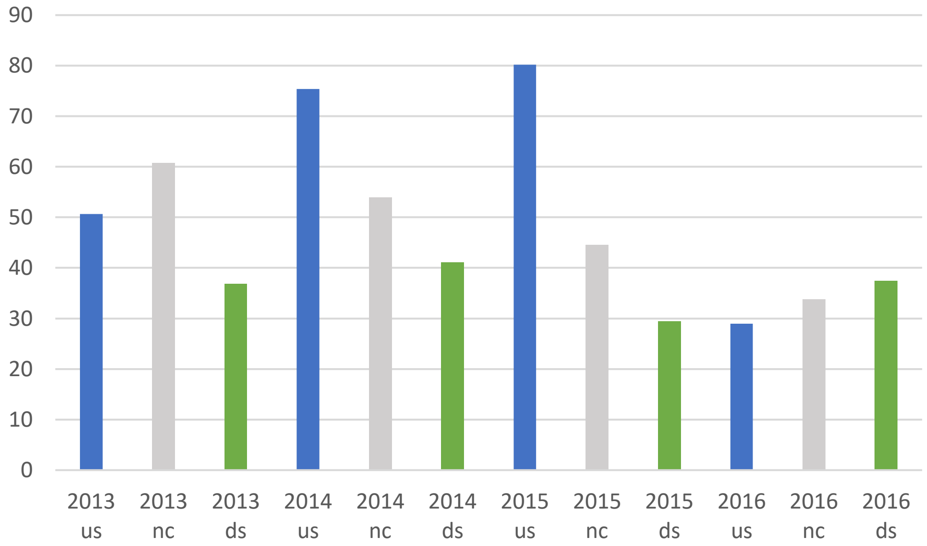

Figure 3: Average %EPT abundance (excl. *Hydroptilidae*) per site at three sites in the Mākakahi River sampled annually 2013 - 2016. us = upstream of the EWWTP, nc = Ngatahaka Creek, ds = downstream of the Ngatahaka Creek confluence and EWWTP discharge.

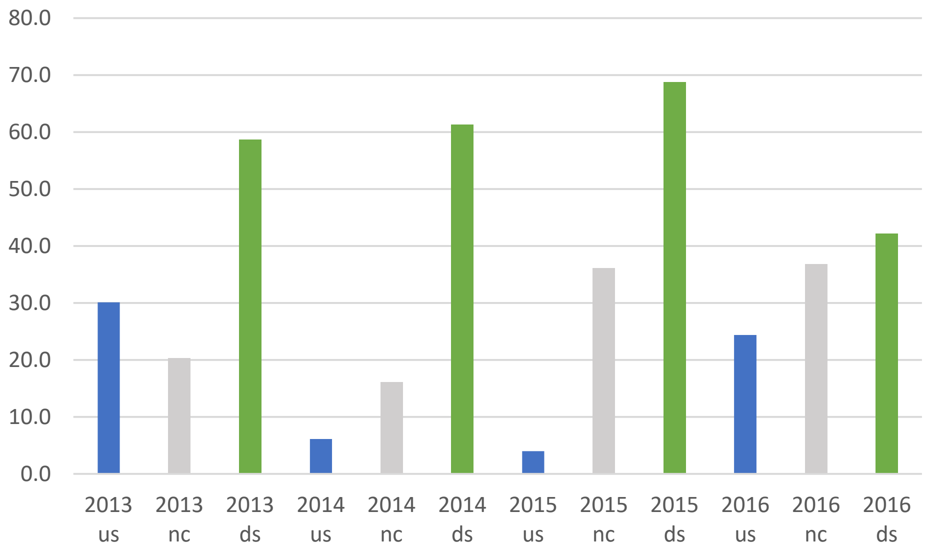

Figure 4: Average % abundance of *Chironomidae* per site at three sites in the Mākakahi River sampled annually 2013 - 2016. us = upstream of the EWWTP, nc = Ngatahaka Creek, ds = downstream of the Ngatahaka Creek confluence and EWWTP discharge.

20. These results support the theory of strong algal grazing pressure at the downstream Mākakahi River site, with a comparatively large number of macroinvertebrates present, comprised largely of Chironomid taxa. This pattern of macroinvertebrate grazers suppressing algal biomass has also been recorded by a number of researchers in the New Zealand literature[6].

21. It is important to remember that what we measure in the water column, or in the case of periphyton on the benthos, is a residual left over after ecological communities have utilised and/or attenuated nutrients or primary production for growth. Nutrient concentrations are the residual after periphyton growth, and periphyton is the residual after macroinvertebrate grazing.

[6] Biggs BJF, Close ME 1989. Periphyton biomass dynamics in gravel bed rivers: the relative effects of flows and nutrients. *Freshwater Biology: 22*, 209-231; Biggs BJF 1996. Patterns in benthic algae in streams. In RJ Stevenson, ML Bothwell, RL Lowe (Eds.) *Algal ecology: freshwater benthic ecosystems* (pp. 31-56). San Diego, Academic Press;

E Exceptional Circumstances

22. Ms Manderson raised the potential for the discharge permit to be granted as an exceptional circumstance. As part of the research for my Master of Applied Science thesis on integrating policy and science for improved freshwater management[7] (Appendix 2) I explored the use of the exceptional circumstances provision for significant point source discharges in the Manawatū Catchment Water Quality Regional Plan (MCWQRP).

23. My findings in that paper were that of the 25 consents issued as non-compliant with the MCWQRP provisions, 15 were granted under exceptional circumstances, even though they failed to meet the DRP and/or periphyton standards. In the hearing, I stated this was 75% of the consents granted under this plan. I wish to correct this statement. It is in fact 60% of those 25 consents, not 75%. Notwithstanding this correction, to grant the EWWTP discharge under an exceptional circumstances provision would not be an exceptional occurrence, when compared to the granting of other discharges in the Manawatū catchment in recent years.

F Limiting Nutrient Theory and Periphyton Risk

24. Dr Ausseil gave evidence on his view of the limiting nutrient for the control of periphyton growth in the Mākakahi River. While I accept that at times one or other nutrient (nitrogen or phosphorus) is in scarcer supply, there are a number of important considerations when attempting to manipulate periphyton growth through limitation of one particular nutrient (in this case through the proposed reduction of phosphorus in the discharge). Again, I caution that the measured nutrient in the water column is the *residual* concentration of that nutrient after periphyton growth.

25. Apparent nutrient limitation can change over time and with changes in flow[8] (Appendix 3). In circumstances where there is high supply of one nutrient (nitrogen in the case of the Mākakahi) this over-supply can drive SIN:DRP ratios in a manner that appears to be limiting. I agree with Dr Ausseil that concentrations *must* be considered, rather than simple ratios, to account for this situation. What appears to be a limitation due to the SIN:DRP ratio may in fact be an unlimited nutrient supply where there is enough of both nutrients needed for growth but the concentration of one is much higher than the other.

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[7] McArthur KJ 2012. Setting Water Quality Limits: Lessons Learned from Regional Planning in the Manawatu-Wanganui Region. *Resource Management Theory and Practice 2012.* Journal of the RMLA.
[8] McArthur KJ, Roygard J, Clark M 2010. Understanding the variation in limiting nutrient status of rivers in the Horizons Region. *New Zealand Journal of Hydrology 49(1):* 15-33.

26. It is my view, and one accepted by the Board of Inquiry for Plan Change 6 in the Tukituki catchment, that managing the risk of nuisance periphyton growth requires control of both nitrogen and phosphorus.

27. As I advised the hearing panel in my oral presentation, relying on limitation of one nutrient (i.e. DRP) while the other nutrient (SIN) is in good supply from diffuse sources in the Ngatahaka catchment may result in poor outcomes with respect to periphyton or macroinvertebrates (QMCI change), despite investment in treatment infrastructure to reduce DRP inputs.

G Periphyton Maxima and Erosion of Environmental Standards

28. I maintain my opinion that the periphyton biomass annual maxima should apply, as stated in Schedule E of the One Plan. In my view, there is a national erosion of environmental standards through the National Policy Statement for Freshwater Management (NPS-FM) National Objectives Framework (NOF) process. Allowances for a proportion of exceedances of the biomass threshold makes a considerable difference to whether there is a periphyton 'problem' or not.

H Location of Monitoring Sites

29. In assessing the mixing and monitoring sites presented in the map produced by Dr Ausseil. I am concerned that shifting the upstream site to downstream of the Ngatahaka Creek confluence may result in influences occurring at the upstream site associated with pond leakage reaching the Mākakahi River at an undefined location. Mr Baker, in his supplementary evidence suggests that an acceptable level of leakage may be as much 10-20% of inflow. He also suggests monitoring bores at three locations between the pond and the river to determine the flow path of any leakage.

30. If the upstream site is to be moved to downstream of the Ngatahaka confluence, provisions requiring pond lining should be included as conditions of consent to remove the potential for leakage to confound the concentrations measured at the upstream site.

I Dissolved Oxygen Monitoring and Ecosystem Health

31. Continuous dissolved oxygen (DO) is a required measurement below point source discharges under the NOF. In my opinion, it is the responsibility of the regional council to understand the state of DO downstream of discharges. This monitoring needs to occur in summer in the manner specified by the NOF. Horizons may require Tararua District Council to undertake this monitoring, although the results will need to be reported at the regional level as part of the NPS-FM.

32. Clapcott and Young[9] examined ecological health using continuous dissolved oxygen monitoring. The daily minimum is an important threshold in determining whether there is likely to be stress to aquatic life with high oxygen demands (e.g. large EPT taxa and fish). The magnitude of diurnal fluctuation affects the Gross Primary Productivity (GPP) and Ecosystem Respiration (ER). Clapcott and Young (2010) found that the Mangatainoka at Pahiatua Town Bridge site had poor ecosystem health in summer when GPP and ER were examined and good to satisfactory ecosystem health for the remainder of the year. The authors of this study, which was part of the technical foundation for the One Plan dissolved oxygen targets, noted that the Mangatainoka site was generally relying on organic matter from upstream and the surrounding catchment to drive primary productivity and ecosystem respiration.

Kathryn McArthur

10 April 2017

[9] Clapcott JE, Young RG 2010. Temporal variability in ecosystem metabolism of rivers in the Manawatu-Whanganui Region – Updated. Cawthron Report No. 1791, prepared for Horizons Regional Council.