BEFORE THE HEARINGS PANEL

IN THE MATTER of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council

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REVISED SECTION 42A REPORT OF DR ROGER GRAEME YOUNG ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. INTRODUCTION

My qualifications/experience

1. My name is Roger Graeme Young. I am a freshwater ecologist and have been employed at the Cawthron Institute in Nelson for the last 1~~1~~2 years. I have the following qualifications: BSc Honours and PhD in Zoology from the University of Otago. I am a member of the New Zealand Freshwater Sciences Society and the North American Benthological Society.

2. My areas of expertise include river health assessment, water quality, freshwater fisheries, and river ecosystem ecology.

3. Over the last 1~~1~~2 years I have undertaken freshwater ecological work throughout New Zealand for clients including power companies, regional councils, Ministry for the Environment, Department of Conservation and Fish & Game New Zealand. I have also been involved with research investigating the effects of catchment management on water quality and river health, developing new tools for river health assessment, and determining links between human pressure indicators and aquatic ecosystem integrity. This latter study involved an assessment of the health of large rivers throughout New Zealand, including the Manawatu and Rangitikei rivers. I have also studied the behavioural response of back country trout to anglers, factors affecting trout abundance, accuracy of drift-dive assessments of trout abundance, and catchment-wide patterns of fish movement. I have written 2~~1~~2 scientific papers and more than ~~40~~50 reports relating to this work.

4. Examples of recent hearings for which I have presented evidence relating to water quality, freshwater fisheries, river ecology and instream habitat include:
   - Otago Regional Council's Water Plan Environment Court Hearing;
   - Natural Gas Corporation's hearing relating to the proposed expansion of the Stratford Power Station;
   - Trustpower's hearing relating to re-consenting the Cobb Power Scheme;
   - Meridian Energy's lower Waitaki North Branch Tunnel Concept Water Resource Consents Hearing; and
   - Fish & Game NZ's hearing relating to its application for a Water Conservation Order on the Hurunui River.

5. I confirm that I have read the Environment Court's practice note entitled Expert Witnesses – Code of Conduct and agree to comply with it. This evidence is within my area of expertise, except where I state that I am relying on what I have been told by another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

My role in the One Plan

6. My role in the One Plan has been as a reviewer of technical documents produced by Horizons Regional Council staff and other agencies.

7. I am a co-author of a report for Horizons Regional Council on water quality guidelines to maintain trout fishery values (Hay *et al.*, 2006).

8. I am also a co-author of a report for Horizons Regional Council on seasonal patterns in ecosystem metabolism in the Rangitikei and Manawatu rivers. This report investigates dissolved oxygen dynamics in these rivers and compares measurements of ecosystem metabolism from these rivers with measurements from other large rivers throughout New Zealand (Clapcott & Young 2009).

Scope of evidence

9. I have been asked by the Horizons Regional Council to provide evidence to this hearing on the following:

- the state of the Manawatu and Rangitikei rivers, with respect to ecosystem metabolism, compared to other large rivers in New Zealand;
- a summary of a recent project examining seasonal changes in ecosystem metabolism in the Manawatu, Mangatainoka and Rangitikei rivers;
- a summary of my reviews of technical reports produced during the development of the Proposed One Plan; and
- a summary of water quality guidelines needed to maintain trout fishery values.

2. EXECUTIVE SUMMARY OF EVIDENCE

10. The concentrations of dissolved oxygen in the water are a critical component affecting the life supporting capacity of a river system. Ecosystem metabolism – the combination of primary productivity (photosynthesis) and ecosystem respiration – is a measure of the main factors controlling dissolved oxygen dynamics in rivers, and indicates how much

organic carbon is produced and consumed in river systems. Recent research has shown that ecosystem metabolism is a useful indicator of river ecosystem health.

11. As part of a study on the ecosystem integrity of New Zealand's large rivers, ecosystem metabolism was measured at 16 sites throughout the country. The results showed that rates of gross primary productivity (GPP) and ecosystem respiration (ER) in the lower Manawatu River at Opiki were among the highest ever reported internationally and well above the thresholds considered to represent the transition from satisfactory to poor ecosystem health (Figure 1). Rates of ER in the lower Rangitikei River at Bulls were also high and indicative of poor ecosystem health, while rates of GPP in the Rangitikei River were within the normal range and not indicative of any concerns (Figure 1).

12. These results were based on measurements of dissolved oxygen changes over one 24-hour period in one location on each river. Further work has subsequently been conducted at five sites to determine if concerns raised about these rivers are consistent over time or among sites. ~~Metabolism rates were consistently high in the Manawatu River and indicative of poor ecosystem health. Rates of metabolism were more moderate in the Mangatainoka and Rangitikei rivers, but still regularly indicative of poor ecosystem health.~~ The initial version of my evidence from these five sites was based on calculations from raw data which has subsequently been shown to have some errors. These errors have now been addressed and metabolism rates for the five sites recalculated.

13. Recalculated metabolism rates were high in the Manawatu River at Hopelands and generally indicative of poor ecosystem health. Rates of metabolism were more moderate in the Manawatu River at Teachers College and Mangatainoka at Pahiatua and indicative of good–satisfactory health in autumn, winter and spring, but indicative of poor ecosystem health in summer. Rates of metabolism from the Rangitikei River at Mangaweka and Onepuhi were generally indicative of good-satisfactory health throughout the year.

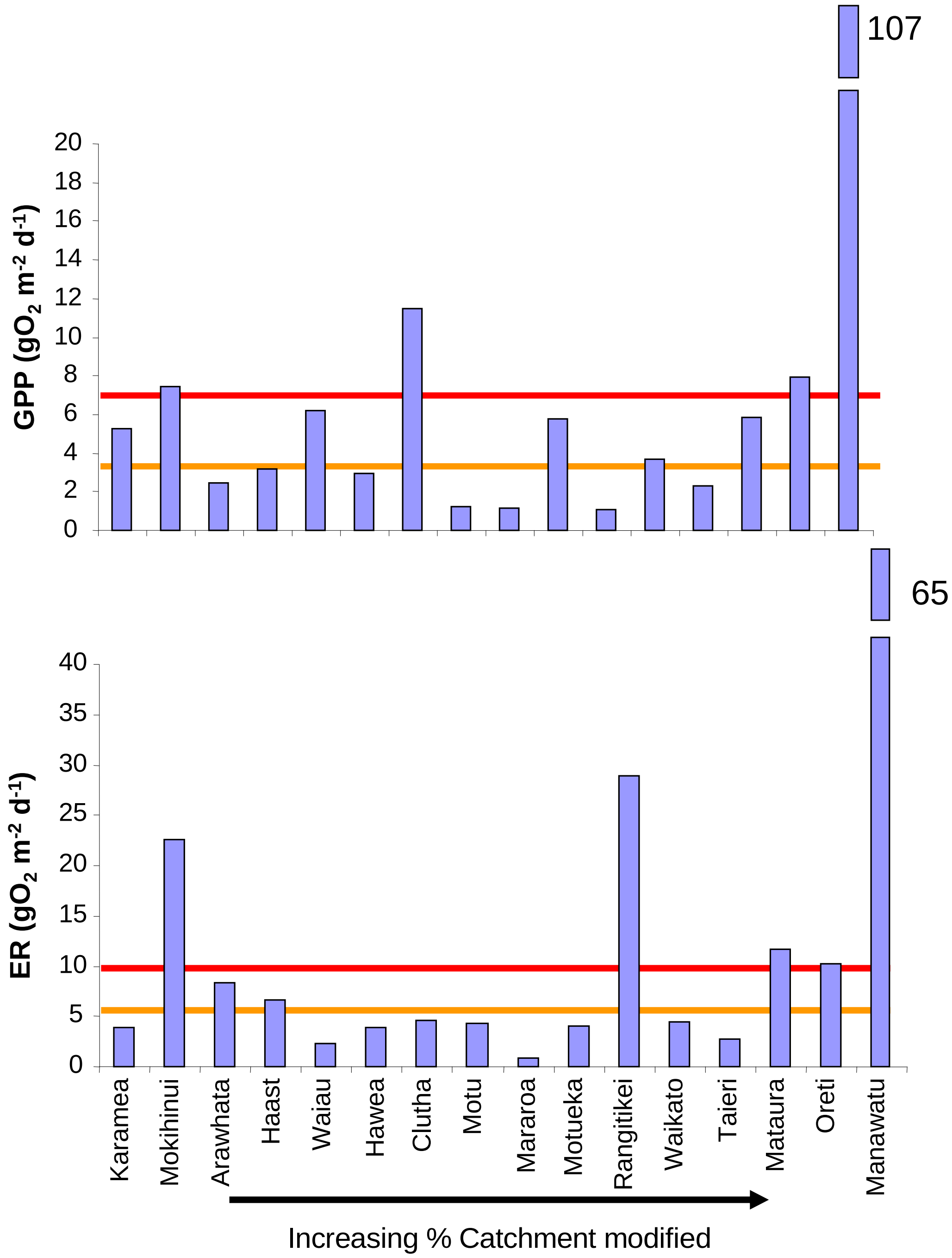


Figure 1. Measurements of gross primary production (GPP) and ecosystem respiration (ER) in a variety of large rivers throughout New Zealand. The rivers are arranged in order of % catchment modified. The orange and red lines are guidelines representing the transition from good to satisfactory health, and satisfactory to poor ecosystem health, respectively

~~13.~~14. Sites with very high rates of ecosystem metabolism are likely to have a lower life supporting capacity than sites that are within the normal range. Sites with high rates of ER will be prone to low minimum dissolved oxygen concentrations and have the potential to kill fish and other aquatic life. Sites with high rates of GPP are likely to experience algal and cyanobacterial blooms that can degrade aesthetic and recreational values, and have potential health implications for humans and animals. High algal densities associated with high rates of GPP can also cause large pH fluctuations, smother habitat for invertebrates, cause taste and odour problems for water supplies, and cause problems with low DO (such as fish kills) when the periphyton mats mature and decompose.

~~14.~~15. ~~A review of data from the five sites indicated that minimum DO concentrations were well below the dissolved oxygen saturation standards proposed in the Proposed One Plan at all five sites and breached these standards on a relatively regular basis.~~ A review of the data used to calculate metabolism from the five sites indicated that minimum DO concentrations were well below the dissolved oxygen saturation standards in the Proposed One Plan at the Manawatu at Hopelands and Mangatainoka at Pahiatua sites and breached these standards on a relatively regular basis. However, DO concentrations at the other sites were generally above the proposed standards during these periods.

~~15.~~16. In general, I support the approach taken by Horizons in the Proposed One Plan, with an initial emphasis on the values to be protected, followed by specific standards that should protect those values. In my opinion, this approach is closely linked with the effects-based philosophy of the RMA. I am particularly impressed at the degree of spatial resolution within the Proposed One Plan with standards set for specific water management sub-zones.

~~16.~~17. The key parameters for the protection of trout fisheries and trout spawning habitat are water temperature, dissolved oxygen, water clarity/turbidity, food supply, and fine sediment. Direct measurement of fine sediments is currently problematic, so standards relating to water clarity and the Macroinvertebrate Community Index (MCI) could act as surrogate controls on fine sediment loads.

~~17.~~18. The most applicable guidelines relating to periphyton biomass and cover for the protection of trout fishery values are contained in the New Zealand Periphyton Guidelines (Appendix 1). These guidelines may be sufficient to protect fishery values in lowland fisheries. However, algal biomass at such levels would be seen as a significant reduction in the ‘pristine’ natural character of many headwater fisheries. The benthic biodiversity guideline would provide better protection of trout habitat, benthic invertebrate habitat and aesthetic values, and I support use of this guideline in the Proposed One Plan for rivers recognised as supporting outstanding fisheries.

3. EVIDENCE

Dissolved oxygen and ecosystem metabolism

~~18.~~19. Concentrations of dissolved oxygen in the water are a critical component affecting the life supporting capacity of a river system. Dissolved oxygen concentrations are affected by three key processes – 1) oxygen production associated with photosynthesis of algae and other aquatic plants, which raises the oxygen concentrations within the water, 2) oxygen uptake associated with respiration of all river life including fish, invertebrates, algae, aquatic plants and microbes, which lowers the oxygen concentrations in the water, and 3) oxygen diffusion through the water surface, which can either raise or lower oxygen concentrations.

~~19.~~20. Ecosystem metabolism – the combination of primary productivity (photosynthesis) and ecosystem respiration – is a measure of the main factors controlling dissolved oxygen dynamics in rivers and indicates how much organic carbon is produced and consumed in river systems. Recent research has shown that ecosystem metabolism is a useful indicator of river ecosystem health, and complements traditional monitoring tools such as water quality analysis, periphyton cover and/or biomass, and invertebrate community composition.

~~20.~~21. Ecosystem metabolism can be measured by monitoring the daily changes in oxygen concentration at a site. Dissolved oxygen concentrations rise during the daytime when sunlight facilitates photosynthesis, and then decline during the night when only respiration is occurring. The size of the daily fluctuations depends on the amount of photosynthesis and respiration occurring within the river and also the flux of oxygen through the river surface. More oxygen diffuses through the surface of fast flowing, shallow, turbulent streams compared to the surface of slow flowing, deep rivers.

~~21.~~22. Sites with very high rates of primary production will normally be characterised by a river bed covered with a high biomass of periphyton (algae and other slimes growing on the substrate) or other aquatic plants. The highest rates of production will occur in situations where there is plenty of light and nutrients available to support plant growth. Sites with high rates of ecosystem respiration are normally characterised by large inputs of organic matter from point source discharges of sewage/waste water, or large diffuse inputs from sources such as agricultural run-off. High biomasses of algae and other aquatic plants are also often associated with high rates of ecosystem respiration.

Comparison of the Manawatu and Rangitikei rivers with other large rivers around New Zealand

~~22.~~23. As part of a study on ecosystem integrity of New Zealand's large rivers, ecosystem metabolism was measured at 16 sites throughout the country. The results showed that rates of gross primary productivity (GPP) and ecosystem respiration (ER) in the lower Manawatu River at Opiki were higher than observed in any of the other rivers that were sampled (Figure 1), and among the highest ever reported internationally. Rates of ER in the lower Rangitikei River at Bulls were also very high, but rates of GPP were relatively low (Figure 1).

~~23.~~24. Rates of both GPP and ER in the Manawatu River at Opiki were well above the thresholds considered to represent the transition from satisfactory to poor ecosystem health (Figure 1). Rates of ER in the Rangitikei River at Bulls were also indicative of poor ecosystem health, while rates of GPP in the Rangitikei River at Bulls were within the normal range and not indicative of any concerns (Figure 1). The high rates of ER and normal rates of GPP in the Rangitikei River at Bulls suggest that discharges of organic waste may be an issue in this river.

~~24.~~25. These thresholds were derived from the statistical distribution of metabolism measurements from 213 relatively unmodified sites around the world which included systems of all sizes from small streams through to large rivers.

Seasonal patterns in ecosystem metabolism at five sites in the Manawatu, Mangatainoka and Rangitikei rivers

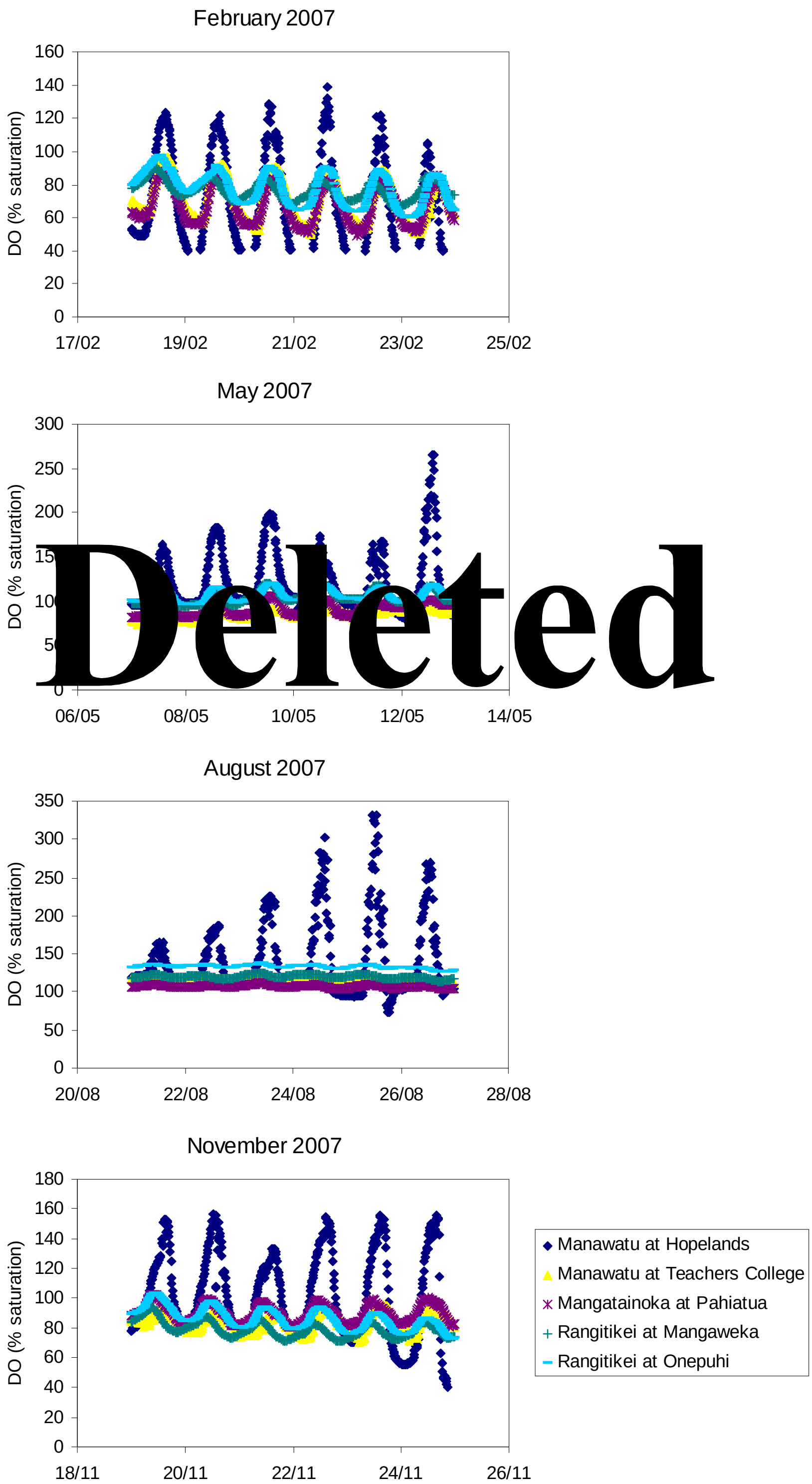
~~25.~~26. The comparison of rates of ecosystem metabolism in the Manawatu and Rangitikei Rivers with other large rivers around New Zealand (Paragraphs 23~~14~~-25~~16~~) was based on measurements of dissolved oxygen changes over one 24-hour period (27 November 2007) in one location on each river. Further work has subsequently been conducted to determine if concerns raised about these rivers are consistent over time or among sites. Since 2005, oxygen loggers have been deployed by Horizons at hydrometric recorder stations at two sites on the Manawatu River (Hopelands, Teachers College), two sites on the Rangitikei River (Mangaweka, Onepuhi) and one site on the Mangatainoka River

(Pahiatua). These provide data every 15 minutes that is suitable for determining ecosystem metabolism.

27. Metabolism was calculated at each of the five sites over a five-day period during summer (February 2007, February 2008), autumn (May 2007, May 2008), winter (August 2006, August 2007) and spring (November 2006, November 2007) (Figure 2). There were some concerns with the calibration of the oxygen loggers, particularly in winter 2007, but the data were corrected where possible (Clapcott & Young, 2009). Improvements in dissolved oxygen measurement technology over just the last decade have now enabled long-term continuous measurement of dissolved oxygen to be conducted in rivers. Prior to this development, oxygen loggers could only be deployed for 1-2 days before requiring sensor maintenance and re-calibration. Protocols for long-term deployment, sensor calibration, data storage and quality control are still being refined based on experience with this relatively new technology. Experience so far suggests that sensor cleaning and calibration is required more frequently than suggested by the instrument manufacturers.

28. Data supplied by Horizons was used for metabolism calculations presented in the original version of my evidence (dated August 2009). Subsequently, we discovered a problem with the dissolved oxygen saturation readings being delivered from the Horizons database, and also found that the dissolved oxygen sensor at the Manawatu at Hopelands site had been damaged by flooding during August 2007 making data from that period unsuitable for metabolism calculations.

26.29. Metabolism was re-calculated from corrected data from each of the five sites over a five-day period during summer (February 2007), autumn (May 2007), winter (August 2007) and spring (November 2007) (Figure 2). There were still some concerns with the calibration of the oxygen loggers at some sites during some seasons, but the data were corrected before metabolism calculation (Clapcott & Young 2009). As mentioned, suitable data was not available for the Manawatu River at Hopelands in winter 2007.



February 2007
DO (% saturation)
0
20
40
60
80
100
120
140
160
17/02
19/02
21/02
23/02
25/02
May 2007
DO (% saturation)
0
250
300
200
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12/05
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August 2007
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November 2007
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Manawatu at Hopelands
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Mangatainoka at Pahiatua
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Rangitikei at Onepuhi

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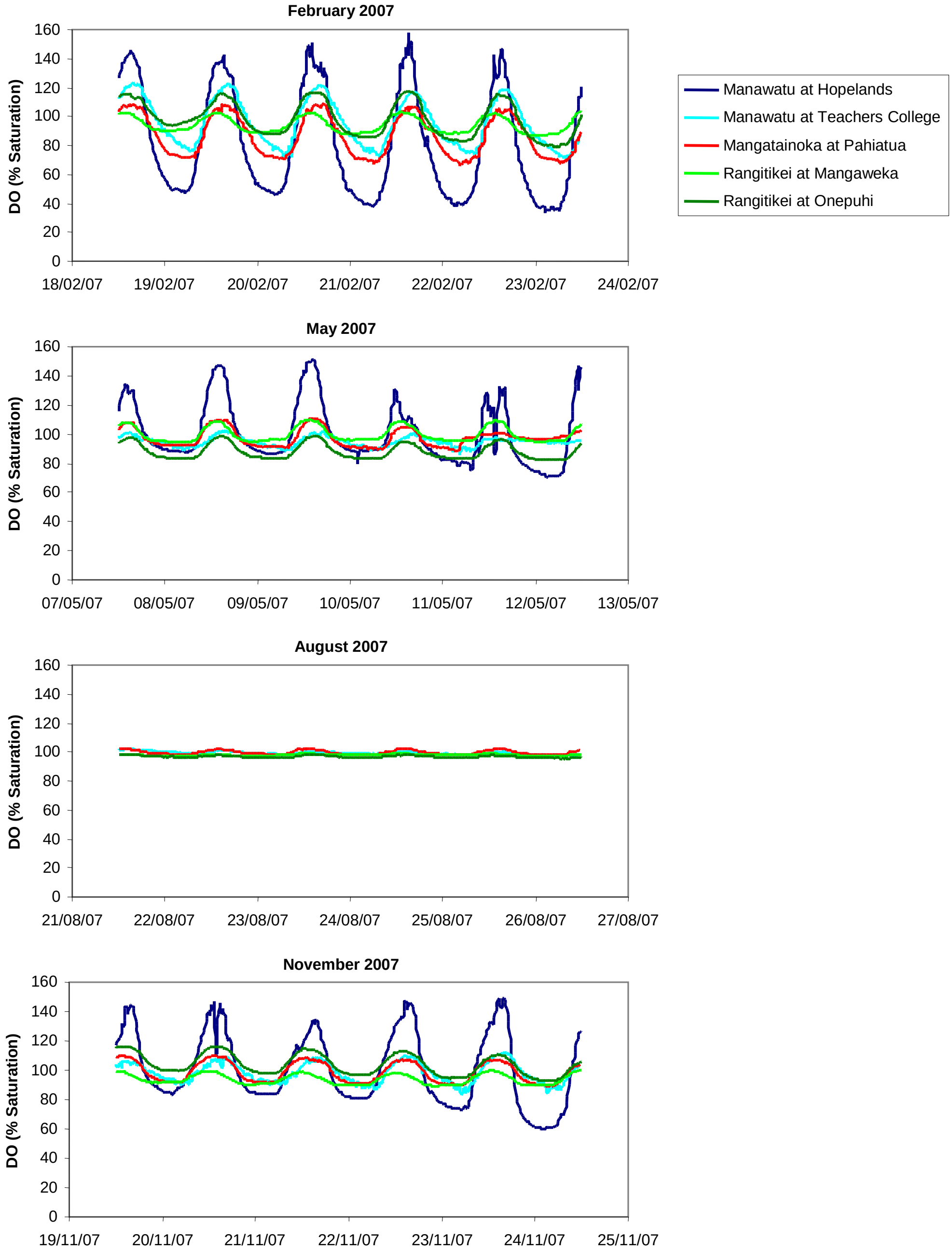


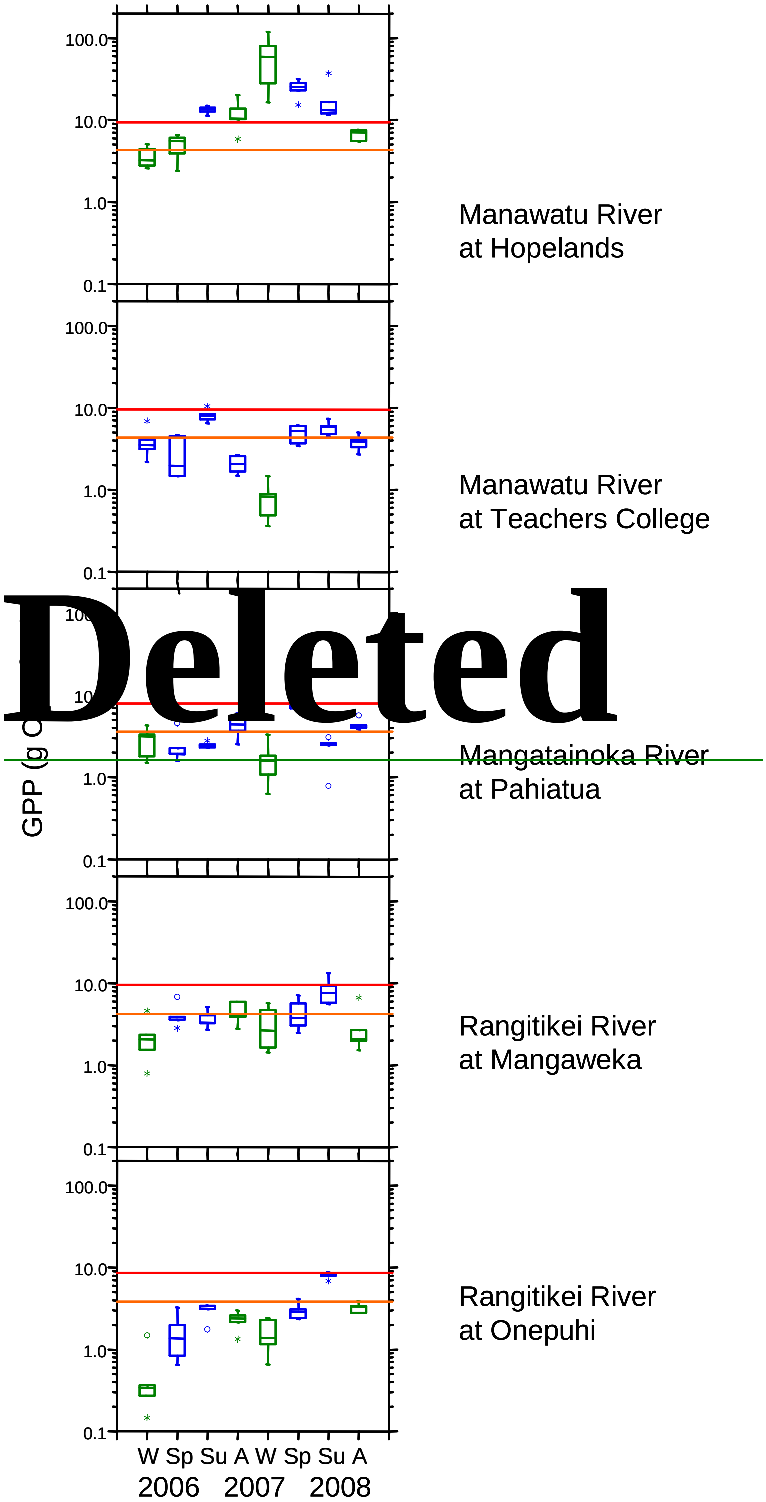
Figure 2. Dissolved oxygen data used in metabolic calculations for each of the five study sites for February, May, August and November 2007. No data is available for the Manawatu at Hopelands in August 2007.

~~27.~~30. Rates of GPP in the Manawatu River at Hopelands were ~~extremely~~ high~~ in winter 2007~~ (up to ~~120~~25 gO_2/m^2/day) and regularly above the threshold indicating poor ecosystem health (Figure 3). Rates of GPP in the Manawatu River at Teachers College site were ~~much~~generally lower~~ throughout the year~~, although ~~there still appears to be some concerns at this site in spring and summer~~ values measured in summer were above the threshold indicating poor ecosystem health (Figure 3).

~~28.~~31. Rates of ER were also ~~consistently~~ high in the Manawatu River at Hopelands and consistently indicative of poor ecosystem health in summer and spring and satisfactory-poor health in autumn (Figure 4). Rates of ER at the Teachers College site were ~~also generally high~~ lower and indicative of poor ecosystem health only during summer (Figure 4).

~~29.~~32. ~~Rates of GPP were more moderate in the Mangatainoka River at Pahiatua and generally indicative of healthy or satisfactory conditions, except in spring 2007 (Figure 3). However, rates of ER were consistently indicative of poor ecosystem health, except in summer 2007 and autumn 2008 (Figure 4).~~ Rates of GPP and ER in the Mangatainoka River at Pahiatua were generally indicative of good-satisfactory conditions (Figures 3 & 4). However, rates of ER during summer were often indicative of poor ecosystem health (Figure 4).

~~30.~~33. ~~Rates of GPP in the Rangitikei River were generally indicative of good-satisfactory ecosystem health at Mangaweka and Onepuhi (Figure 3), whereas rates of ER were often indicative of poor health at Mangaweka and satisfactory-poor health at Onepuhi (Figure 4). I understand that very high algal biomasses are observed at times at Mangaweka.~~ Rates of GPP and ER in the Rangitikei River at Onepuhi were indicative of good ecosystem health (Figures 3 & 4). Rates of GPP in the Rangitikei River at Mangaweka were indicative of good-satisfactory health (Figure 3), whereas rates of ER were indicative of good health in autumn, satisfactory health in spring and summer, and poor health in winter (Figure 4).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GPP (g O
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10.0
1.0
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Manawatu River
at Hopelands
Manawatu River
at Teachers College
Mangatainoka River
at Pahiatua
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at Mangaweka
Rangitikei River
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W Sp Su A W Sp Su A
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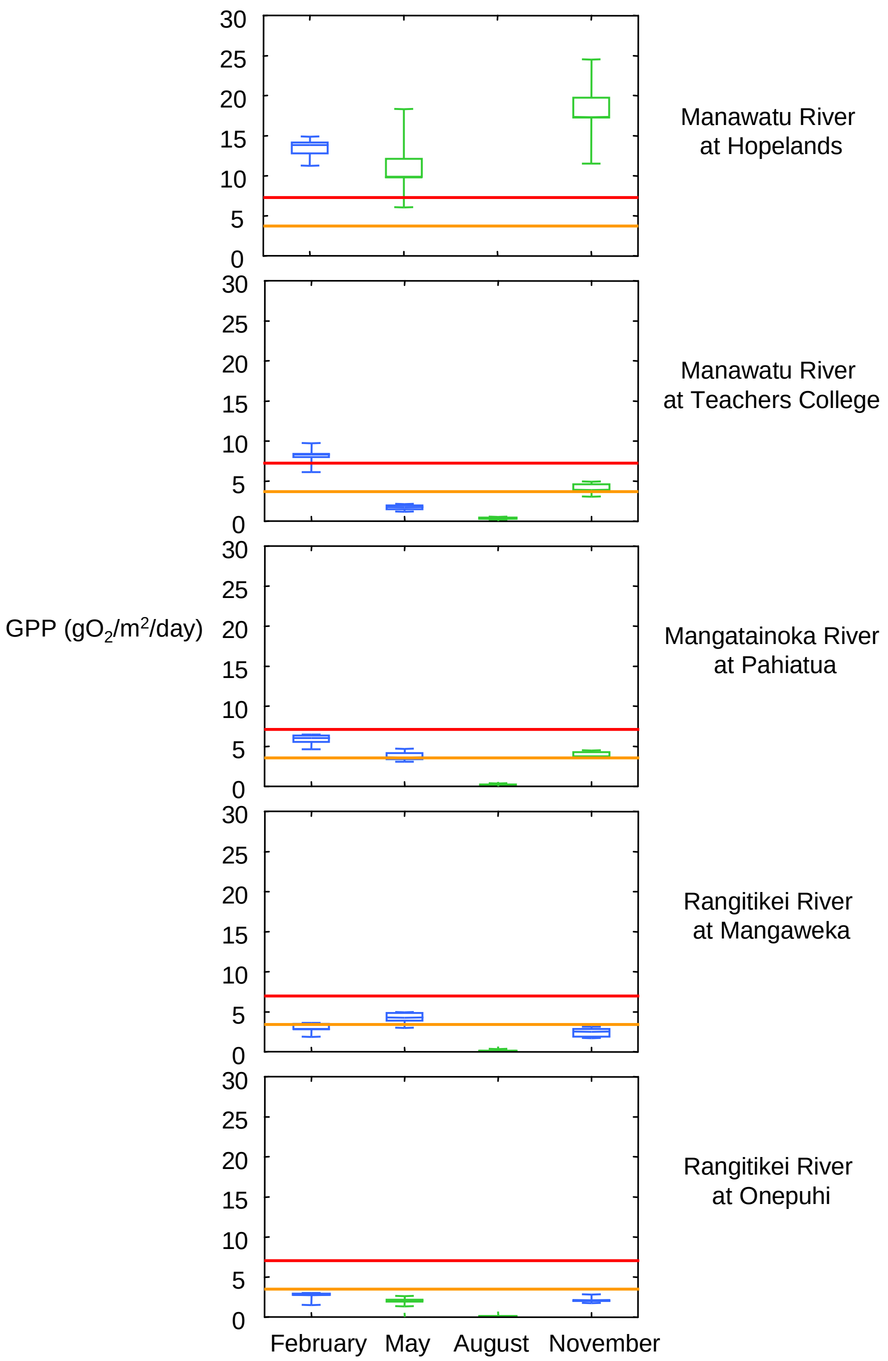
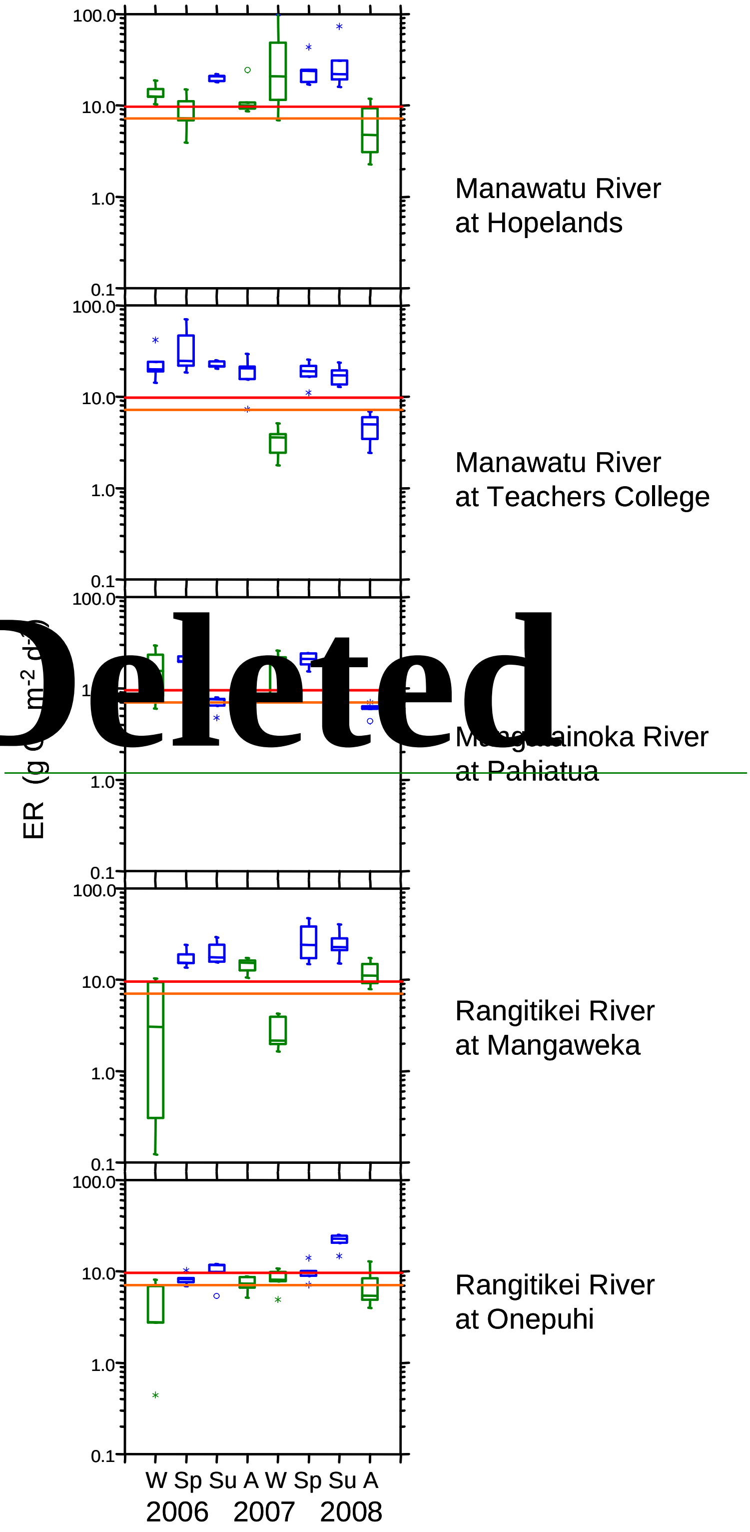


Figure 3. Rates of GPP for the five sites. Box plots show the median, upper and lower quartiles and range of values. Blue boxes indicate GPP calculated using data that did not need correction, while green boxes indicate GPP calculated from corrected data. The orange and red lines are guidelines representing the transition from good to satisfactory health, and satisfactory to poor ecosystem health, respectively. No data is available for the Manawatu at Hopelands in August 2007.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ER (g O2 m-2 d-1)
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10.0
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Manawatu River
at Hopelands
Manawatu River
at Teachers College
Mangatainoka River
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at Onepuhi
W Sp Su A W Sp Su A
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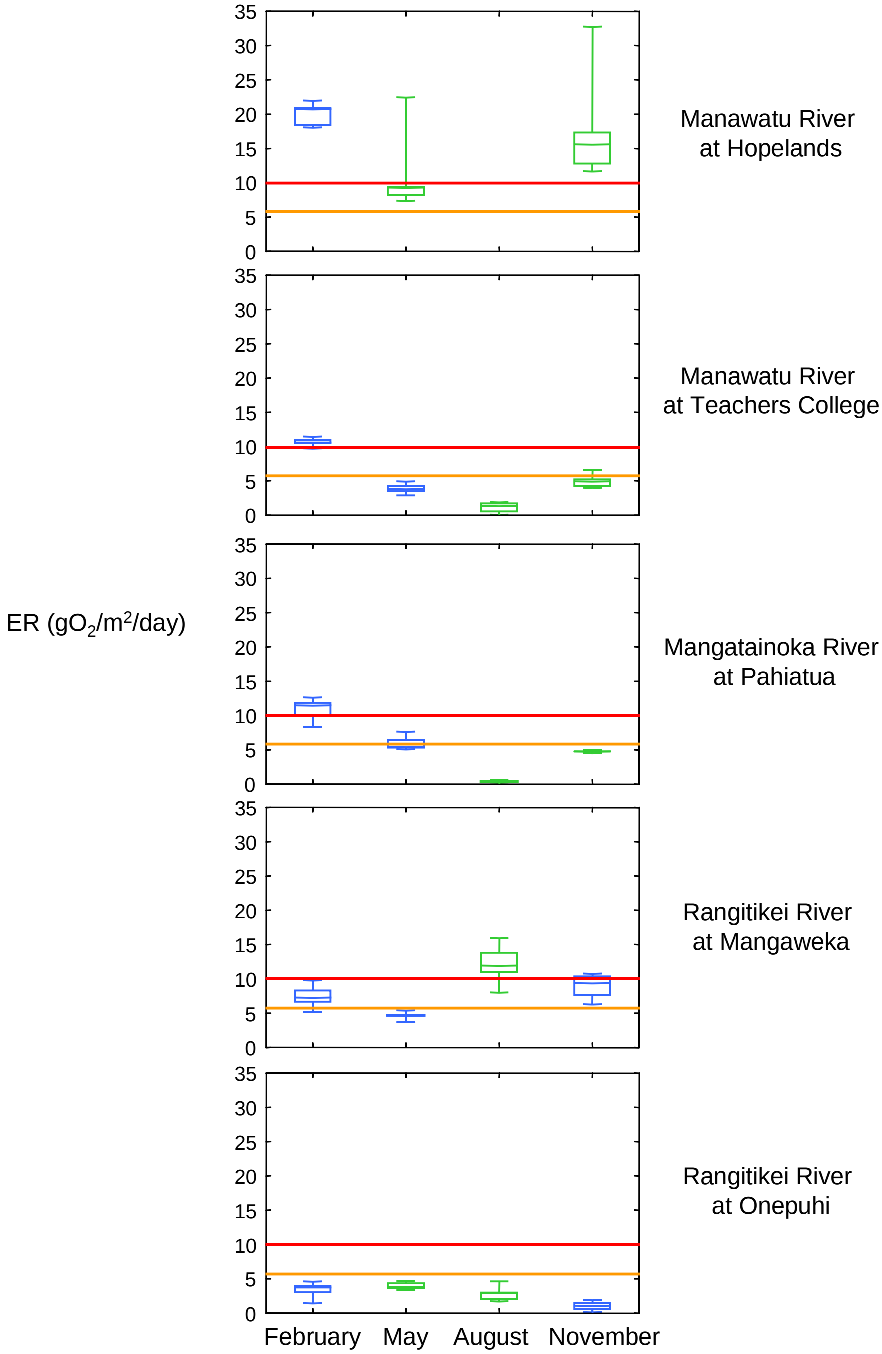

Figure 4. Rates of ER for the five sites. Box plots show the median, upper and lower quartiles and range of values. Blue boxes indicate ER calculated using data that did not need correction, while green boxes indicate ER calculated from corrected data. The orange and red lines are guidelines representing the transition from good to satisfactory health, and satisfactory to poor ecosystem health, respectively. No data is available for the Manawatu at Hopelands in August 2007.

How does this relate to the values that the One Plan seeks to protect?

~~31.~~34. In terms of the values that are listed in the Proposed One Plan, sites that exceed the guidelines for ecosystem metabolism are likely to have a lower life supporting capacity than sites that are within the normal range of values that would be expected. The most direct mechanism for this effect is via dissolved oxygen concentrations. Sites with high rates of ER will be prone to low minimum dissolved oxygen concentrations, especially at dawn. Low dissolved oxygen concentrations have the potential to kill fish and other aquatic life. ~~A review of raw seasonal data from the five sites indicated that minimum DO concentrations were well below the dissolved oxygen saturation standards proposed in the Proposed One Plan at all five sites and that they breached these standards on a relatively regular basis (Table 1).~~ A review of the data used to calculate metabolism from the five sites indicated that minimum DO concentrations were well below the dissolved oxygen saturation standards in the Proposed One Plan at the Manawatu at Hopelands and Mangatainoka at Pahiatua sites and breached these standards on a relatively regular basis (Table 1). However, DO concentrations at the other sites were generally above the proposed standards during these periods.

Table 1. Range in dissolved oxygen data and proportion of time breaching standards at the five study sites, calculated from ~~seasonal summary data provided by Horizons Regional Council~~ the 20 days of data used to calculate ecosystem metabolism. Data was not available for Hopelands during August 2007.

Site	% DO Min	% DO Max	Proportion of measurements breaching proposed DO standard (*>70% Saturation, #>80% Saturation)
Manawatu at Hopelands	34~~40.02~~	158~~332.02~~	19%*~~15%*~~
Manawatu at Teachers College	71~~40.17~~	124~~125.07~~	0%*~~11%*~~
Mangatainoka at Pahiatua	65~~43.14~~	111~~119.57~~	11%#~~22%#~~
Rangitikei at Mangaweka	87~~66.01~~	110~~147.27~~	0%#~~18%#~~
Rangitikei at Onepuhi	79~~47.12~~	117~~145.17~~	0.3%#~~21%#~~

~~32.~~35. Sites with high rates of GPP are likely to experience algal blooms (nuisance periphyton growths) that can degrade aesthetic and recreational values. Toxic cyanobacterial blooms may also result in high rates of GPP and have potential health implications for humans and animals. High algal densities associated with high rates of GPP can also cause large pH fluctuations, smother habitat for invertebrates, cause taste and odour problems for water supplies, and cause problems with low DO (such as fish kills) when the periphyton mats mature and decompose.

~~33.~~36. The Proposed One Plan seeks to maintain water bodies so they support healthy aquatic life and ecosystems. River health traditionally has been assessed with structural measures related to water quality or community composition of invertebrates and fish. However, river ecosystems also have functional components, which include the rates of key ecosystem processes such as ecosystem metabolism. Adequate characterisation of ecosystems requires information on both structure and function because stressors may cause changes to one or both of these elements. Therefore, extremely high or low rates of ecosystem metabolism indicate that the ecosystem is functioning in an unusual way and this should be a concern independent of the other linked effects on values that I have already outlined in Paragraphs 34~~23~~ and 35~~24~~.

Summary of technical report reviews

~~34.~~37. I reviewed three technical reports for Horizons Regional Council. These reports were:

- Sites of significance for aquatic biodiversity in the Manawatu-Wanganui Region (McArthur *et al*., 2007).
- Limiting nutrients for controlling undesirable periphyton growth (Wilcock *et al*., 2007).
- Recommended water quality standards for the Manawatu-Wanganui Region (Ausseil & Clark, 2007).

~~35.~~38. In general, I support the approach taken by Horizons in the Proposed One Plan, with an initial emphasis on the values to be protected, followed by specific standards that should protect those values. In my opinion, this approach is closely linked with the effects-based philosophy of the RMA where controls are specifically linked with the values that are potentially threatened by activities.

~~36.~~39. I am particularly impressed at the degree of spatial resolution within the Proposed One Plan with standards set for specific water management sub-zones. In my opinion, this approach is what is needed to protect aquatic values that are treasured by the community and is a big step up from the region-wide or national standards that are generally applied elsewhere in New Zealand. The high degree of spatial resolution in the proposed plan will help focus rehabilitation efforts on areas that fail to meet the standards and also protect the values present in areas that are currently in good health.

~~37.~~40. The approach used to determine aquatic sites of significance focused largely on fish and whio (blue duck), which in my opinion is a relatively narrow focus. I note that only one of the potential criteria that could be used to determine if a site was significant was actually used to define sites of significance. Further analysis of invertebrate community composition and potentially an analysis of key ecosystem processes/functions would enable a more broad view on the sites that could be considered significant.

~~38.~~41. I also note the difficulties with defining a river reach as a site of significance for a diadromous fish that migrates to and from the sea as part of its life cycle. If a diadromous species is found in a particular location in a river system, then all reaches downstream must be used by that species at some stage during its lifecycle. I realise that it may be impossible to classify the main stem of the Manawatu as a reach of significance for shortjaw kokopu, for example. But there should be recognition of the value of lowland rivers as migratory pathways for these 'significant' fish. The Proposed One Plan has addressed this issue in Chapter 16 by noting fish passage as an aspect of the life supporting capacity value, so that water quality and activities in the beds of rivers and lakes should not affect migration.

~~39.~~42. In relation to the water quality standards report, the relationship between invertebrate communities and particulate organic matter (POM) that was referred to is associated with discharges from oxidation ponds, not with natural sources of POM. I am not convinced that POM needs to be measured, or standards set, throughout the Region in the One Plan. However, given that discharges could potentially occur anywhere in the future, I support Dr Quinn's suggestion that a Region-wide standard of 5 g/m^3 at flows less than median be applied.

Water quality guidelines needed to maintain trout fishery values

~~40.~~43. I am the co-author of a report that summarised the literature on appropriate water quality standards that could be applied in the Proposed One Plan to protect trout fishery values (Hay *et al*., 2006).

~~41.~~44. The four key parameters for the protection of adult trout are water temperature, dissolved oxygen, water clarity/turbidity, and food supply, represented by the Macroinvertebrate Community Index (MCI). Temperature and dissolved oxygen have direct effects on fish metabolism, while water clarity can influence foraging efficiency for trout.

~~42.~~45. For spawning and egg incubation, the main issues are also temperature and dissolved oxygen, and also a need to maintain a relatively low amount of fine sediment in the substrate. Standards relating to water clarity and the MCI could act as surrogate controls on fine sediment loads, since direct measurement of fine sediments is problematic.

~~43.~~46. Excessive growth of periphyton commonly results in a change in aquatic invertebrate community composition, with large, drift-prone, EPT taxa (that is mayflies, caddisflies and stoneflies) being replaced by small (chironomids, algal piercing caddis) or non-drifting taxa (worms, snails). These changes potentially affect the food base for trout, with negative consequences for growth and carrying capacity, and affect angling success and satisfaction by fouling anglers' lures and reducing aesthetic values.

~~44.~~47. The most applicable guidelines relating to periphyton biomass and cover for the protection of trout fishery values are contained in the New Zealand Periphyton Guidelines (Biggs, 2000 – Appendix 1). However, these guidelines may need to be adjusted in light of improved understanding of the inter-relationships between periphyton biomass, invertebrate drift, and trout growth and abundance. Although high densities of invertebrates may be associated with high algal biomass, there is now evidence that these invertebrates may not be as readily available to drift-feeding trout.

~~45.~~48. The periphyton guidelines for trout fisheries suggested in Biggs (2000) (Appendix 1) may be sufficient to protect fishery values in lowland fisheries. However, algal biomass at such levels would be seen as a significant reduction in the 'pristine' natural character of many headwater fisheries. In the sites in Horizons' Region recognised as outstanding fisheries, the guidelines proposed by Biggs (2000) to protect benthic biodiversity values (Maximum chlorophyll *a* 50 mg/m^2) would provide better protection of trout habitat, benthic invertebrate habitat and aesthetic values. I support the use of the latter guideline in the Proposed One Plan for rivers recognised as outstanding fisheries.

4. REFERENCES

Ausseil O & Clark M 2007. Recommended water quality standards for the Manawatu-Wanganui Region. Technical report to support policy development. Horizons Regional Council.

Biggs BJF 2000. New Zealand Periphyton Guidelines: Detecting , monitoring and managing enrichment of streams. Ministry for the Environment, Wellington. 122 p.

Clapcott JE & Young RG 2009 – in preparation. Temporal variability in ecosystem metabolism of rivers in the Manawatu Region. Prepared for Horizons Regional

Council. ~~Cawthron Draft Report.~~ Cawthron Report No. 1672. 31 p. [This report will need to be revised using the updated metabolism calculations]

Hay J, Hayes JW & Young RG 2006. Water quality guidelines to protect trout fishery values. Prepared for Horizons Regional Council. Cawthron Report No. 1205. 17p.

McArthur K, 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.

Wilcock RJ, Biggs BJF, Death RG, Hickey CW, Larned ST & Quinn JM 2007. Limiting nutrients for controlling undesirable periphyton growths. Prepared for Horizons Regional Council. NIWA Client Report HAM2007-006. 38 p.

Roger Young
~~August 2009~~ January 2010

APPENDIX 1

Provisional biomass and cover guidelines for periphyton growing in gravel/cobble bed streams for three main instream values (from Biggs, 2000)

Instream value/variable	Diatoms/cyanobacteria	Filamentous algae
Aesthetics/recreation (1 November – 30 April)		
Maximum cover of visible stream bed	60% >0.3 cm thick	30% >2 cm long
Maximum AFDM (g/m^2)	N/A	35
Maximum chlorophyll *a* (mg/m^2)	N/A	120
Benthic biodiversity		
Mean monthly chlorophyll *a* (mg/m^2)	15	15
Maximum chlorophyll *a* (mg/m^2)	50	50
Trout habitat and angling		
Maximum cover of whole stream bed	N/A	30% >2 cm long
Maximum AFDM (g/m^2)	35	35
Maximum chlorophyll *a* (mg/m^2)	200	120