BEFORE THE	Waikato Regional Council Hearing Commissioners
IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of Waikato Regional Proposed Plan Change 1 – Waikato and Waipā River Catchments

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REBUTTAL STATEMENT OF OLIVIER MICHEL NICOLAS AUSSEIL ON BEHALF OF THE WAIKATO AND WAIPĀ RIVER IWI (Submitter No. 74035)

27 FEBRUARY 2019

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INTRODUCTION

1. My name is Olivier Michel Nicolas Ausseil (pronounced "O-Say").

2. I am Principal Scientist – Water Quality at Aquanet Consulting Ltd. My qualifications and experience are set out in my primary statement of evidence, dated 15 February 2019.

3. I confirm that I have read the 'Expert Witnesses Code of Conduct' contained in the Environment Court of New Zealand Practice Note 2014. My evidence has been prepared in compliance with that Code in the same way as I would if giving evidence in the Environment Court. 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.

SCOPE OF EVIDENCE

4. My rebuttal evidence is provided in response to the Evidence in Chief filed by the following technical witnesses on 15 February:

   (a) Dr Adam Canning and Dr Adam Daniel on behalf of Fish and Game;

   (b) Dr Martin Neale on behalf of Wairakei Pastoral;

   (c) Ms Kathryn McArthur on behalf of the Department of Conservation; and

   (d) Dr Timothy Cox, on behalf of Beef+ Lamb.

SETTING MCI OBJECTIVES - EVIDENCE OF DR ADAM CANNING AND MS MCARTHUR

5. Both Ms McArthur and Dr Canning recommend the inclusion of Macroinvertebrate Community Index (MCI) as an indicator of stream ecosystem health in the list of numerical Attributes/ Objectives contained in Table 3.11-1. However, their approach to formulating these attributes and the recommended numerical objectives they recommend differ.

6. In his evidence (para 3.32), Dr Canning recommends the setting of MCI objectives for all wadable streams, at no less than 20% below the modelled "reference" (i.e. under 100% native forest cover) MCI score.

7. Ms McArthur proposes a minimum score of 80 in most sub-catchments as the short-term objective and a uniform long-term MCI objective for all sub-catchments, being an MCI score of no less than 100 (Appendix 2 of Ms McArthur's evidence).

8. Macroinvertebrate communities are a useful biological indicator of the overall health of streams and rivers. The MCI is one of several indices commonly used to describe the overall "health" of macroinvertebrate communities, by allocating high scores for pollution-sensitive species and low scores to pollution-tolerant species. A high MCI score represents a "healthy" community, a low MCI score represents a not so healthy community. However, and importantly, MCI scores will naturally differ between streams. In a given (hypothetical) stream, the MCI score under natural conditions may be, say 130. In that situation, a MCI of 120 would be close to natural conditions and should be seen as healthy; by contrast, a score of 100 is probably not so healthy for this stream. Let us now consider a second stream where, for example, the MCI score under natural conditions is not expected to exceed 105. In this stream, a score of 95 should be considered as healthy.

9. Although not applicable to most of the Waikato River and part of the Waipā River mainstem, MCI is a relevant indicator of ecological health for smaller (wadeable) streams and rivers. WRC currently monitor MCI at 62 sites in the catchment, including both soft-bottomed and hard-bottomed sites.

10. The Technical Leaders Group (**TLG**) considered the inclusion of MCI as an Attribute for PC1, but recommended that it not be included, primarily due to the lack, or weakness of, causative links between contaminants and MCI, and the resulting inability to undertake a robust cost-benefit analysis[1]. However, although MCI is not an Attribute listed in Appendix 2 of the NPSFM, Policy CB3 requires that regional councils monitor MCI

[1] Report No. HR/TLG/2016-2017/2.1A. Water quality Attributes for healthy rivers: wai ora plan change. 22 June 2016. Page 13.

and establish methods under Policy CB2 to respond to MCI scores below 80 or a declining trend (as also pointed out by Ms McArthur, at paragraphs 94 and 131).

11. Should the Panel be of a view that setting MCI objectives is appropriate in Table 3.11-1, the method / approach used to formulate the numerical objectives needs to be carefully considered.

12. Ms McArthur recommends the setting of a minimum score of 80 in most sub-catchments as the short-term objective, and a minimum score of 100 in all sub-catchments as the long-term (80 years) objective. Ms McArthur does not provide details regarding the methodology used to derive these numbers. In particular, it is unclear whether the achievability of these objectives has been tested. Given the diversity of stream types in the Waikato-Waipā-catchment, it is unclear whether these objectives are (1) achievable and (2) a good representation of a "healthy" macroinvertebrate community.

13. Dr Canning recommends using a modelling approach, by which the MCI score under "natural" conditions is modelled and objectives set at no less than 20% below the natural MCI score. Dr Canning's approach presents the distinct advantage of taking into account natural characteristics of streams, and should, in theory, avoid setting objectives that would be unachievable even in a natural context (a point Dr Canning rightfully makes at paragraph 3.31 of his evidence).

14. However, Dr Canning's evidence does rely heavily on the Clapcott *et al*. model, which, like every model, has limitations and uncertainty. The limitations and uncertainty of the Clapcott *et al*. model should be acknowledged and assessed prior to the approach being used to set freshwater objectives in a regional plan. In particular, the validity, precision and accuracy of the "reference state" model in the Waikato-Waipā catchment should be carefully assessed, for both hard-bottomed and soft-bottomed streams.

15. In my opinion, what form of MCI score might be used, and where, should also be assessed and specified, should MCI objectives be included in Table 3.11-1. For instance:

(a) Macroinvertebrate communities can only be monitored in wadeable streams and rivers, which excludes most of the Waikato River mainstem. The stream/river reaches to which the MCI objectives might apply should be specified or mapped.

(b) The MCI applies to hard-bottomed (i.e. stony) streams. A modified version exists for soft-bottomed streams (sbMCI). Within a given sub-catchment, some streams may be soft-bottomed and some may be hard-bottomed, noting that the boundary between the two stream types is not always clear-cut. The hard- vs. soft-bottomed reaches of streams and rivers should be mapped, to provide certainty as to what form of MCI will be used.

PERIPHYTON OBJECTIVES - EVIDENCE OF MS MCARTHUR

16. Ms McArthur recommends the setting of periphyton biomass (mg Chlorophyll a/m^2) and/or cover (PeriWC) objectives.

17. Periphyton was considered by the TLG as a water quality attribute for PC1[2]. The TLG recommended that it not be included, on the basis of:

(a) limited relevance to many waterways in the Waikato-Waipā catchment (being soft-bottomed and thus not suitable for the development of periphyton); and

(b) although WRC do not monitor periphyton biomass, the available periphyton cover data indicates limited periphyton issues at monitored sites.

18. As expressed in paragraph 40(c) of my primary evidence, I generally agree with the TLG's recommendations, noting that if periphyton is not a significant issue now, it seems unlikely to become one in the near-future given the land use controls placed by PC1. However, periphyton biomass is an NPSFM attribute in relation to the compulsory value of Ecosystem Health, thus periphyton Objectives may need to be set. Should periphyton objectives be set, then my recommendation would be

[2] Report No. HR/TLG/2016-2017/2.1A. Water quality Attributes for healthy rivers: wai ora plan change. 22 June 2016. Page 12.

that they should only be set in areas of relevance (i.e. hard-bottomed stream reaches and/or sub-catchments).

19. In any case, I recommend that WRC commence a monthly quantitative periphyton monitoring programme at suitable sites to more formally assess the state and significance of the periphyton issue.

DISSOLVED NUTRIENT LIMITS AND TARGETS TO CONTROL PERIPHYTON GROWTH OR ECOSYSTEM HEALTH - EVIDENCE OF MS MCARTHUR DR AND ADAM CANNING

20. Both Ms McArthur and Dr Canning recommend the setting of numerical thresholds relative to nitrogen and phosphorus concentrations in sub-catchments.

21. However, the reasons/ methodology are different:

(a) Ms McArthur recommends setting Dissolved Inorganic Nitrogen (DIN) and Dissolved reactive phosphorus (DRP) limits associated with the periphyton objectives; and

(b) Dr Canning recommends setting nitrate-nitrogen and DRP "levels to assist in meeting the desired ecosystem health states based on modelling" (at paragraph 3.33).

22. First, I wish to draw the Panel's attention to paragraph 81 of my primary evidence. In my opinion, nutrient concentrations should not be seen as an end in themselves. Rather, they are controlling factors, and should be seen as "levers" one can act on to maintain (or reach) specific freshwater objectives, such as maximum planktonic or benthic (periphyton) algae biomass. As such, nutrient concentrations are, in my opinion, poorly suited to being expressed as freshwater objectives, and should be expressed as limits, and where exceeded, targets.

23. With regards to setting nitrogen and/or phosphorus limits to control periphyton growth or meeting desired ecosystem health, I am of the opinion that the following aspects must be considered:

(a) What is the relationship between nitrogen and phosphorus on the one hand and periphyton on the other hand?

(b) What is the relationship between nitrogen and phosphorus on the one hand and MCI on the other hand?

(c) Is the level of knowledge and understanding sufficient to confidently set nitrogen and/or phosphorus limits to control periphyton growth or meet desired ecosystem health?

(d) What are the implications of setting nitrogen and/or phosphorus limits?

24. With regards to the first question (nutrient- periphyton relationship), there is a well-established causative relationship between N/P and periphyton. In streams where habitat is suitable for periphyton growth (stony stream bed), and all other things being equal, more nutrients generally result in more periphyton, more often. However, the following should be borne in mind:

(a) Nutrients are only one of the drivers of periphyton. Other drivers, such as the hydrological regime, stream bed substrate and shading are known to be more important drivers of periphyton abundance than nutrients;

(b) There is no generalised robust relationship or model linking nutrient concentrations with periphyton growth or abundance. These relationships tend to be river- or site specific and their understanding generally requires a significant amount of site-specific work. In short, we do not have a readily available tool by which we can link periphyton objectives with nutrient concentration limits in the Waikato catchment. Such tool would be required to confidently define in-stream nutrient concentrations limits to achieve specified periphyton biomass objectives.

25. With regards to the second question (nutrient -MCI relationship), the scientific evidence is clear that:

(a) MCI is directly influenced by a number of factors, including habitat changes, physiological stress and hydraulic stress (refer to Figure 1 in Collier et al (2014)[3] (reproduced below));

(b) There is no direct causative relationship between nutrient concentrations and MCI[4]. The effect pathway between nutrient inputs and changes in MCI must go through increased plant growth, which in turn may modify habitat or dissolved oxygen in order to then cause an effect on MCI. In other words, the link between nutrients and MCI is only a second-degree link.

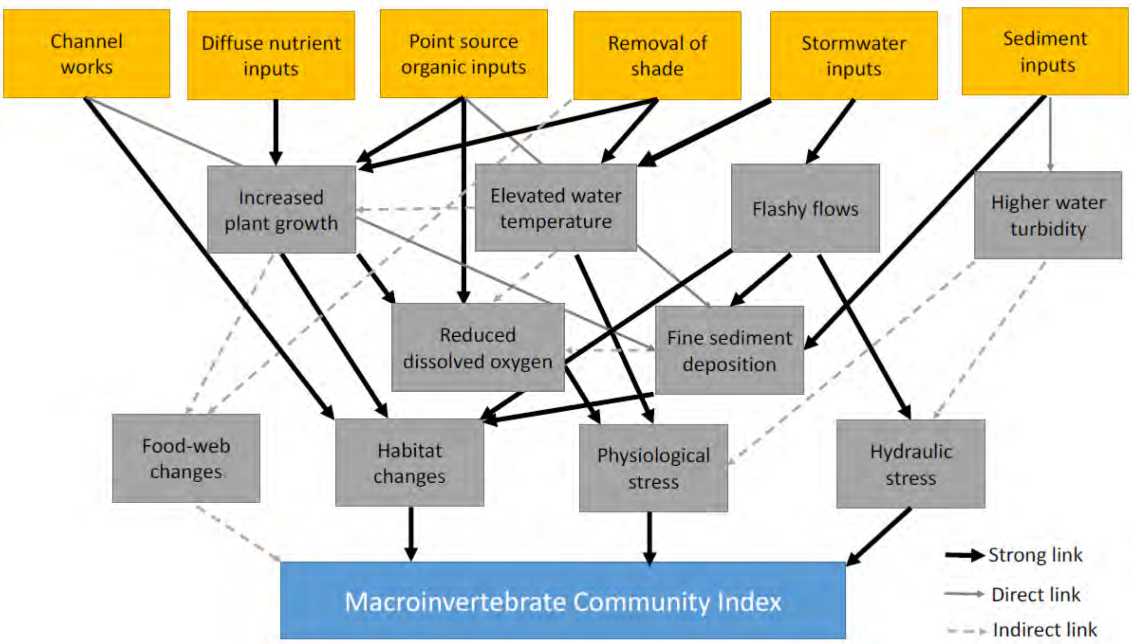

Figure 1: Pathways by which various pressures (orange boxes) influence MCI (reproduced from Collier et al., 2014).

[3] Collier KJ, Clapcott J, Neale M 2014. A macroinvertebrate attribute to assess ecosystem health for New Zealand waterways for the national objectives framework – Issues and options. Environmental Research Institute report 36, University of Waikato, Hamilton

[4] Except where nitrogen is under the form of ammoniacal- or nitrate-nitrogen and at concentrations sufficient to cause significant toxicity.

26. In making his recommendations for nitrate and DRP limits/targets, Dr Canning heavily relies on an article that has been submitted to, but not accepted by, a scientific journal (attached as appendix 3 to his evidence). It is my understanding that this article was first submitted several years ago, but appears to have not been accepted in a scientific journal. It would be useful if Dr Canning could clarify what journal(s) this article has been submitted to, and what the outcome of the independent peer-review process(es) was.

27. In my opinion, the approach taken in the article is fundamentally flawed because it uses a non-causative relationship between variables to define environmental thresholds for one variable (N or P) in order to achieve given state of the other variable (MCI or QMCI). Specifically, it assumes that if certain N or P concentrations are met, then corresponding MCI scores will be achieved. For this to be a valid approach, a direct cause-to-effect relationship between the two variables would be required. For example, Yalden and Elliott (2015) have developed a model linking TP and TN concentrations with chlorophyll *a* concentration in the mainstem of the Waikato River[5]. Within the limitations and uncertainties associated with the said model, it would be, on principle, a reasonable approach to use the model to determine, say, the concentration of TP required to achieve a given chlorophyll a concentration objective. This is because there is an established causal relationship between the two variables.

28. Whilst there is evidence of a statistical correlation between TN and MCI, and TP and MCI, this relationship is non-causative and is, in my opinion, likely the result of co-varying variables. This is expected, as it is well documented that pristine, native bush-clad streams will have comparatively lower nutrient concentrations, higher levels of riparian vegetation and shading, lower temperatures, less modifications of the natural flow regime and lesser amounts of deposited sediment, whilst intensively farmed catchments tend to have comparatively higher nutrients, less riparian vegetation and shading, higher water temperatures, accelerated erosion and sediment inputs and more

[5] Report No. HR/TLG/2015-2016/2.3 A methodology for chlorophyll and visual clarity modelling of the Waikato and Waipā Rivers. Refer particularly to Figure 3.3 of the report

modified flow regimes. Whilst all these things tend to happen together, it does not mean that one necessarily causes the others.

29. One of the fundamental tenets of statistics, and of scientific disciplines that rely on statistics, is that correlation does not mean causation. Correlation is a statistical technique which tells us how strongly the pair of variables are linearly related and change together. Causation means that change in the value of one variable will cause a change in the value of the other variable.

30. In an hypothetical example[6], let's say that the sales of ice creams are increasing compared with the previous month, and so are the sales of sunglasses. It does not mean that the increase in sales of ice cream has caused the increase in sales of sunglasses. It is more likely that the concurrent increase in the two variables is caused by warm, sunny weather. In this case, the two variables co-vary (are correlated) but are not linked by causation. Critically the correlation does not mean that acting on one for the variables (e.g. limiting the sales of ice creams) will cause a change in the other variable (a reduction the sales of sunglasses).

31. Further on this topic, Dr Richard Storey provides a comprehensive review of the approach recommended by Dr Canning in relation to the Wellington proposed Natural resource management plan (pNRP) [see Appendix 1].

32. With regards to the third question (state of knowledge), it seems clear, in my opinion, that current understanding of the nutrient- periphyton relationship in the Waikato catchment is insufficient to reasonably confidently formulate in-stream nutrient concentration limits/targets in relation to specified periphyton objectives. For this reason, I do not recommend adopting the limits recommended by Ms McArthur. Similarly, I do not believe it is a reasonable proposition to formulate nutrient limits on the basis of MCI objectives, and I do not recommend adopting the limits recommended by Dr Canning.

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[6] Example "borrowed" from https://towardsdatascience.com/why-correlation-does-not-imply-causation-5b99790df07e. accessed 26/02/2019

33. A very similar situation was encountered in the Gisborne Region, in the context of the proposed freshwater plan change for the Waipaoa catchment (2016-2017). In that situation, all experts, including Dr Canning agreed that sensible DIN and DRP limits could not be developed given the state of knowledge [see Appendix 2, page 10].

34. With regard to the fourth question (what are the implications of nutrient limits), the key risk that must be considered is one of unintended consequences, specifically under- or over-enabling resource use. The in-stream nutrient limits recommended by both Dr Canning and Ms McArthur would require significant reductions in in-stream nutrient concentrations in most sub-catchments. Their implications, in terms of resource use have not been assessed.

35. In conclusion,

    (a) Whilst setting periphyton objectives is a reasonable proposition, they should only be applied to those stream and river reaches that may support conspicuous amounts of periphyton;

    (b) The direct implication of the above is that setting nutrient concentration limits to control periphyton growth should only be considered in river reaches where periphyton can grow (and in areas located upstream of those reaches);

    (c) Where periphyton is a relevant attribute, the available data does not suggest that periphyton is a significant issue;

    (d) There is no established model or relationship that would enable the formulation of robust numerical nitrogen or phosphorus limits to achieve numerical periphyton objectives in the Waikato-Waipā catchment;

    (e) I strongly disagree with the proposition that non-causative statistical relationships between nitrogen, phosphorus and MCI can be used for the formulation of numerical nitrogen and/or phosphorus limits;

    (f) The nitrogen and phosphorus limits recommended by Ms McArthur and Dr Canning would require significant reductions in nutrient concentrations compared with the existing state. These seem difficult to reconcile with the lack of an obvious periphyton problem in most of the catchment. In any case, the feasibility and implications of these reductions in terms of resource use have not been properly assessed;

(g) For the above reasons I do not recommend adopting the nitrogen and phosphorus limits recommended by either Ms McArthur or Dr Canning.

36. TN AND TP LIMITS IN SUB-CATCHMENTS NUTRIENT LIMITS AND TARGETS - EVIDENCE OF DR MARTIN NEALE, MS KATRHYN MCARTHUR AND DR TIMOTHY COX

37. In paragraph 6 of his evidence, Dr Martin Neale recommends the application of TN and TP attributes to the whole catchment, to provide a greater certainty of achieving the Vision and Strategy, on the basis that nutrients from anywhere in the catchment will affect algal biomass in the mainstem.

38. On principle, I agree with Dr Neale. The logic of developing sub-catchment-scale limits specifically tailored to achieve a specified ecological objective (planktonic algae biomass in the mainstem) is sound, and probably preferable to the nitrate-nitrogen objectives currently set in Table 3.11-1. The application of TN and TP attributes at the sub-catchment scale would have the added advantage of providing greater certainty and clarity for resource user.

39. However, the methodology used to define these TN/TP limits at the sub-catchment scale would have to be carefully developed to ensure that it does not create issues of achievability, or inequity across the catchment. Similarly to the point I make in paragraph 89 of my primary evidence, there would be risk that the development of a future allocation framework for the Waikato-Waipā catchment may be constrained, or its outcomes pre-determined in part, by the TN/TP limits that may be imposed at the sub-catchment scale.

40. In paragraph 105, Ms McArthur recommends that trophic state targets for all of the middle and lower Waikato River mainstem (Waikato at

Narrows, Horotiu, Huntly, Mercer and Tuakau) should be to achieve Band A. This corresponds to TN and TP concentrations of 160 and 10 mg/m^3 respectively. This is similar to (for TN), or significantly lower than (for TP), the modelled 1863 concentrations for the lower Waikato River (143-158 mg/m^3 for TN and 11-16 mg/m^3 for TP)[7]. The implications are that nitrogen losses in the whole of the Waikato catchment would have to be returned to pre-1863 levels, and the TP limits would simply not be able to be achieved even with extensive land use change. I re-iterate that in any freshwater limit-setting exercise, it is crucially important to consider the achievability and implications of the limits being proposed.

41. In paragraph 27 of his evidence, Dr Timothy Cox reaches the conclusion that the long-term nitrogen objectives for the upper catchment may be overly constraining, and would require nearly 100% afforestation of pastoral farms. This conclusion is very similar to what I conclude in paragraph 94 of my primary evidence, and confirms the concerns associated with the process used to determine Table 3.11-1 objectives.

42. As stated in my primary evidence, I am of the opinion that expert caucusing would assist in resolving (or at least narrowing down the differences of view between experts) matters associated with Table 3.11-1.

[7] Report No. HR/TLG/2016-2017/4.3. Prediction of water quality within the Waikato and Waipā River catchments in 1863. Table 3, Pages 14 and 15.

BEFORE THE PROPOSED NATURAL RESOURCES PLAN HEARINGS PANEL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of Water quality
AND	
IN THE MATTER	of the submissions and further submissions set out in the S42a Officer Report

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STATEMENT OF PRIMARY EVIDENCE OF RICHARD GOODWIN STOREY ON BEHALF OF WELLINGTON REGIONAL COUNCIL

TECHNICAL – WATER QUALITY

12 January 2018

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1. SUMMARY

1.1 My name is Richard Goodwin Storey. I am a freshwater ecologist with 13 years' experience at the National Institute of Water and Atmospheric Research (NIWA). I have a Ph.D. in Zoology from University of Toronto and a M.Sc. in Zoology from University of Auckland. I am a member of the Society for Freshwater Science and the New Zealand Freshwater Sciences Society. My area of expertise is in the ecology of aquatic macroinvertebrates, the biological assessment and rehabilitation of streams, and ecological modelling to support freshwater decision-making. In regard to the latter, I have developed a decision-support model for the Ruamahanga catchment in Wellington Region, which involved extensive analysis of ecological and hydrological data from this catchment and consultation with scientists familiar with the catchment. A full copy of my qualifications and experience is available in **Attachment A** of my evidence.

1.2 I have been asked to provide evidence in response to submissions received coded to topic Water Quality for the following specific matters/areas/schedules:

(a) And the relationship between dissolved nutrients and MCI values in Wellington streams and rivers.

(b) And setting region-wide nutrient limits as a means for raising MCI values to meet target values in Wellington streams and rivers.

1.3 The scope of my evidence includes

(a) assessing submissions relating to nutrient management as a means for achieving target MCI values in streams and rivers of the Wellington region, including the technical rigour of the methodologies in these submissions and the appropriateness of setting region-wide nutrient limits for achieving target MCI values.

(b) Summary of alternative methods for deriving a relationship between nutrients and MCI, and for achieving target MCI values.

1.4 The methodology for assessing submissions involved review of published literature and technical reports regarding the relationship between MCI values and

(a) dissolved nutrients

(b) other environmental factors

in streams and rivers in New Zealand and other countries.

1.5 My Evidence addresses matters raised in the submissions of Adam Canning and Russell Death.

1.6 Summary of recommendations

(a) MCI has been shown to be correlated with a decrease in native vegetation cover and an increase in “heavy” pastoral land use in the catchment (Clapcott et al. 2013). A variety of stressors are associated with a change in land use from native vegetation to pastoral agriculture or urban development. Studies have shown that stressors associated with decreased MCI scores following such land use change include elevated water temperature (Quinn et al. 1997a, Collier 1995), fine sediment deposition (Niyogi et al. 2007, Clapcott et al. 2011, Wagenhoff et al. 2011), suspended sediment, excess periphyton growth (Quinn and Hickey 1990, Collier 1995, Matheson et al. 2015), and altered hydrology (Booker et al. 2015; Greenwood et al. 2016).

(b) Expert consensus is that where nutrients are correlated with MCI the causative link is via the effect of nutrients in increasing periphyton biomass, which alters habitat and food quality for stream macroinvertebrates (Miltner 1998, Dodds and Welch 2000, Greenwood et al. 2016, Clapcott et al. 2017). The relationship between nutrients and periphyton biomass may or may not be strong, depending on factors such as light, temperature and frequency of high flows (Snelder et al. 2014).

(c) In my opinion, the approach of achieving target MCI levels in streams by reducing dissolved nutrient concentrations alone (as recommended by Death and Canning) is too simplistic and may be ineffective in many stream reaches.

(d) The reason is that reducing one of the stressors affecting macroinvertebrate communities while not reducing others will not result in significant change to the macroinvertebrate community except where that one stressor is the main cause of degradation in the macroinvertebrate community.

(e) Because of this, effective management to increase MCI levels requires understanding the main stressor(s) that are currently impacting on the macroinvertebrate community in each stream reach. The main stressors are likely to vary depending on catchment land use (e.g. urban catchments place a different suite of stressors on stream macroinvertebrate communities than agricultural catchments, including more severely altered hydrology, more heavy metals and polyaromatic hydrocarbons) and stream type (e.g. low gradient soft-bottomed streams are likely to place different stressors on macroinvertebrate communities than high gradient or gravel-bed streams; Collier et al. 1998). Effective management therefore requires identifying the primary stressors in different catchments and stream types, and targeting management actions to address those stressors.

(f) In many stream reaches the macroinvertebrate community will be affected by more than one stressor (Matthaei et al. 2010, Lange et al. 2014). Therefore, in my opinion, an approach more likely to result in improvement in MCI scores is to take management actions that alleviate a range of stressors associated with catchment land use. One example is riparian planting, which can reduce fine sediment and phosphorus (by preventing stock access to streams, stabilizing stream banks and filtering overland runoff) and water temperature (by shading in small to medium streams). Riparian planting may not reduce nitrate unless groundwater flows through the root zone of riparian plants. However, riparian vegetation can weaken the response of periphyton to high nitrate due to the shading it provides (Matheson et al. 2012). In addition it restores terrestrial organic matter inputs that provide food and habitat for macroinvertebrates.

(g) Policies to increase MCI scores must also consider the scale and location of management actions. Current evidence suggests that recolonization by macroinvertebrates is enhanced where restored sites are located close to sources of recolonists (Parkyn et al. 2003) and where riparian buffer strips (if these are the main management action) are larger than a certain width (e.g. 10-20 m; Parkyn 2004) or represent a greater proportion of stream length in a catchment (Collier et al. 2001). In streams distant from high-quality habitats, reducing stressors may not result in increases in MCI for many years or decades, as macroinvertebrates are unable to recolonize the stream (Parkyn and Smith 2011, Tonkin et al 2014, Leps et al. 2016).

2. INTRODUCTION

2.1 My name is Richard Goodwin Storey. I am a freshwater ecologist with 13 years' experience at the National Institute of Water and Atmospheric Research (NIWA). I have a Ph.D. in Zoology from University of Toronto and a M.Sc. in Zoology from University of Auckland. I am a member of the Society for Freshwater Science and the New Zealand Freshwater Sciences Society. My area of expertise is in the ecology of aquatic macroinvertebrates, the biological assessment and rehabilitation of streams, and ecological modelling to support freshwater decision-making. In regard to the latter, I have developed a decision-support model for the Ruamahanga catchment in Wellington Region, which involved extensive analysis of ecological and hydrological data from this catchment and consultation with scientists familiar with the catchment. A full copy of my qualifications and experience is available in **Attachment A** of my evidence.

2.2 I have been engaged by Great Wellington Regional Council to provide evidence relating to the Proposed Natural Resources Plan for Water Quality.

3. CODE OF CONDUCT

3.1 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note and that I agree to comply with the code. My evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter to detract from the opinions which I express.

4. SCOPE

4.1 I have been asked to provide evidence in response to submissions received coded to topic Water Quality for the following specific matters/areas/schedules:

(a) Assessment of the relationship between dissolved nutrients and MCI values in Wellington streams and rivers.

(b) And setting region-wide nutrient limits as a means for raising MCI values to meet target values in Wellington streams and rivers.

4.2 The scope of my evidence includes

(a) assessing submissions relating to nutrient management as a means for achieving target MCI values in streams and rivers of the Wellington region, including the technical rigour of the methodologies in these submissions and the appropriateness of setting region-wide nutrient limits for achieving target MCI values.

(b) Summary of alternative methods for deriving a relationship between nutrients and MCI, and for achieving target MCI values.

5. SUMMARY OF SUBMISSIONS ADDRESSED BY MY EVIDENCE

5.1 Russell Death's report "Ecosystem health and nutrient concentrations for Wellington rivers and streams."

(a) Dr. Death compares predicted MCI (Macroinvertebrate Community Index) scores of REC (River Environment Classification) reaches in the Wellington Region with target values set in the Proposed Natural Resources Plan. He finds that predicted MCI values are below target values for the corresponding stream type in approximately 93% of REC reaches.

(b) He states that critical management parameters to maintain ecosystem health should include nitrate-nitrogen and dissolved reactive phosphorus.

(c) He estimates a simple correlation relationship between MCI and nitrate concentration in each of four datasets. The first of these involves modelled MCI related to modelled nitrate in over 500,000 stream reaches. The second involves measured MCI values related to modelled nitrate concentrations in 962 sites. The third involves an unspecified dataset. The fourth involves measured MCI related to measured nitrate values in 62 sites.

(d) He uses either the first of these correlations, or all four (it is unclear which) to derive a target nitrate and a DRP value that corresponds to the target MCI score in the PNRP.

(e) He compares the current nitrate and DRP values (presumably modelled nitrate and DRP) to target values for each stream type in the Wellington region. Using this method, he finds that 8-98% of river reaches have nitrate concentrations exceeding target levels and 9-35% of river reaches have DRP concentrations exceeding target levels.

6. METHODOLOGY

6.1 The methodology for assessing submissions involved review of the models that produced the datasets used by Dr. Death, and review of published literature and technical reports regarding the relationship between macroinvertebrate metrics (particularly MCI values) and

(a) dissolved nutrients

(b) other environmental factors

in streams and rivers in New Zealand and other countries.

6.2 Documents that were referred to in preparing this evidence include the PNRP and the references listed at the end of this evidence.

6.3 Issues raised in submissions include:

(a) Validity of the correlations between MCI and nutrients in datasets containing modelled data only.

(b) The strength of correlations using measured values of MCI and nutrients.

(c) Lack of consideration of other factors likely to influence MCI values in addition to nutrients, particularly in urban catchments.

(d) Lack of consideration of the pathway by which nutrients may affect MCI, and what other factors may influence this pathway.

(e) Appropriateness of nitrate and dissolved reactive phosphorus as the most relevant measures of available nitrogen and phosphorus, respectively

(f) Applying a single relationship between MCI and dissolved nutrients to all stream types in the region.

(g) The implied assumption that MCI will improve when a stressor is reduced.

7. RESULTS

7.1 Validity of the correlations between modelled MCI and modelled nutrients

(a) Death (2015) derives the correlation between MCI and nutrients (nitrate and DRP) at least partly (possibly entirely) by relating modelled MCI values to modelled nutrient values. The modelled MCI values are taken from Clapcott et al. (2013). In this dataset, MCI values are predicted for each REC (River Environment Classification) reach in New Zealand on the basis of a number of (mostly catchment-level) physicochemical variables in GIS databases that the authors showed to be correlated with MCI at monitoring sites. The two most influential variables “driving” the model (i.e. determining the resultant MCI values) are % indigenous vegetation and % heavy pastoral land use. The modelled nutrient values are taken from Unwin and Larned (2013). In this dataset, nutrient values are predicted for each REC (River Environment Classification) reach in New Zealand on the basis of a number of (mostly catchment-level) physicochemical variables shown to be correlated with the two nutrients at monitoring sites. The two most influential variables “driving” the nitrate model (i.e. determining the resultant nitrate values) are % heavy pastoral land use and % indigenous vegetation, while the two most influential variables “driving” the DRP model (i.e. determining the resultant DRP values) are catchment-averaged sediment particle size and catchment mean slope. Given that the same two physicochemical factors are used to predict both nitrate and MCI, it is not surprising that there is a strong correlation between these two variables in the modelled dataset. This correlation, therefore, reveals nothing except that both are correlated with land use. The correlation between MCI and DRP is more informative, since each is predicted by different factors.

7.2 The strength of correlations using measured values of MCI and nutrients

(a) Death (2015) states that the correlation between MCI and nitrate for “real”, i.e. measured, data has an r^2 of 0.24 (though it is not clear which dataset he is referring to). This means that nitrate explains 24% of the variance in MCI in this dataset. This is a relatively low proportion, which implies that other factors are important in determining the final MCI value in addition to nitrate. The correlation between MCI and DRP also has an r^2 of 0.24.

7.3 Other factors likely to influence MCI in addition to nitrate

(a) Death (2015) considers only a bivariate (simple) correlation between MCI and nitrate (first) and DRP (second), without accounting for a number of other factors that are known to influence MCI. This is likely to be the main reason that the correlations from measured datasets had relatively low r^2 values. The strong correlations in modelled datasets show that both nitrate and MCI are associated with a decline in catchment indigenous vegetation cover and an increase in catchment “heavy” pastoral cover. These changes in land use are also associated with increased light at the riverbed (which promotes periphyton growth), elevated water temperatures, loss of riparian vegetation as habitat for adult aquatic insects, increased deposited and suspended fine sediment, a shift in food resources from terrestrial organic matter to periphyton, loss of instream habitat complexity and more rapid and extreme changes in flow (Duncan 1995, Quinn 2000). All of these changes are known to affect macroinvertebrates (Collier and Smith 2000, Matthaei et al. 2010, Quinn et al. 1994, Quinn et al. 2000) and many of them are associated with a decline in MCI (Quinn and Hickey 1990, Quinn et al. 1997a, Collier 1995, Stark and Maxted 2007, Niyogi et al. 2007, Clapcott et al. 2011, Wagenhoff et al. 2011, Matheson et al. 2015, Booker et al. 2015). By not accounting for these other important factors, Dr. Death has not made a convincing case that there is a cause-effect relationship between MCI and nutrients. Indeed, from the data provided it could be argued that MCI is responding primarily to changes in one or more of these other factors, and nitrate is simply associated with these changes. This is important in the context of the submissions by Canning and Death because efforts to reduce nutrients may not result in improvements in MCI if they do not include amelioration of other stressors associated with land use change.

7.4 The pathway by which nutrients may affect MCI

(a) Death (2015) assumes a causal relationship between nutrients and MCI. A causal relationship is likely to exist, but it is unlikely to be a direct relationship (unless nitrate reaches concentrations toxic to invertebrates). Consensus among an expert panel of New Zealand stream ecologists (Clapcott et al. 2017) is that “the most likely causal pathway from nutrients to macroinvertebrates [is] via periphyton proliferation”. This is also the prevailing view in international literature (e.g. Miltner 1998, Dodds and Welch 2000). The mechanism underlying this pathway is that excessive periphyton growth leads to a change in the physical habitat and the primary food source available to invertebrates, favouring different species than when periphyton growth is low. Periphyton proliferations are generally inhabited by taxa with low MCI scores (Stark and Maxted 2007).

(b) The indirect nature of the MCI-nutrient relationship, which is not made clear in Death (2015), is important because the strength of the relationship between nutrients and MCI depends on factors that influence periphyton growth. These include the frequency of high flow events (especially flows greater than three times the median flow (Biggs 2000; Snelder et al. 2014, Matheson et al. 2015) or flows with enough power to mobilise sand; Hoyle et al. 2017), light at the riverbed, water temperature and riverbed substrate (Quinn et al. 1997b, Matheson et al. 2012, 2015, Snelder et al. 2014). If one of these factors is limiting periphyton growth in a river reach, then reducing nutrients is unlikely to greatly affect MCI. Matheson et al. (2015) conclude that “[because] nutrient availability is one of a number of factors that affect periphyton abundance in rivers, therefore management of periphyton abundance via controls on nutrient concentrations alone is difficult."

7.5 Appropriate measures of available nitrogen and phosphorus

(a) Death (2015) uses nitrate as the basis of his correlations and his recommendations for nitrogen management.

(b) This is in contrast with most authors who have examined relationships between nutrients and periphyton or macroinvertebrates. Matheson et al. (2015) focus on dissolved inorganic nitrogen, which includes ammonium and nitrate as well as nitrate. Ammonium is typically in lower concentrations than nitrate, but can occur in significant concentrations in certain situations, e.g. associated with sewage treatment plant discharges. It is ecologically important as it is taken up more readily than nitrate by periphyton. Other authors, e.g. Dodds et al. (2002) focus on total nitrogen, which includes organic forms, as organic nitrogen can be rapidly transformed into bio-available inorganic forms through microbial action.

(c) *Phormidium*, a type of cyanobacteria that commonly forms nuisance periphytic growths in rivers, can take up and mineralize phosphorus from sediment (McAllister et al. 2016). Therefore, particulate phosphorus may be a more useful variable than dissolved reactive phosphorus (the form discussed by Death (2015) for management of periphyton.

(d) Dodds and Welch (2000) warn that "control [of periphyton] based on measured levels of dissolved inorganic N and P may not be effective because these pools are replenished rapidly by remineralization in surface waters", and therefore recommend managing total nitrogen and total phosphorus.

7.6 **Use of a single correlation to prescribe management in all stream types**

(a) The correlation in Death (2015) is derived from data covering a wide range of stream and catchment types. This correlation may accurately describe a cause-effect (albeit indirect) relationship between MCI and either nitrate or DRP in some Wellington streams. However, for the reasons given above, it is unlikely to accurately describe a cause-effect relationship equally well in all stream types. For example, in urban streams macroinvertebrate communities are known to be affected primarily by altered hydrology, in addition to habitat simplification, fine sediment, metals and hydrocarbons, more than by dissolved nutrients (Storey et al. 2013, Harding et al. 2016). In lowland, low gradient, soft-bottomed streams, periphyton may not grow well due to lack of hard substrate, and the relationship between nutrients and macroinvertebrates may be different than the one described by Death (2015) (Collier et al. 1998, Stark and Maxted 2007, Wilcock et al. 2007, Greenwood et al. 2012). Moore (2014) shows that among lowland streams of the Canterbury Plains there is little if any relationship between MCI and nitrate. Indeed, the macroinvertebrate community itself is very different in soft-bottomed to hard-bottomed streams, requiring a different (soft-bottom) MCI (Stark and Maxted 2007). The approach taken by Death (2015) and Canning does not take account of the different relationship between MCI and nutrients in different stream types. This creates a risk that nutrient management in certain stream types may be ineffective in improving MCI scores.

7.7 The assumption that MCI will improve when a stressor is reduced or removed

(a) Death (2015) and Canning (2017) do not state explicitly the assumption that MCI will improve when a key stressor is alleviated. However, it is implied by their recommendation to reduce dissolved nutrients in order to meet target MCI values. Only limited data are available to address this assumption, and results have been variable. In some cases the macroinvertebrate community has recovered in association with alleviation of a stressor (e.g. Quinn et al. 2009) whereas in others it has shown minimal change (e.g. Parkyn et al. 2003, Leps et al. 2016). The reasons for this variability are not well established, but possible reasons are the inability of invertebrates to recolonise from source habitats (Parkyn and Smith 2011), resistance to new arrivals by the "degraded" macroinvertebrate community, and lack of habitat for all life stages of invertebrates. This means that if stream water or habitat quality are improved in a stream distant from healthy (diverse) habitats, changes in MCI are unlikely to occur within the space of a few years (Parkyn et al. 2003, Parkyn and Smith 2011, Tonkin et al. 2014). Recolonisation may occur eventually (over longer time periods than have been monitored thus far), but may require decades (Leps et al. 2016).

7.8 Alternative methods of deriving a relationship between dissolved nutrients and macroinvertebrates

(a) Wagenhoff et al. (2017) provide stronger evidence than Death (2015) that a cause-effect relationship exists between nutrients and macroinvertebrates, because they

- Use measured rather than modelled data
- Account for the effects of collinear (correlated) variables on macroinvertebrates

(b) Note that their analysis is based on macroinvertebrate "species turnover" rather than change in MCI. However, species turnover is likely to be related to change in MCI, since the species that decline with increased nutrients are pollution-sensitive with high MCI tolerance scores. In terms of nutrients, they use total nitrogen rather than nitrate. The majority of total nitrogen may be nitrate, but it also includes other dissolved species such as ammonium and also organic forms (dissolved and particulate).

(c) Wagenhoff et al. (2017) find maximum species turnover (mainly due to decreases in sensitive species) occurs at total nitrogen concentrations <0.5 mg/L. Given that total nitrogen includes nitrogen species other than nitrate, this is in the same range to the concentrations recommended by Death (2015) as limits for nitrate (0.18-0.27 mg/L for mid-gradient hard and soft sedimentary streams, 0.25-0.61 mg/L for most lowland streams and rivers).

(d) As other authors do, Wagenhoff et al. (2017) acknowledge that the relationship between nutrients and macroinvertebrates is largely via effects on periphyton biomass.

(e) Despite Wagenhoff et al.'s sophisticated statistical analysis, it remains clear that in some environments there is no clear relationship between nitrate and MCI (Moore 2014).

7.9 Alternative methods to achieve MCI target values in Wellington streams

(a) Effective management to increase MCI levels requires understanding the main stressor(s) that are currently impoverishing the macroinvertebrate community in each stream reach. The main stressors are likely to vary depending on catchment land use (e.g. urban catchments place different stressors on stream macroinvertebrate communities than agricultural catchments; Storey et al. 2013, Harding et al. 2016) and stream type (e.g. low gradient soft-bottomed streams are likely to place different stressors on macroinvertebrate communities than high gradient or gravel-bed streams; Collier et al. 1998). Therefore, reducing nutrients may not be the most effective way to achieve an increase in MCI in all streams. For example, Parkyn et al. (2003) found that among nine Waikato streams with replanted riparian zones, increases in QMCI over time were most strongly related to reductions in water temperature. Wilcock et al. (2007) suggest that streams with soft substrate, not discharging to lentic systems and with low macrophyte cover are largely exempt from nutrient management. Effective management therefore requires identifying the primary stressors in different catchments and stream types, and targeting management actions (or setting limits) that address those stressors.

(b) In most Wellington streams with reduced MCI scores, multiple stressors are likely to be affecting the macroinvertebrate community. Therefore, in my opinion, the most effective management actions to increase MCI scores will be those that reduce a range of stressors. In agricultural catchments one management action that typically reduces a range of stressors is replanting of riparian areas with trees and other tall vegetation. Riparian “buffer” strips of this type typically reduce fine sediment and phosphorus (by preventing stock access to streams, stabilizing stream banks and filtering overland runoff) and water temperature (by shading in small to medium streams). In addition riparian vegetation restores terrestrial organic matter inputs that provide food and habitat for macroinvertebrates.

(c) Management to increase MCI could also include measures that decouple dissolved nutrient concentration from MCI. For example, although riparian planting may not reduce nitrate significantly if buffers are narrow and/or groundwater flows bypass the root zone of riparian plants, it can reduce periphyton growth even in the presence of high nitrate due to the shading it provides. Note, however, that this approach may not reduce nitrate export to downstream receiving waters.

8. CONCLUSIONS – addressing submissions

8.1 Death (2015) shows a correlation between MCI and each of nitrate and phosphate for a) modelled data from over 500,000 reaches throughout New Zealand, and b) measured data from several hundred sites in the lower North Island. On the basis of these correlations, Death (2015) and Canning (2017) recommend reducing nitrate and phosphate as the primary means to raise MCI levels in Wellington streams.

8.2 In my opinion, this logic is flawed because

(a) The correlation between modelled MCI and modelled nitrate is probably inflated due to an artefact of the modelling process.

(b) The correlation does not demonstrate that nutrients are the only or even the primary stressor depressing MCI scores in the sites represented by Death's (2015) data. Both nutrients and MCI are likely to be correlated with a suite of stressors associated with a change in land use from native vegetation to pastoral agriculture or urban development.

(c) A causal link between nutrient concentrations and MCI is probably via periphyton growth. In any stream reach, the relationship of nutrients with periphyton (and therefore with MCI) may be strong or weak depending on various other environmental factors that affect periphyton growth.

8.3 Because of these issues, reducing nitrate and dissolved reactive phosphate concentrations to raise MCI scores is unlikely to be effective in every stream reach in the Wellington region.

8.4 In my opinion, a more effective strategy to raise MCI scores would involve

(a) Actions that reduce a wider range of stressors and restore a variety of ecological processes

(b) Identifying the different stressors impacting different stream types, and streams with different catchment land use, and focusing management actions on alleviating the primary stressors in each situation.

8.5 An important consideration not mentioned by Death (2015) is that attempting to restore stream macroinvertebrate communities by removing environmental stressors inevitably involves high uncertainty, particularly where a stream is far from sources of potential recolonist invertebrates.

9. CONCLUSION

9.1 My evidence provides recommendations regarding submissions made on the setting of nutrient limits to achieve target MCI levels under Proposed Natural Resources Plan topic Water Quality.

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Attachment A
Qualifications and experience

Curriculum Vitae
PART 1

1a. Personal details				
Full name	*Title* Dr.	*First name* Richard	*Second name(s)* Goodwin	*Family name* Storey
Present position	Freshwater Ecologist			
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Contact Address	Gate 10, Silverdale Road			
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1b. Academic qualifications

- 2001 Ph.D. in Zoology, University of Toronto
- 1995 M.Sc. with First Class Honours in Zoology, University of Auckland
- 1992 B.Sc. in Zoology and Botany, University of Auckland

1c. Professional positions held

2007-present	Freshwater Ecologist, NIWA
2004-2007	Postdoctoral Fellow, NIWA
2002-2004	Scientific Officer, A Rocha Lebanon

1d. Present research/professional speciality

Restoration ecology of streams and rivers; citizen science; biological monitoring of rivers; ecology and hydrology of intermittent and headwater streams; ecology of urban streams; Bayesian Belief Networks for freshwater decision-making; nitrogen cycling and emissions in streams and wetlands.

1e. Total years research experience	22 years

1f. Professional distinctions and memberships (including honours, prizes, scholarships, boards or governance roles, etc)

- *2017-present Coordinator, National Advisory Group on Volunteer Freshwater Monitoring*
- *2017-present Society for Freshwater Science member*
- *2015-present Steering Committee, NZ Landcare Trust Citizen Science Initiative*
- *2004-07 FRST NZ Science and Technology Postdoctoral Fellowship*
- *2000 University of Toronto Fellowship*
- *1995-98 University of Toronto Connaught Scholarship*
- *1991 Senior Scholarship in Zoology*
- *1994-present New Zealand Freshwater Sciences Society member*

1g. Total number of *peer reviewed* publications and patents	Journal articles	Books, book chapters, books edited	Conference proceedings	Patents
	17	2	0	0

PART 2

2a. Research publications and dissemination

Peer-reviewed journal articles
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Storey, R., Wright-Stow, A., Davies-Colley, R., Kin, E., van Hunen, S., & Stott, R. (2016). Improving monitoring capacity and community engagement. Paper presented at the Values, Monitoring and Outcomes Regional Council Forum, Wellington. 5 September 2016.

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Storey, R., Jobert, S., Quinn, J., Fowles, C. (2014) Connectivity and macro-invertebrate drift influence stream restoration outcomes. New Zealand Freshwater Science Society Annual Meeting. Blenheim, 24-27 Nov 2014.

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Davies-Colley, R., Verburg, P., Hughes, A., **Storey, R.** (2012) Variables for regional water monitoring underpinning national reporting: variables for national freshwater monitoring, NIWA Client report HAM2012-006 prepared for Ministry for the Environment. 65p.

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Storey, R.G., Neale, M.W., Rowe, D.K., Collier, K.J., Hatton, C., Joy, M., Maxted, J., Moore, S., Parkyn, S., Phillips, N., Quinn, J. (2011) Stream Ecological Valuation (SEV): a method for assessing the ecological functions of Auckland streams. Auckland Council Technical Report 2011/009: 66p.

Storey, R. (2010) Aquatic biodiversity values of headwater streams in the Wellington region, NIWA Client Report HAM2010-095 prepared for Greater Wellington Regional Council. 47p.

Storey, R. (2010) Riparian characteristics of pastoral streams in the Waikato region, 2002 and 2007. NIWA Client Report HAM2010-022 prepared for Waikato Regional Council. 57p.

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Storey, R., Gadd, J. (2010) Project Twin Streams: Stage 3 ecosytem health monitoring action Plan. NIWA Client Report HAM2010-126 prepared for Waitakere City Council: 40p.

Storey, R. (2007) Aquatic invertebrate diversity and distribution at Aammiq Marsh, Lebanon. Report for A Rocha Lebanon.

2b. Previous research work

Research title: Bayesian Networks to support freshwater decision-making in the Ruamahanga catchment
Principal outcome: Predict the outcomes for selected ecological, recreational and aesthetic attributes in the Ruamahanga River and its major tributaries under possible future scenarios.

Principal end-user and contact: Greater Wellington Regional Council, Natasha Tomic.

Research title: Habitat constraints for aquatic rehabilitation
Principal outcome: Determine dispersal abilities and egg-laying habitat requirements of aquatic insects; determine landscape-scale factors driving variable responses to stream rehabilitation efforts.
Principal end-user and contact: Taranaki Regional Council, Chris Fowles

Research title: Monitoring recovery in Waikato Clean Streams
Principal outcome: Determine recovery trajectories for a suite of water quality, habitat and biological variables across seven streams restoring riparian vegetation under Waikato Regional Council's Clean Streams programme
Principal end-user and contact: Waikato Regional Council, Michael Pingram

Research title: Revision of the Stream Ecological Valuation (SEV)
Principal outcome: Lead revisions of the SEV, the main tool used in Auckland and Wellington regions for determining the ecological values of streams and calculating offset mitigation required when urban developments impact on streams
Principal end-user and contact: Auckland Council, Martin Neale (now at Martin Jenkins)

Outcomes from Objectives & Limits Discussion II – 11 July 2017

DRAFT Notes compiled by Ned Norton (14 July 2017)

Purpose

The purpose of these notes is to inform the Hearings Panel of outcomes from the second science discussion workshop held in Gisborne on 11 July 2017. The second workshop was held to complete the discussions started at the first workshop on 2 June 2017. The workshops arose from the Fourth Direction of the Hearings Panel dated 19 May 2017.

Six questions were originally posed in the agenda for the first workshop and progress was made at that workshop to a point halfway through Question 3. In response to reading the outcomes from the first workshop the Hearings Panel forwarded comments and four additional related questions, and invited the group to reconvene to complete the discussions (see Attachment 1 for the second agenda and Panel's questions).

At the second workshop the group completed responses to Questions 3 to 6 and to the Panel's additional four questions. The outcomes are reported below.

These notes should be read in combination with background in the notes from the first workshop.

Attendees

Ned Norton (NN) – Facilitator on behalf of Gisborne District Council
Olivier Ausseil (OA) – representing Mangatu Blocks Inc and Wi Pere Trust
Alan Haronga (AH) – representing Mangatu Blocks Inc and Wi Pere Trust
Tim Blackman (TB) – representing Gisborne District Council
Adam Canning (AC) – representing Department of Conservation
Nic Conland (NC) – representing Horticulture New Zealand
Greg Sneath (GS) – representing Fertiliser Association of New Zealand
Murray Palmer (MP) – Individual submitter

Apologies were received from attendees of the first discussion workshop who were unable to attend the second, as follows: Lois Easton (GDC), James Sinclair (Earnslaw), Graeme Silver (DoC).

Question 1. ***What is the difference between objectives and limits?***

For the record, this question was reported in notes from the first workshop. There was consensus amongst all participants on the response provided.

Question 2. ***Which attributes make good objectives and which are better as limits, targets or indicators?***

This question was reported in notes from the first workshop. There was a high level of consensus in the responses reported.

Question 3(a). ***What are the options for numbers for each attribute? – (recognising the choice of numbers is an informed value judgement to be made by the Panel)***

Partial progress on this question was reported in notes from the first workshop. The completed response for the full list of attributes is now reported in Table 1 below (see orange columns). Some changes were made to some participant's positions as first reported after the first workshop. Table 1 represents the updated position. The level of consensus has increased to the point where there are only a few areas where parties are not in complete agreement, and even then the differences between parties are slight (i.e., compare participant's views across the orange columns in Table 1).

Question 3(b). ***How should each attribute be expressed (e.g. percentiles based on x samples collected over y months)?***

The updated response to this question is represented in Table 1 (see italicized text provided for each attribute in the green column). Some important discussion points to highlight that could easily be overlooked include:

- The group reiterated the need to check which waterways fall into the "default class" versus the "productive class" (for the periphyton attribute), because the compliance regime for these differs, as defined in Appendix 2 of the NPSFM (see first cell in first row of Table 1). If the periphyton thresholds are used in the plan it may be necessary to provide planning maps delineating these two classes.
- The group emphasized that most of the attributes for the Poverty Bay Flats FMU should only apply upstream of the most upstream extent of the tidal salt wedge influence. This is noted where appropriate in Table 1.
- The group noted that compliance with the MCI thresholds should be based on sampling of MCI during summer low flow conditions (as should also compliance with DO thresholds as discussed in more detail later).
- The group noted that some care is needed around monitoring of different attribute thresholds for the Te Arai River above and below Pykes Weir (as suggested for periphyton, MCI, and E.coli objectives for the Te Arai FMU in Table 1). Murray Palmer raised the point that the site actually right at Pykes Weir should not be the compliance monitoring point for the upper catchment above the Weir. Murray suggested that an appropriate site would be upstream, possibly at or near the water supply intake. The group agreed with all of Murray's suggestions here based on his local knowledge of the catchment.

Question 3(c). ***If there is currently insufficient data to define a numeric objective or limit, what is the monitoring, analysis and timeline required to be able to get to a point where we can define the relevant parameter?***

The updated response to this question is represented in Table 1 (see responses in the two blue columns to the far right).

Question 4. ***What are the management actions being used to constrain resource use to achieve the plan limits and objectives?***

The group briefly discussed this question insofar as it was relevant to considering options for numbers for objectives or limits (i.e., discussions for Question 3) and in relation to answering Question 5 below. The main point to note is the group observed that the management actions in the proposed plan are primarily associated with the Farm Environment Plans (FEPs), soil conservation measures, a stream riparian setback requirement, enhancement projects (e.g. riparian and fish passage) and also environmental flows (minimum flows and allocations). Specifically the group was not aware of any actions that would be directly triggered by proposed plan policies or rules linked to numeric objectives or limits.

Question 5. ***Are any management actions linked to monitoring triggers that require short turnaround compliance results?***

Arising from the discussion on Question 4 above, the group identified that the plan does not currently include any policies or rules that require management actions that are directly triggered by any short turnaround monitoring results for compliance with objectives or limits. Therefore (and in combination with taking an "effects-based literature approach" to determining thresholds for objectives), there does not appear to be any requirement for short turnaround assessment of trends in monitored attributes, which would have been problematic.

Question 6. ***What clarification is needed around how compliance with limits and objectives will be assessed by monitoring?***

It is clear from the responses to questions 3(a), (b) and (c) above, that an effects-based literature approach to identifying thresholds for use as objectives and limits means that the statistical compliance and monitoring regime associated with those attributes is in most cases provided with the relevant literature. The group's response on this is provided for each attribute in the green and blue columns of Table 1.

Response to additional comments and questions from the Hearings Panel

Panel comments to focus the discussion on Question 3(a), (b) and (c)

- The focus of the meeting should be on parameters where there is good existing monitoring data and where there are well established guideline values that the panel can refer to. If there are important attributes that we don't have data for then the focus should be on defining a method and time frame to gather the necessary data to define an appropriate objective or limit after sufficient data is collected. The panel has a concern about setting quantitative objectives or limits if we don't know where the current state is sitting. We are interested in the science groups view on this approach and whether they can use that as an approach to focus their discussions.

- As an example of the uncertainty arising from the lack of data, GDC has good data for turbidity and SS but not clarity. Presumably the science group thinks that an Objective for clarity could be based on a document such as "Guidelines for the management of water colour and clarity" (MFE, 1994), with Limits defined in terms of turbidity or suspended solids. Which of these two parameters is preferred for setting the limit? or do we need both and if so, why? But in the absence of any clarity data it is difficult to set a limit and know how it relates to the Objective. Are we better to prescribe a monitoring programme to define this in the future rather than specifying things now?

Response

The group discussed these comments and questions at the beginning of the second workshop and found them useful in working to complete responses to Question 3. In general the group was sympathetic to the Panel's concern and largely agreed with the response floated by the Panel. This can be particularly seen in the group's (consensus) response in Table 1 on how to handle the difficult but important topics of attributes for:

i) Periphyton objectives and consideration of associated limits using DIN and DRP; and

ii) Sediment related objectives (e.g., clarity and deposited fine sediment) and consideration of associated limits using suspended solids.

The group's response on these topics in Table 1 includes draft wording for commitment to a monitoring and reporting programme to inform a future review of plan objectives and limits.

Panel additional question 1

Given the expense of continuous DO sensors long term monitoring at multiple sites is unachievable for GDC. Does the group think that moving the sensor around different sites to get 1 week of continuous reading during warm weather and low flows is a useful and practical alternative?

Response

The group agrees that this is a useful and practical solution, and this has been built into the group's recommendation in the dissolved oxygen row of Table 1.

Panel additional question 2

Can the group provide an agreed wording for narrative objectives covering physical habitat, invertebrate, fish and bird community aspects of ecosystem health.

Response

Possible draft wording for such narrative objectives was briefly discussed at the workshop and circulated by email after the meeting from NN to the group. Feedback was received by email (see Attachment 3).

Table 1: Response to Questions 3(a), (b) and (c):
Question 3(a) What are the options for numbers? (see orange columns)
Question 3(b) How should compliance be expressed? (see green columns)
Question 3(c) Data availability and timeline to assess? (see blue columns)

Attribute (& compliance testing regime)	**What are the options for the numbers?** (participants initials in brackets)						**Do we have data to assess current state?**	**Monitoring & timeline to assess current state**
	FMU	**OA**	**NC**	**AC**	**MP**	**NN**		
Periphyton mg chl-a/m^2 *As per NOF - to be exceeded in no more than 8% of samples (if the site is in the "Default Class") and no more than 17% of samples (if the site is in the Productive Class") – based on monthly monitoring for a minimum of three years.*	Hill Country FMU	120	120	120 for streams < 15 degree slope; 50 for streams >15 degree slope)	Insufficient data to personally suggest a number – but not opposed to suggestions to the left	agreed same left	No – we (the suggestions to the left by the group are based on expert judgement applying the NOF thresholds)	Minimum of 3 years of monthly monitoring data
	Poverty Bay Flats	120 (200 for exceptional sites incl. Whakahu and Tahuheru up to salt wedge)	agreed same left	agreed same left	agreed same left	agreed same left		
	Gisborne Urban	NA	agreed same left	agreed same left	agreed same left	agreed same left		
	Te Arai	120 below Pykes Weir 50 above Pykes Weir	agreed same left	agreed same left	agreed same left	agreed same left		

Attribute (& compliance testing regime)	What are the options for the numbers? (participants initials in brackets)						Do we have data to assess current state?	Monitoring & timeline to assess current state
	FMU	OA	NC	AC	MP	NN		
MCI *As per Collier et al. (2014) - test using a three year rolling mean as the minimum rolling time interval for consecutive sampling years using standard collection methods of Stark et al. (2001).* *The group also recommends MCI sampling be done in summer low flow conditions.*	Hill Country FMU	100	100	100	100	agree same left	Yes (partially) – have 2 years (out of the ideal 3 years) data of 9 SOE sites.	Would ideally have at least three consecutive years and more sites would always be nice
	Poverty Bay Flats	80 (this applies only upstream of the salt wedge influence)	agreed same left	agreed same left (AC notes that his analysis predicts natural state of 90 in this river type so objective should not be set higher than 90)[1]	agreed same left	agree same left		
	Gisborne Urban	NA	agreed same left	agreed same left	agreed same left	agree same left		
	Te Arai	100 above Pykes Weir 80 below Pykes Weir	agreed same left	agreed same left	agreed same left	agree same left		

[1] AC undertook analysis of this since the first discussion (on 2 June 2017) and communicated this finding to the group on 11 July 2017 as context. While the rest of the group has not seen this analysis the group agreed this was useful context and supported the recommendation of an MCI objective of 80 given this FMU is modified not pristine.

Attribute (& compliance testing regime)	**What are the options for the numbers?** (participants initials in brackets)						Do we have data to assess current state?	Monitoring & timeline to assess current state
	FMU	**OA**	**NC**	**AC**	**MP**	**NN**		
E. coli **(per 100mL)** *As per NOF – test using annual median and 95^{th} percentile sample data against chosen NOF thresholds.* *The group also notes ambiguity of assessing a 95^{th} percentile from 12 monthly samples and suggests minimum of 3 years (60 samples) rolling test.*	Use NOF Bands and statistical compliance	All agree	All agree	All agree	All agree	All agree	Yes	Suggest at least 3 year (prefer 5 year) rolling assessment of median and 95^{th} percentiles from monthly sampling
	Hill Country FMU	A band (Wharekopae 95th Percentile B band)	All agree	All agree	All agree	All agree		
	Te Arai FMU	All agree with MP	All agree with MP	All agree with MP	A band (above water intake) B band (below water intake)[2]	All agree with MP		
	Poverty Bay Flats	B band (this applies only upstream of the salt wedge influence)	All agree	All agree	All agree	All agree		
	Gisborne Urban	Enterococci - MOH/MFE min. as per existing p. plan	All agree	All agree	All agree	All agree		

[2] MP suggested that B band was appropriate for the lower catchment but A band should apply to the upper catchment. MP also raised the point that the site actually right at Pykes Weir should not be the compliance monitoring point for the upper catchment above the Weir. MP suggested that an appropriate site would be upstream, possibly at or near the water supply intake. The group agreed with all of MP's suggestions here based on his local knowledge of the catchment.

Attribute (& compliance testing regime)	**What are the options for the numbers?** (participants initials in brackets)						Do we have data to assess current state?	Monitoring & timeline to assess current state
	FMU	**OA**	**NC**	**AC**	**MP**	**NN**		
Dissolved oxygen mg/L *As per NOF – test in summer using either 7-day mean minimum or 1-day minimum; use continuous sensor*	The group all agreed to: 1. Suggest using the NOF bottom line DO concentration for the Poverty Bay Flats FMU - because it needs to improve up to at least that - and apply that everywhere else because the group can't offer options for other FMUs due to lack of any continuous sensor data. 2. Exclude all river reaches downstream of the uppermost salt wedge influence. 3. Recommend using a single continuous DO sensor to monitor DO for 1 week periods shifting the sensor across different sites during low flows in summer (as suggested by the Panel). 4. Suggest that the continuous DO data gathered as described above be used to revise freshwater objectives for all FMUs in line with NOF bands in future. 5. Note that the NOF bottom line DO concentration is a compulsory attribute only in rivers below point sources (see DO table in Appendix 2 of NPSFM).						No – don't have any continuous 24 hour sensor data Do have monthly spot sampling data for several years but only sampled during daytime so not worst case	At least one summer (prefer 3 summers) of sampling whereby a single sensor is moved around different sites for one week at a time giving 1 week continuous data for each site
Ecological toxicity Nitrate mg/L *As per NOF – test annual median & 95th percentiles against chosen thresholds*	All FMUs	Maintain current NOF band for each FMU (unless D go to C)	Maintain current NOF band for each FMU (unless D go to C)	Maintain and improve but OK going with maintain NOF band as long as DIN and DRP levels are adequately addressed	No comment	Agree left	Yes	Suggest 5 year rolling assessment against median and 95th percentile thresholds (using monthly data)
Ecological toxicity Ammonia mg/L *As per NOF – test annual median & 95th percentiles*	All FMUs	Maintain current NOF band for each FMU (unless D go to C)	Maintain current NOF band for each FMU (unless D go to C)	Same comment as for nitrate toxicity in the cell above.	No comment	Agree left	Yes	Suggest 5 year rolling assessment against median and 95th percentile thresholds (using monthly data)

Attribute (& compliance testing regime)	**What are the options for the numbers?** (participants initials in brackets)						**Do we have data to assess current state?**	**Monitoring & timeline to assess current state**
	FMU	**OA**	**NC**	**AC**	**MP**	**NN**		
Benthic cyanobacteria bed cover *As per Wood et al. (2009) - test using max. % bed cover(>1mm thick)*	All FMUs	OA and NC suggest that this attribute be signaled as a narrative objective – with the benthic cyanobacteria cover being monitored as an Indicator – and the response when the 20% cover threshold is breached at swimming locations is to notify public health risk as per the green, orange, red system as designed in Wood et al., 2009.		AC suggests either the option to the left or put the 20% cover threshold in as a numeric objective – and notes the choice between these two is a value call.	No comment	Agree left	No none at all	Same as for periphyton (minimum of 3 years of monthly monitoring data)
%EPT taxa	The group did not assess in detail the potential for use of %EPT taxa as a freshwater objective in the Waipaoa catchment. At this stage the group felt that the objectives recommended above using MCI were sufficient for GDC's purpose without trying to introduce a second macroinvertebrate attribute.						Yes (existing data for MCI could be used)	Same as for MCI above
Narrative physical habitat invertebrates, fish, birds	All FMUs	All agree this is appropriate and useful. The intent is that these narratives help describe the intent served by all the other numeric attributes but also cover the intent of flow and allocation limits, as well as other non-numeric methods such as fish passage initiatives, habitat restoration initiatives etc. Possible draft wording for such narrative objectives was briefly discussed and circulated by email after the meeting from NN to the group. Feedback was received by email (see Attachment 3).					The group was not able to assess the extent to which the current state meets the detailed wording for narrative objectives and, without understanding how policies and methods might be written to achieve narrative objectives, couldn't assess implications such as costs and environmental benefits.	

<table>
<tr><th rowspan="2">Attribute (& compliance testing regime)</th><th colspan="6">What are the options for the numbers? (participants initials in brackets)</th><th rowspan="2">Do we have data to assess current state?</th><th rowspan="2">Monitoring & timeline to assess current state</th></tr>
<tr><th>FMU</th><th>OA</th><th>NC</th><th>AC</th><th>MP</th><th>NN</th></tr>
<tr><td>DIN mg/L</td><td colspan="6" rowspan="2">The group agreed the following statements:
1. We don’t yet understand relationships between DIN, DRP, periphyton, MCI & flow for this catchment.
2. There is a need to monitor all these (DIN, DRP, periphyton, MCI, flow) to inform the next plan review.
3. Setting periphyton and MCI numeric freshwater objectives in the plan (see options given in rows above) would at least provide clarity around the outcomes intended - although there is risk with doing this for periphyton as we have poor knowledge of current state and we therefore don’t understand consequences (for land use) of such objectives (Note: periphyton is a compulsory NOF attribute).
4. There is significant uncertainty around what DIN and DRP concentrations (or loads) would achieve the periphyton and MCI objectives.
5. Further monitoring and information gathered as part of FEP requirements could inform future plan reviews as suggested below.

The group reached consensus (OA, NC, AC, MP, NN) on an option to include a narrative requirement in the Plan to monitor and report to inform future plan review; the group drafted wording as follows:

“GDC will:
1. Keep monitoring DIN, DRP, periphyton, MCI and relevant river flow.
2. Report at 3 and 5 years from the date this plan becomes operative including of:
a) Periphyton and MCI against numeric plan freshwater objectives;
b) State and trends of DIN and DRP compared to current state as at 2017; and
c) The relationship between DIN, DRP, flow, and FMU-scale landuse all compared to the numeric plan freshwater objectives for periphyton and MCI.
3. Review the freshwater objectives and associated limits as part of scheduled plan review in 2025.”

The group considered a second option of also putting DIN & DRP numbers into the Plan as “Indicators” only (specifically not as limits). However the group consensus was a preference for the narrative requirement to monitor and report as defined above. It is noted that current state (e.g., existing DIN and DRP medians and 95th percentiles) have been written into the narrative requirement above and act as indicators in this respect. Other observations on the option of putting DIN & DRP numbers as</td><td>Yes – current concentrations well defined

No – in terms of relationship to periphyton or MCI objectives</td><td>Monitor DIN, DRP, periphyton, MCI and flow to inform next plan review (2025?) that could confirm or establish objectives and limits</td></tr>
<tr><td>DRP mg/L</td><td>Same as for DIN above (but less clarity around relationship between DRP and flow)</td><td>Same as for DIN above</td></tr>
</table>

	"Indicators" included: • There would be a risk that numbers put in the plan could be misused. • What would be the purpose of including the numbers? – the group struggled to identify a purpose other than to provide a benchmark of current state or to reflect chosen guideline numbers. • What policies, rules or other methods would link to the Indicator numbers? – the group was unclear on this. The group considered a third option of putting DIN & DRP numbers into the Plan as "Limits" (based on either current state monitoring statistics, the thresholds from HortNZ model predictions [evidence of Nic Conland], or literature guideline thresholds such as Biggs 2000 or ANZECC 2000). Observations on this option included: • Risk of unintended consequences (either under or over-enabling of resource use). • Any numbers that could be set would not be linked to achieving periphyton or MCI objectives specifically for the Waipaoa catchment. • While this option would put up DIN & DRP concentration numbers as limits and would thereby at least implicitly define the maximum amount of resource use available, there remained the question as to what policies, rules or other methods would link and give effect to these limit numbers? – the group was unclear on this.		

<table>
<tr><th rowspan="2">Attribute (& compliance testing regime)</th><th colspan="6">What are the options for the numbers? (participants initials in brackets)</th><th rowspan="2">Do we have data to assess current state?</th><th rowspan="2">Monitoring & timeline to assess current state</th></tr>
<tr><th>FMU</th><th>OA</th><th>NC</th><th>AC</th><th>MP</th><th>NN</th></tr>
<tr><td>Visual Clarity (VC)
distance in m</td><td colspan="6" rowspan="4">The group agreed the following statements:
1. Of the relevant group of four attributes that indicate sediment and clarity issues (VC, DFS, SS and T) the two attributes with greatest potential for use as freshwater objectives are VC and DFS because these are most directly related to ecological, recreation and aesthetic values. Literature threshold exist relating both VC and DFS to these values (e.g., MfE 1994; Clapcott et al., 2011; Ausseil 2013; Clapcott & Hay 2014; Davies-Colley et al., 2015; Hicks et al., 2016).
2. We don’t have data for either VC or DFS to assess where current state sits for the Waipaoa FMUs.
3. One approach would be to treat the “clear” sub-catchments (e.g., Te Arai and Wharekopae) separately from the “sediment-laden” sub-catchments (e.g., Mangatu and Waipaoa mainstem).
4. It could be possible to set numeric objectives for the “clear” sub-catchments using literature thresholds (e.g., VC>1.6m for recreation values and VC>0.5m for ecosystem values – both to apply only when river flow is less than median; and DFS<20% for ecosystem values – applies at all times). However it is acknowledged there is a risk that we don’t know current state for these attributes even in the “clear” sub-catchments and we therefore don’t understand consequences (for land use) of such objectives.
5. The group does not recommend setting objectives for VC or DFS for the “sediment-laden” sub-catchments because we don’t think that the literature thresholds for these attributes would be achievable in the foreseeable future and there is very limited ability to influence this.
6. The group also does not recommend setting limits for SS or turbidity at this time for any catchment.
7. The group does not recommend turbidity ever for a limit but notes that it is a good tool and can be used as a surrogate monitoring variable when site-specific relationships to VC and SS are established.
8. The group thinks that SS may potentially be a good attribute to use for limits in the future (concentration and/or possibly better as a load) and suggests that further monitoring could inform future plan reviews as suggested below.

The group reached consensus (OA, NC, AC, MP, NN) on an option to include a narrative requirement in the Plan to monitor and report to inform future plan review; the group drafted wording as follows:

“GDC will:</td><td>No – but this attribute is potentially good for describing a freshwater objective (literature thresholds are available)</td><td>Minimum of 3 years of monthly data (preferably with simultaneous SS & turbidity to generate site-specific relationship allowing use of historic SS & turbidity to relate clarity)</td></tr>
<tr><td>Deposited fine sediment (DFS)
% cover</td><td>No – but this attribute is potentially good for describing a freshwater objective (literature thresholds are available)</td><td>Suggest same as for periphyton – minimum of 3 years of monthly monitoring</td></tr>
<tr><td>Suspended sediment (SS)
mg/L</td><td colspan="2">Yes – But not recommended as an objective because not directly related to values (in the direct way that clarity and DFS are)</td></tr>
<tr><td>Turbidity (T)
NTU</td><td colspan="2">Yes – but not recommended as an objective or limit. Useful as a monitoring surrogate where site specific relationship is developed with</td></tr>
</table>

	1. Keep monitoring visual clarity, deposited fine sediment, suspended sediment, turbidity and relevant river flow. *2. Report at 3 and 5 years from the date this plan becomes operative including of:* *a) Visual clarity and deposited fine sediment against any numeric plan freshwater objectives set for these;* *b) State and trends of suspended sediment and turbidity compared to current state as at 2017; and* *c) The relationship between suspended sediment, turbidity and FMU-scale landuse all compared to visual clarity and deposited fine sediment.* *3. Review the freshwater objectives and associated limits as part of scheduled plan review in 2025."* The group also notes that having MCI freshwater objectives (as per the options provided earlier in this table) is useful in the meantime as this at least partly reflects the effects of sediment on ecosystem health in the absence of other numeric sediment-related objectives at this time.						SS and/or clarity.	
Attribute (& compliance testing regime)	**What are the options for the numbers?** (participants initials in brackets)						**Do we have data to assess current state?**	**Monitoring & timeline to assess current state**
	FMU	**OA**	**NC**	**AC**	**MP**	**NN**		
Temperature ^{o}C	All FMUs	The group suggests that temperature could be covered by ensuring that i) a narrative freshwater objective for habitat is included in the plan and that this includes consideration of riparian conditions that can provide shading to manage temperature (at least in small streams); and ii) setting adequate environmental flows (minimum flows and allocations) in the plan.					Yes – spot data only	Continue to monitor
pH	All FMUs	The group doesn't regard pH as being important for use as a freshwater objective or a limit, but suggests it is useful to continue to monitor pH at the same time as DO is monitored (e.g., see suggestion on use of continuous sensor for DO).					Yes – spot data only	Continue to monitor

Attachment 1 – Agenda sent to parties who attended the first discussion on 2 June 2017

Agenda: Science Review Discussion II

Location: Waikanae Surf Life Saving Club (285 Grey St, Gisborne)
Date and time: Tuesday 11 July 2017, between 10am and 4pm

Purpose: The purpose of this second meeting is to continue the discussion started on 2 June 2017, in order to "*...narrow down the technical issues set out in the science review through a discussion [that] will provide sufficient information to allow the Panel to make an informed decision*" – as laid out in the Fourth Direction of the Hearings Panel.

The facilitator of the first meeting on 2 June (Ned Norton) prepared a draft report for the Hearings Panel describing progress on the six questions. That draft report is provided to invitees and shows the progress made to complete Questions 1 and 2, and reach halfway through the list of attributes in Question 3. The primary purpose of this second meeting is to complete Questions 3 to 6.

The Hearings Panel has provided comments to guide the focus of the meeting around particularly Question 3, and has posed two additional questions for the group if there is time (see next page).

This second meeting will also be facilitated by Ned Norton and Council staff will be in attendance. Notes will again be kept and Ned Norton will subsequently prepare a short report for the Panel summarising the outcomes from the meeting.

The following timeline is indicative:

10:00am: Introduction, conduct and structure for the day

10:15am: Question 3(a). *What are the options for numbers (and respective consequences) for each attribute?* – (recognising the choice of numbers is an informed value judgement to be made by the Panel)

Question 3(b). *How should each attribute be expressed (e.g. percentiles based on x samples collected over y months)?*

Question 3(c). *If there is currently insufficient data to define a numeric objective or limit, what is the monitoring, analysis and timeline required to be able to get to a point where we can define the relevant parameter?*

12:30: Lunch break

1:00pm: Question 4. *What are the management actions being used to constrain resource use to achieve the plan limits and objectives?*

1:30pm: Question 5. *Are any management actions linked to monitoring triggers that require short turnaround compliance results?*

2:00pm: Question 6. *What clarification is needed around how compliance with limits and objectives will be assessed by monitoring?*

2:30pm: Two additional questions from the Panel (see next page)

3:45pm: Wrap-up

4:00pm: Meeting concludes

Comments from the Hearings Panel

Comments to focus the discussion on Question 3(a), (b) and (c)

- The focus of the meeting should be on parameters where there is good existing monitoring data and where there are well established guideline values that the panel can refer to. If there are important attributes that we don't have data for then the focus should be on defining a method and time frame to gather the necessary data to define an appropriate objective or limit after sufficient data is collected. The panel has a concern about setting quantitative objectives or limits if we don't know where the current state is sitting. We are interested in the science groups view on this approach and whether they can use that as an approach to focus their discussions

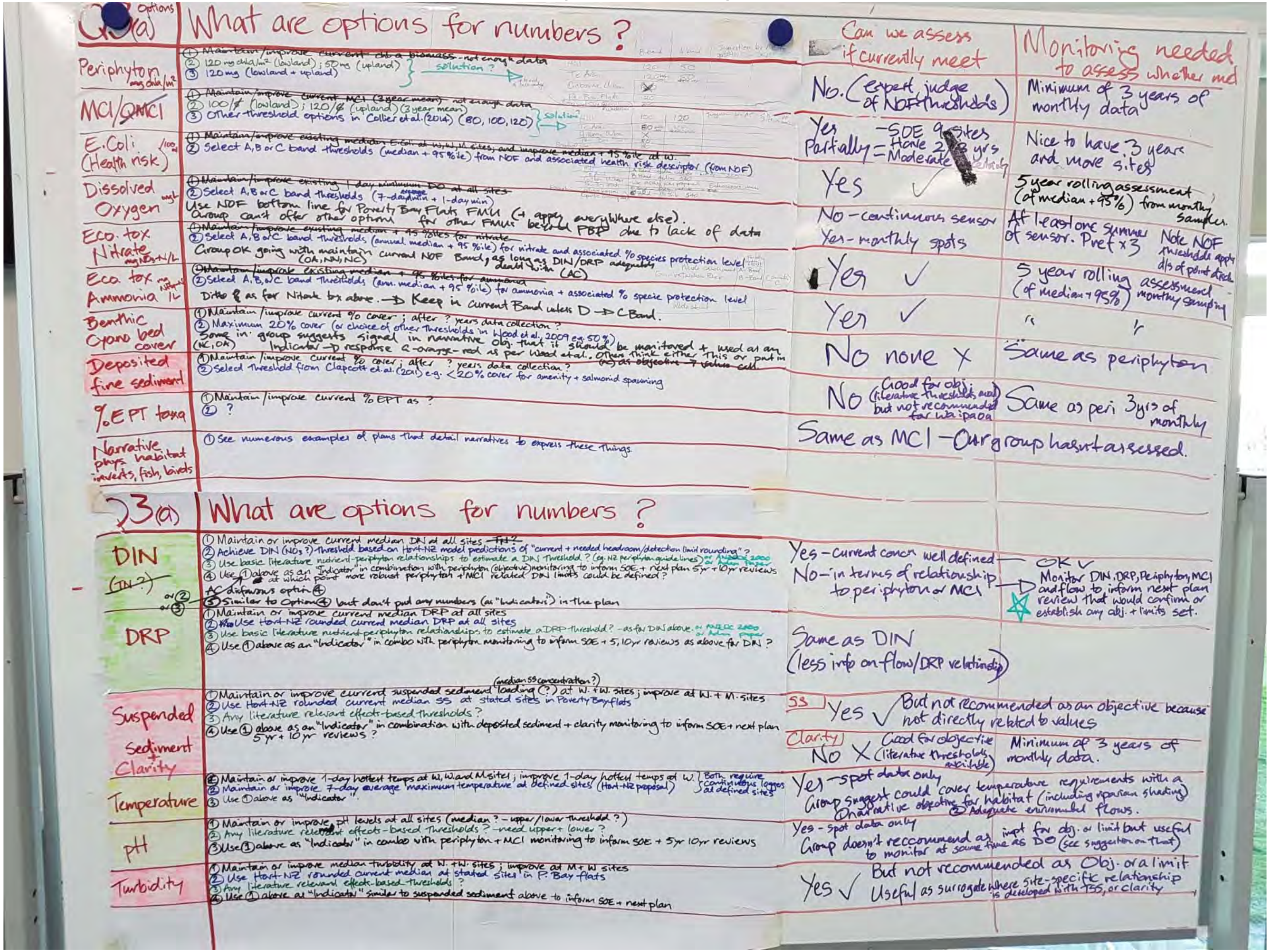
- As an example of the uncertainty arising from the lack of data, GDC has good data for turbidity and SS but not clarity. Presumably the science group thinks that an Objective for clarity could be based on a document such as "Guidelines for the management of water colour and clarity" (MFE, 1994), with Limits defined in terms of turbidity or suspended solids. Which of these two parameters is preferred for setting the limit? or do we need both and if so, why? But in the absence of any clarity data it is difficult to set a limit and know how it relates to the Objective. Are we better to prescribe a monitoring programme to define this in the future rather than specifying things now?

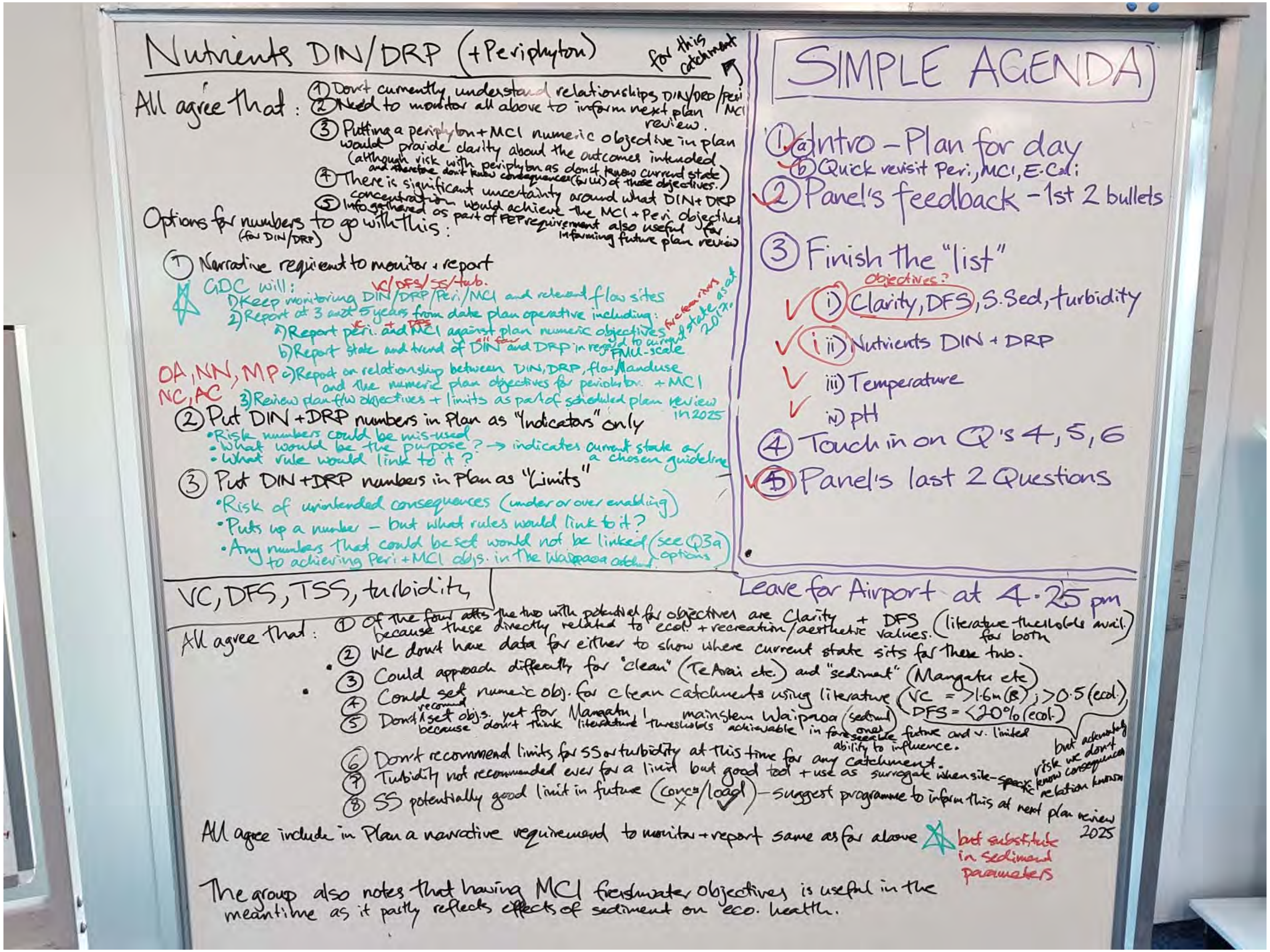
Additional questions to address if there is time

1. Given the expense of continuous DO sensors long term monitoring at multiple sites is unachievable for GDC. Does the group think that moving the sensor around different sites to get 1 week of continuous reading during warm weather and low flows is a useful and practical alternative?

2. Can the group provide an agreed wording for narrative objectives covering physical habitat, invertebrate, fish and bird community aspects of ecosystem health.

Attachment 2 – Photos of A2 sheets recorded in front of all parties on the day




Nutrients DIN/DRP (+Periphyton)
for this catchment
All agree that:
① Don't currently understand relationships DIN/DRP/Peri/MCI
② Need to monitor all above to inform next plan review.
③ Putting a periphyton + MCI numeric objective in plan would provide clarity about the outcomes intended (although risk with periphyton as don't know current state and therefore don't know consequences (for us) of these objectives.)
④ There is significant uncertainty around what DIN + DRP concentration would achieve the MCI + Peri objectives
⑤ Info gathered as part of FEP requirement also useful for informing future plan review
Options for numbers to go with this: (for DIN/DRP)
① Narrative requirement to monitor + report
GDC will:
1) Keep monitoring DIN/DRP/Peri/MCI and relevant flow sites
VC/DFS/SS/turb.
2) Report at 3 and 5 years from date plan operative including:
a) Report peri. and MCI against plan numeric objectives
VC + DFS
for clean rivers
b) Report state and trend of DIN and DRP in regard to current state as at 201x.
all four
FMU-scale
c) Report on relationship between DIN, DRP, flow, landuse and the numeric plan objectives for periphyton + MCI
OA, NN, MP
NC, AC
3) Review plan flow objectives + limits as part of scheduled plan review in 2025
② Put DIN + DRP numbers in Plan as "Indicators" only
• Risk numbers could be mis-used
• What would be the purpose? → indicates current state or a chosen guideline
• What rule would link to it?
③ Put DIN + DRP numbers in Plan as "Limits"
• Risk of unintended consequences (under or over enabling)
• Puts up a number – but what rules would link to it?
• Any numbers that could be set would not be linked to achieving Peri + MCI objs. in the Waipaoa catchment. (see Q3a options)
SIMPLE AGENDA
① a) Intro – Plan for day
b) Quick revisit Peri, MCI, E.Coli
② Panel's feedback – 1st 2 bullets
③ Finish the "list"
Objectives?
i) Clarity, DFS, S.Sed, turbidity
ii) Nutrients DIN + DRP
iii) Temperature
iv) pH
④ Touch in on Q's 4, 5, 6
⑤ Panel's last 2 Questions
Leave for Airport at 4.25 pm
VC, DFS, TSS, turbidity
All agree that:
① Of the four atts the two with potential for objectives are Clarity + DFS because these directly related to ecol. + recreation/aesthetic values. (literature thresholds avail. for both)
② We don't have data for either to show where current state sits for these two.
③ Could approach differently for "clean" (Te Arai etc.) and "sediment" (Mangatu etc)
④ Could set numeric obj. for clean catchments using literature (VC = >1.6m (B); >0.5 (ecol.), DFS = <20% (ecol.)) but acknowledge risk we don't know consequences
⑤ Don't recommend set objs. yet for Mangatu, mainstem Waipaoa (sediment ones) because don't think literature thresholds achievable in foreseeable future and v. limited ability to influence.
⑥ Don't recommend limits for SS or turbidity at this time for any catchment.
⑦ Turbidity not recommended ever for a limit but good tool + use as surrogate when site-specific relation known
⑧ SS potentially good limit in future (conc ✗ / load ✓) – suggest programme to inform this at next plan review 2025
All agree include in Plan a narrative requirement to monitor + report same as for above
but substitute in sediment parameters
The group also notes that having MCI freshwater objectives is useful in the meantime as it partly reflects effects of sediment on eco. health.

Attachment 3 – Possible draft wording for narrative habitat objectives

Possible draft wording for narrative habitat objectives was circulated after the meeting by email from NN to the group. Feedback was received by email as provided below.

Draft wording circulated by email (12-7-2017)
The draft wording is shown on the following page together with the merged tracked suggestions and comments from respondents: Murray Palmer (brown text); Olivier Ausseil (blue comment balloon); Ned Norton (red comment balloon and text). Emailed response comments are shown below.

Response from Greg Sneath by email (13-7-2017)
"*…Thanks for the chance to comment. All good from my perspective. I shared with our CEO, Vera Power, and her only brief comment was in relation to the phrase:*
" generally less sensitive fish species" , with the comment less sensitive to which attributes? e.g. sediment , nitrates , temperature. Perhaps that is reasonably well understood, but I thought it worth passing the feedback on…"

"…I think the consideration was that many native fish species are quite tolerant to sediment…"

Response from Olivier Ausseil by email (13-7-2017)
"…Thanks for sending this. I think the main aspects are covered, apart from one point of detail (see attached).Note that I feel I can't comment on the exact wording of these objectives, as I don't have a good understanding of how they are/ will be translated into policies, rules and other methods in the plan, so cannot comment on the implications of these objectives in terms of the costs, benefits or achievability of the policies and methods that would seek to achieve them…"

Olivier's attached comment is shown on the next page in blue comment balloon

Response from Nic Conland by email (13-7-2017)
"…I have reviewed the physical state freshwater objectives and am comfortable with the general wording.
My only concern how these FW Objectives might be measured.
Otherwise they are useful narrative objectives for a desired state in the assigned FMU's…"

Response from Adam Canning by email (14-7-2017)
"…Looks good to me…"

Response from Murray Palmer by email (13-7-2017)
"Kia ora Ned
I've attached my input into the habitat narratives. Given time, it could have been more detailed, but this is probably sufficient for the panel at this stage perhaps?
I've also included a statement outlining my understanding of some of the points discussed and generally agreed, but including more detailed clarification of my position re these. Possibly to be attached to our agreed outcomes list and explanatory comments material.
Thanks again for guiding a productive workshop process.
Hei kona ra
Murray"

Murray's suggestions on habitat narratives are shown on next page as brown tracked changes.

Murray's supplementary workshop notes are provided in Attachment 4.

Draft narrative habitat objectives for tech group feedback

Hill Country FMU

Physical habitat	Rivers and their riparian margins continue to provide good and diverse habitat for the naturally occurring range of native invertebrate, fish and bird species. Fish are able to utilise their full range of habitats, including spawning and migratory habitat, unimpeded by artificial barriers~~.~~ or adverse land use impacts.
Fish	The naturally occurring range of native fish species live in the rivers, lakes and wetlands, including sensitive or threatened species such as koaro, giant kokopu and torrentfish, and other species ~~with high flow and water quality requirements~~ such as large tuna. The rivers remain a national stronghold for ~~long finned~~longfin eel (tuna).
Birds	Naturally occurring riverine bird species continue to be able to live out necessary parts of their life cycles in the rivers~~.~~ and wetlands. Threatened species such as blue duck (whio) and banded dotterel continue to live and thrive in the rivers, lakes and wetlands.

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Comment [OA1]: Is this intended to mean that longfin eel have high water quality requirements? I am not sure this is really supported by literature (in fact they seem incredibly resilient). Also longfin eel are referred to as "less sensitive" further down in the poverty flats section

Comment [NN2]: Yes I agree with OA's comment here and I therefore suggest just deleting these few words.

Te Arai FMU

Physical habitat	The Te Arai River and its riparian margins continue to provide a good and diverse habitat for the naturally occurring range of native invertebrate, fish and bird species. Fish are able to utilise their full range of habitats, including spawning and migratory habitat, unimpeded by artificial barriers~~.~~ or adverse land use impacts.
Fish	The naturally occurring range of native fish species live in the ~~Te Arai River~~rivers, lakes and wetlands, including sensitive or threatened species such as koaro, shortjaw kokopu, giant kokopu and torrentfish~~.~~, and other species ~~with high flow and water quality requirements~~ such as large tuna. The river remains a ~~national~~ stronghold for ~~long finned~~longfin eel (tuna).
Birds	Naturally occurring riverine bird species continue to be able to live out necessary parts of their life cycles in the river. The areas of native forest in the Te Arai catchment provide some of the best habitat for bird species in the region.

Poverty Bay Flats FMU

Physical habitat	Physical habitat, riparian margins and flow are modified but provide areas for some invertebrates and birds, and for some native fish species to spawn and live. Habitat primarily provides for less sensitive species such as ~~long~~ ~~short finned~~shortfin and longfin eel (tuna) and inanga, including ~~some~~ inanga spawning habitat. Other native fish are more likely to move through to the upper reaches where they live, and are able to do so unimpeded by artificial barriers~~.~~ or adverse land use impacts. The retention or restoration of suitable littoral and riparian vegetation can greatly enhance the values of the lowland river reaches for upstream juvenile fish migration and freshwater eel downstream spawning migration.
Fish	A range of generally less sensitive native fish species live in the lowland waterways. The river remains a national stronghold for ~~long finned~~ longfin eel (tuna). The protection or restoration of inanga spawning habitat can provide an important component to the regional whitebait fishery, and the ecological functioning of the Waipaoa, Te Arai and other lowland waterways in Turanganui a Kiwa.

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Comment [NN3]: I suspect that it is probably both shortfin and longfin?

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Urban FMU

Physical habitat	Physical habitat, riparian margins and flow are modified but provide areas for some invertebrates and birds, and for some native fish species to spawn and live. Habitat primarily provides for less sensitive species such as ~~long~~ ~~short finned~~shortfin and longfin eel (tuna) and inanga, including ~~some~~ inanga spawning habitat in the side streams of the Taruheru River.
Fish	A range of generally less sensitive native fish species live in the waterways , as well as estuarine species and marine species which move into the rivers at high tide. The rivers remain a national stronghold for ~~long finned~~longfin eel (tuna).
Birds	The estuarine environment supports a range of native wading species, including migratory birds.

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Comment [NN4]: I suspect that it is probably both shortfin and longfin?

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Attachment 4 – Supplementary workshop notes received from Murray Palmer (13-7-2017)

Supplementary notes to science workshop July 11 2017 M Palmer

1. *Overall position*: While my support for, or equivocal response to, some of the positions adopted at our recent (Tuesday 11th) workshop reflect my current understanding and experience, I should like to register all as being 'without prejudice' as regards actual objective or limit setting. The reason for this is that current work in the areas of freshwater monitoring, and how these will be integrated into an NPS, appears to contain areas of uncertainty that may be resolved with time. Thus I am reluctant to fully commit to a program of action without the proviso for an iterative process to be incorporated into the plan process (as is generally acknowledged in the references to 3 to 5 year reviews in our workshop outcome statements). Some specific areas I should like to comment on further are outlined below (no.2 to 5 below).
2. *MC*I: My support for the use of MCI envisages that this will include all the metrics that can currently be extracted from the use of the macroinvertebrate community tool. These include: QMCI (and where relevant, SQMCI), EPT taxa, EPT animal abundance, taxa diversity and animal abundance. While the latter two are rarely used in SoE reporting, I believe that they can be useful for habitat or impact assessments.
3. *DIN, DRP, DO and pH*: After our workshop, I considered the possibility that I had not sufficiently considered the role of these analytes as water quality indicators in a typical range of settings, and expressed this to the wider group. Such settings include: site specific impact monitoring and assessment (e.g. significant increases in DRP levels and a rise in pH over very short distances occurring alongside land use intensification); high flow related river nutrient levels, where periphyton growth may be flushed from the reach, effectively removing it from the integrated nutrient/biota assessment process we agreed described best practice in terms of setting objectives and assessing nutrient inputs). Similarly, changes in DO from reach to reach or site to site along a river segment can indicate anthropogenic or other impacts that may be relevant to regional management programs.
4. *Clarity*: While clarity is related to levels of suspended solids and turbidity throughout river systems, in lowland settings such as the Poverty Bay Flats FMU, it may also indicate levels of microalgal growth (typically in the low flow zones just upstream of the salt wedge) or high levels of BOD, possibly related to organic matter discharges into streams such as occurs when vegetation in waterways are treated with herbicide, or cut, and left to decay in-stream.
5. *Macrophyte growth*: While the relationship between nutrient enrichment, periphyton type and abundance, and flow, is recognised as an important tool for assessing both land use and climatic impacts, and their combined effects, in most shallow lowland waterbodies in the Waipaoa catchment macrophyte growth will occupy a similar position as periphyton in such a model. Thus, where relevant i.e. where macrophyte growth rather than periphyton is the dominant in-stream vegetation, below surface, surface reaching and

emergent macrophyte growth will need to be reported on (using e.g. the 'macrophyte channel clogginess' assessment tool viz Collier et al., 207; Collier et al., 2015) and assessed, as part of the integrated objective and limit setting process we have recommended for nutrients, periphyton and MCI.

Murray Palmer, Thursday 13th 2017