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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STATEMENT OF OLIVIER MICHEL NICOLAS AUSSEIL ON BEHALF OF THE WAIKATO AND WAIPA RIVER IWI IN RELATION TO THE HEARING TOPICS FOR HEARING BLOCK 1 (Submitter No. 74035)

15 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. Details of my qualifications and experience are set out at paragraphs 14 to 27 below.

3. I have been engaged by the Waikato and Waipa River Iwi to undertake a technical review of the water quality and freshwater ecology provisions of PC1. My evidence addresses issues arising out of submissions and further submissions on PC1 in relation to technical water quality and freshwater ecology matters. Further details regarding the scope of my evidence are set out at paragraph 30 below.

EXECUTIVE SUMMARY

4. My review primarily focuses on two key questions: Does PC1 give effect to the key water quality provisions of Te Ture Whaimana (**TTW**) and the National Policy Statement – Freshwater Management (NPSFM)? And in doing so, does it create unintended issues of achievability and /or equity in the catchment?

5. Having reviewed the water quality provisions of PC1, I am comfortable that it generally gives effect to the key provisions of TTW and NPSFM, noting that my review is limited to technical water quality aspects. However, my review has raised the following aspects.

6. The exact role, or status, of the numerical thresholds contained in table 3.11-1 should be carefully assessed. In my opinion, they were developed following the NPSFM National Objectives Framework, and it seems more consistent with the NPSFM and recent regional plans if they were called “freshwater objectives”. However, the implications of setting “freshwater objectives” need to be clear and well understood, in particular with regards to the long-term “objectives”.

7. My understanding of setting freshwater objectives under the NPSFM is that they must be met in time, and that limits must be set in order to achieve the Objectives. It is thus critical to get these objectives “right”. Numerical freshwater objectives should give effect to the ecological,

recreational, cultural and socio-economic values associated with the Waikato and Waipā Rivers and their tributaries, i.e. they should protect or restore these values at the desired level of protection. The achievability of the objectives, the implications of meeting them and the risk of creating inequity across different parts of the catchment must also be assessed and communicated to stakeholders.

8. My review has raised a number of concerns (listed below) regarding the numerical thresholds set out in Table 3.11-1. These primarily relate to the long-term thresholds and their implications beyond PC1. It is my understanding that TTW sets long-term aspirations for the Waikato and Waipā Rivers, and it seems logical that long-term aspirational goals be retained in PC1 to give effect to TTW. However, these should retain a degree of flexibility to enable incorporation of new scientific knowledge and understanding and to avoid pre-determining the development of any future allocation of resources. Whilst the short-term thresholds in Table 3.11-1 should, in my opinion, be considered "freshwater objectives" in an NPSFM sense, the long-term thresholds should have a different status, and thus be called differently, possibly "long-term water quality states". Importantly, my evidence is limited to technical water quality matters, and other matters, including planning and legal, will need to be considered in determining the status and name of these numerical thresholds.

9. The process and methodology used to define the "current state" of water quality in the catchment was not documented and should be made available by the Waikato Regional Council (**WRC**) for review by all water quality experts involved in this process.

10. The process that will be followed to assess whether freshwater objectives /states are met in the future, or whether progress has been made towards them, will be fundamental to assessing plan effectiveness. This process and associated methodologies should be clarified, agreed between experts and documented.

11. Consideration should be given to include planktonic cyanobacteria, and possibly dissolved oxygen and periphyton objectives in PC1, on the

basis that they are listed in NPSFM Appendix 2 as Attributes in relation to compulsory values (ecosystem health, human health for recreation).

12. The technical process followed to arrive at the freshwater objectives set out in Table 3.11-1 involved the following principles:

    (a) Where water quality was considered acceptable, statistical descriptors (median, 95th percentile and/or maximum from monitoring data collected over the 2010-2014 period) of the "existing state" were used to define the short-and long-term freshwater objectives/states.

    (b) Where water quality was considered in need of improvement a "next band up" principle was applied, i.e. the long-term "state" was set at Band A if the site was currently in Band B, at Band B if the site was currently in Band C, and at Band C if the site was currently in Band D.

    (c) The short-term objective was set as representing 10% of the "journey" between the current water quality and long-term State.

13. Whilst relatively clear and transparent, the above process was, in my view, applied too rigidly, which has led to a number of issues, or potential issues, including:

    (a) Whilst the intent is consistent with the Objectives of TTW, setting short-and long-term freshwater objectives/states using calculated median/95th percentile/ maximum concentrations is, in my view, fraught with a high risk of these objectives/states being exceeded at some point in the future simply as a result of uncertainty in estimating statistical descriptors from discrete water quality data and natural water quality variability. It would be, in my opinion, useful to recognise and provide for a degree of acceptable variability around all of Table 3.11-1 numerical objectives/states that were determined as the current state. A direct discussion between technical experts would be beneficial to resolve this issue.

(a) It seems the linkages between attributes, or between two statistical descriptors of the same attributes were not considered in developing the numerical objectives.

(b) This has led to rather nonsensical situations where Table 3.11-1 sets 95th percentile and maximum concentration objectives that are lower than the median concentration objectives for the same attribute. I recommend that the objectives for nitrate and ammonia be reviewed to ensure consistency between the median and 95th percentile/ maximum concentration objectives.

(c) This has also led to situations where there does not seem to be a clear link between Chlorophyll-a, water clarity, TN and TP objectives/states for the mainstem of the Waikato River. In my opinion, TN and TP objectives/states should be seen as a means to achieve Chlorophyll-a and visual clarity objectives/states, rather than as an end to themselves. I recommend that TN and TP objectives and states be reviewed to ensure that they are set at levels appropriate (or estimated as such) to meet the Chlorophyll-*a* and water clarity objectives/states.

(d) The degree of improvement required of different parts of the catchment or sub-catchments by the nitrate-nitrogen water quality objectives and states is quite variable. There is, in my opinion, a 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 discrepancies in the degree of reductions required in each sub-catchment.

(e) The long-term TN objectives for the Upper Waikato mainstem are of particular concern. They essentially require nitrogen outputs in the whole catchment above Waipapa to be returned to 1863 levels. They do not appear to have been determined on the basis of a need to meet chlorophyll-a or water clarity objectives/states, in the upper FMU or the rest of the catchment; rather they seem to have solely resulted from a rigid application of the “next band up” principle. Based on my review, their achievability does not

appear to have been demonstrated, and it is unclear whether their implications in terms of land use constraints have been clearly evaluated and communicated. The degree of change required in this part of the catchment is significantly greater than in other parts of the catchments, and there is a risk that this will cause inequity across the catchment.

(f) Whilst excellent science was used to support the development of PC1, the uncertainty associated with the current state of scientific knowledge must be acknowledged. In my opinion, regular (i.e. every 10 years) technical and scientific review of long-term water quality states should be provided for, and signalled in PC1.

(g) To date, there has been no opportunity for the various freshwater experts involved in this process to meet and discuss the above points. In my experience, expert caucusing can be extremely useful in resolving the type of issues I raise in my evidence.

QUALIFICATIONS AND EXPERIENCE

14. I have the following qualifications and experience relevant to the evidence I shall give.

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

16. I have over 15 years' experience in New Zealand as a scientist working in local government and as a private consultant working for regional councils and local authorities, central government and government agencies, and the private sector. Prior to that, I worked as a Research Engineer between 1998 and 2001 for the French Atomic Energy Commissariat during my PhD studies.

17. Prior to forming Aquanet Consulting Ltd, I was employed by the Regional Planning Group of Horizons Regional Council from July 2002

to June 2007, where I held the positions of Project Scientist, Environmental Scientist- Water Quality, and Senior Scientist - Water Quality.

18. Since July 2007, I have been Principal Scientist at Aquanet Consulting Limited. In this position, I have been engaged by 18 different regional, district or city councils, the Ministry for the Environment, a number of iwi/hapū, the Department of Conservation, Fish and Game New Zealand, and various private companies/corporations to provide a variety of technical and scientific services in relation to water quality and aquatic ecology.

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

20. I have authored or co-authored a number of reports making recommendations for water quality limits for regional plan change processes, on behalf of:

    (a) for Horizons Regional Council: I was the primary author of three technical reports underpinning the river classification, river values framework and water quality standards in the notified version of the Proposed One Plan for the Manawatu-Wanganui Region;

    (b) for Hawke's Bay Regional Council: I was the co-author of the technical report making recommendations for water quality limits and indicators for the Tukituki catchment (Regional Resource Management Plan Change 6);

    (c) for Greater Wellington Regional Council: I was the author of a series of technical reports recommending water quality and ecological objectives and limits in relation to recreational and ecological values, including a specific report on nutrient limits.

21. In addition, I was co-author of a recent technical water quality report supporting the Wellington/Hutt Whaitua process. I was a peer-reviewer of Environment Canterbury's technical report providing recommendations on water quality objectives and standards for the Council's Natural Resources Regional Plan (Hayward et al., 2009), and I was involved in the Proposed Gisborne Regional Freshwater Plan (Waipaoa Catchment) on behalf of the Mangatu and Wi Pere Trusts.

22. I have worked as a technical advisor on behalf of the consenting authority, the applicant and/or submitters on well over 150 resource consent applications, compliance assessments and/or prosecution cases for a wide range of activities, including municipal and industrial wastewater discharges to water, forestry harvesting and land use change. A significant proportion of this work is now undertaken within operative or proposed regional plans I have contributed to develop.

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

24. I have authored or co-authored a number of catchment- or region-wide water quality reports for Greater Wellington Regional Council (whole region), Hawke's Bay Regional Council on 7 catchments (in 2008 and 2016), and for Environment Canterbury on the Hurunui catchment and Pegasus Bay. I was engaged by Environment Southland as mentor and peer-reviewer for their 2010 State of the Environment report, and wrote the section of this report relating to nutrient limitation. I also peer-reviewed a number of regional State of the Environment reports for Environment Canterbury, Environment Southland, West Coast Regional Council, and Hawke's Bay Regional Council.

25. I have developed a water quality and periphyton growth model to assess the potential effects of point-source discharges. This model has been applied to several point source discharges in the Manawatu (Feilding, Shannon, Bulls, Marton and Palmerston North wastewater, AFFCO Feilding). In late 2018, I was engaged by Bay of Plenty Regional Council to review the catchment modelling decision support tool for the Rangitaiki and Kaituna-Pongakawa-Waitahanui catchments.

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

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

EXPERT WITNESS CODE OF CONDUCT

28. I confirm that I have read the ‘Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2014. In the same way as I would if appearing in the Court, my evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

SCOPE OF EVIDENCE

29. My evidence addresses the following matters:

    (a) Context – Te Ture Whaimana (TTW) and NPSFM, and the implementation of their water quality provisions into PC1

    (b) Numerical freshwater Objectives – Table 3.11-1

    (c) Definition of current state and its use in the formulation of long-term freshwater objectives

    (d) NPSFM “Grading” and objective setting

(e) Degree of improvement required across FMUs and sub-catchments

(f) Prioritisation of nutrient management

30. My evidence is limited to technical water quality and freshwater ecology matters.

CONTEXT – TE TURE WHAIMANA AND NPSFM

31. It is my understanding that PC1 was developed in the context of Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River (TTW) and the National Policy Statement for Freshwater Management (NPSFM). PC1 must give effect to both Te Ture Whaimana and the NPSFM; where there are inconsistencies between the two documents, Te Ture Whaimana prevails. Paragraph 32 of the S42A report states that the 2017 version of the NPSFM (NPSFM 2014 amended 2017) must be given effect to. On that basis, all references to the NPSFM in my evidence refer the NPSFM 2014 (amended 2017).

32. Te Ture Whaimana is the primary direction-setting document for the Waikato and Waipā Rivers and their catchments which include the lower reaches of the Waipā River. It sets objectives for the Waikato and Waipā Rivers. Of particular relevance to my evidence are the following objectives:

> a. The restoration and protection of the health and wellbeing of the Waikato River.
>
> f. The adoption of a precautionary approach towards decisions that may result in significant adverse effects on the Waikato River, and in particular, those effects that threaten serious or irreversible damage to the Waikato River.
>
> g. The recognition and avoidance of adverse cumulative effects, and potential cumulative effects, of activities undertaken both on the Waikato River and within the catchment on the health and wellbeing of the Waikato River.

h. The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities.

i. The protection and enhancement of significant sites, fisheries, flora and fauna.

k. The restoration of water quality within the Waikato River so that it is safe for people to swim in and take food from over its entire length.

33. I do not provide in this evidence a detailed review of the NPSFM or its implementation in PC1; rather I will concentrate on key water quality aspects, in particular the process set by the NPSFM for the development of freshwater objectives under NPSFM Objective CA1 and Policies CA2 to CA4 (National Objectives Framework, "**NOF**"). My review was undertaken in the context of the numerous submissions or further submissions seeking that additional freshwater attributes or objectives be included in PC1 and/or discussing what the numerical thresholds present in Table 3-11-1 should be called.

34. Specifically, the National Objectives Framework requires that:

(a) Freshwater Management Units (FMUs) are identified, that include all freshwater bodies in the region (Policy CA2).

(b) The Values associated with freshwater bodies within each FMU are identified (Policy CA2 a) and b)).

(c) Attributes relevant to the values are identified (Policy CAc)).

(d) Freshwater Objectives for each Attribute are formulated (Policy CA2 d), e) and f)).

35. In the following paragraphs (36 to 51), I provide a summary of the review I undertook of the process followed to define freshwater objectives/ limits/targets in PC1, with particular regard to whether the provisions of the NPSFM were implemented. I also comment on consistency with other, recent, regional plans.

36. Definition of FMUs (Policy CA2). PC1 covers the whole of the Waikato catchment from the outlet of Lake Taupō to the Waikato River Mouth at Port Waikato, and identifies five FMUs within the catchment. Each FMU is divided in a number of sub-catchments (74 in total). The definition of the FMUs and sub-catchments was guided by physical features of the catchment and the location of existing monitoring sites. This spatial framework and the process used to develop it are, in my opinion, consistent with the requirements of NPSFM Policy CA2 and with those of other regional plans.

37. Definition of values associated with freshwater bodies within each FMU (Policy CA2 a) and b)). These values must include the compulsory National Values of Ecosystem Health and Human Health for Recreation. They may also include any other national values listed in NPSFM Appendix 1 and any other values that the regional council considers appropriate. Section 3.11.1 of PC1 identifies values and uses for the Waikato and Waipā Rivers. These values do include the two NPSFM compulsory values of Ecosystem Health and Human Health for Recreation, as well as a number of other National Values. The set of values identified in PC1 for the Waikato and Waipā Rivers, and the process followed for their development are, in my opinion consistent the requirements of NPSFM Policy CA2 and with those of other regional plans.

38. Definition of Attributes relevant to the values are identified (Policy CAc)). For the Compulsory Values, these must include the Attributes listed in Appendix 2 that are applicable for the freshwater body type. They may also include any other attributes that the regional council considers appropriate for the freshwater body type (i.e. Lake or River). The process followed to define Attributes for PC1 is documented in a technical report[1].

39. The whole of the Waikato River was considered to be a lake-fed river, due to the presence of a series of hydro lakes between Taupō and Karapiro. As a result, Attributes relevant to lakes and lake-fed rivers were used. The Attributes selected include all but one of the compulsory

[1] Report No. HR/TLG/2016-2017/2.1A Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change

Attributes relative to the Ecosystem Health Value for lakes (Phytoplankton, Total Nitrogen, Total Phosphorus, Nitrate, Ammonia), and one of the two compulsory Attributes for Human Health for recreation (*E.coli*). It also includes visual water clarity.

40. The Attributes defined in PC1 are generally consistent with the National Objectives Framework. I also agree that the addition of visual water clarity is sensible, as it is directly related to core ecological, recreational and cultural values; however, I note the following:

(a) The NOF sets two possible numeric Attribute States for Total Nitrogen in Lakes: one for seasonally stratified and brackish lakes, and the other for polymictic lakes[2]. The Attribute State for seasonally stratified lakes was used for the definition of Freshwater Objectives in PC1's Table 3.11-1. I have not seen evidence to support (or contradict) this decision, and suggest it would be useful if WRC's officers were able to provide it;

(b) PC1 does not define freshwater objective(s) relative to planktonic cyanobacteria, despite it being one of the NOF Attributes for Human Health and Recreation, i.e. one of the "Compulsory Attributes" for lakes and lake fed rivers. It is interesting to note that the technical report[3] does recommend the adoption of a planktonic cyanobacteria Attribute. I am uncertain as to why this recommendation was not adopted. In my opinion, the NPSFM is clear that this is an Attribute associated with a compulsory value, and thus should be seen as a "compulsory" Attribute for lakes and lake fed-rivers, where relevant. I agree with the technical report's conclusion that planktonic cyanobacteria is relevant to human health for recreation value in the mainstem of the Waikato River and suggest it should be included in PC1.

(c) PC1 does not define freshwater objective(s) relative to periphyton biomass. This Attribute was considered by the technical expert panel, and rejected on the basis of its limited relevance in most streams and rivers in the Waikato-Waipa catchment, and limited

[2] NPSFM Appendix 2, p31.
[3] Report No. HR/TLG/2016-2017/2.1A Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change. Pages 7-8.

issues with periphyton where it is relevant[4]. Having considered the evidence and comments from the expert panel, I tend to agree that there is no evidence that excessive periphyton growth currently is a significant issue in the Waikato catchment. It also seems unlikely that it will become a significant issue in the future, on the basis that PC1 seeks maintaining or reducing nutrient losses from the catchment. On that basis I support not including the periphyton Attribute in PC1. I note however, that it is a "compulsory" Attribute in relation to the Ecosystem Health value, and there may be valid planning or legal reasons to include it.

(d) PC1 does not define freshwater objectives in relation to Dissolved Oxygen. Dissolved Oxygen is also one of the NOF Attributes for the Ecosystem Health compulsory value, and should thus be considered a compulsory Attribute, noting however that it is only defined in the NOF for below point source discharges.

41. Formulating Freshwater Objectives for each Attribute. Policy CA2 d) and e) require that freshwater objectives be formulated for each Attribute. The freshwater objectives must be formulated in numeric terms for Attributes specified in Appendix 2 of the NPSFM, and in numeric terms where practicable (narrative if not) for Attributes not listed in Appendix 2.

42. A number of submissions have raised the question of what the numerical thresholds in PC1's Table 3.11-1 should be called. In my opinion, they were developed following the NPSFM National Objectives Framework, and it seems more consistent with the NPSFM and recent regional plans if they were called "freshwater objectives". However, the implications of setting "freshwater objectives" need to be clear and well understood, in particular with regards to the long-term "objectives".

43. My understanding of setting freshwater objectives under the NPSFM is that they must be met in time, and that limits must be set in order to achieve the Objectives. It is thus critical to get these objectives "right". Numerical freshwater objectives should give effect to the ecological,

[4] Report No. HR/TLG/2016-2017/2.1A Water Quality Attributes for Healthy Rivers: Wai Ora Plan Change. Page 12.

recreational, cultural and socio-economic values associated with the Waikato and Waipā Rivers and their tributaries, i.e. they should protect or restore these values at the desired level of protection. The achievability of the objectives, the implications of meeting them and the risk of creating inequity across different parts of the catchment must also be assessed and communicated to stakeholders.

44. The review I have undertaken of the process used to formulate the numerical thresholds set in Table 3.11-1 has raised a number of concerns (as detailed in paragraphs 46 to 104 below). These concerns primarily relate to the long-term thresholds and their implications beyond PC1. It is my understanding that Te Ture Whaimana sets long-term aspirations for the Waikato and Waipā Rivers, and it seems logical that long-term aspirational goals be retained in PC1 to give effect to Te Ture Whaimana. However, these should retain a degree of flexibility to enable incorporation of new scientific knowledge and understanding and to avoid pre-determining the development of any future allocation of resources. Whilst the short-term thresholds in Table 3.11-1 should, in my opinion, be considered "freshwater objectives" in an NPSFM sense, the long-term thresholds should have a different status, and thus be called differently, possibly "long-term water quality states". Importantly, my evidence is limited to technical water quality matters, and other matters, including planning and legal, will need to be considered in determining the status and name of these numerical thresholds.

45. Having considered the selection of Attributes used in PC1, I now turn to the definition of the numerical freshwater objectives contained in PC1's Table 3.11-1.

46. First considering the units and statistical descriptors used for each numerical freshwater objective or state, e.g. median or 95th percentile concentrations. For most Attributes, Table 3.11-1 uses the same units and statistical descriptors as those in NPSFM Appendix 2, specifically:

    (a) For phytoplankton, the annual median and maximum concentrations of chlorophyll-a, expressed as mg/m^3;

    (b) For Total Nitrogen (TN) and Total Phosphorus (TP), the annual median concentration, expressed as mg/m^3;

(c) For Nitrate, the Annual median and 95th percentile concentrations, expressed as mg NO_3-N/L;

(d) For Ammonia, the annual median and maximum concentrations, expressed as mg NH_4-N/L.

47. However, for *E.coli*, PC1 Table 3.11-1 only uses the 95th percentile concentration, whilst the NOF defines four descriptors (% exceedances over 540 cfu/100mL, % exceedances over 260 cfu/100mL, median concentration and 95th percentile concentration). The discrepancy between PC1 and the NPSFM may in part be explained by the fact that the 2017 amendments to the NPSFM introduced changes to the definition of the *E.coli* Attribute. Nonetheless, as noted in the S42A report, PC1 must give effect to the latest version of the NPSFM, and consideration should be given to aligning Table 3.11-1 with the most recent NOF definition of the *E.coli* Attribute.

48. I also note that a number of submissions seek to exclude flood flows to the application of the *E.coli* Attribute. I tend to agree this is often sensible in river systems, as microbiological water quality is often degraded during flood flows, and the 95th percentile concentration of *E.coli* can be significantly influenced by a few high concentrations recorded during flood events. As a result, the 95th percentile concentration may not provide a good indication of the suitability for contact recreation during periods of settled river flows, which are also often the periods when most recreational activities tend to occur in rivers. I have made recommendations to exclude flood flows from the calculation of *E.coli* indicators in other regions, which have been adopted in now operative regional plans[5]. However, I note that the Waikato River is characterised by a series of impoundment lakes, on which recreational use is likely less influenced by river flow conditions than in a free-flowing river system. It is also relevant to note that the NOF specifies that the *E.coli* Attribute States are defined on the basis of "*a minimum of 60 samples collected over a maximum of 5 years, collected on a regular basis regardless of weather and flow conditions*". This specifically does not provide for exclusion of data collected under

[5] E.g. Horizons One Plan, Tukituki Plan Change 6.

high flow conditions. On that basis, I do not recommend excluding flood flows from the definition of the *E.coli* Attribute.

49. Table 3.11-1 does not specify the statistical descriptor used for visual water clarity Attribute. It merely states the unit (metres). This omission is noted in the S42A report, which recommends that clarity should be taken as the median clarity "under baseflow conditions" [6]. However, the S42A report does not define what constitutes baseflow conditions. This recommendation is made on the basis of a 2016 TLG report, which does specify that baseflow conditions is taken in that report as "excluding any measurements taken during the top 10% of flows". I agree with the recommendation made in the S42A report that Table 3.11-1 should include the assessment criteria, although the wording should be "excluding any measurements taken during the top 10% of flows" as opposed to "under baseflow conditions".

50. A number of submissions also seek the addition of a wide range of additional Attributes, such as DO, temperature, pH, fish, macroinvertebrates, macrophyte cover, sediment cover, etc. Some of these Attributes have potential value as freshwater objectives; however, their applicability to the Waikato River may be questionable (e.g. MCI) and/or significant technical work would be required to define sensible thresholds. PC1 focuses on four key contaminants, and, in my opinion, the list of attributes in PC1 is suitable to manage most, if not all, freshwater issues currently facing the Waikato River. The clear focus of PC1 on the four key contaminants is, in my opinion, an advantage, and I see little to be gained by inserting a plethora of Attributes without clearly understanding what issue they seek to manage and the implications of setting additional freshwater objectives/states.

51. In conclusion, I am of the opinion that the process used to define freshwater management units, identify values and select Attributes is generally consistent with the objectives of Te Ture Whaimana and the provisions of the NPSFM, particularly the National Objectives framework, with the following exceptions:

[6] S42A report, page 108, para 613.

(a) PC1 does not define freshwater objectives relative to planktonic cyanobacteria, periphyton or dissolved oxygen downstream of point source discharges, in spite of these attributes being associated with compulsory values under the NPSFM.

(b) The *E.coli* freshwater objectives in PC1 are formulated in a way that uses a sub-set of the statistical indicators used in the NPSFM *E.coli* Attribute. Consideration should be given to using the full NPSFM *E.coli* Attribute.

(c) The Total Nitrogen freshwater objectives in PC1 were formulated on the basis of the Waikato River being a series of seasonally stratified lakes. It would be useful for WRC to document the basis for this decision.

(d) Should the Panel be of a mind to consider including or changing any of the above Attributes in PC1, then I suggest that expert caucusing would likely be helpful to recommend technically robust numerical freshwater objectives.

NUMERICAL FRESHWATER OBJECTIVES - TABLE 3.11-1

52. Having considered the process used to identify relevant Attributes, I now turn to considering the final outcome of the process, i.e. the definition of the numerical freshwater objectives/states themselves. These are contained in Table 3.11-1. With regards to water quality, Table 3.11-1 is central to PC1. It defines the numerical freshwater objectives or states the plan seeks to achieve, in the short and long term. In essence, it aims at providing a numerical translation of key water quality aspects of Te Ture Whaimana.

53. The technical method(s) used to formulate freshwater objectives must be guided by the provisions of the NPSFM, in particular Policy CA2 d), e) and f):

(a) CA2(d) sets that for Attributes specified in Appendix 2, the Attribute State must be assigned at or above the minimum acceptable state for that Attribute; in other words, one cannot set

numerical freshwater objectives that are below (i.e. worse than) the "National Bottom Line";

(b) CA2 e (iia) sets that, for Attributes listed in Appendix 2, freshwater objectives must be set at least within the same attribute state as existing freshwater quality; in other words, this means that if existing water quality at a site is in Band B for a specified Attribute, then one cannot set a freshwater objective allowing the water quality to degrade to Band C. An objective can however be set within Band B or Band A.

(c) For Attributes not listed in Appendix 2, freshwater objectives must be set so that values will not be worse off when compared to existing water quality.

(d) I also note that Pol CA2 f) requires that the implications of setting freshwater objectives must be considered. I comment further on this point later in my evidence.

54. The process used to arrive at Table 3.11-1 is not particularly well documented; however, based on tables provided to the TLG[7] and in the Scenario evaluation reports[8], I understand that the process involved the following steps:

(a) Define the current state for each Attribute. The "current state" for each Attribute was estimated as the calculated median, 95th percentile and/or maximum of existing datasets held by WRC for the 2010-2014 period;

(b) Where the current state was considered acceptable (i.e. within NPSFM Band A for this Attribute), the long-term objective was set as the estimated current state (i.e. calculated median, 95th percentile and/or maximums the 2010-2014 period). For example, for the Waikato River at Waipapa Tailrace, the "current" annual median Chlorophyll-a concentration was estimated as 4.1

[7] TLG 2015 Document# 3597165

[8] Report No. HR/TLG/2015-2016/4.2. Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments. Assessment of second set of scenarios. 24 September 2015. Page 15, Table 1.

mg/m^3. This was considered acceptable, and thus the short and long-term objective/state for this site are 4.1 mg/m^3;

(c) Where the current state was considered insufficiently good (i.e. when it was not in Band A), the long-term target required a "one band up" improvement, to Band A if the current state was in Band B, to Band B if the current state was in Band C[9], etc.

(d) The short-term target was then defined as being 10% of the "journey" between the current state and the long-term target. For example, if the current median TP concentration was 30 mg/m^3 and the long-term target was 20 mg/m^3, a reduction of 10 mg/m^3 would be required to achieve the long-term target. The short-term target was calculated as being the current state (30) minus 10% of the 10 mg/m^3 reduction (i.e. 1 mg/m^3). In this situation the short-term target would be: 30-1=29 mg/m^3.

55. Whilst presenting the advantage of being clear and transparent, the approach taken to define the long-term "States" has, in my opinion, been applied too mechanically and has resulted in a number of issues, as follows:

(a) The use of statistical descriptors of the "current state" to define long-term "states" raises a number of technical issues (as detailed in paragraphs 67 to 76 below);

(b) The "grading", i.e. the determination of which NPSFM Band each Attribute falls into at each monitoring site, seems to have been undertaken individually for each Attribute (and even for each statistical descriptor of a given Attribute), without considering other Attributes or other statistical descriptors of the same Attribute. This has led to the issues detailed in paragraphs 77 to 84.

(c) For each Attribute, the range of concentrations within each Band is quite wide, and the size of the movement (i.e. the degree of

[9] The only exception to this was for the TP Attribute in the Lower Waikato River (at Mercer Br and Tuakau Br). The "current state" was determined as being in Band D, and the long-term State was set as Band B.

improvement required) between the current water quality and the "next band up" depends on where the site currently sits in relation to the band thresholds. The result is some situations where, for example a sub-catchment with relatively better water quality is required to make a greater proportional improvement than a neighbouring sub-catchment with more degraded water quality. The issue appears to be particularly critical for the Upper Waikato mainstem, as detailed in paragraphs 85 to 104.

DEFINITION OF CURRENT STATE AND ITS USE IN THE FORMULATION OF LONG-TERM FRESHWATER OBJECTIVES.

56. The current state of water quality at each monitoring site was defined as the calculated median, 95th percentile and/or maximum concentration or visibility distance (in the case of visual water clarity), based on monitoring data collected over the 2010 to 2014 period[10]. I understand that the time period used for the *E.coli* Attribute is longer; however I have not been able to find a clear reference to this.

57. As indicated above, where the current state was considered acceptable, the calculated statistic (median, 95th percentile, annual maximum) became the long-term /80 year objective. Where the current state was considered in need of improvement, the long-term objective was set on the basis of NPSFM or regional NOF thresholds (for water clarity), but the current state was still used to calculate the short-term objective (as explained in paragraph 54(d) above).

58. The definition of the current state of water quality in the Waikato catchment was thus central to the formulation of the freshwater objectives in Table 3.11-1.

59. Further, one can anticipate that, in the future, the statistical descriptors of Table 3.11-1 will need to be re-calculated on the basis of future data to gauge progress, or otherwise, towards the freshwater objectives or states. This, potentially combined with temporal trend analysis, appears fundamental to monitoring plan effectiveness.

60. It is thus critically important that:

[10] PC10 p56.

(a) the existing state is robustly defined, i.e. that the numbers in Table 3.11-1 accurately and robustly represent the “current” state; and

(b) the calculated statistics are representative of the actual/ true existing state; and

(c) the methodology and process used to estimate the current state are well documented and able to be replicated, now and in the future.

61. Unfortunately, the data management and analysis methods used to define the “current state” were not documented. It is my understanding however that WRC are in the process of documenting in detail these methods. I cannot comment further until this report is made available and suggest that expert caucusing following receipt of the report may be useful for the water quality experts involved in this process to examine the methodology and resolve any differences of opinion.

62. I note that the use of the current state to define long-term freshwater objectives in places where water quality is currently in Band A is, in my opinion, more stringent than (although not contrary to) the requirements of the NPSFM Policy CA2 (e)(iia)(A), which requires that freshwater objectives be set at least within the same Attribute State as existing freshwater quality. A common interpretation of this policy, which I support, is that some degree of movement within a given band is acceptable, on the basis that increases or decreases within a band do not affect the overall State of the Attribute and do not materially affect (positively or negatively) the value associated with that attribute. In other words, the overall level of protection afforded to the value remains the same as long as the Attribute remains within the same Band.

63. For example, for ammonia toxicity, the NPSFM “Band A” corresponds to no observed effect on any species tested. The median concentration threshold between Band A and Band B is 0.030 mg/L. This means that if the current concentration is, say, 0.010 mg/L and reduces to 0.005 mg/L or increases to 0.015 mg/L (i.e. a 50% movement but still well within Band A), then the overall degree of ammonia toxicity (i.e. the level of protection) should not be affected in a more than minor way.

64. This approach presents the distinct advantage of allowing some, albeit relatively small, movement around the calculated current concentration, which caters for an unavoidable degree of uncertainty around what the "current state" of water quality is and natural variability in water quality.

65. However, and importantly, PC1 seeks to give effect to both NPSFM and Te Ture Whaimana. Of particular relevance are Te Ture Whaimana Objectives f, g and h, which specifically state that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities (objective h), that cumulative effects are recognised and avoided (objective g) and the adoption of a precautionary approach (objective f). On that basis, the approach taken, i.e. defining long-term objectives based on current state to avoid any further cumulative degradation appears the most appropriate technically to give effect to Te Ture Whaimana.

66. The use of the "current state" to define long-term freshwater objectives raises a number of significant technical issues detailed below.

67. The "true" concentration of a given contaminant in an individual sample is unknown. Analytical uncertainty for most laboratory methods is typically 15-20% at best for most water quality parameters. In theory this "error" should be equally distributed around the true value. However, in practice, a change in laboratory, or even relatively subtle changes in laboratory analytical methods can lead to an overall bias or skew in the data. This is clearly illustrated by the issues identified in the recent water quality trends report in the WRC phosphorus data[11].

68. The actual "current state" of water quality is unknown; it can only be estimated on the basis of existing data. For all Attributes used in PC1, data available are limited to discrete water quality data, i.e. measurements taken from individual water samples (as opposed to continuous measurements). In this situation, samples were generally collected monthly. This means that we are trying to estimate the true concentration of a contaminant over a period of 5 years on the basis of 60 individual samples, each only representing a discrete point in time.

[11]Vant (2018). Trends in river Water Quality in the Waikato region, 1993 – 2017. Waikato Regional Council Technical Report 2018/30. December 2018.

69. Water quality in a river or stream will continuously vary as a result of a large number of external and intrinsic factors, including climatic (e.g. temperature, rainfall), hydrological (river flow, groundwater interaction), geological (underlying parent rock), morphological (e.g. channel shape), and biological (e.g. periphyton biomass).

70. As a result, most determinands we measure will vary on a:

    (a) Daily basis, for example pH and Dissolved Oxygen follow diurnal cycles;

    (b) River flow basis (water clarity is generally poorer during high river flows);

    (c) Seasonal basis (water temperature and phytoplankton biomass are generally lower in winter);

    (d) Inter-annual basis – for example the median annual nitrate concentration is expected to be higher during a wet year than during a dry year;

    (e) Inter-decadal basis, as it affects the distribution of warm and cold and wet and dry years within a given sub-set of years[12]. For example, a 5-year period may contain a greater proportion of dry years when compared with the long-term average.

71. A sample or measurement taken at a monitoring site hours, days or weeks later will most likely give different results. Without entering into the details of statistical theory, this mean that the samples taken as part of a routine monthly monitoring programme during the course of a year will only represent a very small subset of all the samples that could have been taken during that year, i.e. a very small snapshot of the water quality that occurred during that year. This means that any descriptive statistic that may be derived from the dataset, (e.g. the calculated median value) is in fact only an estimate of the true median value, with an associated degree of uncertainty.

[12] Scarsbrook M.R., McBride C. G., McBride G.B. and Bryers G. (2003). Effects of climate variability on rivers: consequences for long-term water quality analysis. Journal of the American Water Resources Association, December 2003, p1435-1447.

72. I also note that the freshwater objectives in Table 3.11-1 are expressed with a seemingly high degree of accuracy (e.g. third decimal place for nitrate and ammonia), which is somewhat unnecessary, and does reflect analytical and statistical uncertainty.

73. What this all means it that:

(a) calculating the median (or 95th percentile) of monthly monitoring data only provides us with an estimate of the true median or 95th percentile. The calculated median/95th percentile are associated with a degree of uncertainty, which should, in my opinion, be recognised.

(b) estimates of annual (or 5-yearly) median and 95th percentiles are likely to change over time as a result of inter-annual and inter-decadal variability.

(c) As a result, Table 3.11-1 numerical objectives defined on the basis of estimated "current" median or 95th percentiles are, in my view, highly likely to be exceeded at some point in the future simply as a result uncertainty in estimating their true value and of variability in water quality.

74. For example, the *E.coli* objective/state for the Waikato River at Ohakuri Bridge is a 95th percentile concentration not exceeding 15 *E.coli*/100mL. Let's assume that in 5 years time, the calculated 95th percentile is 25 *E.coli*/100mL. Such apparent increase could easily be caused by a small number of samples, could occur without any material changes in land use in the catchment, and would be well within the laboratory analytical uncertainty. In fact, exceedance of the objective/state has already happened: the 95th percentile *E.coli* at that site for the 2012-2017 period is 20 *E.coli*/100mL. The calculated 5-year 95th percentile concentration at that site has fluctuated between 8 and 24 *E.coli*/100mL during the 1998 to 2017 period, and has included significant periods of time during which the 15 *E.coli*/100 mL PC1 objective/state was nominally exceeded (2007-2009, 2010-2015 and 2017). However, the overall swimmability of the Waikato River at that point has remained excellent (i.e. well within Band A) throughout the whole monitoring period.

75. The key risk of not addressing this issue is to draw incorrect conclusions with regards to future situation in relation to, or progress towards, the freshwater objectives/states (i.e. concluding that the objective/ state is not met when in fact the situation has not changed). This should be seen in the context of PC1 not being explicit as to the implications of not meeting the freshwater objectives.

76. I recommend that some form of uncertainty margin be placed around the short- and long-term targets that are based on estimates of current state, to account for uncertainty of measurement and the potential influence of climatic patterns. This uncertainty margin should be identified and provided for in the definition of the freshwater objectives and in the methods that will be used to assess progress towards, or compliance with, these freshwater objectives in the future.

NPSFM "GRADING" AND OBJECTIVE SETTING

77. The NPSFM Attribute states for nitrate and ammonia are defined on the basis of two statistical descriptors: median and 95th percentile (for nitrate) and median and maximum concentration (for ammonia).

78. In the determination of Table 3.11-1, the two statistical descriptors seem to have been treated as separate Attributes. This has led to situations where Table 3.11-1 prescribes 95th percentile (for nitrate) or maximum (for ammonia) concentration objectives that are lower than the median concentration objectives.

79. For example, for the Whatawhiriwhiri Stream[13], the long-term "states" for ammonia are 0.24 mg/L (Band B/C threshold) for median concentration and 0.05 mg/L (Band A/B threshold) for annual maximum concentration. Whilst the mechanics of how these numbers were derived is sufficiently clear (the "one band up" principle), the outcome is rather nonsensical and should be reviewed.

80. In my experience, it is more common to undertake the "grading" (i.e. determine in which NPSFM Band a site falls) on the combined basis of the median and 95th percentile/maximum concentrations. For example, if the median falls into Band B and the 95th percentile in Band C, then the

[13] Whatawhiriwhiri Stream at Edgecumbe Street (Sub-catchment 28).

site falls into Band C. There is little point in setting a "Band A" objective for the annual maximum concentration and a "Band B" objective for the annual median concentration. The level of effects (and thus the level of protection afforded to the value) will be determined by the lower grading. In my opinion, the setting of objectives should provide for consistent "grading" for the median and 95th percentile/maximum concentrations of ammonia and nitrate.

81. On a different but similar issue, the freshwater objectives set in Table 3.11-1 for chlorophyll-*a*, TN and TP also appear to have been determined individually, without regard for their interconnection. Whilst all are listed as Attributes in the NPSFM Appendix 2, their nature is very different from a water quality point of view. Chlorophyll-*a* is a measure of planktonic algae biomass, which we want to maintain at or below reasonable levels in order to protect a number of values (ecological, recreational, cultural etc.). By contrast, TN and TP concentrations are "controlling" factors, i.e. they control how much planktonic algae will grow. TN and TP concentrations are not directly linked with ecological, recreational or cultural values; rather they should be seen as "levers" one can act on to control a potential effect on the values (chlorophyll-*a*).

82. Freshwater objectives are set for a clear reason: to give effect to, and protect or maintain freshwater values at a given level of protection. This should be the key guiding principle that is applied to the formulation of freshwater objectives. With specific regards to chlorophyll-a, TN and TP objectives, I am of the opinion that one should start with setting chlorophyll-a objectives/ states (being what we are trying to achieve), then set TN and TP objectives to meet the chlorophyll- a objectives/states, both within a given FMU, and considering downstream environments.

83. For example, in the Upper Waikato, Chlorophyll-*a* concentrations are within Band A at all sites monitored by WRC (Ohaaki, Ohakuri and Waipapa). Long-term Chlorophyll-*a* objectives were set to maintain the current state. This means that reductions in TN or TP are not directly required to maintain Chlorophyll-*a* within Band A in the Upper Waikato FMU. However, chlorophyll-*a* objectives are <u>not</u> met further down in the Waikato River (e.g. at Narrows and Horotiu) and it seems fair and

reasonable that the upper part of the catchment contributes to meeting these objectives. However, in my opinion, this contribution should be determined on the basis of a "fair share" of the improvement required to achieve objectives in the middle and lower river, as opposed to simply based on a mechanical application of the "next band up" principle that was used in Table 3.11-1.

84. A similar reasoning should be applied to linking TN and TP to water clarity objectives / states in the reaches of river where phytoplankton biomass has been identified as a key driver of water clarity.

DEGREE OF IMPROVEMENT REQUIRED ACROSS FMUS AND SUB-CATCHMENTS.

85. For monitoring sites where water quality was considered in need of improvement (i.e. not in Band A), the long-term freshwater objective was defined as the numerical threshold to the "next band up". A potential issue is that the size of the movement (i.e. the degree of improvement required) between the current water quality and the "next band up" depends on where the site currently sits in relation to the band thresholds.

86. For example, for the Mangamingi Stream[14], the current median nitrate concentration is estimated at 2.800 mg/L. This places this site in Band C for nitrate. The long-term "state" was accordingly set at 2.4 mg/L, which is the threshold between Band C and Band B. This represents a 14% reduction to be achieved over 80 years. Now considering the Pokaiwhenua Stream[15]. The current median concentration at this site is estimated at 1.755 mg/L, which places the site in Band B. The long-term "state" was set as the threshold between Band B and Band A, i.e. 1.0 mg/L, requiring a 43% reduction in nitrate concentration. There are many such examples in Table 3.11-1.

87. Whilst the mechanism by which these numbers were determined is reasonably clear, it seems counter-intuitive that a more degraded catchment would be required to achieve a smaller proportional improvement than a comparatively less degraded catchment. This, in my

[14] Mangamingi Stream at Paraonui Rd (sub-catchment 48)
[15] Pokaiwhenua Stream at Arapuni-Putaruru Rd (sub-catchment 45)

opinion, is a particularly significant issue as it may lead to inequity in the amount of reduction in contaminant losses that may be required from land uses in each sub-catchment of the Waikato and Waipā Rivers.

88. Within PC1 as it stands, the discrepancies between sub-catchment probably only have limited practical implications, given that most, if not all, land use related controls (objectives, policies, methods) are very similar across the whole catchment. In particular, PC1 does not, at this stage, include a contaminant allocation framework but it does signal, through Policy 7, that property or enterprise-level allocation of diffuse discharges of contaminants will be required by subsequent regional plans.

89. However, if long-term freshwater objectives are set in PC1, then it is likely that any future allocation framework will have to give effect to these objectives (i.e. be developed in a way that ensures that the objectives are met). There is, in my opinion, a 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 discrepancies in the degree of reductions required in each sub-catchment. One option to avoid this risk would be either remove the catchment-scale long-term (80 year) nitrate-nitrogen objectives, or, for example, to insert a clarification that these are not freshwater objectives in an NPSFM sense and should not influence the definition of a future allocation framework.

90. Another significant issue arises from the way the freshwater objectives were determined, that of achievability and how implications are assessed, and expectations managed. The freshwater objectives/ states in Table 3.11-1 were determined from a simple application of the NPSFM Bands and the “one band up” principle and, although extensive modelling was carried out, their achievability was not always demonstrated.

91. This is particularly the case for TN objectives in the mainstem of the upper Waikato River. A key example is the Waikato River at Waipapa Tailrace, which is the most downstream site monitored on the Waikato

River mainstem in the Upper Waikato FMU[16]. The current estimated median TN concentration at this site is 336 mg/m^3, which places this site in Band B, but very close to the Band B/Band C threshold (350 mg/m^3). Following the "one Band up" principle, the long-term "state" was set as the Band A/Band B threshold, i.e. 160 mg/m^3. This means that an overall 52% reduction in TN concentration would be required in the catchment above Waipapa Tailrace in order to achieve the long-term target.

92. By contrast, the Waikato River at Narrows (Central Waikato FMU) has a current TN concentration of 410 mg/m^3, which places the site in Band C. The long-term objective for this site was set at 350 mg/m^3 (Band B/Band C threshold) requiring a much more modest reduction of 14% over 80 years.

93. Interestingly, the reduction required at Waipapa is entirely driven by the fact that the current TN concentration was calculated as just below the Band B/Band C threshold. If it had been marginally higher (e.g. 355 mg/m^3), the long-term target would have been set as 350 mg/m^3, and only a small reduction would have been required at that site. It is interesting to note that the 5-year rolling median TN concentration at this site since the 2010-2014 "current state" was calculated has fluctuated between 0.331 and 0.350 mg/L.

94. More concerningly, the median TN concentration in the Waikato River at Waipapa in 1863 was modelled[17] as 153 mg/m^3, which is essentially similar (i.e. well within the accuracy with which we are able to define the "current state") to the long-term "state". In other words, nitrogen outputs in the whole catchment above Waipapa would have to be returned to 1863 levels if the long-term "state" was to be achieved at that point.

95. Extensive water quality and economic modelling was undertaken as part of the process leading to the development of PC1. A range of scenarios were evaluated[18], with Scenario 1 being selected by the Collaborative

[16] The bottom of the Upper Waikato FMU is Waikato River at Karapiro; however, no monitoring data are available for this site.
[17] Report No. HR/TLG/2016-2017/4.3. Prediction of water quality within the Waikato and Waipa River catchments in 1863. Table 3, Page 15.
[18] Report No. HR/TLG/2015-2016/4.1. Economic evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments Assessment of first set of scenarios 24 August 2015.

Stakeholder Group to form the basis for the long-term water quality "targets" in PC1. It is thus my understanding that "Scenario 1" is based on meeting all of Table 3.11-1 long-term freshwater "states". Further modelling was undertaken to evaluate the extent of change was required to achieve 10, 25, 50, 75 and 100% of "Scenario 1"[19]. Whilst not directly forming part of PC1, the modelling was instrumental to informing decision-making by the CSG. It was also extensively used to support the S32 evaluation report.

96. The modelling outputs from the "100% of Scenario 1" scenario indicate that the TN concentration at the Waikato at Waipapa Tailrace is predicted to "only" reduce to 283 mg/m^3 [20] This represents only a 16% reduction from the "current state", significantly less than the 52% reduction required to achieve the 160 mg/m^3.

97. This situation also applies to other Upper Waikato River sites (at Ohakuri and Whakamaru). The long-term TN target at these sites was set at, or very close to, the 1863 modelled concentrations and neither of these sites come close to meeting the 160 mg/m^3 objective set in Table 3.11-1 under the "100% of Scenario 1" scenario.

98. The modelling report does acknowledge that some sites do not meet the concentration objectives (these are reported as "breaches" in the report[21]); however, the report does not specifically acknowledge that three of the four Upper Waikato mainstem sites fall well short of meeting the long-term TN "states". It also does not address the corollary question – what would need to happen in order to meet the long-term TN "states"? Similarly, the S32 evaluation report makes extensive use of the catchment modelling but does not seem to specifically raise the issue of achievability of the long-term TN "states" in the upper Waikato mainstem or answer the above question. In my opinion, the answer is simple, nitrogen losses from land in the whole catchment above Waipapa would need to return to levels at, or very close to, those of 1863.

[19] Report No. HR/TLG/2015-2016/4.2. Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments Assessment of second set of scenarios. 24 September 2015.
[20] C6. TLG 2015. Concentration data for CSG(3646804). Excel spreadsheet.
[21] Report No. HR/TLG/2015-2016/4.2. Evaluation of scenarios for water-quality improvement in the Waikato and Waipa River catchments Assessment of second set of scenarios. 24 September 2015. Page 36, Table 11.

99. No other part of the Waikato mainstem is required to return to 1863 levels. The long-term TN "states" for the middle and lower Waikato are 350 mg/m^3, i.e. about 2.3 times the estimated 1863 concentration (c. 150 mg/m^3 for the whole Waikato River mainstem).

100. To be clear, I am not saying the TN objectives for the Upper Waikato River are unsuitable, as these need to be determined by the community; however I am concerned that their implications in terms of land use restrictions may not have been fully assessed or clearly communicated (noting that NPSFM Policy CA2(f) specifically requires that implications for resource users be communicated). I am also concerned that significant smaller reductions in TN concentrations are required of other, lower sections of the Waikato River. Given the scale of TN reductions in the upper and middle Waikato mainstem respectively, it seems likely that, if the TN reductions in the upper catchment were achieved, then the middle catchment would only be required to make very small reductions (if any) in order to achieve the TN "states" at the Narrows and Horotiu monitoring sites.

101. In my opinion, there is a risk that, should the long-term TN "states" be maintained as they are, the upper Waikato catchment will be required to achieve proportionally much greater reductions in nutrient outputs than other parts of the catchment, potentially well in excess of its "fair share".

102. One option may simply be to set the level of TN reduction for the sites in the Upper Waikato FMU that currently are not in Band A at the same level as that required at the Waikato at Narrows, i.e. a 14% reduction from current concentrations. The short-term objectives can then be calculated as 10% of the difference between the current state and the long-term "state". The short-term objectives and long-term "states" for the Upper Waikato sites would become:

    (a) Waikato River at Ohakuri Tailrace: 208 mg/m^3 (short-term Objective) and 181 mg/m^3 (long-term State);

    (b) Waikato River at Ohakuri Tailrace: 267 mg/m^3 (short-term Objective) and 233 mg/m^3 (long-term State);

(c) Waikato River at Waipapa Tailrace: 331 mg/m^3 (short-term Objective) and 289 mg/m^3 (long-term State);

103. Ideally, the TN and TP long-term objectives for the Waikato River mainstem should be reviewed more in-depth, with a particular focus on the Upper Waikato River. The guiding principles of this review should include:

(a) An evaluation of the TN/TP reduction required within each FMU to meet the Chlorophyll-a objectives/states at the various locations along the Waikato River;

(b) A clear evaluation and communication of the land use implications or requirements to meet the TN and TP objectives.

104. In conclusion, I recommend that the TN and TP long-term objectives for the Waikato River mainstem be reviewed, with a particular focus on the Upper Waikato River. The guiding principles of this review should include:

(a) An evaluation of the TN/TP reduction required within each FMU to meet the Chlorophyll-a objectives/states at the various locations along the Waikato River;

(b) A clear evaluation and communication of the land use implications or requirements to meet the TN and TP objectives.

PRIORITISATION OF NUTRIENT MANAGEMENT

105. It is significant to note that several strands of technical evidence point to the fact that chlorophyll-*a* concentrations in the Waikato River appear to be primarily driven by the availability (concentration) of phosphorus, but much less so by the concentrations of nitrogen. For example, the recent water quality trends report published by WRC shows that Chlorophyll-*a* and TP concentrations in the Waikato mainstem have reduced significantly since 2003, in spite of increasing TN concentrations and concludes that “phytoplankton growth in the river is less dependent on

the availability of nitrogen"[22]. Similarly, bioassays indicate that the Waikato River water is "unlikely to be N-limited to phytoplankton growth", although the addition of both N and P elicited the largest growth response[23]. A further technical report[24] concludes that "chlorophyll-*a* is mainly responding to TP not TN in the Waikato River main stem under current conditions", although "occasional N limitation may occur during summer and autumn". Having reviewed these three reports in some detail, I agree with the conclusions drawn by the authors.

106. TTW objectives place a strong focus on the management of cumulative effects, avoiding further degradation and, importantly, adopting a precautionary approach. On that basis, it appears justified that PC1 places relatively strong management on nitrogen; however, phosphorus-specific provisions should be a priority in PC1, given the scientific evidence points to this nutrient being the key driver of chlorophyll-a in the Waikato River mainstem, and of water clarity (upstream of the Waipā confluence), and that chlorophyll-a and visual clarity are critical Attributes for a number of ecological, recreational and cultural values.

[22] Vant (2018). Trends in river Water Quality in the Waikato region, 1993 – 2017. Waikato Regional Council Technical Report 2018/30. December 2018. Page 12

[23] Report No. HR/TLG/2015-2016/3.1 Waikato River Bioassay Study 2013-14 - Assessment of nutrient limitation. Page 18.

[24] Report No. HR/TLG/2015-2016/3.6 Nutrients and phytoplankton (chlorophyll a) in the Waikato River. Pages 7 and 10.