To Hon David Parker, Minister for the Environment CC Hon Damien O'Connor, Minister of Agriculture, Biosecurity, Food Safety, and Rural Communities			Tracking #: 2018-B-04474
Security Level	In confidence	Number of Attachments 1	Titles of attachments 1. Science and the NPS-FM: Notes from an informal (ad hoc) discussion
Date Submitted:		Response needed by:	11 May 2018
MfE Priority:	Non-Urgent	Actions Sought:	Decision and Noting

Freshwater: Resolving NPS-FM science differences

Key Messages

1. An informal meeting recently took place between freshwater ecologists, some of whom have made contributions to the National Policy Statement for Freshwater Management (NPS-FM), and/or have been publicly critical of New Zealand's freshwater policy. Notes were taken during the meeting and shared with the Ministry for the Environment (MfE). The notes were also shared with the Land and Water Forum, who will discuss the content at their next Plenary Meeting on Thursday 26 April 2018.
2. This briefing provides a summary of the ecologist's discussion, accompanied by comment from officials on substantive points. The aim of the meeting was to comment on the science behind the NPS-FM, noting where the ecologists agree, provide their opinion of its strengths and shortcomings, and identify needs for policy development in the future.
3. The ecologists explain that in many cases their apparent disagreements are only a matter of degree. They acknowledge that some disagreements arose from misinterpretation of the NPS-FM. The meeting notes indicate that some minor confusion may still exist.
4. There appear to be many areas across which the ecologists do agree, including on the overall principle behind the National Objectives Framework, and the benefits of having a consistent nation-wide definition for ecosystem health. They also agree that weaknesses of the NPS-FM largely centre on the incompleteness of the existing national water quality measures (known as "attributes"), the lack of clarity and speed of future attribute development, and slow implementation progress by local government.
5. The ecologists consider that the NPS-FM needs additional attributes so as to manage ecosystem health. Our draft work programme partially addresses this as it prioritises work on sediment, heavy metals, ecological flows, and a framework for the holistic assessment of overall ecosystem health.
6. Our draft work programme does not currently prioritise development of other attributes. Officials can provide additional advice and recommendations on other attributes that can be developed, and the timeframes for doing so.
7. A Science Review Panel has been used in the past to advise officials on populating the compulsory attributes in the NPS-FM. The panel was last convened in September 2016.
8. This recent meeting presents a good opportunity to refresh the way we engage and collaborate with the freshwater science community in future. This could include identifying and prioritising additional attributes for development. The Ministry is currently considering the role of the Science Panel, with one option being to expand both its scope and membership.

Recommendations

9. We recommend that you:

   a. **Note** that areas of disagreement between these freshwater ecologists, regarding the science foundation of the NPS-FM, are not large.

   b. **Note** that the ecologists agree that the principle of the National Objectives Framework of the NPS-FM, in regards to having a set of values supported by attributes with national bottom lines, is appropriate.

   c. **Note** that the ecologists agree the National Objectives Framework needs improvement and expansion to additional attributes.

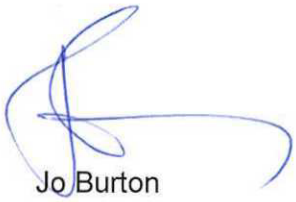
   d. **Note** that the Water Directorate has a work programme which will address some of the scientists' concerns, but would require reprioritisation to address all of the concerns raised.

   e. **Indicate** whether you require advice and recommendations on developing additional attributes, and the timeframes for doing so.

      Yes/No

   f. **Note** that the Water Directorate will be refreshing the membership and role of a Science advisory body to inform and test our ongoing work and help engage with the Science community.

Signature



23 April 2018

Jo Burton
Director, Water **Date**

Hon David Parker
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Freshwater: Resolving NPS-FM science differences

Supporting material

Context

1. This briefing provides a summary of key points from an informal meeting on 12 March 2018 between some freshwater ecologists who contributed to the NPS-FM and/or have spoken publicly about New Zealand's freshwater policies. Notes were taken during the meeting and shared with MfE. A full copy is attached as **Appendix 1**.
2. Views of officials are provided on the points raised, including whether our draft work programme will address these issues, or if there are opportunities to do so.

Meeting of freshwater ecologists

3. The aim of the meeting was to comment on the science behind the NPS-FM, noting where the ecologists agree, provide their opinion of its strengths and shortcomings, and identify needs for policy development in the future.

Table 1: Meeting participants

Name	Background
Dr Clive Howard-Williams	NIWA, Chief Science Advisor Natural Resources Chair of the Science Review Panel tasked with advising the Water Directorate on the National Objectives Framework and associated national values and attributes. The panel last met in September 2016.
Dr Mike Joy	Massey University, Senior Lecturer Awarded the Universities New Zealand 'Critic and Conscience of Society Award' for drawing attention to water quality issues (2017) Awarded the Royal Society of New Zealand's 'Charles Fleming Award for Environmental Achievement' (2013), for contributing to the sustainable management and protection of New Zealand's freshwater resources.
Dr John Quinn	NIWA, Chief Scientist – Freshwater and Estuaries Member of the project team commissioned to report on macroinvertebrate metrics for the NPS-FM, published in November 2017.
Dr Marc Schallenberg	Otago University, Research Fellow President of the New Zealand Freshwater Sciences Society, representing approximately 350 members.
Prof Russell Death	Massey University, Professor of Freshwater Ecology Member of the project team commissioned to report on macroinvertebrate metrics for the NPS-FM, published in November 2017. Contributing to the Assessment Framework for Ecosystem Health project (in progress).
Dr Scott Larned	NIWA Freshwater Science Manager Land Use Suitability Programme Lead for the 'Our Land and Water National Science Challenge'

Previous correspondence with meeting participants

4. Prof Russell Death and Dr Mike Joy are freshwater ecologists who have been publicly outspoken about water quality and ecology issues, including New Zealand's freshwater policy and the science that underpins it.
5. Prof Death wrote to you on 15 November 2017, concerned that he was being denied the opportunity to contribute to a closed Ministry tender because of his public criticism of the NPS-FM and associated science.
6. On 29 January 2018, Dr Joy provided your office with a written critique of the NPS-FM, in which he described his basis for disagreement with policy and the science. We provided notes to your office summarising this critique, and providing officials' views, on 31 January.

The National Objectives Framework

7. The NPS-FM sets out the National Objectives Framework (NOF), which requires regional councils to identify the 'values' that the community associates with the water bodies in their regions. These values must include the two compulsory values of ecosystem health and human health for recreation, as well as any other values the community holds, such as fishing or food production.
8. Councils establish freshwater objectives in order to achieve those values, and set limits on resource use in order to meet freshwater objectives (as illustrated in Figure 1 below). In doing so they consider the total quantum of resource that can be safely allocated, which encourages management of cumulative effects and should drive improvements. This contrasts to managing resource use on an *ad hoc* reactive basis only as consents are lodged, or in isolation of knowing the total quantum available for sustainable allocation.

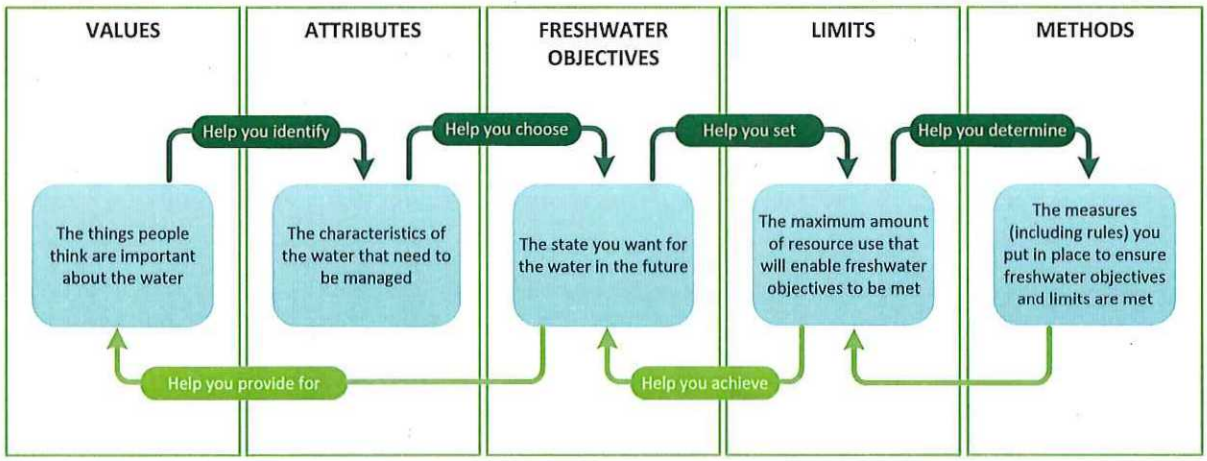


Figure 1: the National Objectives Framework process

9. The NPS-FM provides a set of measurable characteristics of freshwater (called attributes) that apply nationally, with which all councils must set freshwater objectives in their regional plan. To date these national attributes have focussed largely on characteristics that are already measured widely by councils, and represent the "low-hanging fruit" with regards to a combination of data availability to understand the current state nationally, and ability to associate changes in state with a relatively small range of important drivers.

The Science Review Panel

10. The Water Directorate has previously used a Science Review Panel (SRP) to develop and test the science underpinning the freshwater attributes in the NPS-FM, particularly during the 2014 amendments. The SRP comprised invited science representatives from academia, CRIs, iwi and regional councils and was assisted by officials. The SRP last

met in September 2016 and did not contribute substantially to the 2017 NPS-FM amendments.

Analysis and Advice

11. The meeting covered discussion of the overall approach of the NPS-FM, existing NOF attributes, and their recommendations on potential future attributes. It is notable that they only had one specific area of disagreement, and agreed on the overall principle behind the NOF.

12. The scientists are all freshwater ecologists, and their comments focus on this aspect of science and policy. They agreed that they do not have the expertise to comment on the *E.coli* attribute, or the human health for recreation value more generally.

13. Differences of opinion are common in science fields with a high degree of complexity and uncertainty, such as applied ecology. The freshwater ecologists recognised that such disagreements are a healthy part of advancing good science. In some cases they acknowledge the apparent disagreements were small, or the result of confused communication or interpretation of the policies, rather than in the science itself.

Notable areas of support for the NPS-FM

14. The ecologists agreed with the overall principle behind the NOF approach: having a set of values supported by specific attributes with national bottom lines, and requiring limits to be set on resource use. This support is contingent on a holistic evaluation of the extent to which values are being provided for. This is expressed in the NPS-FM, and the Water Directorate has a project aimed at informing holistic ecosystem health assessments.

15. The ecologists also recognised that a strength of the NPS-FM is its nation-wide application, which promotes a consistent, strong and broad compulsory value for Ecosystem Heath. They supported the definition of ecosystem health in the NPS-FM.

Observed areas of weakness of the NPS-FM

16. Observed weaknesses of the NPS-FM were largely centred on the incompleteness of the existing national attributes, lack of clarity and speed of future attribute development, and slow implementation progress by local government. Key points from the meeting are summarised in Table 2 with accompanying comments from officials, including the extent to which these issues are addressed by the draft work programme emailed to your office on 10 April, and discussed with you on 12 April 2018.

Table 2: Synthesis of meeting participants' discussion of the NPS-FM

Synthesis of participants comments	Information, and Officials comments
The current range of attributes in the NPS-FM is not sufficient to provide for ecosystem health. Important measures such as sediment, dissolved oxygen (non-point source), temperature, pest species and habitat (e.g. connectivity and flow) should be included.	Dr Joy emphasised this when he wrote to you on 29 January 2018, providing an example of how a waterbody could be in the best (A grade) band for all the attributes in Appendix 2, but still be considered to have poor ecosystem health overall. At present, Councils must identify additional attributes, or develop other methods to provide for values like ecosystem health that are appropriate for the specific waterbodies they are managing. Regional Councils also have other management instruments available to them beyond the NPS-FM. Officials agree that to provide for values like ecosystem health it is insufficient to only manage the parts of the ecosystem that relate to the current attributes in the NPS-FM. Work is ongoing to inform potential future national level attributes for sediment, as well as other

Synthesis of participants comments	Information, and Officials comments
	instruments such as guidance. As an example of this, MfE participated in developing the recently published 'NZ Fish Passage Guidelines' to encourage better management of habitat connectivity. **Partially addressed by our work programme. Development of a sediment attribute is continuing. Ongoing research includes work on a flow metric and a fish prey index.**
The existing attributes in the NPS-FM have focussed on those that are relatively easy to develop, but progress has been slow adding other important but more complex attributes. Implementation by local government has also been slow. There is a lack of clarity about which attributes will be developed in the future, and no clear milestones to track progress.	The ecologists acknowledge that new attributes will potentially be more difficult or complex to develop than those already in place. This has contributed to the perception of slow progress. Notably, the ecologists recognised that even in cases where the science is less than adequate, management decisions must still be made. However they did not acknowledge the difficult position of councils having to defend their decisions through the appeals process. While there have been no new attributes added to the NPS-FM since 2014, a number of current and planned research projects could contribute to future attribute development. This includes research on wetlands, additional water quality measures such as temperature and dissolved oxygen, fish abundance and habitat, and toxic algae in rivers. The Science Review Panel was last convened in September 2016. Refreshing the way we engage and collaborate with the freshwater science community would improve clarity of the work, and may help address perceptions of slow progress. **Partially addressed by work programme. The Water Directorate is considering convening a Science Panel for advice, and to improve the clarity of our work programme**
An incomplete list of attributes in the NPS-FM risks inappropriately focussing management efforts, at the expense of the broader goal of 'Safeguarding life supporting capacity' (part of the purpose of the Resource Management Act 1991).	Ministry guidance is clear that the NPS-FM does not provide an exhaustive list of all measures to manage to provide for values like ecosystem health. Nor is an attribute's inclusion in the NPS-FM meant to imply they are the most important characteristics to manage for ecosystem health in any specific waterbody, or that council's broader responsibilities under the Resource Management Act 1991 are of lesser importance. The Water Directorate has procured advice on a framework for assessing ecosystem health, with the aim of describing the range of characteristics necessary to evaluate the extent this value is provided for. This could inform policy or guidance to address the risk the ecologists describe. **Addressed by work programme, work on holistic ecosystem health indicator is ongoing**
Lack of acknowledging multiple stressor effects, including climate change.	Ecosystems are extremely complex, comprising different organisms interacting with each other, and with all the other stressors and characteristics of their environment. For the sake of simplicity and usability, the NPS-FM considers the effects of single attributes on a value such as ecosystem health, in isolation of other stressors. Multiple stressor effects are addressed by requiring monitoring not only of specific attributes, but also evaluation of the extent overall values are being achieved. The 2017 NPS-FM amendments require councils to monitor the extent they are providing for ecosystem health, using holistic measures that integrate multiple stressors, such as macroinvertebrates and indigenous flora and fauna (i.e. fish). **Partially addressed by existing Policy. Ongoing work on holistic ecosystem health indicator will assist council implementation**

Synthesis of participants comments	Information, and Officials comments
Lack of attributes covering Māori values	The NPS-FM contains no compulsory attributes specific to Māori values, and none are proposed in the work programme. However, Māori values were accounted for in developing the existing attributes through interaction with Iwi Leaders Groups. The Ministry has also been working with Māori to develop indicators for environmental reporting that could potentially be incorporated into freshwater management. To become attributes that achieve the desired outcomes, additional work would be required to link metrics to actions on land or in waterbodies, and limits on resource use. This would depend on Crown/Māori relationship to inform further work. **Not addressed by the draft work programme at this stage**
Lack of guidance on how to interpret band grades with regards to maintaining water quality, and concern that some attribute bands are so broad so that water quality variability within the band could represent a real degradation. The ecologists also expressed concern that the approach to develop attribute bands is not transparent, and that inconsistent approaches have been used for different attributes. They consider there is a need to adopt a single, rigorous approach.	The Ministry published a fact sheet to accompany the 2017 amendments describing that 'maintaining' water quality means staying within the boundaries of a band. Most of the existing attributes, bands, and bottom lines were developed with the LAWF and informed by the Science Review Panel. This process involved making value judgments as to where to draw the band boundaries. There is a trade-off between having precise bands, and the number and complexity of bands in the attribute tables and whether it's appropriate for directing regional council policy. It may not always be appropriate to adopt a single band development process to cover all types of attributes; this may be the case for a sediment attribute. Bands for some attributes may need to be tailored to categories of environmental condition. **Guidance does exist, likely there is a role for a refreshed Science Review Panel to advise on bands**

Area of apparent disagreement

17. The only area of apparent disagreement concerned the management of nutrients and periphyton. Dr Joy has previously expressed concern that the nitrate attribute only manages the effects of toxicity, rather than effects from it being a nutrient. This is correct, however the NPS-FM does include an attribute for managing periphyton that requires limits to be set on nutrients.

18. The 2017 amendments to the NPS-FM included text to further clarify the periphyton requirements, and technical guidance is being prepared to help councils set nutrient limits. However, this meeting of ecologists could not agree that periphyton was the only nutrient effect that required management. Some members of the group considered that the relationship of nutrients to invertebrates and fish health should also be addressed.

Key issue of concern: Water Directorate work programme to develop new attributes

19. The ecologists consider the NPS-FM needs additional national attributes to manage ecosystem health. Officials agree that all the attributes they identify in Section 4 of their meeting notes (in Appendix 1) are important. Management of these is left to individual regional councils at present.

20. Prior to February 2017, the Ministry for the Environment had a work programme to develop other national attributes, including temperature and dissolved oxygen. However, this work was paused to focus on implementation of existing policies, and finalising amendments to the NPS-FM.

21. Our draft work programme partially addresses concerns the ecologists raise. It prioritises work on sediment, heavy metals, ecological flows, and a framework for the holistic assessment of overall ecosystem health.

22. Officials can add development of other attributes to the draft work programme, and can provide you with advice and recommendations on the range of attributes that can be developed, and the timeframes for doing so. Note this will require reprioritisation of other work, or additional resourcing.

23. Note some of the attributes the ecologists propose are more complex and difficult than those developed previously. This may be due to poor data availability, or that they are subject to multiple drivers which could make it more difficult to predict the degree that investment in mitigation can achieve freshwater objectives. Other policy mechanisms might also deliver better outcomes.

Next Steps

24. The ecologists generally agree on the strengths and weaknesses of the NPS-FM. Some of the issues raised are already the subject of existing guidance. This suggests that the delivery of this message could be improved. Officials will consider other ways we can help stakeholders understand what the NPS-FM does, what it requires, and best practice.

25. There is an opportunity to refresh the way we engage and collaborate in order to involve the freshwater science community more broadly. This could include identifying and prioritising additional attributes for development. The Water Directorate is currently considering the role of the Science Panel, with one option being to expand both its scope and membership. Topics for the refreshed Panel to consider could include:

    - The relevance for management purposes of the relationship of nutrients to periphyton, as opposed to fish and invertebrates
    - Attribute bands
    - Management and decision making, given uncertainty
    - How to use holistic measures of ecosystem health to evaluate policy outcomes
    - The work required to develop additional attributes for the NPS-FM, or another policy instrument

Appendix 1: Science and the NPS-FM – Notes from an informal discussion

Science and the NPS-FM: Notes from an informal (ad hoc) discussion

Venue: Massey University; Date: 12 March 2018

Participants: *Dr Clive Howard-Williams (NIWA Chief Science Advisor Natural Resources), Mike Joy (Senior Lecturer, Massey University), Dr John Quinn (NIWA Chief Scientist - Freshwater and Estuaries), Dr Marc Schallenberg (University of Otago and President of NZ Freshwater Sciences Society), Prof Russell Death (Massey University) and Dr Scott Larned (NIWA Freshwater Science Manager)*

1. There have been recent comments made referring to apparent disagreements amongst scientists regarding perceptions of the NPS-FM.
2. We recognize that technical disagreements amongst scientists are a healthy feature of good science but, because of the important nature of the freshwater debate, the scope and substance of any scientific disagreements needs to be clarified. In many cases the apparent disagreements are matters of degree and, in some cases, result from confusion in the way the policies have been presented.
3. We recognize that science is one (usually initial) step in policy formulation. Subsequent steps include: stakeholder advice regarding practicalities of implementation; assessments of economic consequences; and ensuring that the policy is in accordance with other legislation and is legally valid and enforceable.
4. Therefore, as scientists we need to be aware that what might appear as good science initially may not always end up in policy. However, we agree that it is imperative that the initial starting point for science-based policy is that the science retains scientific integrity and is as robust as possible.
5. We, as an *ad hoc* group of interested scientists, had no formal mandate to seek agreement on the NPS-FM and the NOF, but wished to provide constructive commentary on the science (recognizing practical and legal considerations) behind the NPS-FM (2017), its advantages and shortcomings, and to clarify the apparent disagreements mentioned in point 1.
6. At a preliminary meeting in November 2017, our group agreed that a process of clarification could be initiated by holding a small workshop among the participants listed above and documenting our comments in the form of meeting notes.
7. We recognize that others may choose to consider the points we have made in these meeting notes as part of developing their own thoughts and comments on the NPS-FM and the science behind it.

Meeting Goal:

To provide constructive commentary on the science behind the NPS-FM (2017) and in particular behind the National Objectives Framework (NOF), and its strengths and shortcomings. We aim to document where there is agreement between us and where there is still work to be done, and to comment on potential future developments of the policy.

Meeting Deliverables:

- Provide comment on 'Scene-setting Questions' relating to the NPS-FM.
- Provide comment on each of the existing attributes of the NOF
- Provide comment on any proposed attributes listed below (and others that may arise during the workshop) to extend the NOF.
- Ensure that, where there is no unanimous agreement, this is documented
- Provide a set of meeting notes amongst the group

Next Steps:

- One or more follow-up meetings of this group may be appropriate to extend or refine our discussion and address topics raised in the first meeting.
- As we have no mandate to develop a set of formal comments, we will circulate the meeting notes as "Informal Statements" firstly amongst the group. Once the meeting notes are approved by the group, they may be forwarded to interested parties with agreement of the group.

Comments:

The meeting covered three aspects:

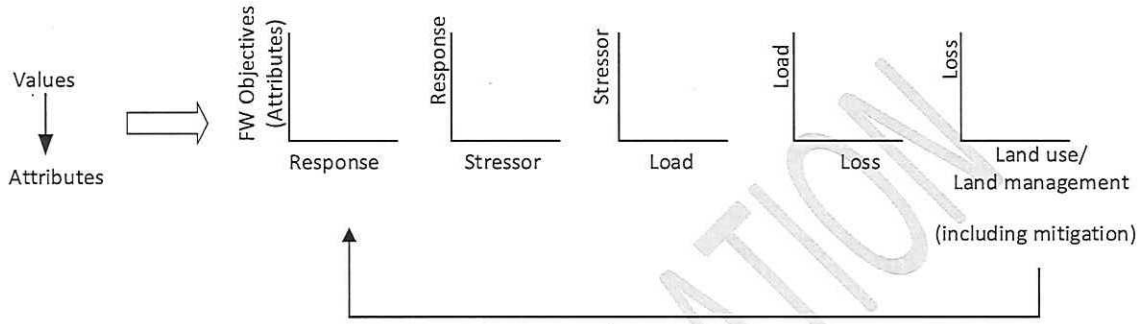
1. Scene-setting questions on the NPS-FM;
2. Specific Questions on the NOF that may not have been covered above;
3. Systematic coverage of the existing attributes in the NOF and additional attributes that may be considered for inclusion in the NPS-FM. In the time available we did not complete discussions on the list of proposed attributes.

The meeting was held in a collegial atmosphere and the notes below reflect the main points of the (often extended) discussions on each of the questions and the individual attributes.

1. Scene-setting questions on the NPS-FM

Scene-setting questions	Comments
1. What are the strengths and weakness of the NPS-FM and its underlying processes in relation to its potential to make change to freshwater quality and ecosystem health.	NPS Strengths • Sets limits for controlling degradation due to cumulative effects of resource use • Nation-wide application (but for some attributes, bands will need to be set for specific environmental classes) • Encourages catchment-scale perspectives in freshwater management • Effective limit setting processes will result in landuse & discharge management that drive improvements • Involves communities in identifying values and setting objectives for waterways • Promotes strong and broad compulsory values • Promotes a definition of a National Values concerning Ecosystem Health and Human Health • Stronger recognition of Maori values and co-management than previously Weaknesses • Roll out has focused on relatively easy, nationally applicable *E. coli*, nitrate toxicity and ammonia toxicity attributes, while progress on other important attributes has been lagging • Slow progress on attributes concerning nutrients for periphyton and macrophyte management, which may require environmental classifications • Slow progress on sediment, DO, temperature and habitat attributes • Lack of consideration of the importance of physical habitat (e.g., connectivity and flow) • No inclusion of biosecurity (pest species) attributes and no explanation as to why not (as per the ecosystem health compulsory value) • Lack of clarity about all attributes to be developed in the future. Clear milestones are needed to track progress • Risk that people will focus on few attributes in NPS tables and forget RMA requirement on "Safeguarding Life Supporting Capacity" • Lack of attributes covering Maori values that relate to ecosystem health (eg mahinga kai) • Lack of acknowledgement of multiple stressor effects (including climate change) and how these might affect limit setting • Lack of guidance about how to interpret various band grades as overall acceptability • Apparent slow uptake within Regional Councils in adopting community agreement on the freshwater objectives corresponding to the bands they want

	• Greater transparency is needed regarding the approaches used to derive all the attribute bands with guidance as to how the limits/bands were to be derived (attempt to bring some consistency to the process for future attributes). Perhaps consideration of degree of uncertainty around the bands? • Different approaches have been used to develop the existing attributes and to set bands (e.g., pressure-response relationships, percentiles of response variable data). Need to adopt a single, rigorous process (See Q 5 below).
2. Is limit-setting the best method to deal with cumulative impacts of land use and the problems of 1st-come 1st-served in the consenting process?	• Setting limits is a key step required in any kind of robust management approach • Not ideal for coping with biosecurity issues and needs a framework for multiple stressors • Weak connection between NPS-FM and National Coastal Policy Statements. Better alignment is needed (advice on freshwater impacts on coast needs to be strengthened) • Needs guidance for generating the data and knowledge required for linking load limits and land management to freshwater objectives and attributes (see diagram below) • Lack of technical and financial support for grassroots community/Maori input to NPS-FM collaborative processes vs. industry groups • There is a need to improve how science informs the collaborative process including deriving freshwater values as well as technically linking these values to stressors. We agreed that "Scott's cascade diagram" below is a useful way of looking at this. • We note the current review of collaborative progress underway in the National Science Challenge Our Land and Water; this review addresses the identification of values and objectives, but does not address other steps in the cascade diagram • Need improved access to existing land use data (as opposed to Land Cover data) including mitigations (e.g., wetlands, riparian buffers, exclusion fencing) to allow interpretation of the cascade diagram below • Need to consider the link within the NPS-FM (particularly nitrogen limits) and greenhouse gas mitigation

	
3. Does the cascade of processes (in diagram above) that links values through objectives, stressors and limits to land-use (and infrastructure – eg. WWTPS) require further thought?	• The cascade of relationships linking land use/land management practices to freshwater objectives is a useful conceptual model highlighting the science needed to robustly link land use practice to freshwater objectives, but there are many gaps in data and knowledge and there are serious challenges in accurately modelling the entire cascade • Decisions must be made in cases where the science is inadequate. How should this be done and what level of uncertainty is considered acceptable? Is a limit developed with a high degree of uncertainty better than no limit at all? • The cascade approach leading to land use or infrastructure management is difficult to reconcile with aquatic biosecurity issues and with climate change issues
4. Do we agree on the <u>principle behind</u> the National Objectives framework - having a set of values supported by attributes with national bottom lines?	• OK but needs to be balanced by an holistic approach (i.e., multiple stressor issue and also the multi-dimensionality of the concept of ecosystem health as defined by the Compulsory Value) • Management by attributes alone will not meet the holistic nature of freshwater management • We note the intent to ensure that the holistic approach expressed in the NPS-FM Ecosystem Health value is reflected in Regional planning
5. If so, how can the NOF be improved? (see NOF Questions 1 – 3 below to take this further)	• Some attribute bands are broad so there may be issues if water quality is allowed to vary within a band • Where possible, there needs to be consistency in how bands are developed across attributes • These need to be strongly data driven and transparent using appropriate data with expert assessment where necessary • It is likely that many of the new attributes will need to be applied with environmental classification systems

	• We are concerned over a lack of detail in the requirement in the NPS to 'maintain or improve' water quality state as measured by NOF attributes and, in particular, whether this means maintaining water quality within a band as opposed to maintaining 'current state' • "Maintain or improve" needs to be clearly defined and procedures developed for testing whether attributes are being maintained, improved or degraded. • Science advice will vary depending on whether the "maintain and improve" requirement is applied to individual monitoring sites, groups of sites or entire FMUs, and whether "maintain and improve" applies to each attribute or to selected attributes (eg., the attributes that are in the lowest band) • We believe that 'maintain or improve' should apply to each attribute individually (not just the lowest one)
6. If not, what would replace this?	We agreed that the NOF concept was valid but that it needed improvement and possibly expansion as per notes above and below.

2. **NOF Questions**

NOF Questions 1-4	Comments
NOF Q1: Is there a case for further attributes that have complex interactions with the environment such that land use is only one factor determining the attribute state?	Yes – see notes above and below.
NOF Q2: Is there a case for development of attributes that have little to do with land use or infrastructure but strongly influence ecosystem health as a value?	Yes – need consideration of freshwater biosecurity
NOF Q3: Is there a case for attribute band thresholds to be derived from percentiles of existing data (eg. ANZECC Guidelines) and not through calibration against land use?	Difficulties with ANZECC approach were recognised (from 80 percentiles for "unimpaired sites"; not effects-based). See notes in scene-setting Q3above re land use. We recognise that there are both direct attributes resulting from land use that affect ecosystem health and indirect effects such as chlorophyll *a*, DO, etc. Often the indirect effects of land use (eg., periphyton Chlorophyll, DO) are more closely associated with ecosystem health). In addition, there are other stressors not directly linked to land use that interact with land use to impinge on ecosystem health (e.g., pest species, climate change). The inclusion of stressors that end up as attributes may not need to be limited only to those that can be "sheeted home" to land use.
NOF Q4: Is there a case for environmental classification of water bodies to allow NOF bottom lines and band levels to vary spatially (ie. with climate, hydrology, geology).	Yes, bands for some attributes may need to vary across environmental classes to account for natural variability (eg. in geology, morphology, mixing, residence time). For example, the NOF attributes for lakes already consider a few classes, based on mixing regimes and salinity. We are aware of potential difficulties in management and planning if too many classes are invoked. For attributes with predominantly physiological effects (eg., nitrate toxicity, hypoxia), national bands may be sufficient, without classification of receiving environments

3. Existing Values and Attributes in the NOF

Existing Values	Comments
Ecosystem Health	We support the definition and note the holistic concept implied in the Ecosystem Health value but current attributes are not comprehensive enough to reflect that value. The NOF currently includes attributes that are drivers of others (responses) which may in turn be drivers of higher trophic responses. There may be room for discussion on the definition of Ecosystem Health in the future
Human health	Human health – definition good
Existing attributes	**Comments**
a. Value: Ecosystem health	
i. Lakes including ICOLLS (Trophic state)	
1. Phytoplankton Chlorophyll a	Group OK with lakes attributes and bands
2. Total N	Group OK with lakes attributes and bands
3. Total P	Group OK with lakes attributes and bands
ii. Rivers	
1. Periphyton (Trophic state) Chlorophyll a (noting nutrient-related footnote)	• Group agreed that we can live with current bands as long as DO and invertebrate attributes are also enacted, and the periphyton attribute is subdivided into multiple river environment classes. • Ensure that the NPS-FM process for assigning "periphyton productive class" (eg. - REC dry/soft & volcanic geology Classes) is followed correctly. Productive refers to naturally nutrient-enriched river reaches with low frequencies of bed-moving floods, not reaches that are enriched due to local land use. • We note the current MFE-funded study on the NOF periphyton note for setting DIN & DRP levels.

2. Nitrate (Toxicity)	• We are concerned about the potential for misinterpretation of the NO_3 toxicity attribute as an ecosystem health attribute. Nitrate toxicity only accounts for part of the effects of nitrogen enrichment on ecosystem health. It is highly likely that lower DIN levels are needed to protect ecosystem health effects via eutrophication.
3. Ammonia toxicity	• Group OK with attributes and bands
4. Rivers (below point sources) Dissolved Oxygen (DO)	• Dissolved oxygen is a fundamental measure of ecosystem health. Need to deal with independent effects of periphyton/macrophyte biomass on DO (possibly with modelling). • Concern about negative effects of both hypoxia and hyperoxia . • Recommend DO attribute be applied across all river sites – need to have an environmental classification to allow for natural deoxygenation in flood plains. • In addition to DO in rivers, we recommend considering DO in polymictic lakes and stratified lakes. May need environmental classification to distinguish lakes with natural versus anthropogenic hypoxia.
b. Value: Human health for recreation	• This group of ecologists don't want to go outside our expertise, so no comment.
i. Lakes and Rivers	
1. *E. coli*	As above
ii. Lakes and lake-fed rivers	
1. Cyanobacteria-Planktonic	Seems reasonable

4. Proposed Attributes in the NOF

	Ecosystem type	Attribute	Comment	Further discussion
4.1	**Rivers: (Mike's table)**	Deposited sediment	Crucial measure and protocols available. With MfE for development of the attribute	In progress, we reserve judgement
		Water quantity (Natural flow regime/ecological flows)	In irrigated areas, flows and levels are crucial variables and environmental flows need to be set.	We encourage reconsideration, updating and possible finalisation of the NES on Environmental Flows and Levels
		Pest species	At some sites very important Biosecurity not included in NPS	Need to link NPS-FM to Biosecurity 2025 (National Direction Statement)
		Macrophytes	At some river sites very important With MfE for further consideration	To be discussed as ecosystem health indicator at a later date
		Fish IBI	Protocols and fish IBI data available	To be discussed as ecosystem health indicator at a later date
		Heavy metals	Unknown importance but levels are increasing at some sites. LaWF (Cu, Zn under discussion)	In progress - meeting with science advisors, MfE and EPA staff in April to update on status of potential attribute
		Habitat quality	Protocols available Referred to in LaWF 2nd report	MfE let a contract to Cawthron on scoping habitat modification to be delivered in May 2018.
		Phosphate (DRP)	Key nutrient for periphyton growth	Work is underway with MfE to develop numeric attribute states for DRP in relation to periphyton abundance. Death et al. (ms) have recommended concentrations for DRP using a weight of evidence approach comparing DRP with invertebrate, fish and periphyton metrics We note that the group were not able to agree whether the best approach for developing a DRP attribute is based on DRP-periphyton relationships alone, or DRP-invertebrate/fish/periphyton relationships.

		Macroinvertebrates (MCI)	Included but levels set too low	To be discussed at a later date
		Nitrate	Key nutrient for periphyton growth. Currently Included for toxicity only hence relevant to only a few sites.	Work is underway with MfE to develop numeric attribute states for DIN (which is predominately nitrate-N in most waters) in relation to periphyton abundance. Death et al. (ms) have recommended concentrations for nitrate using a weight of evidence approach comparing nitrate with invertebrate, fish and periphyton metrics. We note that the group were not able to agree whether the best approach for developing a DIN attribute is based on DIN-periphyton relationships, or DIN-invertebrate/fish/periphyton relationships.
		Benthic cyanobacteria	Potential to kill children, known to kill dogs	With MfE (rivers only) for further work

4.2	**Rivers and lakes: -other proposals**	Fine sediment (suspended)	Issue for water clarity - Currently with MfE	In progress, we reserve judgement
		Dissolved Oxygen at all sites	Important ecosystem health measure. Complex relationship to land use – Currently with MfE	See preceding notes on DO in Table 3
		River pH	Important ecosystem health measure. Complex because of natural processes. MfE has considered. Difficulty due to technology	No discussion
		River nutrients as drivers of periphyton	How far can we go? Can we use the REC to constrain natural variability? Preliminary investigation by MfE – could be investigated further with appropriate river classification	Need to await results of current MfE project (due June 2018)
		River macroinvertebrates	New quantitative measures to supplement MCI is underway with MfE	Recognise that JQ and RD are on the microinvertebrate expert panel. Progress is being made.
		River phytoplankton	Do we need a river trophic state indicator for rivers that do not support periphyton? Preliminary investigation – by MfE	No discussion held
		River temperature	Important ecosystem health measure. Complex relationship to land use. MfE has modelled this	No discussion held
		Lake dissolved oxygen	Complex because of natural deoxygenation processes. Has been considered. No longer on agenda	No specific discussion held but see note under River DO in Table 3 above

		ICOLL-specific attributes	Lack of good data. MfE's ICOLL Expert Group	No discussion held
4.3	**Wetlands: (MFE proposal)**	Planktonic Chlorophyll a	Lack of data and robust relationships between ecosystem health constrains further progress	No discussion held
		TN	As above	No discussion held
		TP	As above	No discussion held
		Sediment	As above	No discussion held
		E.coli (2ndry contact)	Could be inserted – but note wildfowl issue with natural *E.coli* levels.	No discussion held
4.4	**Groundwater: (MfE proposal)**	Salt intrusion		No discussion held