Freshwater Science and Technical Advisory Group:

26 February – priority paper compilation

Paper Author	Various	Classification	**Confidential**

Meeting date	26 February 2019	Agenda item (number)	

Contents:

Papers not in compilation - please see portal:

Agenda Item	Title
4	Briefing note: Managing all aspects of Ecosystem Health (on portal under Joint freshwater advisory group page)
6	Nutrients - short summary with suggested reading, sent by email 28 January 2019. The longer summary paper on page 29 expands on this.

Science and Technical Advisory Group Meeting

Agenda

Dates and Location: Tuesday 26 February 2019 9.30am-4.00pm, Room 1A (Matairangi), Ministry for the Environment, 23 Kate Sheppard Place, Thorndon.

STAG Members present: Adam Canning, Bryce Cooper, Chris Daughney, Clive Howard-Williams, Dan Hikuroa (TBC), Graham Sevicke-Jones, Ian Hawes, Jamie Ataria (TBC), Jenny Webster-Brown, Joanne Clapcott, Jon Roygard, Mahina-a-Rangi Baker, Marc Schallenberg, Mike Joy, Russell Death, Ra Smith.
Additional participants: Cathy Kilroy, Chris Nokes

Apologies: Ken Taylor, Bev Clarkson, Tanira Kingi

Items:

	8.30 am	*Coffee and tea*	(30 mins)
1.	9.00 am	Previous meeting minutes and actions arising, apologies (Bryce Cooper)	(15 mins)
2.	9.15 am	Report back on Maintain or Improve small group session	(15 mins)
3.	9.30 am	Dissolved oxygen	(10 mins)
4.	9.40 am	Ecosystem Health	(50 mins)
	10.30 am	*Morning tea*	(10 mins)
5.	10.40 am	Flows	(30 mins)
6.	11.10 am	Nutrients a) Introduction by MfE staff b) Short presentations with time for questions: Chris Nokes, Cathy Kilroy, Russell Death, Ton Snelder	(1 hour 20)
	12.30 pm	*Lunch*	(30 mins)
	1 pm	Nutrients continued	(2 hours)
	3 pm	*Afternoon tea*	(10 mins)
	3.10 pm	Nutrients continued – with time to collate thoughts to report to other groups	(1 hour 50)
	5.00 pm	*Meeting close*	

Papers distributed in compilation:

Agenda Item	Paper	Confidential?
1	Agenda and meeting minutes from 24 January	Yes
2	Maintain or Improve update - No paper	-
3	Dissolved oxygen update - No paper	-
4	Ecosystem Health	Yes
5	Flows	Yes
6	Nutrients (longer summary)	Yes

Papers distributed separately:

Agenda Item	Paper	Confidential?
4	Briefing note: Managing all aspects of Ecosystem Health (on portal under Joint freshwater advisory group page)	Yes
6	Nutrients (short summary with suggested reading – sent by email 28 January 2019)	Yes

Action register

Meeting date	Action	Who	Due date	Status	Comment
26-Jan-19	Officials to follow up with Adam, Mike, Ton, Clive, Jon, Bryce for further work on “maintain or improve” subgroup	Nik Andic	26-Feb-19	Complete	Workshop held 15/2/19; group to report back at meeting on Feb 26
26-Jan-19	Officials to send STAG nutrient documents ASAP	Jen Price	30-Jan-19	Complete	Sent 29 January
26-Jan-19	Officials to circulate Ton Snelder's flows paper	Jen Price	30-Jan-19	Complete	On portal 29 January
26-Jan-19	At-Risk Catchments team to follow up with group members for future work	Oscar Montes de Oca Munguia	26-Feb-19	Complete	
26-Jan-19	Officials to continue discussion on definition of ecosystem health by email	Carl Howarth	26-Feb-19	Complete	
26-Jan-19	Present results of ecosystem health prioritisation at joint workshop on 30 January	Mike Joy	30-Jan-19	Complete	
26-Jan-19	Officials to provide worked examples to inform sediment discussion - (1) worked example to help the group consider whether to support the decision to base attributes on rolling medium-term (~2 years) measures of central tendency; (2) comparison of how continuous suspended sediment data compare to monthly sampling, across several rivers; (3) worked example of the analytical framework relating annual sediment load to environmental state variables in attribute tables; (4) more information or analysis on the 2-year period for medians. Horizons to provide data	Stephen Fragaszy	26-Mar-19	Incomplete	

Meeting date	Action	Who	Due date	Status	Comment
26-Jan-19	Officials to amend Threatened Species value to incorporate suggestions from group	Kirsten Forsyth	26-Feb-19	Incomplete	
26-Jan-19	Investigate inclusion of third column in attribute table for mean dissolved oxygen	Jen Price	26-Feb-19	Incomplete	
26-Jan-19	Circulate papers on ecosystem respiration and gross primary productivity – to be discussed at future meeting	Jen Price	26-Feb-19	Incomplete	
26-Jan-19	Officials to provide further information on ecological responses to sediment when NIWA work is complete	Stephen Fragaszy	26-Mar-19	Incomplete	
29-Nov-18	Officials to provide a worked example of "maintain or improve" to sub-group	Nik Andic	26-Feb-19	Incomplete	Sub-group will report back to main group again following consideration of worked example. This will likely be at 26 March meeting
18-Oct-18	Officials to keep group up to date with climate policy developments	?	Ongoing	Incomplete	

Essential Freshwater Roadmap

Key:
Red: Ministerial decisions and meetings
Orange: Advisory Groups
Blue: Internal Processes
★: Briefings and advice

2019 — Feb | March | April | May | June | July

At Risk Catchments

- Collect national level information
- Exemplar case studies, test possible interventions
- ★ Decisions on exemplars
- ★ National catchment vulnerability and risk maps
- ★ Controls on intensification etc in ARCS (Ag package)

Fair Allocation

- Draft blueprint
- Preparation of Cabinet papers and consultation material
- Cabinet Process
- ★ Initial proposals
- ★ First draft of blueprint
- ★ Feedback from advisory groups
- ★ Draft Cab Paper and RIS
- ★ Final Cab Paper and RIS

National Direction

- Develop policy options
- Preparation of Cabinet papers and consultation material
- Cabinet Process
- Provide advice and seek final decisions
- ★ Maori values/Te Mana o te Wai decisions, Exceptions
- ★ Draft Cab Paper and RIS
- ★ Nutrients, dissolved oxygen
- ★ Ecosystem Health
- ★ Final Cab Paper and RIS
- ★ Sediment, Agriculture package
- ★ Wetlands
- ★ Nutrients, outstanding issues
- Drafting NPS/NES

Public Consultation

Ministerial Meetings

- *13/14 March*
  - Overview of Essential Freshwater Package
  - Te Mana o te Wai
  - Allocation
- *2 April*
  - Nutrients
  - Exemplars
- *1 May/2 May*
  - Sediment
  - Agriculture package
  - Allocation
  - Wetlands
- *30 May*
  - Cabinet papers
- *13 June CAB*
- *6 June*
  - TBC
- *13 June CAB* Back up
- *Late February* Budget Ministers consider Treasury advice on Productive and Sustainable Land Use Package
- *Early March* Cabinet Committee considers rec from Budget Ministers
- *18 April*
  - Te Mana o te Wai
  - Ecosystem Health
- *9 May*
  - Nutrients
  - Outstanding issues
- *13 June*
- *13 June* CBC (Final back up)
- *13 June DEV* (Back up)
- *From mid- March* Possible bilateral meetings on budget package
- *Beginning May* Joint Ministerial Oversight Group on Budget Implementation

Advisory Networks

- Freshwater Leaders' Group, Kahui Wai Māori, and Science and Technical Advisory Group providing input into development of policy options
- Independent Advisory Panel convened
- *26, 27, 28 February* FLG: Overview, Ag package, nutrients; KWM: RM reform, Te Mana o te Wai; STAG: Nutrients. Flows. Ecosystem Health
- *16, 17 April* FLG: Sediment, national direction final decisions, allocation; STAG: National direction final decisions
- *29, 30 April* KWM: Allocation, national direction final decisions
- *19, 20 March* FLG: NPS/NES package (wetlands, ecosystem hlth), allocation; KWM: Te Mana o te Wai, allocation, RM reform
- KWM Report back
- *8, 9 May* FLG: Discussion document, allocation
- *26 March* STAG: Sediment, ecosystem hlth, wetlands
- *28, 29 May* KWM: Discussion document, allocation
- Engaging core sector stakeholders (primary, generators, ENGOs)
- Ongoing engagement with Freshwater Leaders' Group, Kahui Wai Māori, and Science and Technical Advisory Group

Science and Technical Advisory Group Meeting

Minutes

Dates and Location: Thursday 24 January 2019 9.30am-4.00pm, Room 1C (Ahumairangi), Ministry for the Environment, 23 Kate Sheppard Place, Thorndon.

STAG Members present: Adam Canning, Bryce Cooper, Clive Howard-Williams, Bev Clarkson, Graham Sevicke-Jones, Jon Roygard, Ken Taylor, Mike Joy, Joanne Clapcott, Ra Smith. **MfE staff present:** Helli Ward, Jen Price, Jo Burton, Jo Mason, Carl Howarth, Lucy Bolton, Vicki Addison, Isaac Bain

Apologies: Russell Death, Marc Schallenberg, Jenny Webster-Brown, Ian Hawes, Dan Hikuroa, Jamie Ataria, Mahina-a-rangi Baker, Tanira Kingi, Chris Daughney

---

Items:

1. **Previous meeting minutes and actions arising, apologies, conflict of interest (Ken Taylor)**

Ken noted that extended timeframes mean we now have another 2 months. Ken reiterated the confidentiality requirements of some reports being provided to STAG, particularly those that are still in draft form.

The minutes of the 29 November meeting were discussed. MfE officials were asked to follow up on worked examples to aid understanding, particularly for sediment.

A point was raised in relation to targets for wetland extent (pg 11, bullet point 3): do we have a clear policy preventing wetland loss? The response was that the current policy is inadequate, but this is an area of current work. It was noted that time frames of different policy options are an important consideration.

Ken and MfE officials asked for completion of any outstanding conflict of interest forms at the meeting, which was done.

The group approved the minutes.

Maintain and Improve

Ken summarised the group's previous discussions: The provisions for "maintaining or improving" in the NPS-FM are not satisfactory from a technical standpoint, and the group needs to provide some technical advice on this topic. Options examined in a previous meeting were to have more bands, or have a more quantitative definition of maintain or improve. It would be helpful to form a sub-group to develop recommendations.

Discussion points included:

- An issue is that "maintain or improve" is a good communication and policy tool but difficult from a technical standpoint. Natural variability and climate signals complicate this. Even defining whether a water body is in a particular band is technically complicated particularly when natural variability is high.

- The group asked MfE to clarify if "maintain or improve" is a policy directive, or a performance measure for assessing Council's performance. The first is subjective. Clarity is needed from policy people on this. The public view is that the second would also be true.
- Clarity is also needed on whether maintain or improve applies to a particular measure at a particular site? How does it apply to a whole FMU? Can we measure across sites and variables?
- MfE officials clarified that "maintain or improve" applies to both policy setting and performance assessment. Councils need to evaluate the effectiveness of their plans. At the minimum it is by attribute. You can't trade one attribute against another or aggregate them. Councils have flexibility in how freshwater objectives are set, e.g. Environment Canterbury sets objectives by site. You could also set objectives for the main stem. Freshwater Management Units (FMUs) have to have at least one freshwater objective, but they can have multiple objectives for different sites within the FMU.
- The state of a waterbody (as measured by bands) can vary a lot across catchments and over time. How do we scale up and get the intent that everyone wants? People implementing policy need clarity on intent and meaning.
- How we define FMUs is also related - the FMU concept and flexibility with how it is applied will need to be considered in this discussion.

Actions	To be completed by
Follow up on worked examples for sediment	Stephen
MfE to follow up with Adam, Mike, Ton, Clive, Jon, Bryce for further work on "maintain or improve" subgroup	Nik

Work programme update

The timeframes have been extended. Final policy decisions will now be made in April, rather than February.

Lucy gave an update on the wider advisory group network. There is a joint advisory group on 30 January, the papers are available now.

The joint workshop in December had the following outcomes:

- There will be regular joint workshops
- Papers for the next joint workshop will be based on the revised time frame and key decision points will be presented.
- There was a lot of interest in the impact testing of proposals. There has been a workshop on 17 January discussing this among a subgroup of advisory group members, and there will be a report back on this at the joint workshop on 30 January.
- At the 30 January workshop there will be an opportunity for STAG to report back, especially on prioritising ecosystem health metrics.
- One of the topics will be the allocation principles discussion.

The group asked about the sequencing of decisions and which agenda items would be included in the first tranche of policy decisions and advice to Ministers. MfE clarified that the process of seeking advice from STAG is iterative and all items are plausible for inclusion in the first tranche at the moment.

Allocation principles

Claire Graeme gave an outline of the allocation work:

- At the joint workshop on 17 December there was a discussion on principles for nutrient allocation. Kahui Wai Māori provided principles that were discussed at the meeting.
- Notes from the meeting have been used to draft allocation objectives. These are now on the portal for group members to look at and discuss at the next joint workshop on 30 Jan.
- Claire asked the group to get in touch with any comments, gaps or questions. The objectives are not completely fixed, but will be used in further discussions.
- Questions were raised by the group about how the principles and objectives would be implemented, particularly in relation to Māori rights and interests. STAG has not had the opportunity to discuss allocation yet. MfE officials noted that there are overarching Treaty of Waitangi and Te Mana o te Wai principles guiding the objectives. KWM has provided other principles. There will be the opportunity to discuss this matter further in the future and the KWM members on STAG will also provide linkages.

2. Confirmation of plan for February discussion on nutrients (Ken Taylor)

Ken outlined the key points to cover in the discussion at the next meeting:

- What the regulation says now and what it covers
- Is what's there at the moment adequate?
- Overview of different approaches suggested by others
- Why this work is needed
- Consideration of human and ecosystem health issues

-Bryce – more work is required based on Cathy Kilroy's work to derive numbers. – need to be clear – how far do reports take us, what further work is required?

-Martin – this is a really important issue for this group to resolve to give advice to Ministers and also to provide advice to the other advisory groups.

Actions	To be completed by
Documents to go on portal ASAP	MfE

3. Ecological flows and levels (Carl Howarth for Kirsten Forsyth)

Carl gave a summary of current issues with the way the NPS-FM directs councils to set objectives and limits for water quantity, and a suggested narrative attribute table to clarify objective and limit setting. The table is intended to provide an attribute table to help guide objective setting in the same way water quality attributes do.

Ken noted that the narrative attribute table presented in the paper assumes a certain approach. There was discussion of the narrative attributes suggested in relation to the National Environmental Standard for Environmental Flows that was previously drafted but not fully implemented. Key points included:

- The NES was informative and Regional Councils have said that it was useful in its current form as guidance.
- Group members noted the usefulness of the quantitative approach as set out in the NES, but also noted that it was not suitable for all rivers, e.g. small, flashy rivers.
- The existing legislation in the RMA requires Councils to set minimum flows for habitat requirements.

- Councils need to consider habitat, variability, and surety of supply. Around the country there are different methods for flow allocation incorporating other values as well as ecosystem health. How would this table improve the situation and add value?
- Councils are currently using quantitative objectives that are related to the amount of habitat provided for certain fish species. These are often based on extensive field studies. What would the narrative attribute add to this?
- Group members expressed a preference for progressing a numeric approach rather than a narrative approach.
- The table is confusing because it talks about flows in the first section, then the habitat components that flow provides for later on. Species requirements are mentioned. It's not clear what the table is trying to achieve.
- How would modifications such as flood protection works be taken into account in flow objective setting?
- Adopting the natural flow regime as the "A" state would have implications and might be counterintuitive to species flow requirements.
- This table assumes that setting flow allocation is only ecosystem based, but social, cultural and economic dimensions are also used to make allocation decisions. Looking purely at the ecosystem health dimension might leave out important considerations. There are knowledge gaps in social and cultural flow requirements.
- There is existing work on how the NES could be improved[1]. The default values in the NES are based on maintaining a proportion of the low flow, which is based on maintaining habitat. Flows can be calculated that will maintain a given amount of habitat. One way to make the NES clearer would be to do this. Because hydrology is variable, the outcomes provided by rules of thumb will vary. This shouldn't be the case – it would make more sense to have a consistent objective then work out the flows required to achieve those (these flow objectives would vary spatially)
- Important considerations are: the amount of habitat at minimum flow, when is habitat reduced, and reliability of flow. These can all be calculated. The sensitivity of rivers to reductions in flow is dependent on the size of the river. If you set an objective based on habitat for trout, you can reduce flow in large rivers a large amount – but this might reduce habitat for other species, therefore it becomes complicated to set flow limits.
- Addressing the narrative attribute table proposed in the paper: Sometimes a narrative is waiting for a number, sometimes numbers are waiting for a narrative. Overseer is an example of this, where a narrative wasn't provided to explain the numbers. Narratives can bring numbers together. Numbers don't bring communities along with us, and narratives do.
- The NES provided numbers without considering what the objective was. We need to know the objectives, then give scientists the job to work out the numbers.
- There is support for the description of the "A" state, but describing it in terms of habitat is not enough.
- There are rivers that are running dry. The narrative table might help for these cases.

Ken's summary was that group members were uncomfortable with the proposal to include a narrative table for ecological flows. This group has concerns about inconsistencies in purpose and lack of clarity around what problem this table is trying to solve. The group wants to know more about context, reasons for looking at this, as well as how this fits in with social and cultural considerations.

Actions	**To be completed by**

[1] Snelder, T., Booker, D., & Lamouroux, N. (2011). A Method to Assess and Define Environmental Flow Rules for Large Jurisdictional Regions 1. JAWRA Journal of the American Water Resources Association, 47(4), 828-840.

Circulate Ton Snelder's paper	MfE - done

4. Threatened Species value (Carl Howarth for Kirsten Forsyth)

Carl summarised the paper, which proposes adding an optional Threatened Species value.

Discussion points included:

- This conversation needs to be broader than the NPS-FM. There are other work streams that are also addressing threatened species. For example, the NPS for Indigenous Biodiversity deals with threatened species, but it does not apply to freshwater. This leaves a gap that the NPS-FM needs to address.
- Wetlands are managed by the NPS-FM and NPS-IB, the two documents will complement each other.
- The value needs to define what is meant by "threatened" – e.g. DOC's Threatened Species Classifications.
- National direction and focus is needed to manage threatened species.
- Existing information on this topic includes: a national GIS layer of threatened species (compiled by Mike Joy); information in regional plans, Our Fresh Water 2017
- It may be worth making explicit that the value applies to all threatened aquatic species (i.e., wider than threatened fish, includes threatened native plants and invertebrates).
- The terminology "necessary requirements" needs to be defined to avoid legal arguments. This relates to habitat requirements for species, as well as population numbers.

Ken's summary was that there is agreement among the group that the value is appropriate and that we need a threatened species value. The group also raised a question: what is the national level of protection for freshwater threatened species?

Actions	**To be completed by**
Amend value to incorporate suggestions as above	Kirsten

5. Dissolved oxygen (Jen Price)

Jen summarised the paper outlining recent work on dissolved oxygen and how it is managed in the NPS-FM at the moment. A summary was provided of work that was proposed in 2016 but never went ahead, and the group was asked if this work was still required.

Ken suggested re-framing question 1(b) as: should, from a technical point of view, management of dissolved oxygen be mandated?

Discussion points included:

- Dissolved oxygen (DO) is a fundamental and critical measure of ecosystem health and the attribute should apply to all rivers. There was agreement among group members on this.
- The attribute was originally applied to point sources as there is a direct and obvious cause-effect relationship and knowledge of how to manage them, which fits with the NPS-FM thinking at the time.
- A question was posed whether we need to clarify drivers to fit DO into an NPS structure. We know the drivers (e.g., periphyton and macrophytes in unshaded rivers) – so do we need to commission work to quantify the relative importance of drivers?
- Previously we've operated under the assumption that we need to be able to recommend management actions to achieve the required attribute band status – is this still the case?

- It was noted that a key management action to improve dissolved oxygen concentrations is to increase shading to decrease growths of nuisance periphyton and macrophytes.
- If the attribute was more widely applied it would be important to provide guidance on DO measurement protocols and assessing whether sites meet the attribute band thresholds. Does this apply to sites or entire catchments?
- We need more data on natural variation, this doesn't have to be a massively complicated analysis. It would be more helpful to do work on management actions that could be taken to improve the DO status of rivers
- Would ecosystem respiration and gross primary productivity also be included? This is a matter for further discussion. There is existing work by Roger Young from Cawthron on this.

Actions	To be completed by
Investigate inclusion of third column in attribute table for mean dissolved oxygen	MfE
Circulate papers on ecosystem respiration and gross primary productivity – to be discussed at future meeting	MfE

6. At-Risk Catchments update (Oscar Montes de Oca Munguia)

Oscar, Carly O'Connor and Isaac Bain from the At-Risk Catchments team attended this session. Oscar gave a Powerpoint presentation summarising progress to date on the At Risk Catchment project and proposed work streams incorporating Matauranga Māori, biophysical science and social science. Two main goals of the project are to identify exemplar catchments for initial focus, as well as compiling national level data to complete a risk assessment and prioritise further work. The final paper will be released in late April for public consultation.

Questions from group members included:

- This project includes social and biophysical science in two work streams – do they come together enough to be considered one knowledge base? Oscar responded that to move forward, we need to structure our conversations to find where things fit.
- Was the goal to prioritise catchments for quick action, or is this for longer term work? Oscar responded that both outcomes may be possible, and the key is to ensure a robust and defensible process is followed to inform outcomes.
- What is the purpose and goal of the project? Carly responded that we need to get an understanding of all catchments in NZ and their current state. The exemplar catchments will be case studies of how different restoration actions and regulations can be applied. The catchments will have a representative range of issues. The national level data can be used for policy decisions and prioritising funding.
- As background information: feedback from Councils has been that the NPS drives change slowly through the planning process, but how can we achieve things quickly? The Minister asked the Land and Water Forum how the Government could demonstrate change quickly. The At-Risk Catchments philosophy came from this. The idea is to come up with examples where we could demonstrate rapid change. It's a wider range of interventions than just regulation.
- A question was raised about whether there is an appetite for wider change, and whether this would be a truly collaborative process? Oscar responded that this process involves trying a new model, and we are looking for collaboration rather than peer review.

Ken indicated that group members may also be willing to help in future when there are specific tasks to be completed.

Actions	To be completed by
Project team to follow up with Ton and Mike for further work	Oscar

7. Sediment (Ton Snelder for Stephen Fragaszy)

Ton gave a summary of the sediment paper.

There was a discussion on the lack of correlation between measures of deposited sediment and clarity. Key points included:

- It's strange that there is a lack of correlation between and deposited sediment and clarity. Is this a measurement problem rather than a real lack of correlation? Deposited sediment is a more integrated measure over time than suspended sediment, which is typically a snapshot.
- Knowledge of suspended sediment is needed to assess impacts on downstream ecosystems, particularly lakes and estuaries.
- Suspended sediment measurements are a function of supply from the catchment. Deposited sediment also depends on storage capacity. Systems that have high suspended sediment wouldn't always have high deposited sediment.
- The standardised method for assessing deposited sediment looks at a run, which may not always be a depositional environment.
- The maps for deposited sediment and turbidity look similar on a national scale, so doesn't that mean there must be a relationship between deposited and suspended sediment over a national scale over a long time period?
- Not necessarily - It may be that places with low clarity (high turbidity) might be places that have low deposited sediment. If you coloured the maps by the reference state values, they may not correlate. At the beginning of the study we did work on the relationship between environmental state variables (ESVs - such as deposited sediment and clarity) and sediment supply. We can derive good empirical relationships between catchment load of sediment and median clarity and suspended solid concentration. But there were poor relationships between sediment supply and deposited sediment, even with explanatory values such as slope included. Places that have high sediment supply often have very clean coarse substrates. Christoph Mattei has done work on what happens with deposited sediment: particularly in lowland situations, freshes clean out sediment. On the receding limb of the hydrograph, sediment deposits out. So deposited sediment is independent of what the catchment load is. Lateral inflows influence this and we don't understand this very well. We can characterise patterns in deposited sediment but we don't understand the mechanisms causing deposited sediment, or what the mitigations would be. Gross sediment load is strongly related to ESV state – median clarity and turbidity/SSC. There is therefore a clear intervention logic for directing mitigations for suspended sediment. In summary- the ways you would manage for deposited and suspended sediment would likely be different.

Ken asked the group if they are comfortable defining some kind of numeric threshold for sediment in its two forms (suspended and deposited). The group was comfortable with this.

There was discussion about the importance of both suspended and deposited sediment – there are good reasons to manage both. A key point is that we know how to manage suspended sediment better than deposited sediment. However, members raised points that the policy levers are the same for both types, and sediment fingerprinting can be used to track the source of deposited sediment.

It was reiterated that the group would like to see a comparison of continuous monitoring of suspended sediment/turbidity and spot measurements. It's important in any introduced attribute to define how measurements should be taken.

There was further discussion about methods of the study. Key points included:

- What data from the NZFFDB did you use, were old and new data used and could this have affected the results? Response: the initial step would have used all data, reference conditions came in to the later steps. Reference conditions were calculated based on land cover, this is very stable over time.
- To what extent would changing the ways of measuring dissimilarity change the clustering results? Response: this can have quite a strong influence on results. But the REC class groupings from the clustering analysis make sense.
- The options are to have 2, 4, 8 or 12 classes – when you measure deposited sediment there is high variability in the measurements. How do you reconcile having a large number of classes with such a variable measurement? Response: the next step in the process will incorporate the ecological response across classes. If there are similar responses, the classes can be aggregated.
- It was noted that having more classes helps the policy to be more realistic and precise.
- What is the error around the reference state condition? What are the implications for bands? Response: the error can be seen in Figure AX12 (in the technical appendix provided). The 95% confidence interval shows there can be quite a lot of uncertainty. AX13 compares the estimated reference condition using the linear regression method (and its uncertainty), with the mean turbidity (and its interquartile range) within the lowest decile of heavy pasture coverage. That's compared on each panel, and on the right hand side is the observed range across all sites irrespective of how impacted they were. You can see that the estimated reference condition is consistent with the observed relatively low-impact sites. In general, the range across all impact levels in the class is more than the range in reference condition. This is the best that can be done with the data available.
- The ecological impact work currently being finalised by Cawthron will be helpful for understanding how to proceed.
- Ken posed the questions: Does anyone see any bad holes in the approach? The response from the group was that they had no major reservations, but wanted to see the ecological response information and analysis of continuous data. It was suggested that given the measurement error, it may be more valid to just have a bottom line, rather than attribute bands.

Actions	To be completed by
Provide a comparison of continuous vs. spot monitoring	Stephen
Provide further work on ecological responses when complete	Stephen

8. Ecosystem Health: definition, prioritising metrics (Carl Howarth)

<u>Definition</u>

Carl summarised the paper which proposes minor changes to the definition of Ecosystem Health in the NPS-FM.

Key discussion points included:

- It was questioned whether resilience was needed in the definition, as some natural systems are sensitive to external stressors and not resilient at all.
- We need to be clear about what the definition of resilience is, and what ecosystems are resilient to. One possible definition would be that resilience is the ability of a system to maintain its life supporting capacity over time.
- It should be made clear that systems need to be resilient to adverse human impacts, as not all human impacts are bad.
- The phrase "high sediment levels" – needs to change because high sediment levels might be natural. A qualifier is needed, e.g. "excessive sediment"
- The first sentence after the definition has stressors – it would be helpful to describe these as aspects to be managed etc. instead of "matters to take into account"

The group agreed we should update the definition of Ecosystem Health.

Actions	**To be completed by**
Draft a new definition for group to approve	Carl and Joanne

<u>Prioritising metrics</u>

Three groups were formed to workshop and prioritise the indicators in Appendix 1, guided by the criteria of: (1) urgency (magnitude of the associated problem) and (2) representativeness (whether the five components of ecosystem health are represented).

The following summaries are from the groups:

<u>Group 1</u>

Overall messages:

Rivers and aquatic life were the highest priority water body and ecosystem health components respectively – but we need a mix of outcomes and stressors. Water quantity wasn't seen as a priority issue at the national scale, but could be locally important e.g. in Canterbury [relevant to flows work]. The group ranked indicators in order of priority – as indicated below. Less priority was placed on existing attributes as they are already being managed now.

Rivers

Aquatic life: fish and invertebrates most important **(1, 2)** (it's the ecosystem health outcome we want), water birds are transitory and issues exist locally so are a lower priority. Physical habitat is a major driver of decline and the next most important indicator at all scales (reach and catchment) – this could be managed through site-scale Rapid Habitat Assessment **(3)**, and consider the Habitat Quality Index for broader scale (Death et al.) including connectivity (both floodplain and fish passage) **(5)**. Dissolved oxygen **(4)** is also important (given work on nutrients and dissolved oxygen is underway). If doing oxygen, work should also proceed on temperature and Biogeochemical Processes (e.g. gross primary productivity [GPP]) as well, as these would not require much more work and are important. Biotic interactions are too difficult/insufficient measures are available.

It was felt that Water Quantity, while important in some areas, isn't such a significant national issue to warrant top priority over the above.

Lakes

This group considered that developing new NOF attributes for lakes was not as urgent as for rivers. Exotic (pest) fish and plants are key stressors **(6)**, and their presence can make a lake resistant to improvement. Given nutrients are managed already through inclusion in the NOF **(9)**, other priority gaps are substrate (deposited sediment) **(7)**, dissolved oxygen **(8)** and indigenous fish **(9)**. Thought a lake fish index of biotic integrity (IBI) may be required (this does not exist yet). Some councils (e.g. Horizons) do fish surveys of lakes.

Wetlands

Wetland extent is the most important indicator **(10)**

Groundwater

Nutrients are important, because of the link with surface water. Surface and groundwater need to be managed as one hydrological system, not as separate components.

We lack detailed understanding of the ecology of aquatic life (invertebrates and microbes) in groundwater systems and therefore do not fully understand their biodiversity value or role in ecosystem processes. This should be a priority for research as current human activities could be having a significant impact on these forms of aquatic life.

<u>Group 2</u>

This group indicated ten priorities for rivers, groundwater and lakes but didn't rank them. Wetlands weren't addressed due to lack of time.

Overall messages:

In ten years' time, we want to be able to understand ecosystem health better. Incorporating measures of aquatic life are a high priority due to the previous focus on water quality and quantity. This should include fish and macroinvertebrates as a priority, also incorporating pest species. Habitat loss is the most significant issue facing streams, and riparian areas are of importance for understanding this, though the importance of riparian vegetation is greater in smaller streams. There are key knowledge gaps in groundwater ecotoxicology and emerging contaminants.

Rivers

In rivers, plants, invertebrates, fish, connectivity, riparian, dissolved oxygen, temperature, nutrients, emerging contaminants, hydrological variability, extent, and biogeochemical processes were identified as priorities. Pest species are important in certain places.

Incorporating measures of aquatic life are a high priority due to the previous focus on water quality and quantity. Fish and invertebrates can indicate whether the rest of the ecosystem is functioning. However, we need measures of all ecosystem components. For example, if fish and invertebrate populations aren't healthy – this is when other measures of water quality become really important to help diagnose the cause.

For the general public, periphyton and fish are important indicators because they are the most visible.

Macroinvertebrate indicators for rivers require further work so that we can understand the drivers of species change. The work underway on stressor-specific macroinvertebrate metrics helps our understanding here.

Riparian areas are a priority and their importance for river health is greater in smaller rivers. The most significant issue facing streams is habitat loss.

Groundwater

Priority areas for this group were microbes, invertebrates, extent, dissolved oxygen, nutrients, toxicants, and biogeochemical processes.

Populations of microbes and invertebrates are heavily interlinked with biogeochemical processes, dissolved oxygen and nutrients in groundwater. We lack knowledge to effectively manage ecosystem health in groundwater and there is research needed in this area. Contaminants are also a priority for further work as once in the groundwater, some contaminants can persist longer term. We need basic ecotoxicology work for groundwater species to find the effects of key contaminants. Groundwater extent is also an important indicator as this needs to be managed with respect to water abstraction and recharge rates.

Lakes

In lakes, plants (including pest plants), fish (including pest fish), nutrients, and biotic interactions (e.g. relating to pest species) were identified as priorities. Of these, nutrients and pest species were flagged as being particularly important. Nutrients are important as key drivers of other process in lakes.

We need indicators that address both the littoral (near-shore) zone as well as the pelagic (open water) zone. LakeSPI is a good example of a metric that addresses plant community composition in the littoral zone and also incorporates measures of pest species.

<u>Group 3</u>

Overall messages:

Wetlands are the highest priority for management as the current management focusses on rivers and lakes. It was felt if the rivers and wetlands had good ecosystem health then this would lead to good lake ecosystem health.

There needs to be a measure of cumulative effects – what is the effect of one indicator with another, and multiple stressors over time, e.g. correlate the sediment and plant indicators.

The top 10 indicators were:

1. Extent of wetlands – compared to original state. Highly correlated to ecosystem health and easiest to determine
2. Wetland hydrological regime e.g. intactness
3. Wetland plants – and species occupancy compared to the natural state, including pest plants
4. Dissolved oxygen in rivers
5. Nutrients for rivers
6. Fish for rivers – this was important to communities and due to the fact there are many threatened fish
7. Lakes - the cumulative effects of a number of indicators including biogeochemical processes – this was a reflection of mauri ora
8. Substrate for lakes (e.g. deposited sediment)
9. Suspended sediment in rivers. This can have a large impact on rivers and downstream environments (estuaries and lakes).

10. Nutrients in wetlands as this would give an indication of the capacity for restoration

Other comments:

Riparian buffers were important – there were already tools and methods established to measure these

Physical habitat, including form and connectivity of rivers was also important- including lateral connectivity.

The biogeochemical processes indicator was linked to dissolved oxygen, as well as gross primary productivity (GPP) and ecosystem respiration (ER)

Indicators that were not required for wetlands: microbes, DO, temperature, clarity and suspended sediment, toxicants.

Biogeochemical processes and biotic interactions were too hard to determine for wetlands but that peat condition was an important indicator that could be used for ecological processes.

Discussion among whole group:

Following the small group discussions, the following topics were discussed by the whole group:

- There are several habitat assessment tools available that operate at different scales. There may be opportunities to harmonise these. Group members flagged this as an area where the Water Taskforce should work together with Environmental Reporting.
- In relation to the Ecosystem Health definition: Ecosystem Health is made up of five components – all are affected by combinations of stressors. We need to measure a combination of indicators and stressors.
- There are parallels with the way we talk about mental health – often we talk about illness rather than wellness. Can we talk about environmental wellness instead of environmental illness?
- Is the NPS-FM the best way to manage aspects influencing ecosystem health such as pests? More broadly, are the policy mechanisms in the NPS-FM the right way to tackle ecosystem health? For example, addressing habitat needs to be done collectively. Limiting resource use (the current underlying philosophy of the NPS-FM) is not going to fix habitat.
- Green economics provides a way of looking at this problem, as it doesn't ask about limiting resource use but asks how the activity gives back to the system.
- We need to look at the catchment holistically and take collective action. This is an approach that involves both biophysical and social sciences.
- The approach in the NPS-FM of managing single stressors from individual resource users (e.g. nitrogen discharge allowances) is necessary but not sufficient. We've provided the technical framework for this approach to happen. How can we present the framework in a way that facilitates a different approach?
- The group talked about flipping the old approach by also looking at the desired outcome, as well as the stressors.
- It's not enough to put enabling processes into policy and hope that people will do the right thing. There are other mechanisms that sit outside the RMA. It's always been acknowledged that a range of changes are required, not just the NPS.

Actions	To be completed by

MfE to provide a list of regulatory and non-regulatory approaches to improving ecosystem health	MfE
Present results of ecosystem health prioritisation at joint workshop on 30 January	Mike, assisted by MfE

Papers distributed:

Agenda item (number)	**Paper title**	**Classification - confidential yes/no?**
1	Science and Technical Advisory Group Meeting Minutes – 29 November 2018	Yes
2	No paper	-
3	Ecological Flow and Levels	Yes
4	Threatened Species Value	Yes
5	Dissolved oxygen	Yes
6	No paper	-
	Sediment – discussion paper on classification systems	Yes
7	Sediment – technical appendix on classification systems (see portal)	Yes
8	Ecosystem Health definition	Yes
8	Ecosystem Health: prioritisation of metrics	Yes

Science and Technical Advisory Group (STAG) Meeting

Minutes

Thursday 18 October 2018 10am-5pm, Thorndon 1 Room, Terrace Conference Centre, Levels 2-4, St John House, 114 The Terrace.

Attendees: STAG: Ken Taylor – Chair; Dr Bryce Cooper; Dr Clive Howard-Williams; Dr Chris Daughney; Dr Bev Clarkson; Graham Sevicke-Jones; Prof. Ian Hawes; Prof. Jenny Webster-Brown; Dr Joanne Clapcott; Dr Jon Roygard; Dr Marc Schallenberg; Ra Smith (11am onwards); Prof. Russell Death; **Ministry for the Environment (MfE) officials:** Lucy Bolton; Jo Burton; Nik Andic; Ton Snelder; Vicky Addison; Jen Price; Helli Ward; Kirsten Forsyth; Oscar Montes De Oca Munguia (afternoon)

Friday 19 October 2018 9am-3pm, Ahumairangi Room (1C), MfE, 23 Kate Sheppard Place, Thorndon.

Attendees: STAG: Ken Taylor – Chair; Dr Bryce Cooper; Dr Clive Howard-Williams; Dr Chris Daughney; Dr Bev Clarkson; Prof. Ian Hawes; Prof. Jenny Webster-Brown; Dr Joanne Clapcott; Dr Jon Roygard; Dr Marc Schallenberg; Dr Mike Joy (11am onwards); Ra Smith; Prof. Russell Death (morning); **MfE officials:** Lucy Bolton; Jo Burton; Nik Andic; Ton Snelder; Vicky Addison; Jen Price; Helli Ward; Kirsten Forsyth; Stephen Fragazsy; Carl Howarth

Apologies: Dr Adam Canning; Dr Dan Hikuroa

Items: Thursday 18 October

1. **Welcome and introductions from Vicky Robertson – Secretary for the Environment, MfE, Martin Workman – Director – Water, MfE, Hon David Parker – Minister for the Environment**

Introductions were made about the work programme and the group's role. The Minister talked about the role of science in informing policy and resolving controversy, and about areas of focus in the current Essential Freshwater programme such as sediment, wetlands and estuaries.

2. **Terms of Reference (TOR), working with Freshwater Leaders Group and Kahui Wai Māori**

The Terms of Reference were discussed, particularly in relation to confidentiality and working with the other advisory groups. Officials were asked to clarify these points in the TOR. There was discussion around the scope of the group being focussed on biophysical science, but also being informed by kaupapa Māori approaches.

Outcome: Officials will present an updated version of the TOR to the group

3. **Te Mana o te Wai**

MfE staff outlined the concept of Te Mana o te Wai as an overarching concept for the NPS-FM. There was discussion on how to integrate Te Mana o te Wai into a biophysical framework.

4. **NPS overview**

MfE staff gave a presentation on the NPS-FM and how it works by directing regional plans. Limits are placed on resource use to achieve freshwater objectives.

5. **Discussion on NPS-FM**

MfE staff provided an outline of the feedback received on the NPS-FM by Fish & Game NZ, Land and Water Forum, and others. It was noted that MfE was prioritising addressing this feedback.

6. **At-Risk Catchments update**

MfE staff gave a presentation on the progress to date of the At-Risk Catchments programme.

Outcome: The group agreed it would be useful for officials to give a summary of the latest water quality state and trends work, recently commissioned by MfE.

Items: Friday 19 October

7. Summary of previous day and introduction

The Chair reiterated some of the broad themes from Minister's talk, then referred to the Essential Freshwater work programme document, and highlighted its timeline with key themes, encompassing regulatory changes as well as work on at-risk catchments. He discussed the work programme of STAG as being focussed on testing and advising on scientific aspects of the NPS-FM.

Outcome: MfE officials were asked to provide more information on the forward work programme and schedule of meeting goals.

8. Different options for managing stressors (e.g. attributes, guidance, rules, NES)

MfE staff presented an overview of the function of attributes within the NPS-FM and how the intervention logic works by limiting resource use. This mechanism may not be suitable for some stressors such as pest plants and animals, but that other approaches could be required. Restoration is another example where other approaches might be necessary. The group was asked to consider other approaches than attributes, but it was noted that the group wasn't expected to make decisions around which regulatory mechanism would work best – that is the job of the policy analysts. There was discussion on these subjects.

9. Evidence requirements for policy development

MfE staff discussed the criteria that were applied to the existing attributes developed in the National Objectives Framework. A key point is that NPS attributes are compulsory, which has driven the need for due diligence to ensure that attributes can be applied nationally. MfE staff outlined the regulatory impact statement process that Cabinet needs to go through to change any regulations. There was discussion about the criteria and how they might be applied going forward, the situations in which they are suitable, and how they relate to the precautionary principle. There was discussion on the potential alternatives to attributes, such as guidance, and where they might be suitable. The role of STAG is to provide science advice that informs policy development, there needs to then be an iterative process where policy staff report back on progress. The definition of "maintain or improve" was noted as a topic requiring further discussion.

Outcome: The criteria will be framed as things that need to be considered, rather than strict decision gates. The definition of "maintain or improve" will be discussed further at a future meeting.

10. Ecosystem Health Framework

MfE staff summarised the Biophysical Ecosystem Health Framework report.

Discussion focussed on the importance of reference conditions, how mauri fits into the Framework, and application of the Framework as part of the NPS-FM. STAG members discussed potentially contributing to consistent ways to aggregate and harmonise data, how to make the framework nationally applicable, and how to apply the Framework to the NPS-FM.

Outcome: Statement from group: We are comfortable with the five components of the Ecosystem Health Framework to proceed with further work, noting that there is a caveat around Te Mana o te Wai and Maori views which are not measured directly by the framework, and that the Framework specifies that measurements must make comparisons to a defined reference state.

Additional agenda item: Brief introductions from Alison Dewes and Corina Jordan from Freshwater Leaders Group (FLG)

11. Wetlands update

MfE staff gave a brief update about wetlands to signal future work, and the management of wetlands was briefly discussed.

Outcome: It was flagged that this topic is to be discussed further at a subsequent meeting.

12. Sediment

MfE staff gave a presentation about the attribute development. There was discussion about the methods used to develop the draft attributes. New work will ensure consistency and comparability of classifications so that thresholds from different lines of evidence align, are comparable and have robust and transparent information behind them. This work will be discussed with STAG at future meetings.

Outcome: The group will focus on sediment further at future meetings and MfE staff will provide worked examples to assist.

13. Summary

The chair summarised the meeting and outlined potential agenda items for 29 November: current state and trends, sediment, wetlands, maintain/improve.

Science and Technical Advisory Group Meeting

Minutes

Dates and Location: Thursday 29 November 10am-4.30pm, Room 1A (Matairangi), Ministry for the Environment, 23 Kate Sheppard Place, Thorndon.

STAG Members present: Bryce Cooper, Chris Daughney, Clive Howard-Williams, Bev Clarkson, Graham Sevicke-Jones, Ian Hawes, Jon Roygard, Ken Taylor (chair), Marc Schallenberg, Mike Joy, Russell Death, Joanne Clapcott, Ra Smith, Tanira Kingi, Mahina-a-rangi Baker, Jenny Webster-Brown (in the afternoon, by phone), Adam Canning (by Skype). **MfE staff:** Jen Price, Oscar Montes de Oca Munguia, Isaac Bain, Vicki Addison, Dan Elder, Helli Ward, Nik Andic, Jo Burton, Lucy Bolton, Carl Howarth. **Apologies:** Dan Hikuroa, Jamie Ataria

Items:

7. Previous meeting minutes and actions arising, Terms of Reference, apologies, conflict of interest

The chair outlined the agenda in relation to timing and prioritisations of the work programme. The group was briefed on the proceedings of the Freshwater Leaders Group and Kahui Wai Māori meetings.

1. A) Indicative work programme, milestones, timing of meetings, topics for discussion

MfE staff presented the indicative timetable for the advisory group network with timing of decisions by ministers, and outlined the plan for the joint Advisory Group meeting on 7 December. These were discussed and it was noted that the Group needs to have enough time to consider proposals and provide feedback.

8. State and trends

MfE staff gave a presentation on state and trends in NZ freshwaters, based on Land Air Water Aotearoa (LAWA) data. Discussion points included survey site considerations, analysis of water quality parameters compared to a more holistic approach, and matters to consider relating to interpreting trends.

9. Maintaining/improving water quality

MfE staff presented a paper on how the issue of maintaining and improving water quality is dealt with in the National Policy Statement for Freshwater Management (NPS-FM), and outlined options to better manage the "bands test" for Appendix 2 attributes. The group agreed that a decline within a band "might constitute a material (i.e. more than minor or significant) decline in ecosystem health, for at least some existing attributes". The group identified attributes where this might apply, including the "A" band for lakes, nitrate toxicity bands, and *E. coli* bands. The group felt that bands are a useful tool for setting community objectives and communicating to the public and councils; however they can cause some detail to be lost. Further clarity is needed on how to define "maintain" statistically. MfE staff were asked to provide worked examples to help further this discussion.

10. Sediment

The group discussed sediment attribute components – metrics and exceedance criteria for potential attributes. The group discussed the decision to base attributes on rolling medium-term (~2 years) measures of central tendency, and asked for MfE to provide a worked example illustrating the implications of this. It was agreed that suspended and deposited sediment were appropriate indicators. The group then discussed policy principles to guide bottom-line attribute development. It was discussed that it is key to have provision for, and meaningful recognition of, Te Mana o te Wai in the Principles, and that bottom lines need to be measurable and related to the purpose or outcomes being sought.

11. Wetlands

There was discussion on wetland identification and delineation, water level changes, setbacks, wetland size, national targets and the wetland condition index. The Biodiversity Collaborative Group (BCG) has also provided wetland policies in the draft NPS Indigenous Biodiversity (NPS-IB) and officials are working together.

12. Updates/shorter sessions: indicators of health from a Māori perspective, nitrate, copper and zinc, dissolved oxygen

Note: flows and dissolved oxygen were scheduled but were postponed until the next meeting due to time constraints.

<u>Indicators of health from a Māori perspective</u> – MfE staff and Kahui Wai Māori representatives gave an outline of work planned and under way on this topic, and this was discussed. Work is in the early stages and MfE staff will report back to the group again at a later stage.

<u>Nitrate</u> - The processes set out in the 2018 MfE report "*A draft technical guide to the Periphyton Attribute Note*" were outlined. Some members of the group would like to see attribute tables in the National Objectives Framework for the trophic state effects of nitrogen and phosphorus in rivers. Monitoring considerations and the influence of groundwater were discussed.

<u>Copper and zinc</u> – MfE staff outlined work to date. There was discussion on the importance of other contaminants of concern.

4pm *End of meeting*

Ecosystem Health

Please refer to attached Briefing Note: Managing all aspects of Ecosystem Health

Purpose: To provide information on mechanisms proposed to protect and restore ecosystem health yet to be discussed with you, and to discuss how all the proposed mechanisms meet the objectives of this work.

Questions: Are there any gaps in this package? Is anything else required?

Problem: Nationally ecosystem health is degraded, with three quarters of indigenous fish species under threat of extinction, reduced water quality, altered hydrology, diversion and changing flow regimes, loss of wetlands and modified or lost habitats.

Objectives: To protect and restore ecosystem health by:

a. Stopping further degradation and loss of freshwater ecosystems

b. Reverse past damage by promoting restoration activity

c. Directing that the management of ecosystem health in the NPS-FM includes aquatic life, habitat and ecological processes not just water quality and quantity and this should be reflected in the stages of the NOF process, eg objective setting, monitoring and reporting.

d. Directing a more proactive, integrated and strategic approach to manage the stressors that affect the components of ecosystem health, particularly the incremental or cumulative loss of habitat.

We have identified seven mechanisms to address, protect and restore ecosystem health:

1. No net loss of ecosystem health
2. Strategic freshwater planning
3. Objectives and policies for better management of fish passage
4. Monitoring and reporting requirements on aquatic life, habitat and ecological processes
5. Add a new optional value to the NPS-FM for Threatened Indigenous Species
6. Amendments to the definition of the ecosystem health value
7. New metrics for aquatic life, habitat and ecological processes (metrics to be phased in on a longer timeframe)

1. We have previously discussing mechanisms 5-7 with you. The briefing note provides information on all the mechanisms.

2. Direction for a precautionary approach was originally proposed as a mechanism under Ecosystem Health but we are now progressing this as a separate work stream due to wider application that also encompasses Te Mana o Te Wai and human health aspects.

Possible use of an attribute table to set objectives for flow regimes in rivers

Summary of the problems

Rivers: Setting appropriate flow regimes in rivers to safeguard ecosystem health is technically difficult and often controversial

The National Policy Statement for Freshwater Management has confusing direction for setting objectives and limits for water quantity

Context

The National Policy Statement for Freshwater Management directs councils to set freshwater objectives using the applicable attributes in Appendix 2.

Councils are setting freshwater objectives for water quality using those attributes (for example periphyton), and then setting limits on resource use (for example nitrogen and phosphorus) to achieve those objectives.

In terms of river flows, councils are setting limits on resource use by setting river flow restriction regimes and allocation limits. The combination of allocation limits and restriction regimes in rivers allow people to take water while preventing a rapid decline in flow up to and past the point at which the area of sufficient suitable habitat diminishes. The limits are generally designed to retain a proportion of the historic flows or flow variability, or retain habitat.

It is not clear whether councils are setting the limits to achieve a specific objective for habitat or flow variability. This means that the physical habitat and hydrological regime requirements of the aquatic ecosystem are not necessarily what is driving the flow restriction regimes and water allocation limits.

This could be resolved by adding an attribute table for physical habitat and hydrological regime requirements to the National Policy Statement for Freshwater Management.

The objectives set using this attribute table will direct choices councils make for the minimum flows and allocation limits set in the regional plan. The limits may include a set of cut off thresholds at various flows, with the restrictions stepping up as the flow decreases to the minimum flow.

Policy CB1 of the NPSFM requires councils to monitor progress towards the achievement of freshwater objectives. If objectives are set in accordance with an attribute table in the NPSFM, councils would be better placed to assess how their water quantity limits (the allocation limit, the minimum flow and the intermediate restriction thresholds) are achieving ecosystem health objectives.

VERY ROUGH FIRST CUT of possible attribute table for setting water quantity objectives in rivers

Value	Ecosystem health
Water body	Rivers
Attribute	Habitat as affected by [human induced] flow variations
A	There is an abundance and diversity of habitat types to support the species assemblage that would expected without the adverse impacts of water abstraction or diversion. There is a variety of flows needed to influence channel morphology and bed movement. The flow regime provides for all ecosystem processes.
B	There is some reduced habitat but of short duration. Effects of abstractions or diversions can be mitigated (for example by shading or flow augmentation). There is a variety of flows needed to influence substrate movement. The flow regime provides for all ecosystem processes.
C	There is some reduced habitat of long duration, but still sufficient habitat to support the species populations. Variety of habitat is reduced.
D	Available habitat is likely to decrease even without continued abstractions or diversions. The remaining habitat cannot sustain populations long-term. This is the threshold where abstractions and diversions must cease to allow for natural decline without loss of life-supporting capacity.
E	There is no connectivity with other water bodies. Indigenous species are stressed by high temperatures and low dissolved oxygen in the water. There is insufficient food and space for the species that have lived there.

The descriptions above follow a similar approach to the narrative attribute states in the final columns of the water quality attributes. The A state describes a largely unmodified river system (such as would be found on Stewart Island). The E state describes an unacceptable state. Hydrologically modified catchments, such as the Waikato, might be somewhere in the middle.

The use of an attribute table is being considered in terms of its recognition of Te Mana o te Wai

- In terms of the first principle of Te Mana o te Wai – the first share of the water goes to the river.
- Te Mana o te Wai recognises the values of Mana Atua: mauri, wairua, natural character, mana, life-supporting, ecology, biodiversity and native fish. These values are not subordinate to other values.
- Te Mana o te Wai recognises the values of Mana Tangata: ceremonial, drinking, transportation, economic, recreation and food gathering.

Questions for the Science and Technical Advisory Group

1. Do the draft narrative descriptions above make sense from a biophysical aquatic ecosystem perspective? How could they be improved?
2. Would it be useful and defensible to specify thresholds in the B and C state as departures from the A state (the C state still provides for ecological function)?
3. Could the various states be measured using stream habitat assessments and hydrology?

Freshwater Science and Technical Advisory Group:

Nutrient management in the NPS-FM

Paper Author	Jen Price, Ton Snelder, Isaac Bain	Classification	**Confidential**

Meeting date	26 February 2019	Agenda item (number)	6

Paper summary:

There will be a substantial discussion about nutrient management at the meeting on 26 February. This paper presents:

- A summary of the way the NPS-FM currently directs the management of nutrients (p30);
- Problems that have been raised with the current approach (p30);
- Health implications of elevated nitrate concentrations in groundwater (p30);
- Some examples of how far councils have progressed through the objective setting process (p31);
- A summary of recent NIWA research on periphyton (p33);
- Three options to consider for nutrient attributes (p35);
- A comparison of the number and length of stream segments falling within each attribute band, for the different options (p38);
- Questions for STAG (p49);
- The suggested background reading to inform this discussion, with a brief outline of the information that is in each document and location of summary (where relevant; p50)
- Appendix 1: NPS attribute tables (p53)
- Appendix 2: Summary of A draft technical guide to the Periphyton Attribute Note (p59)
- Appendix 3: Notes for the STAG regarding LaWF discussions on nutrient attributes (p61)

Summary of nutrient management in the NPS-FM

Nutrients in rivers are managed in the NPS-FM by councils setting objectives for periphyton levels and other outcomes in nutrient sensitive downstream receiving environments. The minimum requirement for rivers is to set instream concentrations for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP). Ammonia and nitrate are also managed as toxicants. In lakes, nutrients are managed by way of attributes for total nitrogen and total phosphorus, and indirectly by a chlorophyll *a* (chl *a*) attribute. The relevant attribute tables are included in Appendix 1 of this document.

Accompanying the periphyton attribute in Appendix 2 of the National Objectives Framework is a Periphyton Attribute Note. The Note requires Councils to set instream concentrations for DIN and DRP to achieve objectives for periphyton and sensitive downstream receiving environments, or where the Freshwater Management Unit (FMU) does not support conspicuous periphyton, set criteria to achieve any other relevant freshwater objectives. The Periphyton Attribute Note has the same legal implications as all other parts of the NPS-FM. There is technical guidance for councils to set appropriate instream concentrations and exceedance criteria for nitrogen and phosphorus to achieve periphyton and other objectives (see Appendix 2 for summary). In addition, the Draft Guide to Attributes in Appendix 2 of the National Policy Statement for Freshwater Management 2014 (Draft Guide) addresses sampling considerations.

The periphyton attribute was developed in the initial NOF because high biomass causes a range of effects including dissolved oxygen and pH fluctuations, a reduction in the diversity and productivity of invertebrates and fish, as well as affecting recreational values (Snelder et al. 2013). Periphyton abundance is influenced by a range of factors that can be managed, such as nutrient concentrations, flow regimes, and light. These factors can be used to define limits on resource use relating to nutrient discharges, water use, and land uses impacting on riparian vegetation. Chlorophyll *a* was chosen as a measurement method as it is the most commonly recognised standard method internationally and nationally, and had stronger performance in models relating periphyton to water chemistry, flow and ecosystem health measures (Snelder et al. 2013).

For a more detailed discussion of trophic state in rivers and the periphyton attribute, please see the text under Option 1 below.

What is the problem?

There is concern about the potential for misinterpretation of the toxicity attributes as ecosystem health attributes, which could lead to overly permissive nutrient objectives.

There are also concerns that the periphyton attribute could be inappropriately applied and incorrect nutrient objectives set.

Health implications of nitrate in groundwater

High concentrations of nitrate in groundwater can have health implications. The Maximum Acceptable Value (MAV) for nitrate-nitrogen in groundwater is 11.3 mg/L nitrogen (or 50 mg/L nitrate).

Recent research showed an increase in colorectal cancer risk was associated with concentrations of nitrate in drinking water that are below the current drinking water standard of 50 mg/L nitrate[2]. The current standard is designed to protect formula-fed babies from methemoglobinemia (blue baby syndrome).

A 2016 groundwater survey by Environment Canterbury[3] showed that 22 (7.0%) sites had nitrate-nitrogen concentrations above the MAV. There were increasing trends in nitrate in approximately 23% (48 of 212) monitoring wells. The Ashburton and Selwyn-Waihora water management zones had the highest proportions of increasing trends.

At the meeting, Chris Nokes (ESR) will give a presentation on recent research on nitrates in drinking water and the implications for management of drinking water sources.

How far are councils along in the NPS-FM process?

Regional Councils are required to fully implement the NPS-FM by 31 December 2025, or they may extend this date to 31 December 2030 under certain circumstances. This section gives some examples of progress councils have made in the plan change process as directed by the NPS-FM.

Horizons

The Horizons Region One Plan was notified in 2017 and contains water quality targets[4] for all water management zones and sub-zones for pH, temperature, dissolved oxygen, BOD_5, particulate organic matter, periphyton, dissolved reactive phosphorus, soluble inorganic nitrogen, deposited sediment cover, MCI, ammoniacal nitrogen, and visual clarity.

Region-wide targets apply to *E. coli*, periphyton filamentous cover, diatom or cyanobacterial cover, and QMCI.

Greater Wellington Regional Council

GWRC has divided the region into five Whaitua (the Māori word for catchment or space).

The following whaitua committees have been established:

- Ruamāhanga Whaitua – established December 2013 (Implementation Programme completed; freshwater objectives set)
- Te Awarua-o-Porirua Whaitua - established December 2014 (Implementation Programme in progress)
- Te Whanganui-a-Tara - established November 2018

The following two committees to be established are:

- Kāpiti Coast Whaitua
- Wairarapa Coast Whaitua

---

[2] Schullehner, J., Hansen, B., Thygesen, M., Pedersen, C. B., & Sigsgaard, T. (2018). Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study. International journal of cancer, 143(1), 73-79.

[3] Hanson, M. 2017. Annual Groundwater Quality Survey 2016. Groundwater Science Section. Environment Canterbury Report No. R17/17. Environment Canterbury Regional Council.

[4] Water quality target means an objective or result for water quality towards which efforts are directed. The word "target" in the One Plan does not have the same meaning ascribed to it by the National Policy Statement for Freshwater Management 2011.

West Coast Regional Council

By 2023, WCRC will:

- Complete first daft of RL&WP and release for stakeholder feedback (PC3).
- Proposed changes to RL&WP, incl. Inangahua, Hokitika, Paparoa and South Westland FMU's specific provisions, notified under Schedule 1 of the RMA. PC3 will also include the following NPSFM requirements:

Freshwater quantity

- Freshwater quantity management units for rivers, lakes and aquifers –Policy CA1.
- Freshwater quantity objectives – Policy B1
- Freshwater quantity limits for each FMU, except for minimum level for aquifers and allocation limits for lakes (refer Policy B1)
- Policy and rules to improve and maximise the efficient allocation and efficient use of water (Polices B2, B3 and B4)
- Policy and rules to avoid over-allocation (Policy B5)

Freshwater quality

- Water quality standards in rivers (periphyton, nitrate toxicity, ammonia toxicity, dissolved oxygen, E. coli and cyanobacteria – for lake fed rivers).
- Water quality standards for lakes (phytoplankton, total nitrogen, total phosphorus, ammonia toxicity, E. coli and cyanobacteria).
- Policy to maintain overall water quality
- Provisions to manage discharges to land and water, including rules requiring the adoption of the best practicable option to manage discharges of contaminants (refer Policy A3)
- Provisions to manage the disturbance of the beds of lakes, rivers and certain uses of land.

Northland Regional Council

Circa 2021, NRC will notify a change to the regional plan to:

- Identify freshwater quality management units for rivers (refer Policy CA1).
- Include numeric freshwater quality objectives for rivers using the water quality attributes in Appendix 2 of the NPS-FM (refer Policy A1)
- Include in-stream concentration standards and exceedance criteria for dissolved inorganic nitrogen and dissolved reactive phosphorus in rivers for the purposes of achieving numeric freshwater quality objectives for periphyton (refer Appendix 2).
- Include relevant nitrogen and phosphorus criteria (instream concentrations or loads) for sensitive estuaries (refer Appendix 2).
- Include relevant freshwater quality limits (refer Policy A1).

Summary of recent periphyton research

Two recent reports have highlighted the multiple factors influencing periphyton growth in NZ rivers and the challenges involved in modelling periphyton. These are summarised below.

At the meeting, Cathy Kilroy (NIWA) will give a presentation on recent periphyton research.

Summary of "Modelling periphyton in New Zealand's rivers. Part 1. An analysis of current data and development of national predictions" (Kilroy et al. *in draft*)

This report presents an analysis of periphyton data, which was used to develop relationships and models between periphyton and environmental variables. The aim was to assess the extent of nuisance periphyton across NZ.

Steps 1 and 2: Data was acquired from six regional councils (Northland, Bay of Plenty, Horizons, Greater Wellington, Canterbury and Southland), and included in further analysis if there was a monthly time series of at least 20 months. The data set included up to 196 sites, with flow data at 136 sites.

Step 3: Chl *a* and flow data were analysed at individual sites to find the effective flow (EF) that reduces periphyton to low levels. The effective flow can be used to calculate accrual period or mean interval between removal events. An attempt was made to identify predictors of EF across the REC network using random forest models, but a useful model could not be identified.

Step 4: Relationships between periphyton and environmental variables were quantified using multiple regression techniques (with cross validation). The 92^{nd} percentiles and means of chl *a* and weighted composite cover (WCC) were used. Predictor variables were:

- mean accrual period calculated from the EF(at sites where it was identified),
- measured dissolved inorganic nitrogen (DIN),
- dissolved reactive phosphorus (DRP),
- conductivity,
- substrate composition
- temperature.

No national model could be identified for WCC. For chl *a*, the strongest national models incorporated DIN, DRP, conductivity and accrual period calculated from the EF. However, all regional datasets except the Canterbury dataset outperformed the national dataset in terms of model strength and predictive ability for chl *a*.

Step 5: Results were compared with previous studies.

Step 6: Due to weak regression model performance, limited spatial coverage of data, and failure to identify a national model for EF, the regression models were not used to make predictions of periphyton across the river network. Instead, random forest models were employed to predict periphyton chl *a* across the river network, using modelled variables as predictors. The most important variables for the chl *a* models were conductivity, nitrate-N, TN and rainfall variability.

Step 7: Based on the models developed in Step 6, predictions were made of which reaches fall into bands A, B, C and D of the NPS-FM periphyton attribute, presenting the results by REC class and region.

Important points

Different predictor variables were important for chl *a* and WCC, leading to differences in predictions for these two variables. There were also differences in the relationships between chl *a* and WCC among regions. Reasons for this could be:

(1) different analysis methodologies for chl *a* around the country – a National Environmental Monitoring Standard (NEMS) is under preparation to address this;

(2) differences in methods for visual assessments of periphyton – will also be addressed in the NEMS

(3) The relationship varies due to differences in periphyton community composition.

Very few sites were predicted to exceed the 92nd percentile bottom line of the periphyton attribute in the NPS-FM. The report authors attributed this partly to the behaviour of random forest models; random forest models do not make predictions outside the range of training data. Including sites with fewer than three years of monitoring data would also have reduced the accuracy of the estimates of the 92nd percentile of chl *a*.

The authors compared the 92nd percentile of chl *a* to predictions of nitrate and dissolved reactive phosphorus from another recent study of modelled river water quality (Whitehead 2018). The nitrate and dissolved reactive phosphorus concentrations corresponding to the chl *a* attribute bands C and D varied widely around the country.

Summary of "Modelling periphyton in New Zealand's rivers. Part 2. A review and prospects for mechanistic modelling" (Kuczynski, *in draft*)

This report compares empirical and mechanistic approaches to modelling periphyton to address the question: What environmental conditions are required to meet river periphyton biomass (chlorophyll a) targets?

Empirical models have been used to date to predict periphyton in NZ rivers (e.g. the Part 1 report summarised above) and are recommended in the Guide to the Periphyton Attribute Note (see Appendix 2) as a way to compare different nutrient loading scenarios and support decision making in freshwater management. A key benefit of empirical models is the ability to develop straightforward relationships that can be applied to management questions. Some disadvantages of these kinds of models are that they may not determine cause and effect relationships, and rely on historical data so that extrapolating beyond the range of the input data is highly uncertain.

Mechanistic models use knowledge of physical, chemical and biological processes driving periphyton growth and therefore can be used to predict the responses to conditions that have not yet been observed. Several different mechanistic modelling approaches are available, ranging in complexity. Examples of factors mediating biomass growth that can be modelled include temperature, light, internal and external nutrient effects, nutrient dynamics and carrying capacity, and factors influencing biomass loss include respiration, grazing, sloughing, and mortality.

The report sets out a recommended series of steps that could be taken to inform nationwide periphyton management using mechanistic models.

Options

This section describes the following options to consider:

1. The status quo: a periphyton attribute for rivers
2. Attribute tables for nitrate-nitrogen and dissolved reactive phosphorus – applicable nationally
3. Attribute tables for nitrate-nitrogen and dissolved reactive phosphorus – for different river classes

Option 1. Status quo: A periphyton attribute for rivers

The periphyton attribute of the National Objectives Framework (NOF) sets the trophic state of rivers as a management objective and not their nutrient concentration *per se*. The rationale for this is based on (1) scientific understanding of trophic state, (2) the purpose of freshwater objectives in the NPS-FM, and (3) uncertainty associated with defining appropriate nutrient concentrations. There has been considerable debate concerning the inclusion of the periphyton attribute and the omission of nutrient concentrations as attributes for rivers in the NOF. This section provides a brief rationale for why periphyton is included as an attribute in the NOF and why, to date, river nutrient concentrations for trophic state have not been included as attributes.

Scientific understanding of trophic state in rivers

Trophic state is a term used to indicate the biological productivity of aquatic ecosystems (i.e., the amount of living material supported within the system). Systems may be classified as oligotrophic, mesotrophic or eutrophic depending on their biological productivity. Although all states can occur naturally, healthy ecosystems are generally characterised by oligotrophic or mesotrophic states and eutrophic states are associated with degraded conditions.

Eutrophic states in rivers are associated with periodic, relatively frequent, high biomass (“blooms”) of periphyton (slime) or macrophytes (rooted plants). Eutrophic states affect ecosystem health by causing adverse fluctuations in dissolved oxygen and pH, smothering habitat, and altering invertebrate communities. Eutrophic conditions are also associated with changes to water colour, odour, and alteration of the general appearance of the river bed, which have detrimental effects on human use values.

The maximum periphyton biomass is an indicator of trophic state for gravel bed rivers, which comprise a large proportion of New Zealand’s rivers. The maximum abundance of macrophytes is an indicator that is relevant for soft bottomed streams (i.e. muddy or sandy) and is discussed briefly later. The NOF periphyton attribute defines maximum periphyton biomass states in terms of chlorophyll for four environmental states (A, B, C and D bands).

The concentrations of nutrients, primarily nitrogen and phosphorus, are fundamental determinants of maximum periphyton biomass. Thus, river nutrient concentrations must be managed to restrict the periphyton biomass to a level (i.e. achieve a trophic state) that supports their ecological health. However, there are other factors involved in determining periphyton biomass that must be considered when setting nutrient concentration criteria.

In rivers, a simple conceptual model of periphyton biomass dynamics is represented by two “competing” processes: growth and loss. Growth rate is determined primarily by light, temperature and nutrient concentrations. Biomass loss is determined primarily by invertebrate grazing and flow variations that scour and remove periphyton. Maximum biomass is determined by the length of the accrual period (the period of stable flows in which growth rates exceed loss rates). Accrual periods are terminated by high flows that considerably reduce periphyton biomass. The flow magnitude required to reduce periphyton varies between sites in association with stream hydraulic conditions (i.e. velocity, substrate stability).

There is considerable spatial variation in light, temperature, grazing and accrual period length in New Zealand rivers. This means that nutrient concentration criterion to achieve a given trophic state (e.g., mesotrophic) are expected to vary considerably between locations. In addition, many of the additional factors themselves are altered by human activities. For example, water resource use affects flow regimes and land use affects light and temperature through activities such as deforestation and changes to riparian vegetation. These factors are super-imposed on natural variation and must also be accounted for in the definition of justifiable nutrient concentration criteria.

The purpose of freshwater objectives

The inclusion of periphyton as a NOF attribute makes managing the trophic state of rivers a national requirement. Objectives for periphyton are appropriate because it is an aspect of environmental state that is readily understood by the public and is quantifiable scientifically. Because the effects of resource use on periphyton is understandable by the public, maximum biomass provides a basis for discussing the trade-offs between resource use and environmental protection and for deciding on limits to resource use. In addition, periphyton objectives provide a basis for defining limits for several types of resource use; the discharge of nutrients from point and non-point sources, water uses that alter flow regimes, and activities impacting on riparian vegetation.

While nutrient concentrations must be managed to achieve a trophic state outcome, a given nutrient concentration does not have a spatially uniform outcome for trophic state. Even at a site, the consequence of given nutrient concentrations will depend on other managed variables including flow regime and riparian vegetation. Nutrient criteria to achieve a specified periphyton objective must therefore be derived for specific water bodies and often specific sites based on the local conditions and the biomass objective.

Nutrient concentration criteria uncertainty

Many studies both nationally and internationally have shown that relationships between nutrient concentrations and periphyton biomass are uncertain. Defining national level nutrient concentration criterion would have two implications. First, the uncertainty (error) associated with any set of criteria mean they will be under-protective and over-protective in different environments. Second, mandating nutrient criteria will disincentivise regional councils from specifying concentrations cautiously and conducting investigations to more accurately determine appropriate concentrations. It is noted that subsequent to 2013 regional councils have significantly increased periphyton monitoring and have started to invest in science to define nutrient criteria.

Provisos

Not all rivers have suitable physical conditions for the growth of conspicuous periphyton. In particular soft (i.e. muddy or sandy) bottomed lowland streams are often not a suitable habitat for periphyton because of the instability of their beds. These streams are often dominated by macrophytes and abundance can often reach problematic levels. There is currently insufficient understanding of the relationship between macrophytes and nutrient concentrations to propose using macrophyte biomass to define trophic state objectives for rivers. A major reason for this is that all rooted macrophytes derive a significant proportion of their nutrients from the sediment. This proportion varies considerably with the species present.

An important proviso concerning the management of nutrient concentrations *per se* is in situations where they may have impacts other than on periphyton biomass. At very high concentrations, forms of nitrogen (nitrate and ammonia) are toxic. It is possible that trophic state criteria can be met in some situations, but nitrogen could be present in toxic concentrations (e.g. highly shaded lowland streams). The NOF nitrate and ammonia attributes apply in these situations. Another proviso concerns the export of nutrient to other receiving environments. In this case nutrient limits would need to take into account the objectives set for the downstream receiving environment as well as the in-river concentrations. The NOF recognises the inter-connected nature of water bodies and requires that regional councils establish objectives that have regard to this.

The 2017 amendments to the NPS-FM clarifies the intent of the periphyton, nitrate toxicity and ammonia toxicity attributes by requiring regional councils to set instream concentrations of dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP). In addition, the amendments define a clear process for setting concentrations to achieve objectives in downstream receiving environments.

The periphyton attribute is compulsory i.e. councils must set objectives and therefore corresponding DIN and DRP criteria (including those appropriate for any receiving environments) whether they have periphyton or not. Therefore, in almost all cases, the required nutrient criteria will need to be set at a more stringent level to meet periphyton objectives than for toxicity. The 2017 amendments to the NPS-FM also added a note to the Nitrate (toxicity) attribute table to clarify this point[5].

Option 2. Attribute tables for nitrate-nitrogen and dissolved reactive phosphorus – applicable nationally

This option presents attribute tables that would be applicable nationally, as described in Death et al. (in prep.)[6].

Please refer to introductory paper provided separately by Adam Canning.

At the meeting, Russell Death (Massey University) will give a presentation on nationally applicable attribute tables for nitrate-nitrogen and DRP.

Option 3. Attribute tables for nitrate-nitrogen and dissolved reactive phosphorus – for different river classes

This option would provide an attribute table for nitrate-nitrogen and DRP in different classes of river. This would look like a matrix table of NOF bands and river classes for each of nitrate-nitrogen and DRP.

An example of this kind of approach is described by Snelder (2018)[7], who used models of periphyton biomass in 78 gravel-bed NZ rivers to derive concentration targets for total

[5] "Note: This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent."

[6] Death, R. G., Magierowski, R., Tonkin, J. D., and Canning, A. D. (in prep.). Clean But Not Green: A Weight-of-Evidence Approach for Setting Nutrient Criteria in New Zealand Rivers.

[7] Snelder, T. 2018. Nutrient concentration targets to achieve periphyton biomass objectives incorporating uncertainties. Lower Hutt (NZ): GNS Science. 41p. (GNS Science report; 2018/38). doi:10.21420/ajsh-nw16.

nitrogen (TN) and DRP. Temporal exceedance criteria were used to specify that the biomass threshold would not be exceeded in more than 8% of samples. Spatial exceedance criteria were built into the model to allow a management objective to restrict biomass to acceptable levels in 10%, 20% or 50% of locations within a domain of interest.

At the meeting, Clive Howard-Williams (NIWA) and Ton Snelder (Land and Water People) will talk about approaches to nutrient objective setting.

Comparison of attribute bands

Introduction

This section presents an analysis of the length of rivers and streams that would fall into each attribute band, for the different proposed attributes:

1. Nitrate and ammonia toxicity attributes;
2. Nitrate and DRP attributes proposed by Death et al.
3. Nitrate and DRP concentrations corresponding to the periphyton attribute.

The main aim of this analysis is to illustrate the differences in how much stream and river length would fall under the bottom line, for each approach.

Methods

This analysis was conducted using modelled water quality between 2009 and 2013[8]. Stream segments were defined using REC 2.4[9]. Maps show all stream segments order 3 and greater; tables include all stream orders.

Attribute tables used in the analysis were:

Table 1. NOF attributes – nitrate and ammonia toxicity

Attribute state	Annual Median (Nitrate)	Annual Median (Ammonia)
A	≤1.0	≤0.03
B	>1.0 and ≤2.4	>0.03 and ≤0.24
C	>2.4 and ≤6.9	>0.24 and ≤1.30
D	>6.9	>1.30

[8] https://data.mfe.govt.nz/table/53601-predicted-river-water-quality-200913/
[9] https://www.niwa.co.nz/freshwater-and-estuaries/management-tools/river-environment-classification-0

Table 2. Death et al. attributes – nitrate and DRP

Attribute state	Annual Median (mg/l) (NO3N)	Annual Median (mg/l) (DRP)
A	≤ 0.10	≤ 0.006
B	>0.10 and ≤0.28	>0.006 and ≤0.013
C	>0.28 and ≤0.46	>0.013 and ≤0.019
D	>0.46 and ≤0.89	>0.019 and ≤0.038
E	>0.89 and ≤1.32	>0.038 and ≤0.057
F	>1.32	>0.057

Table 3. Periphyton attributes – total N and DRP (Snelder 2018). Abbreviations: WX – warm extremely wet; WW – warm wet; WD – warm dry; CX – cool extremely wet; CW – cool wet; CD – cool dry; GM – glacial mountain; M – mountain; H – hill; L – low elevation, Lk – lake.

	TN (mg/m³)			DRP (mg/m³)		
REC Source of Flow	T50 (A/B Band)	T120 (B/C band)	T200 (C/D band)	T50 (A/B Band)	T120 (B/C band)	T200 (C/D band)
CX/GM	66	336	816	1.8	56.7	161.2
CX/M	117	582	1427	8.2	114.1	289.3
CX/H	120	607	1440	7.2	107.3	273.4
CX/L	85	433	1033	2.4	67.3	186.8
CX/Lk	27	134	321	0.2	6.5	43.2
CW/GM	31	155	367	0.3	13.1	69
CW/M	33	174	411	0.3	14.5	69.1
CW/H	37	189	451	0.3	15.8	68.9
CW/L	29	143	351	0.2	5.2	37.6
CW/Lk	18	92	221	0.2	2.2	21.7
CD/M	20	99	240	0.2	2.4	23.7
CD/H	17	89	213	0.2	1.2	12.7
CD/L	18	90	224	0.2	1.2	12.6
CD/Lk	16	80	191	0.2	1.1	11.8
WX/L	32	160	386	0.2	8.8	50.5
WX/H	36	180	430	0.3	13.4	63.7
WW/H	52	260	636	0.6	27.3	94.5
WW/L	19	95	231	0.2	1.6	15.6
WW/Lk	18	91	221	0.2	1.3	13.9
WD/L	9	47	113	0.1	0.2	1.5
WD/Lk	21	108	259	0.2	1.2	13.1

Results

Nitrate toxicity

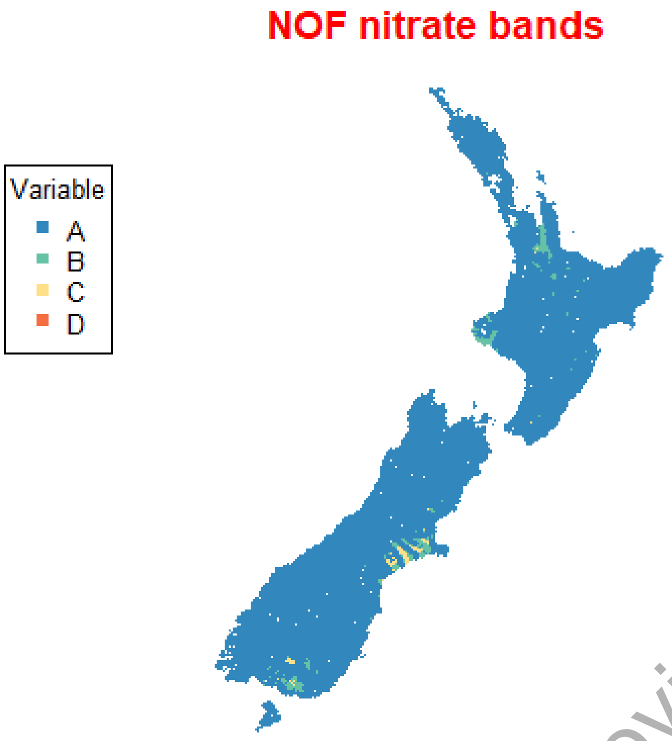

Figure 1. Map of stream segments in each attribute band, for nitrate toxicity.

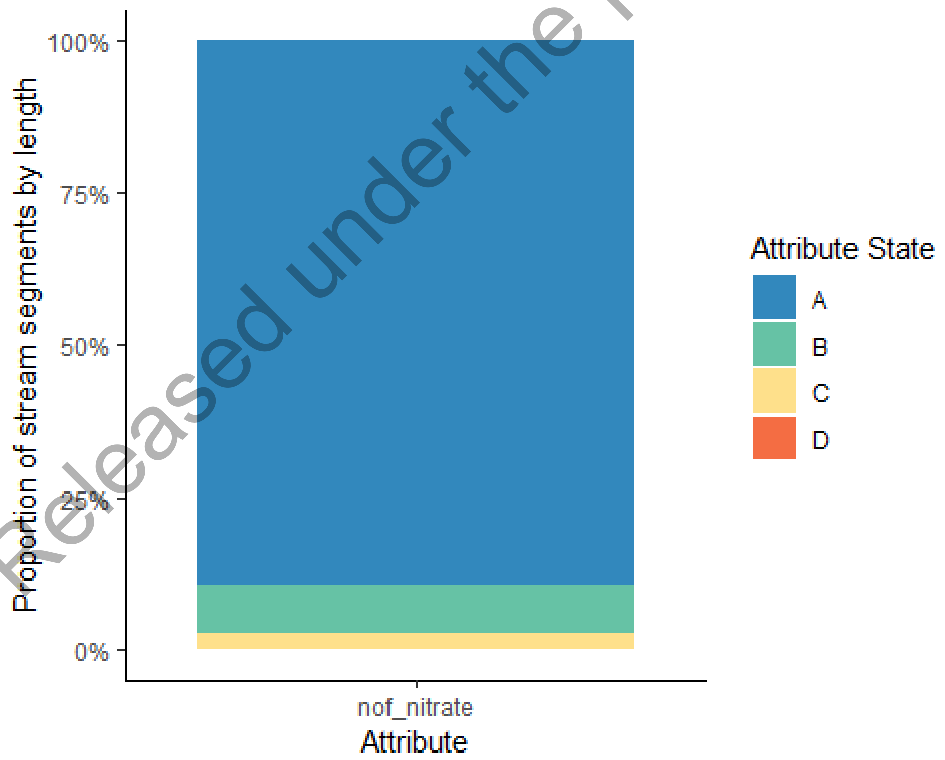

Figure 2. Proportion of stream segments by length in each attribute band, for nitrate toxicity.

Ammonia toxicity

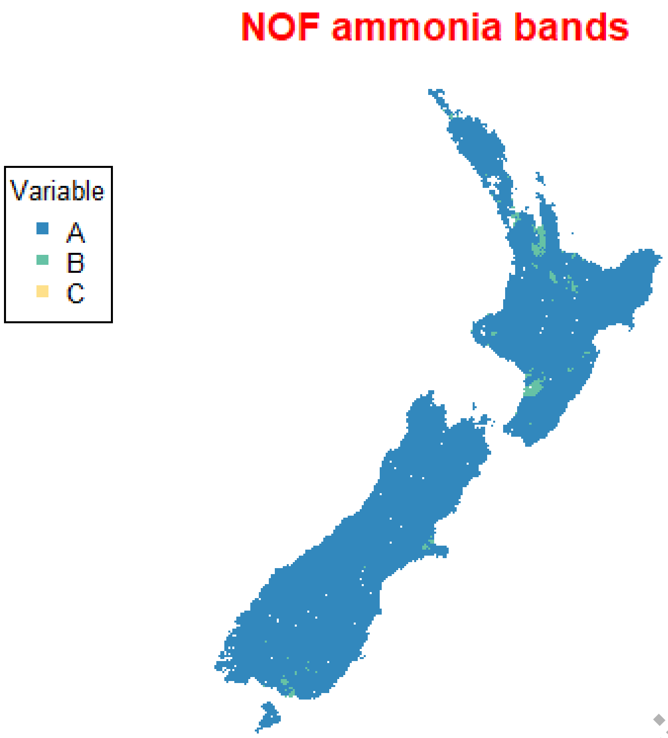

Figure 3. Map of stream segments in each attribute band, for ammonia toxicity.

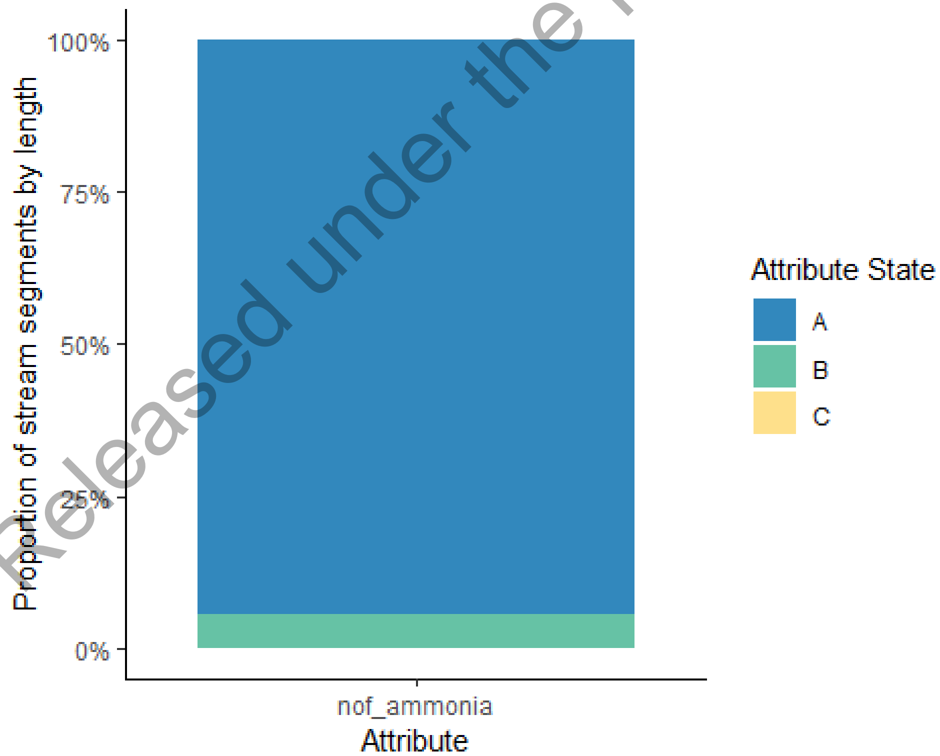

Figure 4. Proportion of stream segments by length in each attribute band, for ammonia toxicity.

Death et al. nitrate

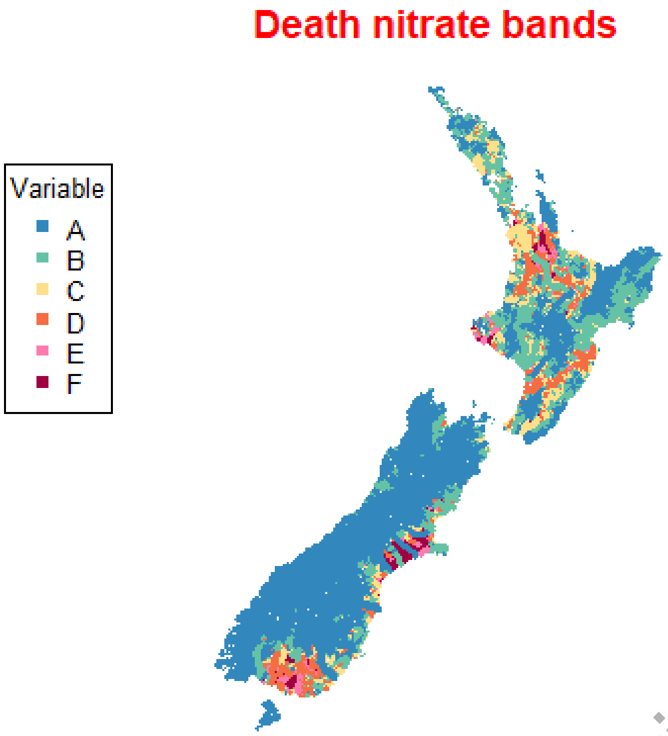

Figure 5. Map of stream segments in each attribute band, for Death et al. nitrate attribute.

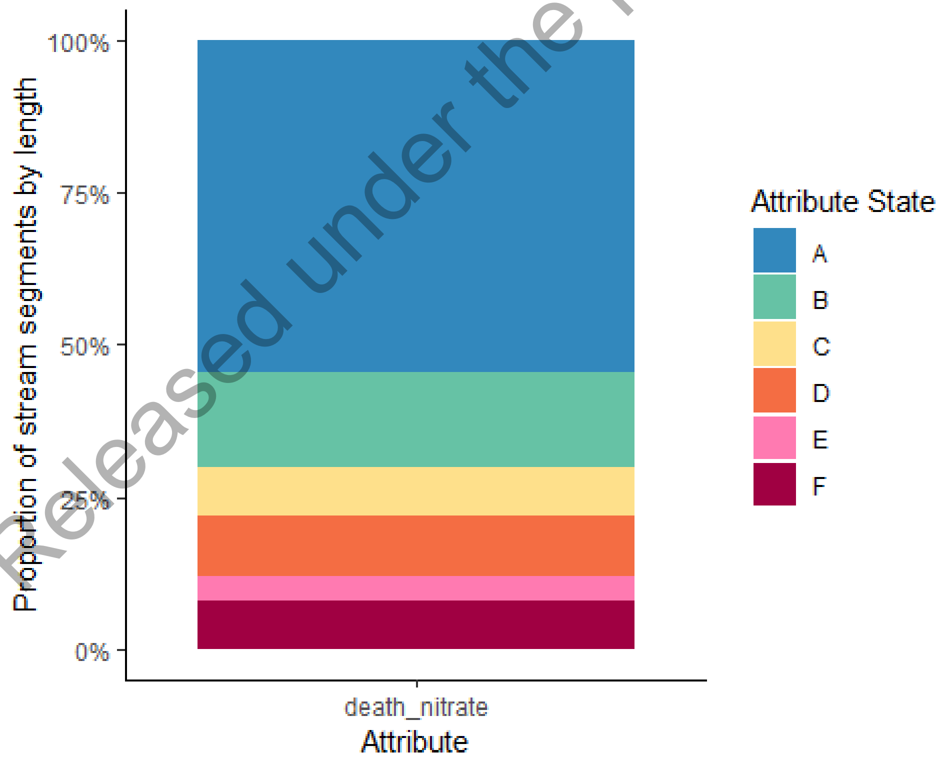

Figure 6. Proportion of stream segments by length in each attribute band, for Death et al. nitrate attribute.

Death et al. DRP

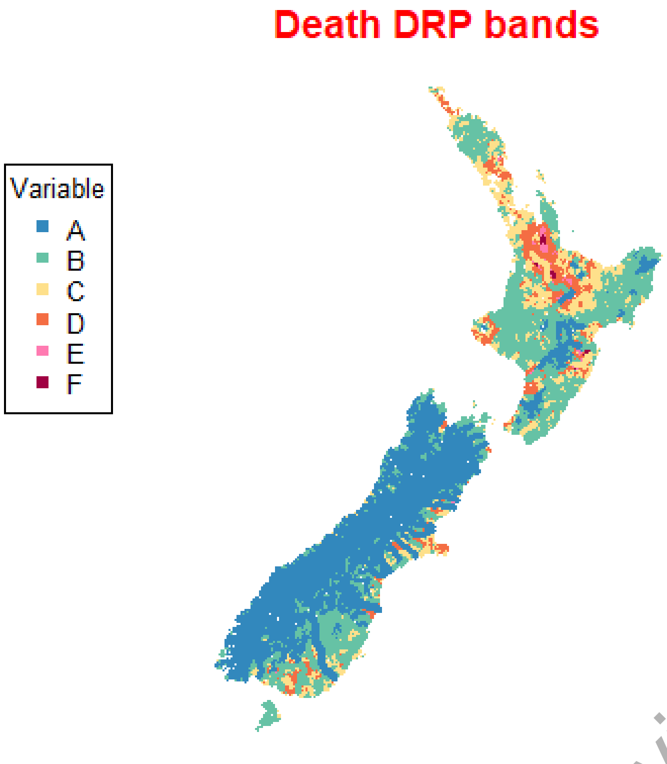

Figure 7. Map of stream segments in each attribute band, for Death et al. DRP attribute.

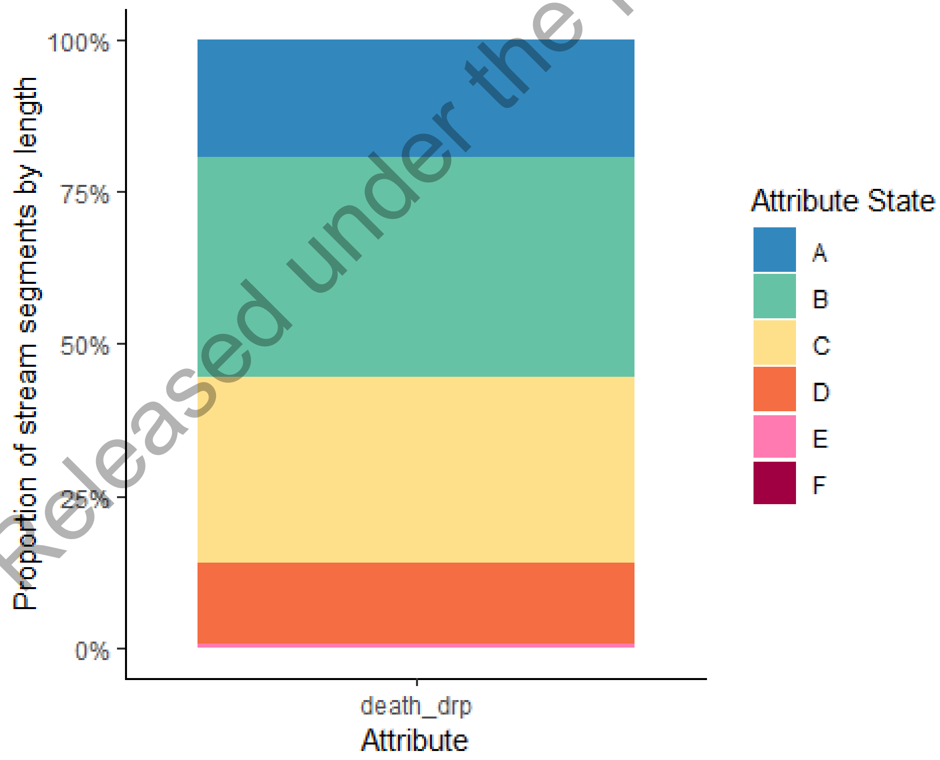

Figure 8. Proportion of stream segments by length in each attribute band, for Death et al. DRP attribute.

Periphyton TN

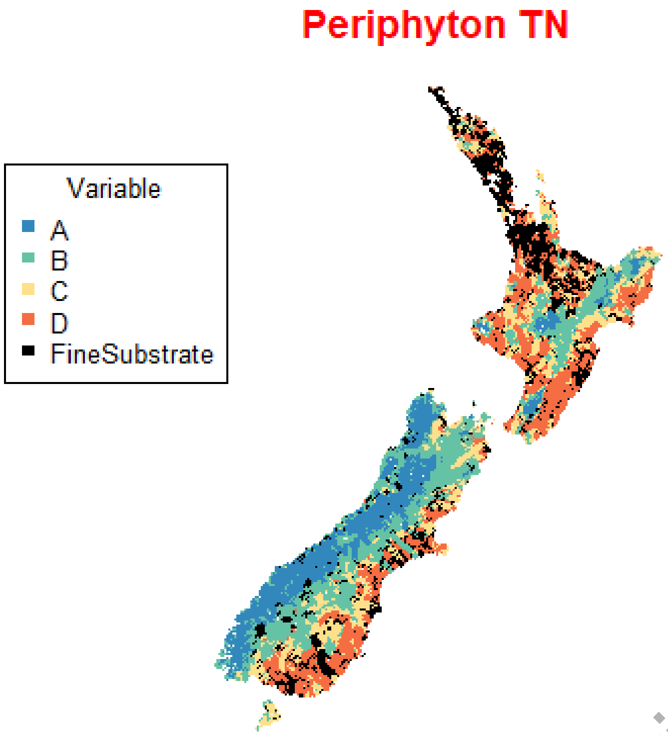

Figure 9. Map of stream segments in each attribute band, for Periphyton TN attribute.

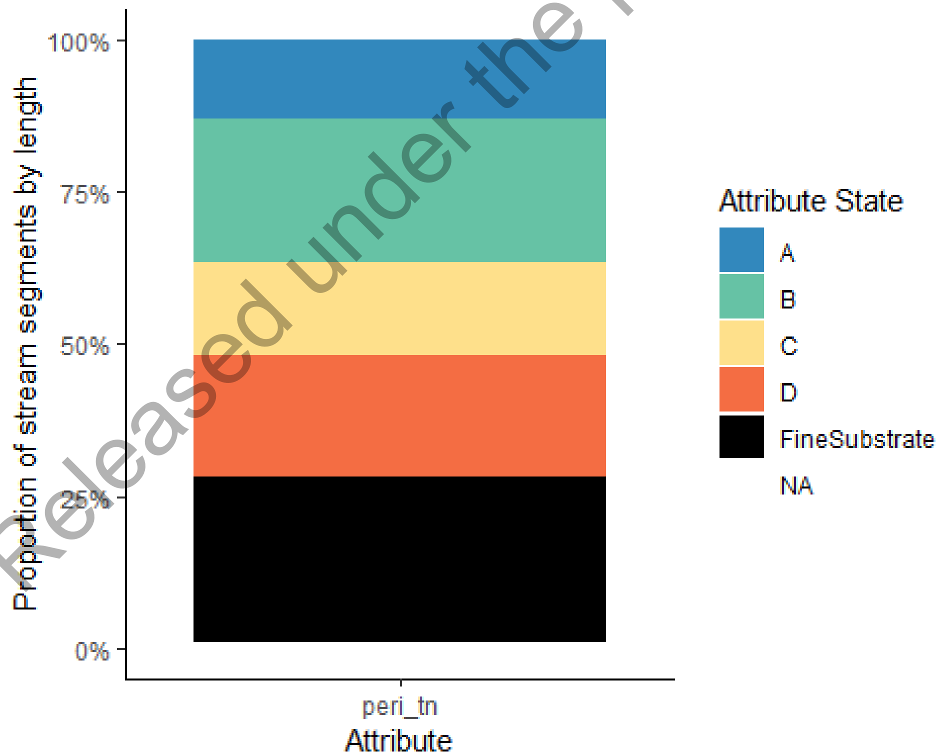

Figure 10. Proportion of stream segments by length in each attribute band, for Periphyton TN attribute.

Periphyton DRP

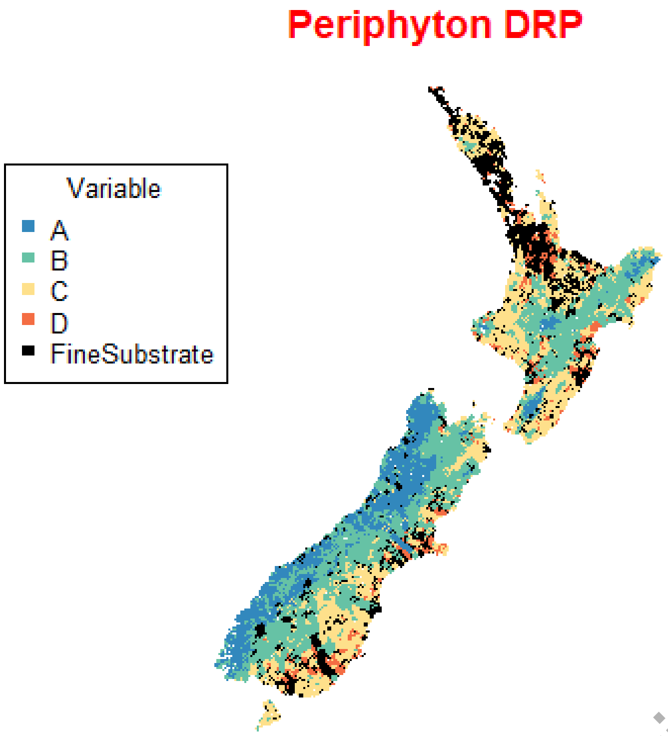

Figure 11. Map of stream segments in each attribute band, for Periphyton DRP attribute.

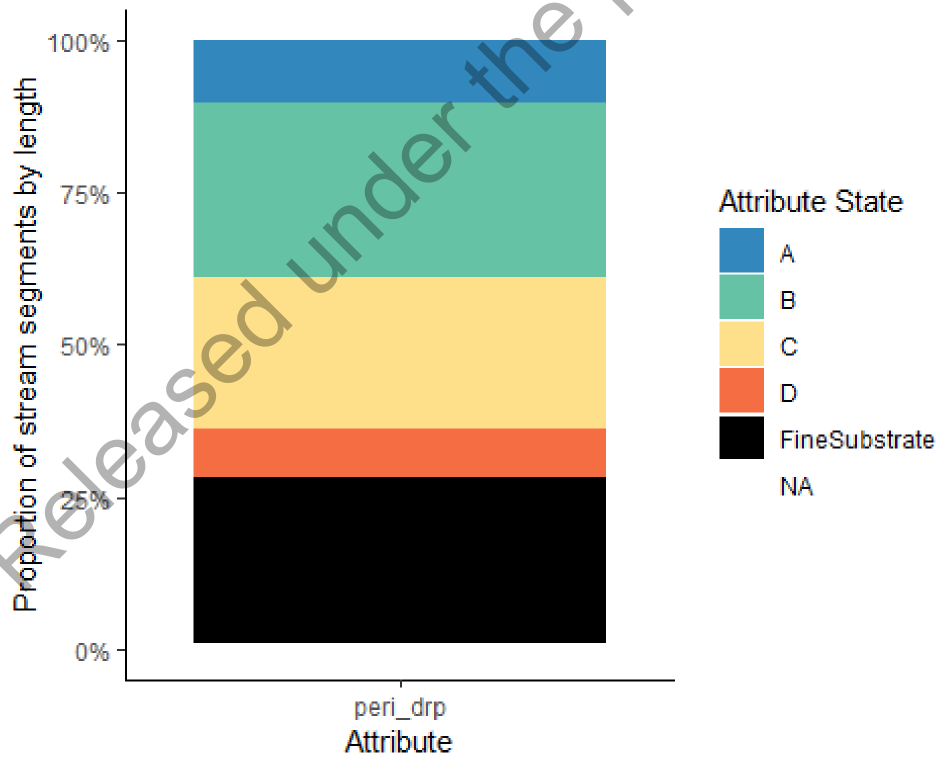

Figure 12. Proportion of stream segments by length in each attribute band, for Periphyton DRP attribute.

Periphyton TN and DRP combined

This section shows the worst attribute state (of TN or DRP) for each segment.

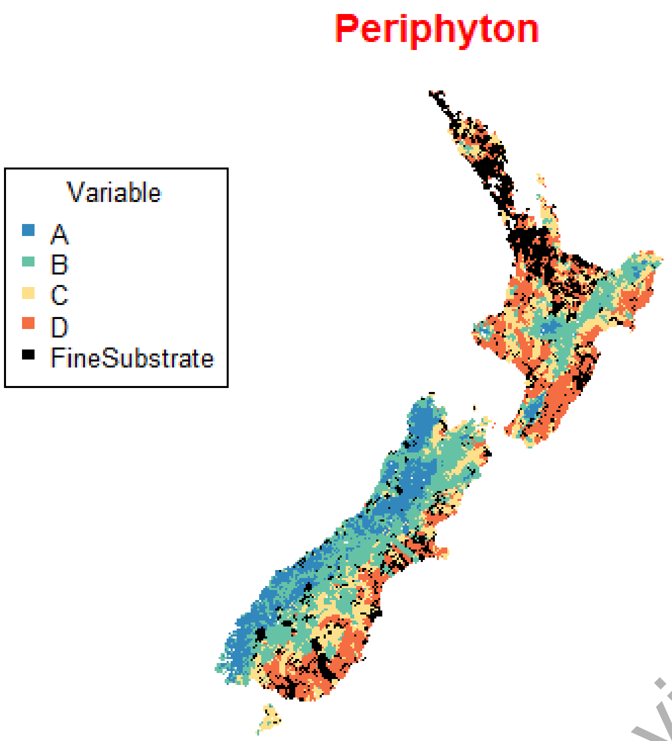

Figure 13. Map of stream segments in each attribute band, for Periphyton TN and DRP combined (showing the worse of the two values for each reach).

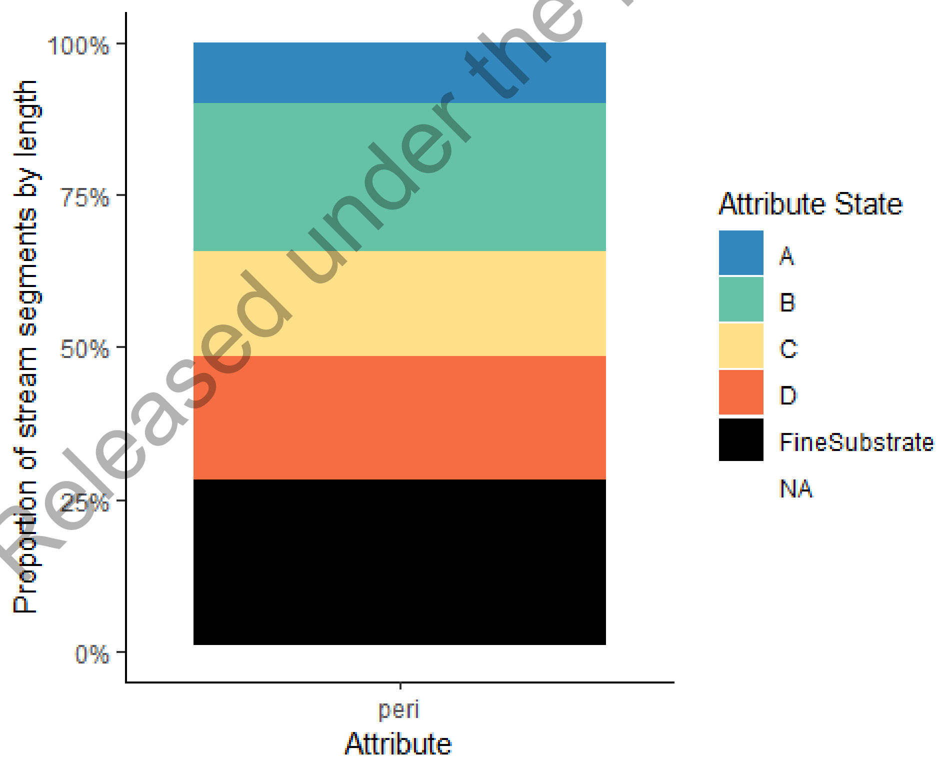

Figure 14. Proportion of stream segments by length in each attribute band, for Periphyton TN and DRP combined (showing the worse of the two values for each reach).

Combined comparison tables

Table 4. Comparison of stream segments (by number, length and percentage) in attribute state bands (nitrogen).

Attribute	Attribute state	Number of segments	Stream length (m)	Stream length (%)
Nitrate toxicity	A	546,244	369,524,044	89.4%
	B	37,951	33,290,516	8.1%
	C	9,248	10,309,977	2.5%
	D	1	2,292	0.0%
Ammonia toxicity	A	563,498	390,137,453	94.4%
	B	29,945	22,986,927	5.6%
	C	1	2,449	0.0%
	D	0	0	0
Death et al. Nitrate	A	347,614	225,372,153	54.6%
	B	90,502	64,608,786	15.6%
	C	46,841	33,167,456	8.0%
	D	54,698	41,023,558	9.9%
	E	19,637	16,540,695	4.0%
	F	34,152	32,414,180	7.8%
Periphyton TN	A	88,312	53,928,591	13.1%
	B	148,754	97,067,330	23.5%
	C	92,125	63,425,825	15.4%
	D	113,676	82,854,664	20.1%
	FineSubstrate	143,753	112,518,823	27.2%
	NA	6,824	3,331,596	0.8%

Table 5. Comparison of stream segments (by number, length and percentage) in attribute state bands (DRP).

Attribute	Attribute state	Number of segments	Stream length (m)	Stream length (%)
Death et al. DRP	A	125,068	80,025,538	19.4%
	B	218,505	148,967,993	36.1%
	C	178,125	127,100,292	30.8%
	D	67,942	54,043,669	13.1%
	E	3,263	2,542,149	0.6%
	F	541	447,188	0.1%
Periphyton DRP	A	69,896	42,879,355	10.4%
	B	178,146	117,691,754	28.5%
	C	147,507	102,516,774	24.8%
	D	47,318	34,188,526	8.3%
	FineSubstrate	143,753	112,518,823	27.2%
	NA	6,824	3,331,596	0.8%

Table 6. Comparison of stream segments (by number, length and percentage) in attribute state bands (TN and DRP combined – taking the worst attribute state for each segment).

Attribute	Attribute state	Number of segments	Stream length (m)	Stream length (%)
Periphyton – TN and DRP combined – taking the worst attribute state of TN and DRP, for each segment	A	67,235	40,880,454	9.9%
	B	154,962	100,550,070	24.3%
	C	103,896	71,136,237	17.2%
	D	116,774	84,709,648	20.5%
	FineSubstrate	143,753	112,518,823	27.2%
	NA	6,824	3,331,596	0.8%

Questions

1. Are the current provisions in the NPS-FM sufficient to maintain or improve ecosystem health in rivers?
    a. If not, why not?
2. How far does current understanding take us? What further work is required?
3. Would it be (1) feasible and (2) necessary to provide default concentrations for DIN and DRP?
    a. If so, how would the DIN/DRP concentrations need to be derived to provide for maintaining or improving ecosystem health in different river types?
    b. What should be the process for defining them?
    c. Are classification systems needed to appropriately vary the default DIN and DRP concentrations?

Suggested background reading list

Number	Reference	Read this for…	Summary provided?
1.	Death, R. G., Magierowski, R., Tonkin, J. D., and Canning, A. D. (in prep.). Clean But Not Green: A Weight-of-Evidence Approach for Setting Nutrient Criteria in New Zealand Rivers. Provided on portal and by email	The rationale for, and explanation of, proposed nitrate and DRP attributes that would apply nationally.	Yes – see paper provided by Adam Canning
2.	Kilroy, C., Whitehead, A., Howard, S., & Greenwood, M. (2019). Modelling periphyton in New Zealand's rivers. Part 1. An analysis of current data and development of national predictions. Prepared for the Ministry for the Environment by NIWA Provided on portal and by email	The most recent national analysis and empirical modelling of the factors driving periphyton biomass.	Yes – see page 33 of this document
3.	Kilroy, C., Greenwood, M., Wech, J., Stephens, T., Brown, L., Matthews, A., Patterson, Maree., Patterson, Mike. (2018). Periphyton – environment relationships in the Horizons region: Analysis of a seven-year dataset. Prepared for DairyNZ and Horizons Regional Council by NIWA. Provided on portal and also available at: https://www.manawaturiver.co.nz/wp-content/uploads/2018/12/Periphyton-Environment-Relationships-in-the-Horizons-Region.pdf	A wide-ranging analysis of between- and within-site relationships between periphyton and environmental drivers.	No – suggested background reading
4.	Kuczynski, A. (2019). Modelling periphyton in New Zealand's rivers. Part 2. A review and prospects for mechanistic modelling. Prepared for the Ministry for the Environment by NIWA Provided on portal	A review of empirical and mechanistic approaches to modelling periphyton to address the question: What environmental conditions are required to meet river periphyton biomass (chlorophyll a) targets?	Yes - see page 34 of this document
5.	Matheson, M., Quinn, J., & Hickey, C. (2012). Review of the New Zealand instream plant and nutrient guidelines and development of an extended decision making framework: Phases 1 and 2 final report. Prepared by NIWA for the Ministry of Science & Innovation Envirolink Fund. Provided on portal and also available at:	A decision making/risk assessment framework for Regional Councils to define plant abundance and nutrient objectives, incorporating predictive models of nuisance filamentous periphyton and macrophyte growths.	No – suggested background reading

	http://www.envirolink.govt.nz/assets/Uploads/Review-of-the-NZ-instream-plant-and-nutrient-guidelines-and-development-of-an-extended-decision-making-framework.pdf		
6.	Ministry for the Environment. (2018). A draft technical guide to the Periphyton Attribute Note Under the National Policy Statement for Freshwater Management 2014 (as amended 2017). Wellington: Ministry for the Environment. Provided on portal and also available at: http://www.mfe.govt.nz/publications/fresh-water/draft-technical-guide-periphyton-attribute-note	Sets out a process for Councils to set nutrient objectives in relation to periphyton and sensitive downstream environments	Yes – see page 59 of this document
7.	Schullehner, J., Hansen, B., Thygesen, M., Pedersen, C. B., & Sigsgaard, T. (2018). Nitrate in drinking water and colorectal cancer risk: A nationwide population-based cohort study. International Journal of Cancer, 143(1), 73-79 Provided on portal	A study that showed an increase in colorectal cancer risk associated with concentrations of nitrate in drinking water that are below the current drinking water standard of 50 mg/L nitrate.	No – suggested background reading
8.	Snelder, T. (2018). Nutrient concentration targets to achieve periphyton biomass objectives incorporating uncertainties. Lower Hutt (NZ): GNS Science. 41p. (GNS Science report; 2018/38). doi:10.21420/ajsh-nw16. Provided on portal	Guidance for setting total nitrogen and DRP objectives for different river types incorporating temporal and spatial exceedance criteria.	No – Ton will outline this report in the meeting
9.	Wagenhoff A, Clapcott JE, Lau KE, Lewis GD, Young RG. 2017. Identifying congruence in stream assemblage thresholds in response to nutrient and sediment gradients for limit setting. Ecological Applications 27: 469-484	Identifies points at which stream assemblages change most dramatically in response to multiple stressors, and explores how this can inform objective setting.	No – suggested background reading
10	Wagenhoff A, Liess A, Pastor A, Clapcott JE, Goodwin EO, Young RG. 2017. Thresholds in ecosystem structural and functional responses to agricultural stressors can inform limit setting in streams. Freshwater Science 36: 178-194.	Analysis of change in multiple functional and structural indicators and different organism groups in streams, providing multiple lines of evidence for ecosystem change with small changes in N.	No – suggested background reading

Other relevant background documents

These documents may also be of interest:

1. Hickey, C. 2013. Updating nitrate toxicity effects on freshwater aquatic species. NIWA Client Report No. HAM2013-009. Prepared for the Ministry for the Environment by NIWA. Hamilton: NIWA. http://www.mfe.govt.nz/publications/fresh-water/updating-nitrate-toxicity-effects-freshwater-aquatic-species
2. Hickey, C. 2014. Derivation of indicative ammoniacal nitrogen guidelines for the National Objectives Framework. Memo to Ms Vera Power of MfE, from Chris Hickey of NIWA. Wellington: Ministry for the Environment. https://www.mfe.govt.nz/publications/fresh-water/derivation-indicative-ammoniacal-nitrogen-guidelines-national-objectives
3. Snelder, T., Biggs, B., Kilroy, C., Booker, D. 2013. National Objective Framework for periphyton. Prepared by NIWA for Ministry for the Environment. NIWA Client Report no. CHC2013-122. Christchurch: NIWA. https://www.mfe.govt.nz/sites/default/files/national-objective-framework-periphyton.pdf

Appendix I: NPS Attribute Tables

Periphyton

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	**Periphyton (Trophic state)**		
Attribute Unit	mg chl-a/m^2 (milligrams chlorophyll-a per square metre)		
Attribute State	Numeric Attribute State (Default Class)	Numeric Attribute State (Productive Class)[1]	Narrative Attribute State
	Exceeded no more than 8% of samples[2]	**Exceeded no more than 17% of samples[2]**	
A	≤50	≤50	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
B	>50 and ≤120	>50 and ≤120	Occasional blooms reflecting low nutrient enrichment and/ or alteration of the natural flow regime or habitat.
C	>120 and ≤200	>120 and ≤200	Periodic short-duration nuisance blooms reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat.
National Bottom Line	**200**	**200**	

D	>200	>200	Regular and/or extended-duration nuisance blooms reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.

1. Classes are streams and rivers defined according to types in the River Environment Classification (REC). The Productive periphyton class is defined by the combination of REC "Dry" Climate categories (i.e. Warm-Dry (WD) and Cool-Dry (CD)) and REC Geology categories that have naturally high levels of nutrient enrichment due to their catchment geology (i.e. Soft-Sedimentary (SS), Volcanic Acidic (VA) and Volcanic Basic (VB)). Therefore the productive category is defined by the following REC defined types: WD/SS, WD/VB, WD/VA, CD/SS, CD/VB, CD/VA. The Default class includes all REC types not in the Productive class.

2. Based on a monthly monitoring regime. The minimum record length for grading a site based on periphyton (chl-a) is 3 years.

Note: To achieve a freshwater objective for periphyton within a freshwater management unit, regional councils must at least set appropriate instream concentrations and exceedance criteria for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP). Where there are nutrient sensitive downstream receiving environments, criteria for nitrogen and phosphorus will also need to be set to achieve the outcomes sought for those environments.

Regional councils must use the following process, in the following order, to determine instream nitrogen and phosphorus criteria in a freshwater management unit:

a) either –

   i) if the freshwater management unit supports, or could support, conspicuous periphyton, derive instream concentrations and exceedance criteria for DIN and DRP to achieve a periphyton objective for the freshwater management unit; or

   ii) if the freshwater management unit does not support, and could not support, conspicuous periphyton, consider the nitrogen and phosphorus criteria (instream concentrations or instream loads) needed to achieve any other freshwater objectives:

b) if there are nutrient sensitive downstream environments, for example, a lake and/or estuary, derive relevant nitrogen and phosphorus criteria (instream concentrations or instream loads) needed to achieve the outcomes sought for those sensitive downstream environments:

c) compare all nitrogen and phosphorus criteria derived in steps (a) – (b) and adopt those necessary to achieve the freshwater objectives for the freshwater management unit and outcomes sought for the nutrient sensitive downstream environments.

Nitrate

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Nitrate (Toxicity)		
Attribute Unit	mg NO_3-N/L (milligrams nitrate-nitrogen per litre)		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median	**Annual 95th Percentile**	
A	≤1.0	≤1.5	High conservation value system. Unlikely to be effects even on sensitive species.
B	>1.0 and ≤2.4	>1.5 and ≤3.5	Some growth effect on up to 5% of species.
C	>2.4 and ≤6.9	>3.5 and ≤9.8	Growth effects on up to 20% of species (mainly sensitive species such as fish). No acute effects.
National Bottom Line	6.9	9.8	
D	>6.9	>9.8	Impacts on growth of multiple species, and starts approaching acute impact level (ie risk of death) for sensitive species at higher concentrations (>20 mg/L).

Note: This attribute measures the toxic effects of nitrate, not the trophic state. Where other attributes measure trophic state, for example periphyton, freshwater objectives, limits and/or methods for those attributes will be more stringent.

Ammonia

Value	Ecosystem health		
Freshwater Body Type	Lakes and rivers		
Attribute	Ammonia (Toxicity)		
Attribute Unit	mg NH_4-N/L (milligrams ammoniacal-nitrogen per litre)		
Attribute State	Numeric Attribute State		Narrative Attribute State
	Annual Median*	Annual Maximum*	
A	≤0.03	≤0.05	99% species protection level: No observed effect on any species tested
B	>0.03 and ≤0.24	>0.05 and ≤0.40	95% species protection level: Starts impacting occasionally on the 5% most sensitive species
C	>0.24 and ≤1.30	>0.40 and ≤2.20	80% species protection level: Starts impacting regularly on the 20% most sensitive species (reduced survival of most sensitive species)
National Bottom Line	1.30	2.20	
D	>1.30	>2.20	Starts approaching acute impact level (ie risk of death) for sensitive species

* Based on pH 8 and temperature of 20°C.

Compliance with the numeric attribute states should be undertaken after pH adjustment.

Total nitrogen

Value	Ecosystem health		
Freshwater Body Type	Lakes		
Attribute	Total Nitrogen (Trophic state)		
Attribute Unit	mg/m^3 (milligrams per cubic metre)		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	Annual Median	Annual Median	
	Seasonally Stratified and Brackish	Polymictic	
A	≤160	≤300	Lake ecological communities are healthy and resilient, similar to natural reference conditions.
B	>160 and ≤350	>300 and ≤500	Lake ecological communities are slightly impacted by additional algal and/or plant growth arising from nutrient levels that are elevated above natural reference conditions.

C	>350 and ≤750	>500 and ≤800	Lake ecological communities are moderately impacted by additional algal and plant growth arising from nutrient levels that are elevated well above natural reference conditions.
National Bottom Line	**750**	**800**	
D	>750	>800	Lake ecological communities have undergone or are at high risk of a regime shift to a persistent, degraded state, (without native macrophyte/seagrass cover) due to impacts of elevated nutrients leading to excessive algal and/or plant growth, as well as from losing oxygen in bottom waters of deep lakes.

Note: For lakes and lagoons that are intermittently open to the sea, monitoring data should be analysed separately for closed periods and open periods.

Appendix 2: Summary: A draft technical guide to the Periphyton Attribute Note[10]

This guidance provides a step-by-step process, worked examples and case studies to help councils with the process set out in the Periphyton Attribute Note. It does not set out a preferred method for deriving instream nutrient criteria, but provides information to help councils select the most appropriate method for their circumstances.

Step (a): Determining if the FMU supports, or could support, conspicuous periphyton and deriving appropriate nutrient criteria

Hard-bottomed rivers

The Guidance provides details of existing guidelines and models linking periphyton biomass to nutrient concentrations, providing existing options that could be adopted or modified to derive nutrient criteria for rivers. Considerations for didymo and benthic cyanobacteria are provided.

Guidance is provided for developing a statistical model for developing nutrient criteria by region, river class of FMU using the following steps:

1. Consider applying a river classification system to account for natural variation in factors controlling periphyton
2. Select suitable periphyton monitoring sites, ensuring adequate coverage of river classes, flow disturbance and nutrient regimes
3. Monitor periphyton biomass as chl *a* (as a minimum)
4. Collect data on controlling factors such as days of accrual or effective flushing flow frequency, dissolved nutrient (DIN, DRP) concentrations, shade or light at bed, conductivity, substrate composition, water temperature, and density of macroinvertebrate grazers.
5. Select appropriate model type – linear models are more straightforward
6. Identify best-fit model, check for bias and assess goodness-of-fit
7. Validate best-fit model, for example using independent data or whole dataset
8. Determine nutrient criteria for monitoring sites based on model predictions
9. Reconcile upstream-downstream criteria. Check any criteria are consistent with any sites downstream.

Soft-bottomed rivers

In soft-bottomed rivers, conspicuous periphyton growths may occur, but their ecosystem health effects are not as well studied as in hard-bottomed systems. If a soft-bottomed river supports periphyton, the NOF periphyton attribute applies.

Nutrient criteria in soft-bottomed rivers should take into account other NPS-FM attributes such as nitrate and ammonia toxicity, and regional attributes for macrophytes, epiphyton and phytoplankton.

Step (b): Are there sensitive downstream receiving environments?

The Guidance focuses on rivers (e.g. mainstems or downstream FMUs), wetlands and lakes that are connected to surface waters of FMUs, and estuaries. Available nutrient criteria are described and limitations discussed.

[10] Ministry for the Environment. 2018. A draft technical guide to the Periphyton Attribute Note Under the National Policy Statement for Freshwater Management 2014 (as amended 2017). Wellington: Ministry for the Environment. http://www.mfe.govt.nz/publications/fresh-water/draft-technical-guide-periphyton-attribute-note

A guide is provided for using the Estuarine Trophic Index as a first step screening level approach to identify trophic state objectives for an estuary and setting corresponding TN concentrations.

Considerations for dealing with differently defined FMUS are given, e.g. those based on catchment or sub-catchment boundaries compared to those that span multiple catchments.

Step (c): How are nutrient criteria reconciled across the FMU and downstream receiving environments?

The Guidance provides detailed instructions and worked examples for determining if criteria set for rivers will be protective of trophic state objectives for lakes and estuaries, including:

- Converting FMU nutrient concentrations to receiving environment concentrations (e.g. DIN in rivers to TN)
- Converting FMU nitrogen criteria into predicted estuarine concentrations, using the dilution factor and annual flows and loads in the Estuarine Trophic Index (ETI) CLUES Estuary module .
- Converting FMU instream criteria to required receiving environment concentrations for lakes, using Vollenweider empirical lake models as a screening approach to determine where comprehensive assessments (e.g. using lake ecosystem modelling) may be required.
-

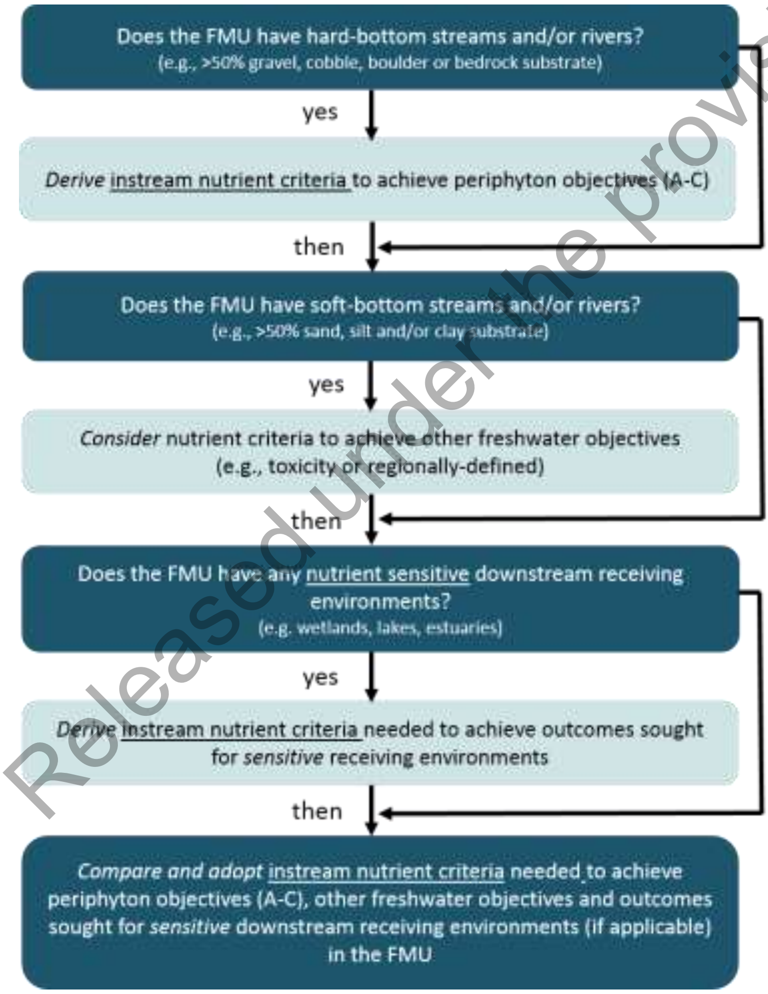

Figure 15 from *A draft technical guide to the Periphyton Attribute Note*: Flow diagram of the process outlined by the Note

Appendix 3: Notes for the STAG regarding LaWf discussions on nutrient attributes

Clive Howard-Williams

The NOF reference Group and the NOF Science Review panels have had several discussions between 2015 and 2017 on the potential applicability of setting nutrient levels as attributes for Ecosystem Health in the NOF given the confusion over the nitrate and ammonium attribute tables that related to toxicity. These discussions were duly reported to the Land and Water Forum (LaWF) where further discussion and decisions were made.

The has been consistent agreement within the groups that nutrients have to be managed to much lower levels than those (in the case of nitrogen) specified to manage toxic level concentrations.

However, no agreement was reached by these groups as to how to set nutrient concentrations as <u>national attributes</u> to manage ecosystem health.

Hence, the setting of nutrient concentrations has been devolved to regional councils who (in the 2017 amendment to the NPS-FM) are required to "at least set appropriate instream concentrations and exceedance criteria" for DIN and DRP so as to achieve freshwater objectives for periphyton within a Freshwater Management Unit.

A note on the process to do this was inserted in the 2017 amendment to the NPS-FM.

The lead-up to this from June 2016 is summarised below.

At the 9 June 2016 meeting of the LaWF Small Group three papers were considered:

1. Prof. Russell Death provided a paper "*Clean but not green: A weight of evidence approach for setting nutrient criteria in New Zealand Rivers*".
2. *Discussion paper: managing dissolved inorganic nitrogen*
3. *NOF Reference Group Advice – Cover Note* that included a section on options for including additional requirements around DIN and DRP in the NPS-FM

In addition it was noted that NOF Reference Group process for 2016 included amongst other items: *Whether DIN should be included as a new attribute or included in the NPS-FM in another way.*

At the 21 June 2016 LaWF meeting a paper entitled: *Advice on National Objectives Framework issues- COVER NOTE* had a section reporting on the NOF Reference Group's advice on nitrogen as a nutrient.

At the 4 August 2016 LaWF meeting a paper: *Options for how the NPS-FM should address nitrogen and phosphorus as nutrients in rivers (trophic state)* presented four options for dealing with DIN and DRP. These were:

Option1: NPS-FM directions requiring DIN and DRP concentrations to be set as freshwater objectives in regional plans to support the periphyton objective in the NOF.

Option 2: Same as Option 1 but with default DIN and DRP numbers for use by councils in a limited range of circumstances and as an interim measure

Option 3: NOF Attribute tables for DIN and DRP to support the current periphyton objective (which originated from Professor Death's paper)

Option 4: Maximum allowable nutrient concentrations in rivers.

Of these, Option 1 was the most favoured with Options 3 and 4 as not recommended as feasible 'by most in the Reference Group'

The reasons were that both the NOF Reference Group and the NOF Science Review Panel felt that single NOF attribute tables for DIN and DRP to support the periphyton attribute would not be feasible or scientifically defensible due to the extensive site-specific factors that need to be taken into account. These include flow regime, temperature, light, substrate and grazing. There would be too much uncertainty in the numbers.

However, the Science Review Panel suggested it would be theoretically possible to develop under Option 2, default numbers and present them in a look-up table for use by councils that would be applicable to a river site or reach (rather than nationally). However, the SRP cautioned that default numbers should not be used where there are sensitive downstream receiving environments or where there are existing dams or abstractions/diversions.

A table was presented for consideration under Option 2 as an example of an approach for setting default maximum in-stream nutrient concentrations. This was a matrix table of six river classes (based on the REC climate and flow classes) versus NOF Bands for both DIN and DRP that would satisfy the attribute bands for periphyton. This table is attached.

A classification approach falls between a single NOF attribute table for (say) DIN and a site-by-site allocation of nutrients as proposed under Option 1.

Small Group 4 August: Item 1.2 DIN and DRP

Appendix 2
Possible approach for default maximum in-stream nutrient concentrations to support periphyton objective

The numbers in the table are based on expert opinion and a review of data derived from several analyses, and how show how spatial variation could be addressed using a nationally defined set of numbers. However, the numbers are uncertain due to other site specific factors that cannot be modelled. These numbers would NOT be appropriate where there are artificial flow regime modifications which can have a considerable impact on the appropriate DIN and DRP numbers. **The level of uncertainty is not illustrated in the table but is significant. Due to this uncertainty the specific numbers should be seen as estimates and should NOT be promoted as appropriate to real rivers at the present time.** In addition, the numbers are only relevant to periphyton, not macrophytes or phytoplankton.

Since the introduction of the NOF in 2014 councils have been collecting more periphyton data. If nutrient attributes for rivers to support periphyton objectives were found to be palatable by the group then more up to date numbers could be derived from more up to date data and using a combination of methods and improved statistical techniques – it is possible (but not guaranteed) that less uncertain numbers could be derived.

Value	Ecosystem health												
Freshwater body type	Rivers [DO NOT USE IN REAL RIVERS – HIGH LEVELS OF UNCERTAINTY]												
Unit of measurement	mg / m³												
Default maximum in-stream nutrient concentrations to support periphyton objective setting													Narrative attribute state
Climate/Flow new class BAND	Northern low		Northern medium		Northern high		Southern low		Southern medium		Southern high		These narrative attribute states reflect the corresponding periphyton narrative attribute states.
~~Climate and flow class~~	DRP	DIN	DRP	DIN	DRP	DIN	DRP	DIN	DRP	DIN	DRP	DIN	
A	≤1	≤19	≤1	≤32	≤2	≤45	≤1	≤29	≤2	≤48	≤3	≤67	Rare occurrence of high plant biomass reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
B	>1 and ≤3	>19 and ≤84	>1 and ≤6	>32 and ≤140	>2 and ≤8	>45 and ≤196	>1 and ≤5	>29 and ≤126	>2 and ≤8	>48 and ≤210	>3 and ≤12	>67 and <294	Occasional occurrence of high plant biomass reflecting low nutrient enrichment and/ or alteration of the natural flow regime or habitat.
C	>3 and ≤7	>84 and ≤336	>6 and ≤11	>140 and ≤560	>8 and ≤15	>196 and ≤784	>5 and ≤10	>126 and ≤504	>8 and ≤16	>210 and ≤840	>12 and ≤23	>294 and ≤1176	Periodic short-duration occurrence of high plant biomass reflecting moderate nutrient enrichment and/or alteration of the natural flow regime or habitat.
National Bottom Line	7	336	11	560	15	784	10	504	16	840	23	1176	
D	>7	>336	>11	>560	>15	>784	>10	>504	>16	>840	>23	1176	Regular and/or extended-duration occurrence of high plant biomass reflecting high nutrient enrichment and/or significant alteration of the natural flow regime or habitat.

Explanation of classes

Northern = warm northern climates
Southern = cool southern climates

Low = infrequent floods/long durations between floods
Medium = average frequency of floods/and durations between floods
High = frequent floods/short durations between floods

THIS TABLE IS CONFIDENTIAL TO THE NOF RG AND LAWF MEMBERS AND MUST NOT BE DISTRIBUTED OR USED OUTSIDE DELIBERATIONS OF THESE GROUPS