Freshwater Science and Technical Advisory Group:

1 May – priority paper compilation

Paper Author	Various	Classification	**Confidential**

Meeting date	1 May 2019	Agenda item (number)	

Contents:

Optional background reading, not in compilation - please see portal:

Agenda Item	**Title**
2	LakeSPI: A method for monitoring ecological condition in New Zealand lakes. Technical Report
2	LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual
4	Monitoring change over time: Interpreting water quality trend assessments
6	Technical Guidelines for Drinking Water Source Protection Zones

Science and Technical Advisory Group Meeting

Agenda - DRAFT

Dates and Location: Wednesday 1 May 2019 9.30am-4.00pm, Meeting Room 1A - Matairangi, Environment House, 23 Kate Sheppard Place, Wellington.

STAG Members present: (TBC)

Apologies: (TBC) Chris Daughney, Ra Smith, Ian Hawes, Jamie Ataria, Russell Death, Graham Sevicke-Jones (will be late ~ 10am)

Items:

9.00 am *Coffee and tea* (30 mins)

1. 9.30 am Previous meeting minutes and actions arising, apologies, feedback from other advisory groups (15 mins)

2. 9.45 am Ecosystem Health metrics (Aim: finalise recommendations on fish, lake dissolved oxygen, LakeSPI, macroinvertebrates, ecosystem metabolism, periphyton, and prioritise metrics for future work) (45 mins)

10.30 am *Morning tea* (10 mins)

10.40 am Ecosystem Health metrics continued (1 hour)

3. 11.40 am Nutrients for ecosystem health (Aim: discuss any remaining questions and finalise recommendations) (30 mins)

12.10 pm *Lunch* (30 mins)

4. 12.40 pm Maintain or Improve (Aim: finalise recommendations) (30 mins)

5. 1.10 pm Kahui Wai Māori report summary (for information - the report will have implications for STAG's work) (1 hour)

6. 2.10 pm Three Waters (Aim: seek STAG advice on metrics for stormwater monitoring and source water protection) (50 mins)

3.00 pm *Afternoon tea* (10 mins)

3.10 pm Three Waters continued (20 mins)

7. 3.30 pm Water metering (for information) (30 mins)

4.00 pm *Meeting close*

FOR STAG CONSIDERATION ONLY **NOT GOVERNMENT POLICY**

Meeting date	Action	Who	Due date	Status
18-Oct-18	Officials to keep group up to date with climate policy developments	?	Ongoing	Incomplete
27-Feb-19	Commission research on extent and effects of superoxygenation in all ecosystems, and deoxygenation of lake hypolimnia.	Jen Price	? Long term	Incomplete
26-Mar-19	Conduct a case study of how proposed dissolved oxygen attribute would be implemented	Jen Price		Incomplete
26-Mar-19	Sub-group recommendations to be finalised	STAG sub-groups, MfE	16-Apr-19	Incomplete
26-Mar-19	Provide advice on how uncertainty is taken into account in NOF attributes: 1. In the face of uncertainty how much of a margin are we giving to the environment, and 2. How confident are we that the number will provide the intended level of protection (may be qualitative).	STAG, MfE	?	Incomplete
26-Mar-19	Develop principles on uncertainty for attributes	STAG, MfE	? Longer term	Incomplete
26-Mar-19	Communicate uncertainty in attribute tables (may be qualitative).	STAG, MfE	When attribute tables are put forward	Incomplete
26-Mar-19	Provide more information to the group on a more sensitive macroinvertebrate indicator such as average score per metric	Carl		Incomplete
26-Mar-19	Investigate developing an attribute table with bottom line and bands for average score per metric, including what is the national state of this metric, how many waterways do not meet the bottom lines, implications for monitoring	?		Incomplete
26-Mar-19	Discuss fish metrics further at next meeting	All		Incomplete
26-Mar-19	Collate existing data and development of attribute tables for ecosystem metabolism metrics	MfE to commission		Incomplete
16-Apr-19	Develop tables based on DRP, DIN and nitrate, median and 95th percentile, recirculate to group	Adam	1-May	Incomplete
16-Apr-19	Circulate ANZ guidelines for comparison	MfE	1-May	Incomplete
16-Apr-19	Address wording of narratives for macroinvertebrates	MfE/STAG	1-May	Incomplete
16-Apr-19	Produce maps showing distribution of scores of different macroinvertebrate metrics	MfE	1-May	Incomplete

Science and Technical Advisory Group Meeting

Minutes

Dates and Location: Tuesday 16 April 2019 9.30am-4.00pm, Terrace Centre Centre, 114 The Terrace, Wellington

STAG Members present: Ian Hawes, Clive Howard-Williams, Jenny Webster-Brown, Ken Taylor, Bev Clarkson, Bryce Cooper, Jon Roygard, Russell Death (tentative), Adam Canning, Marc Schallenberg, Chris Daughney, Mike Joy, Ra Smith. **MfE staff:** Jen Price, Jo Burton, Claire Graeme (agriculture discussion), Irene Parminter (agriculture discussion), Stephen Fragaszy (agriculture and sediment discussions), Claire Conwell (agriculture and sediment discussions)

Apologies: Joanne Clapcott, Graham Sevicke-Jones

Items:

1. Previous meeting minutes and actions arising, apologies, feedback from other advisory groups

The chair noted the importance of members clearly stating their agreement or otherwise, and reasons for their position. He reiterated the STAG's role in providing science advice rather than designing policy.

Relating to the minutes of the previous meeting:

- Page 18 – One of the group asked for clarification on timeframes in relation to what is being included in this round of advice. The minutes mention a second tranche of work. MfE staff provided clarification that the NPSFM is always being updated and Jo's best guess is that the next update will happen in the next 18-24 months. Copper and zinc will be an example of attributes that will require further work and would fall into the next round of changes. The current round of changes will be in force in May next year.
- Copper and zinc – group members were surprised that work had been slowed down on this attribute and suggested that other attributes also had challenges with councils being able to control sources of diffuse contaminants. It might be possible to introduce copper and zinc measures as a compulsory measurement metric rather than an attribute. If councils monitored some of these emerging contaminants, it would improve our knowledge and enable management of these contaminants in the future. STAG recommends that more information is required on several contaminants.
- The chair suggested that time should be made to have a brainstorming session in the future to prioritise future work. Monitoring should be on the agenda.
- Page 9 – It was pointed out that there are questions around the sediment attribute and the STAG does not unanimously support sediment bottom lines, it was suggested that a statement mentioning STAG support should be modified to reflect this.
- In the ecosystem health metrics section there is a suggestion that attributes should match up/be harmonised. Clarification was sought on this point. It means there should be a common approach for developing attributes and ensuring that the narrative descriptions match up. The approach for defining bands should be consistent.

Action	For
Update minutes from previous meeting	MfE
In the agenda for the next meeting, include a brainstorming session to prioritise future work	MfE

2. Nitrogen cap

MfE staff introduced the proposed nitrogen leaching cap approach, as outlined in the Ag Package briefing paper.

Discussion points included:

- STAG members asked what would be achieved by this approach, and what the implications would be for nitrogen loading to rivers. There is a risk that this policy will be seen as the only solution being progressed, and that the intent of the policy will not be understood.
- The proposed approach is to collect data on nitrogen leaching using Overseer and then specify a percentile of uses that need to be reduced.
- STAG members suggested that input controls would be more effective than output controls.
- A member asked which dataset would be used to set targets? Regional Councils would need to collect data from farmers and set targets based on data collected.
- It was recommended that when collecting data, the average loss rate per hectare per farm should be used, rather than average loss rate per farm.
- It was suggested that a different approach would be needed for horticulture – input controls would be needed. The initial cohort for the policy would be irrigated sheep and beef and dairy.
- One of the STAG members found it strange that neighbouring farms in different catchments might have very different rules to comply with.
- It was pointed out that there is existing analysis on identifying the high nitrogen impacted catchments.
- MfE staff outlined that other options would be to have a hybrid input/output approach, or an input approach. Feedback has been received that Overseer is widely used and the data can easily be incorporated. Just looking at inputs would not take into account on-farm mitigations that would reduce N outputs.
- One of the group members pointed out the intensification section of the briefing mentions regulation of specific activities and input controls – this is not consistent with the N cap approach. Manaaki Whenua Landcare Research has produced a N leaching map.
- MfE staff clarified that the Manaaki Whenua Landcare Research data is based on a theoretical understanding of farming practise, the current proposal is to collect actual data.
- STAG asked, what advice has been sought from agricultural or soil scientists? MfE staff responded that the current approach is being designed to meet tight time frames based on existing science.
- It was recommended that groundwater concentrations should also be considered in developing this policy. Is the percentile approach being applied on the leaching rate, or does it take into account the area over which the land use (i.e. the load)? Response: Yes this is why the policy is being targeted towards dairy and sheep and beef. There is a debate whether vegetable growing should be included.
- Another STAG member pointed out that groundwater also has relevance for drinking water supply. They supported the consideration of groundwater as an at risk water body.
- One member asked, how will the enforcement capability and will of councils be measured? Response: the action required is tied to farm environment plans and related consents. This gives the councils the ability to take enforcement actions. The additional resourcing required by councils has been noted.

- It was noted that a positive effect of this policy would be to give councils the push to collect data on land use.
- This is a stop gap measure for catchments without rules. How do we incentivise catchments to manage N? This policy would give councils incentive to collect the information that they need.
- MfE staff asked the group if they had any thoughts on identifying highly impacted catchments? STAG members recommended using the NIWA nitrogen model and considering whether this process overlaps with the At-Risk Catchments project.

3. Rural package

MfE staff outlined the proposed package, which is targeted at holding the line. Longer term change will be addressed through the allocation workstream.

Discussion points included:

- It was asked what has been the science input into these policies. Response: Risky activities were identified based on existing science showing impacts.
- It was asked what the justification was for recommending a five metre setback. Response: there are many publications giving approaches for calculating setbacks. For national policy, a simplified approach is needed. Farmers could apply for a consent during the farm environment plan process if they wanted to use a different setback to the one specified.
- The current proposal is that everyone must exclude stock. The time frames are different for different land slopes.
- One of the STAG members mentioned that critical source areas are important to identify and exclude stock from. The package represents a massive step forward.
- One of the group had feedback on wetland policies. Most wetlands have a drain around their border – how should setbacks be calculated? Wetlands should have a staged approach where larger wetlands should be fenced sooner than the blanket policy of fencing in 3 years.
- How will inanga spawning habitat be provided for? Response: Regional plans will need to be more stringent than the agricultural package and will identify these areas.
- One of the group members suggested that viewing resources in terms of scarcity can be a helpful way of framing things.
- Another group member pointed out that it is necessary to be realistic about the likely outcomes of this package. It won't make rivers swimmable because you're not dealing with the inputs from smaller and ephemeral streams which may not be fenced.

4. Sediment

MfE summarised the questions put to STAG.

The following discussion points related to the suggestion to include deposited sediment in the NPSFM as a monitoring requirement, similar to MCI, with a threshold that would trigger the requirement for a management plan.

- One member pointed out that in the NPS process, there is often the case where you can't link a particular metric with a specific management action. Periphyton is an example. How is deposited sediment any different?
- It was noted that regional councils have models linking land use to suspended sediment concentration.
- MfE staff noted that for deposited sediment, research has shown that in many cases it's not possible to link the suspended sediment load to deposited fine sediment. There is a stronger relationship between the hydrograph and deposited sediment so there are different

management actions. For deposited sediment, you can't prove that a particular management action will lead to a particular deposited sediment level.

- A group member expressed concern about whether there is enough of a requirement for councils to make a plan to address high sediment levels.
- Another group member noted that we know that deposited sediment is crucial for ecosystem health and that it is related to suspended sediment.
- MfE staff outlined to the group that it would be possible to present two options for deposited sediment (an attribute and monitoring requirement), but MfE has received advice from scientists that it is not possible to conduct impact testing for deposited sediment. Ability to impact test something is one of the key requirements of the policy process. We also need to consider the capacity of councils to set limits, and how much of their resources will need to be devoted to this task. These are the reasons why the current suggestion is to have a monitoring requirement for deposited sediment rather than an attribute.
- One of the members asked to clarify the map in the notes. The map shows catchment boundaries. Across the whole catchment, you will need up to 20% (or whatever percentage) suspended sediment load reductions, in order to meet the annual median turbidity bottom line. There is science available to impact test this work.
- One member suggested that we know that suspended sediment is linked to deposited sediment, and that this should be sufficient information to make deposited sediment an attribute.
- It was noted that instances of high suspended and deposited sediment do not coincide as much as you might expect. But one of the issues is that deposited fine sediment hasn't been monitored as well.
- MfE staff clarified that the monitoring requirement would contain a threshold, similar to the way MCI is currently included in the NPSFM.

<u>Differences between attributes and monitoring requirements:</u>

- The differences between monitoring requirements and attributes were discussed. The policy requirements are not vastly different, but there may be a difference in public perception. Both options need to have plans in place by 2025.
- The management levers would be very similar for a monitoring plan, but you might be able to fine tune the responses to a particular catchment. If it's an attribute and you can't achieve it, there is a requirement to formally register it as an exception. If it was a monitoring plan, there wouldn't be a requirement to formally register the exception.
- It was noted that there would be the same monitoring requirements for a monitoring regime, compared to an attribute.
- The length of time you take to achieve the necessary improvements is flexible for both approaches. An attribute table has bands and the community sets objectives, a monitoring requirement does not have these things.
- One member noted that it's important to distinguish attributes that have clear links to management actions, and metrics that are useful to measure but where the management actions may not be as well defined.

<u>General discussion:</u>

- One member noted that it's not this group's job to consider economic implications, and supported wider ranging policies to create a step change. Council funding might need to change to support such changes.

- MfE staff outlined the impact testing process which will test whether the proposed bottom lines can be feasibly reached using land use change. The derivation methods of the attribute, or the monitoring measures, may change in response to the analysis.
- There was a discussion on the relative merits of using suspended sediment and turbidity as a metric. It was noted that suspended sediment concentrations are easier to relate to land use, however there is not sufficient information on suspended sediment concentrations to be able to assess the ecological impact. Turbidity is easier to measure and this is calculated back to suspended sediment concentrations to determine management actions. STAG members were keen to see research continuing on suspended sediment as a measure.
- We need to monitor what is happening on land so that we can understand the linkages between land use and water quality. This was discussed in the "maintain or improve" sub-group and Nik has asked for feedback on what land use activities might be monitored.

Outcomes

The chair gave a summary: The science connecting land use and river water quality is strong. The view around the table is that somewhere in the regulatory structure, there needs to be bottom lines for both suspended sediment and deposited sediment. Our thinking will develop over time and we may need to revisit the measure we are using for sediment. There is a high degree of consensus about having numbers in place for deposited and suspended sediment. There is a gap in our knowledge about ecological thresholds for sediment- but in the previous meeting there was support for the approach presented.

Some members of the STAG (4 or so) felt strongly that both suspended and deposited sediment should be attributes because our experience tells us that attributes are more effective.

The group is comfortable with continuing with the turbidity thresholds that were agreed to last month. Eleven members agreed with this proposal, and none were against it. One member agreed based on councils testing the thresholds.

For deposited fine sediment, six members were comfortable with deposited sediment continuing as a monitoring requirement with a bottom line. Reasons for this were deposited sediment is clearly of concern but doesn't meet the requirements of evidence for an attribute. STAG supports having the same bottom lines as would be required for an attribute.

Six members supported having an attribute table for deposited sediment with bands and a bottom line. The reasons for this were that we have enough science evidence. An attribute is a more proactive approach and this is the reason why an attribute is more suitable.

The group members all agreed on the need for a threshold value for deposited sediment, whether in an attribute table or monitoring requirement.

5. Wetlands

MfE staff gave an update of the proposed policies for wetlands.

Discussion points included:

- Stock access to wetlands is still an issue. It will be important to define wetlands properly. Fencing of wetlands will be in the agriculture policy package, the definition needs to be applied to those policies and rules too.

- One of the members mentioned an example where a habitat didn't look like a wetland but had several hundred black mudfish – investigated as part of the Carterton wastewater treatment plant. This suggests that a wider definition of wetlands is needed.
- There are wetland delineation tools based on soils, hydrology and plants, these will be incorporated in the policy.
- There are wetlands associated with existing hydropower stations – e.g. wetland at Lake Arapuni provides important habitat for birds. There are quite large variations in water level. These wetlands will be exempt from the water level regulations.

MfE staff gave an update of the proposed research on wetland water levels.

Discussion points included:

- It's important to have a range of wetland types in the reference and impact sites. HBRC has 10 transducers in Tukituki catchment, WRC has also installed some.
- It's important to include wetlands that dry out, some animals such as tadpole shrimps and mudfish rely on seasonal drying to exclude predators.
- What about discharge of stormwater into wetlands, and using for flood control? This is an area for future discussion.
- Wetlands provide an opportunity to mitigate impacts on lakes or rivers and can be a more appropriate tool than hard engineering structures. We should be encouraging the use of wetlands as infrastructure.
- Would stopping drainage of wetlands include groundwater extraction, would there be direction in this policy to regulate this? Yes, this is in the water level regulations.

MfE staff gave an update of the proposed research on wetland drainage setbacks.

Discussion points included:

- It would be important to take into account the 4 wetland types and have about 5 examples of each (recommended the 'medium' approach).
- There would be opportunities to build on the water level work.
- It was pointed out that in some areas the drains have been in place for over 100 years, these are highly modified systems, how would the research account for this?
- You need to take into account the full range of human impact, from reference to completely modified.
- Tile drains can shift the point at which water accumulates and can deliver nutrients.
- Looking at the vegetation levels would be important, this is only in the 'high' scenario at present.

MfE will also be progressing a wetland mapping project to assist with high resolution, repeatable mapping. In Northland there is a radiometric survey being done at the moment. LiDAR is being rolled out throughout the country, there is another project under way looking at using this data for wetland identification.

How to restore and reconstruct wetlands is another area where more advice is needed.

6. Nutrients

The group considered the MfE analysis of relationships between macroinvertebrate data and water quality.

Discussion points included:

- Issues brought up by STAG members include lack of consistency in council monitoring, and assumptions of linear modelling not being met in analyses of macroinvertebrate relationships with water quality.
- It was noted that there is a need to keep the existing periphyton attribute, this was made clear by the analysis. What is the temptation for planners to take the easiest option when setting nutrient limits (i.e. not do periphyton process). It's important that the most stringent would apply.
- In cases where modelling was difficult, councils might default to Russell's numbers – this is a risk
- There was discussion about the need for MfE to ensure that objectives and limits are set properly.
- There was discussion about the possibility to use a median and 95th percentile. The challenge with the percentile approach is that it's difficult to determine the 95th percentile.
- Derivation methods were discussed; why go for a trend line rather than 80% prediction interval? Using a trend line has a degree of uncertainty associated with it and may draw criticism. The response was that a percentile approach has been used along with quantile regression.
- It would be informative to see how the proposed attributes line up with the updated ANZ Guidelines.
- It was pointed out that the A/B band boundary for nitrate toxicity is similar to the proposed bottom line for nitrogen for ecosystem health. It was proposed that the proposed N attribute for ecosystem health should be presented as a change to the nitrate toxicity attribute, and that the mechanism for protecting ecosystem health is via avoidance of toxicity. There was much discussion on this topic. At least one STAG member was strongly not in favour of this proposal. Others pointed out that toxicity attributes are based on lab studies and may not reflect real world conditions. The conclusion reached by the group was that it was useful to point out that the proposed N bottom line relates to the bottom of the nitrate toxicity A band (and therefore avoids toxicity effects), but that it was important to introduce the proposed attributes in terms of multiple lines of evidence, not just the avoidance of toxicity.

Adam Canning presented three options for deriving bands and bottom lines for N and P to provide for ecosystem health. The tables presented are for TN and TP. Option 1 is closest to the original numbers that were presented by Russell Death. Option 3 uses the most sensitive ecosystem health component to derive each band.

There was discussion about which metrics to use:

- There was a discussion about whether the attributes should be expressed as nitrate, dissolved inorganic nitrogen or total nitrogen.
- If the table is expressed as nitrate, the existing nitrate toxicity attribute would not be needed. If the table is expressed as dissolved inorganic nitrogen, this measure also includes ammonia and therefore the ammonia toxicity attribute would not be needed.

The following framework was developed to assist our thinking and help present the proposed attribute tables to others:

Ammonia toxicity	Periphyton	Nitrate toxicity	Russell Death's numbers
Applies everywhere Mostly useful for determining effects of point sources	-Councils set objectives for DIN and DRP -Keep the same approach and consider Adam's comments to Draft Guide to Periphyton Note -Ton's table as guidance	-Has the most effect in soft-bottomed waterways not captured by periphyton attribute	-Will have the most effect in soft-bottomed waterways not captured by periphyton attribute

General discussion points:

- The most stringent metric should apply.
- The nitrate toxicity attribute should be replaced with a nitrogen attribute for ecosystem health. An option would be to keep the ammonia toxicity attribute and to develop the copper and zinc attributes in the future.
- One of the group members expressed reservations about applying the proposed attributes to all groundwaters and recommended that more thought and discussion was needed on whether these numbers are appropriate for groundwater. It may be possible to limit the numbers to apply to oxic groundwaters, or groundwaters connected to rivers.
- There was discussion about whether it would be appropriate to add a value for 95th percentile, this will be presented to the group for consideration.
- Further discussion is required on the possibility that: if the ammonia toxicity attribute is retained, ammonia may be high due to a point source discharge and this may be acceptable based on comparison with the ammonia toxicity attribute. This would be inconsistent with the suggested N table for ecosystem health.

<u>Agreed statements</u>

- The group supports nutrient tables to provide for ecosystem health.
- The group supports a single set of tables to be applied nationally.
- DRP and either DIN or nitrate will be progressed; further consideration required
- If the table is expressed as nitrate, the existing nitrate toxicity attribute would not be needed. If the table is expressed as dissolved inorganic nitrogen, this measure also includes ammonia and therefore the ammonia toxicity attribute would not be needed.
- There was support for pointing out that the A/B band for nitrogen toxicity is similar to the proposed N bottom line for ecosystem health. It was agreed that toxicity is a part of ecosystem health.
- These tables will apply to rivers only.

One of the members wished to record that they did not agree with Russell's numbers and recommended that the nitrate toxicity table should be modified so that the bottom of the A band is now the C/D band.

Action	For
Develop tables based on DRP, DIN and nitrate, median and 95th percentile, recirculate to group	Adam
Circulate ANZ guidelines for comparison	MfE

7. Ecosystem health metrics

MfE staff outlined that advice going to Ministers this week will include a general description of new metrics for ecosystem health. These can be finalised by STAG on 1 May.

Macroinvertebrates

The Average Score per Metric was introduced. A score of 0.3 is equivalent to an MCI of 90. Joanne Clapcott has recommended adopting Average Score per Metric (b) (see comments in Appendix)

Discussion points included:

- One of the group members was in favour of using QMCI, and suggested that by averaging scores (in the Average Score per Metric) you might lose some detail. This metric has been developed and used in the Waikato and might need further testing. Percent EPT abundance is useful, particularly for showing effects of sediment. Percent EPT taxa is less useful.
- The importance of standardising sampling was pointed out.
- It was clarified that these metrics can be calculated using standard macroinvertebrate 200-count data.
- There have also been discussions between MfE and researchers about doing more work on the O/E approach.
- It's agreed that we definitely need macroinvertebrates in the NPSFM, the discussion is just talking about different metrics. This will not change the sample processing for most samples, but some councils are using the SQMCI and so would need to change to full counts.
- One of the members suggested that the narrative in the ASPM was more suitable, and that the wording for MCI needs to be revised.
- One of the members asked whether the group is committing to an attribute? The chair summarised that we want a decent indicator of macroinvertebrates with numbers we can back. For an attribute, we need to specify what cause-effect relationships and indicate level of confidence. We need to make sure we communicate the level of uncertainty.
- One of the members supported introducing an attribute table for macroinvertebrates, and noted that we are confident in the MCI, it's been around since the 1980s. It probably has the most support and confidence around the numbers.

Outcome: The Chair summarised that we are committed to a recommendation on macroinvertebrates, there is further discussion needed. STAG is keen to develop attribute tables and maps of distribution of scores.

Action	For
Produce maps showing distribution of scores of different metrics	
Address wording of narratives	STAG

Periphyton

Adam has amended the table from the NPSFM to remove the productive river class. The onus would be on councils to show that the exceedance would have occurred based on natural conditions at that site.

Discussion points included:

- Often there are blooms only a couple of times a year so it doesn't make sense to exclude 17% of samples.
- Often, sites will exceed the criteria once every 5 years or so. There was discussion about whether lack of oxygen for a short time was acceptable.
- One of the members noted that there is potential for councils to game the system. There is a problem with allowing exceedances that could cause lethal effects.
- It was suggested that the allowance for any exceedances could be removed.
- One of the members pointed out that the table wording seems wrong because the numbers are concentrations and the narrative describes exceedances.

Summary: The chair summarised that this table allows for periodic exceedances, and there are vulnerabilities with the table as it is at the moment. The note and sampling considerations should remain.

Lake dissolved oxygen

This will be discussed on 1 May

8. Flows

MfE staff outlined that the problem with the status quo is that the councils are not articulating what they are trying to achieve. Technical guidance is needed to help councils to set objectives that will be protective for different ecosystem types.

Adam Canning provided STAG with a proposed attribute tables for flows, by email. This is based on a deviation from natural flows.

MfE staff have received advice that it was not feasible to set a nationally applicable flows attribute based on a rule-of-thumb approach. Such an approach would be protective in some rivers by not others. MfE is proposing to develop full technical guidance to assist with flow allocation.

Comments from STAG members included that there was a need to set ecological bookends in the form of numerical thresholds, and that strict requirements were required to make sure the process is protective enough. Minimum standards are needed to protect habitat. It would be helpful to bring in a flow expert to discuss the matter further with STAG.

It was agreed that the current proposal from MfE doesn't adequately protect ecosystem health, even when considered together with other ecosystem health metrics being proposed.

It was noted that flows are a fundamental issue and we need to ensure advice from the group is robust. There is an issue here about the amount of resource being allocated to this topic.

MfE staff noted that the proposed changes are not and end in themselves and will add additional pressure to make further improvements to the way flows are managed.

Outcome: There was a desire from STAG to discuss this matter further and to receive more technical advice and information to inform the discussion.

Appendix 1: comments from Joanne Clapcott

Kia ora koutou

I am not able to join the next meeting so wanted to share my thoughts before going on annual leave.

Suspended sediment. Wow this is another layer of testing I wasn't aware of… if we can't meet the bottomlines then they are too stringent?!

Deposited sediment. Should a sentence read "Our research on deposited sediment management shows that suspended sediment is *an important but not statistically significant predictor* of deposited sediment". The fact that we are currently unable to quantify the relationship between deposited sediment and land use (via suspended sediment) does not negate the fact that the primary management intervention is to limit the amount of sediment entering waterways. I am disappointed that this is not progressing as an attribute given that deposited sediment is a major stressor in freshwater systems (probably more important than nutrients in many rivers) and increased deposited sediment beyond natural levels is a direct result of land use change. However, I would support including it as a monitoring tool if that means we get councils collecting the robust data we need to one day quantify the relative effect of management interventions.

Impact testing. Why does the map on suspended sediment have a required load reduction of 0 for the Waiapu River, which has the largest sediment load as a direct result of land clearance? Or is a small part of the headwaters classified as 0.8?

Sediment attribute implementation. Without seeing the maps, I think a blanket grading (option 1) is most transparent. I see no reason why different classes should be afforded different grades (option 2) and the percentage allocation (option 3) is just confusing, in my opinion.

Wetlands. Agree with general approach and no further comment.

Nutrients. A good analysis by Adam demonstrates the benefit of introducing NO3N and DRP attributes for ecosystem health to protect soft-bottom streams in particular from enrichment. I think this has addressed most of our questions and I support the recommendation of the proposed attribute states (his Table 1) and agree the most stringent (current NOF vs proposed EH) should apply. Did I miss the analysis/discussion around whterh TN and TP are more appropriate than NO3N and DRP?

EH attributes. Periphyton – no comment. Macroinvertebrates –ASPM(b). I prefer the normalised nature of these metrics which helps correct for spatial variation in reference state, compared to fixed MCI bands. Previous analysis (e.g. Collier et al 2014 for MfE) suggests 3-yr rolling mean would be sufficient. Fish – I'm not sure. Ecosystem metabolism – looks good in a table!, but probably needs more testing before application.

I hope you have a productive meeting.

Kind regards | Ngā mihi

Joanne

Fish metric

Problem

Freshwater fish are the highest-valued group of aquatic biota. They are valued as part of healthy ecosystems and contribution to biodiversity and for their cultural value, particularly as mahinga kai, but also as game. Despite their importance, fish are not systematically monitored in most regions of New Zealand. Policy CB1 of the NPS-FM requires that every council develops a monitoring plan that inter alia includes measures of the health of indigenous flora and fauna. Policy CB2 requires establishing methods to respond to monitoring that indicates freshwater values will not be met.

The only national scale indicator for freshwater fish is health is change in Conservation Status (as defined by Department of Conservation). Of the 39 species of native fish, 28 are threatened or at risk of extinction according to the Department of Conservations Threat Classification System[1].

Threats to native fish that are associated with land and water resource use include habitat degradation by loss of access due to barriers, loss of wetlands, channelisation of waterways, increased sedimentation, loss of riparian margins, nutrient enrichment and reductions in flow. Impacts on fish are also associated with pressures other than land and water resource use including exotic fish introductions and harvesting.

Monitoring methods

There are existing national protocols for monitoring fish in wadeable streams and rivers. Monitoring fish in larger waterbodies is more difficult and expensive, and standard national protocols have not yet been developed. For this reason, the following two proposals **apply to wadeable streams and rivers only**.

The requirement to monitor fish is well justified by their value, extinction risk of indigenous species, and the RMA. To be effective, monitoring needs a level of organisation at the national level. This is because fish are mobile and pressure in one region may have impacts in another. The Department of Conservation has a role because they are responsible for the monitoring of flora and fauna on conservation land. There may be value in also considering how monitoring of commercially harvested species (eels) is incorporated into monitoring effort.

Costs

Monitoring fish communities is expensive because it involves specialised skills (e.g., electric fishing, in the field identification). It is also a complex and time-consuming task relative to other measures such as water quality. Cost estimates (including travel and time) are approximately $1500 to $2500 per reach, per visit. To address this problem, a cheaper and faster molecular tool for detecting fish species in freshwater is being developed, funded by a $299,000 MBIE Envirolink Tools Grant.

Proposal A: Fish IBI NOF attribute

Inclusion of the Fish IBI as an attribute specifically. This means that councils would need to measure its current state, and devise policies to maintain and improve the IBI where it was unacceptably low.

[1] Department of Conservation (2017). *Conservation status of New Zealand freshwater fishes*

Refer to paper by Adam Canning, and below context.

The IBI was developed in 2004 and is used to assess the health of fish communities. It compares the species present at a site, to the species that would be expected in the absence of human impacts. The IBI was developed using a database of the species found present at sites dating back to 1901. Because sample collection in this database is not standardised and most records are one-off surveys, it is only useful to inform the presence or absence of species found at that site and time. Information on abundance would be more informative, but it has not been possible to be include it to date.

Considerations

Some possible limitations of the IBI being used as a tool to manage fish community health to consider are:

1) It leans on adequately estimating the expected fish community in natural conditions. However, the methods for quantifying the expected values of IBI are potentially not sufficiently advanced for this to be done with confidence[2].
2) Both the originators of the IBI[3] and other scientists[4] consider that further work is needed to understand how the IBI responds to various pressures.
3) Adoption of the Fish IBI might perpetuate the use of presence and absence sampling. This has less relevance as abundance is not considered. It is unclear that this approach would provide the information needed to adequately measure and manage the state of fish health.

Proposal B: Monitoring and responding to declining fish health

Amending the NPS-FM to require councils to:

1. monitor fish health in wadeable rivers (as a minimum), using measures of **diversity** and relative **abundance**.
2. assess possible degradation relative to a minimally disturbed reference state, and publically report (as per the proposed direction on ecosystem health reporting).
3. prepare and implement action plans when monitoring indicates fish health is in a poor state, or is declining.

Monitoring and reporting should:

1. allow an understanding of the state of the value within FMUs (or catchments), and their regions
2. enable the pressures that are limiting fish communities to be understood
3. be suitable for aggregation and analysis at the national level.

Considerations

The advantage of this policy is that because it describes the outcome (rather than the method) that we want, it will encourage further development of fish health measures by Councils (e.g. through an

[2] The originators of the IBI only accounted for elevation and distance from the coast as predictors of natural fish communities. It is however understood that other natural factors such as temperature and biogeographical patterns strongly influence fish communities.
[3] Joy, M.K. and R.G. Death, 2004. Application of the Index of Biotic Integrity Methodology to New Zealand Freshwater Fish Communities. Environmental Management 34:415–428.
[4] Storey, R., C. Kilroy, F. Matheson, M. Neale, S. Crow, and A. Whitehead, 2018. Scoping Indicators for Impacts on Freshwater Biodiversity and Ecosystem Processes of Rivers and Streams. NIWA Client Report, NIWA, Hamilton, New Zealand.

Envirolink Tools Grant) or others, for future national direction (particularly useful if there is insufficient evidence for the Fish IBI now).

The proposal allows the IBI to be used, but is flexible enough to encourage further development of fish health measures by Councils (e.g. through an Envirolink Tools Grant) or others.

Questions

1) Are you satisfied that there is sufficient evidence to support inclusion of the fish IBI as an attribute in national direction now? Consider the above considerations (possible limitations), and the "metric guiding criteria", particularly:
    a. Link to the ecosystem health value (e.g. presence/absence).
    b. Evaluation of current state of the metric on a national scale
    c. Relationship to resource use limits and/or management
2) Are you satisfied that there is sufficient evidence to support stronger policy to require Monitoring and Responding to declining fish health, using measures of diversity and abundance?

Proposed additional ecosystem health attributes for rivers (carried over from 16 April meeting)

Adam Canning

1. For periphyton an amended attribute table is suggested. The changes shift the burden of proof for higher exceedance criteria onto Regional Council to reduce the gaming of exclusion criteria (current incentive to discharge high nutrients during months where exceedances are likely to be excluded).
    a. Should the burden of proof for the higher exceedance criteria be shifted onto Regional Council?

2. For invertebrate health, there are two attribute tables. One is based on MCI & QMCI, the other is based on Average Score Per Metric (MCI, %EPT abundance and EPT richness).
    a. Should we include both attribute tables? Or just one, if so which one?
    b. If we have the MCI & QMCI attribute table, are bottom-lines of 90/4.5 appropriate? An MCI of 90 was at the approximate inflection point with increasing nitrate based on Prof Death's nutrient paper. An MCI of 90 also represents a community that is nearly but not quite completely composed of pollution tolerant species.
    c. If we have the ASPM attribute table, which banding option should we use? Option (a) uses percentiles (75th, 50th and 25th) of current state, option (b) sets the A-band at reference condition (using logistic regression) and remaining bands equally, as per Clapcott et al., (2017). %EPT-abundance A-band calculated by converting %EPT-richness from Clapcott et al., (2017) to %EPT-abundance using regression. MFE to delete the unwanted column.

3. For fish health, the Fish-IBI has been proposed. The bands are created via percentiles (as per original IBI banding). One table includes salmonids as a positive indicator of ecosystem health given their sensitivity to water quality, reflects the RMA requirement for their protection and the Minister's cabinet paper. The other option has salmonids as a negative indicator along with other introduced species.
    a. Should trout be included as a positive or negative weighting in the Fish-IBI?

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**	**Narrative Attribute State**
	Exceeded no more than 8% of samples[1,2]	
A	≤50	Rare blooms reflecting negligible nutrient enrichment and/or alteration of the natural flow regime or habitat.
B	>50 and ≤120	Occasional blooms reflecting low nutrient enrichment and/ or alteration of the natural flow regime or habitat.
C	>120 and ≤200	Periodic blooms reflecting moderate nutrient enrichment and/ or moderate alteration of the natural flow regime or habitat.
National Bottom Line	**200**	
D	>200	Regular and/or extended-duration nuisance blooms reflecting very high nutrient enrichment and/or very significant alteration of the natural flow regime or habitat.

1. May be exceeded in up to 17% of samples if shown that the exceedance would have happened at that site in natural nutrient, flow and riparian cover conditions.

2. Based on a monthly monitoring regime.

Invertebrates

Option one – MCI/QMCI:

Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Macroinvertebrate Community Index and Quantitative Macroinvertebrate Community Index (Ecosystem Health)		
Attribute Unit	QMCI and MCI scores		
Attribute State	**Numeric Attribute States**		**Narrative Attribute State**
	QMCI	**MCI**	**Description**
A	≥6.5	≥130	Very clean water, indicative of pristine conditions with almost no organic pollution or nutrient enrichment.
B	≥5.5 & <6.5	≥110 & <130	Probable mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution/nutrient enrichment.
C	≥4.5 & <5.5	≥90 & <110	Probable moderate organic pollution or nutrient enrichment. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment.
National Bottom Line	4.5	90	
D	<4.5	<90	Probable severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment.

1. Applies only to wadeable streams and rivers.
2. Stark JD, Maxted, JR 2007. A user guide for the Macroinvertebrate Community Index. Prepared for the Ministry for the Enviroment. Cawthron Report No. 1166. 58
3. Objectives should not be set higher than is attainable in reference conditions, with guidance from: Clapcott, J. E., Goodwin, E. O., Snelder, T. H., Collier, K. J., Neale, M. W., & Greenfield, S. (2017). Finding reference: a comparison of modelling approaches for predicting macroinvertebrate community index benchmarks. New Zealand Journal of Marine and Freshwater Research, 51(1), 44-59. doi:10.1080/00288330.2016.1265994
4. MCI and QMCI to be determined using fixed counts with at least 200 individuals surveyed using at least five Surber samplers per site annually between December and March inclusive). Sites with sediment state classes 1, 5 & 11 are to use the soft-sediment sensitivity scores. Taxonomic resolution and sensitivity scores to be use is that from Table A1.1 from:

   Clapcott, J., Wagenhoff, A., Neale, M., Storey, R., Smith, B., Death, R., … Young, R. (2017). *Macroinvertebrate metrics for the National Policy Statement for Freshwater Management*. Cawthron: Nelson, New Zealand.

5. Current state is calculated as the five-year rolling average score.

Option two – ASPM:

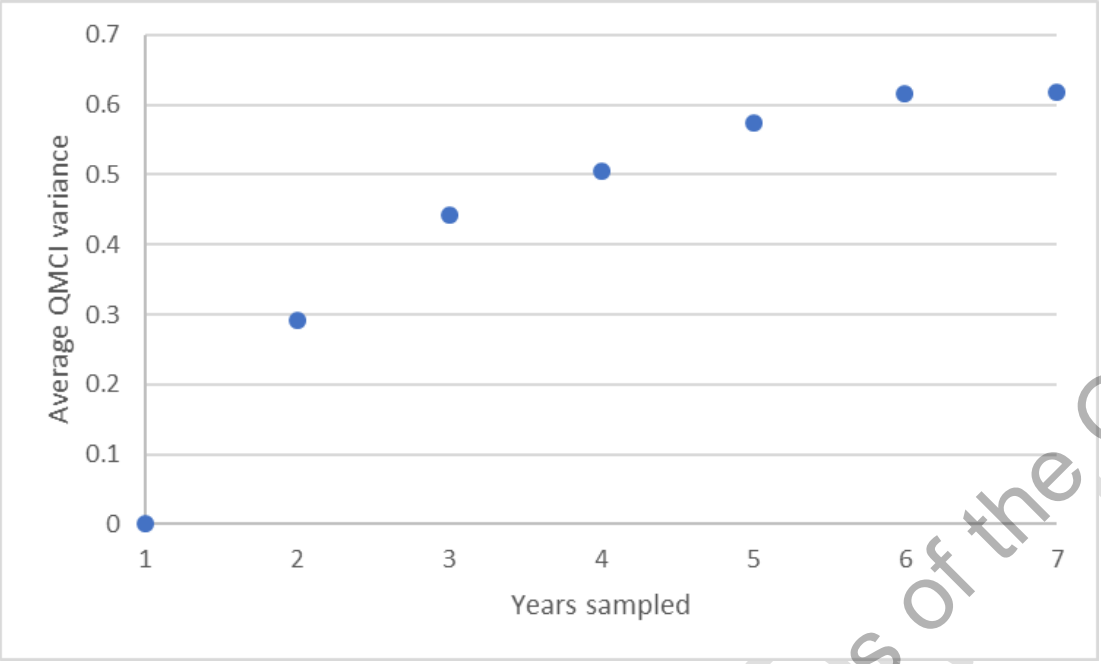
Value	Ecosystem health		
Freshwater Body Type	Rivers		
Attribute	Average Score Per Metric (Ecosystem Health)		
Attribute Unit	0-1 score		
Attribute State	**Numeric Attribute State**		**Narrative Attribute State**
	ASPM (a)	**ASPM (b)**	**Description**
A	≥0.54	≥0.6	Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions.
B	<0.54 & ≥0.42	<0.6 & ≥0.4	Macroinvertebrate communities have mild-to-moderate loss of ecological integrity.
C	<0.42 & ≥0.27	<0.4 & ≥0.3	Macroinvertebrate communities have moderate-to-severe loss of ecological integrity.
National Bottom Line	**0.27**	**0.3**	
D	<0.27	<0.3	Macroinvertebrate communities have severe loss of ecological integrity.

1. Applies only to wadeable streams and rivers.
2. ASPM to be determined using fixed counts with at least 200 individuals surveyed using at least five Surber samplers per site annually between December and March inclusive). Sites with sediment state classes 1, 5 & 11 are to use the soft-sediment sensitivity scores. Taxonomic resolution and sensitivity scores to be use is that from Table A1.1 from:

   Clapcott, J., Wagenhoff, A., Neale, M., Storey, R., Smith, B., Death, R., … Young, R. (2017). *Macroinvertebrate metrics for the National Policy Statement for Freshwater Management*. Cawthron: Nelson, New Zealand.

3. Current state is calculated as the five-year rolling average score.
4. When normalising scores for the ASPM, use the following minimums and maximums: %EPT-abundance (0-100), EPT-richness (0-29), MCI (0-200).

   Collier, K. J. (2008). Average score per metric: an alternative metric aggregation method for assessing wadeable stream health. *New Zealand Journal of Marine and Freshwater Research, 42*(4), 367-378.



Average QMCI variance for 356 sites nationally, sampled yearly 2010-2016.

As per Stark & Phillips (2009), seasonal variability is small and annual surveys are sufficient.

As per Duggan, Scarsbrook & Quinn (2003), scores should be determined using fixed counts with at least 200 individuals surveyed using at least five Surber samplers per site annually between December and March inclusive.

As per figure above, current state should be defined as a rolling five-year average.

Fish

IBI with salmonids as positive indicator

Value	Ecosystem health	
Freshwater Body Type	Rivers	
Attribute	**Fish Index of Biotic Integrity (F-IBI)[1]**	
Attribute Unit	Score between 0-60	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
	Average	
A	≥36	High integrity of fish community. Habitat has minimal degradation.
B	<36 and ≥28	High-moderate integrity of fish community. Habitat is mildly degraded.
C	<28 and ≥20	Moderate integrity of fish community. Habitat is moderately degraded.
National Bottom Line	**20**	
D	<20	Low integrity of fish community. Habitat highly degraded.

1. The F-IBI as defined by Joy, M. K., & Death, R. G. (2004). Application of the Index of Biotic Integrity Methodology to New Zealand Freshwater Fish Communities. *Environmental Management, 34*(3), 415-428. doi:10.1007/s00267-004-0083-0
   Varied to give salmonids "honorary native" status as they are ubiquitous, are valued introduced and reflect generally good conditions, as per Joy (2015,2015 & 2013).
2. Applies only to wadeable rivers and fish are to be surveyed at least annually between December and March (inclusive) following the protocols in:
   Joy M, David B, and Lake M. 2013. *New Zealand Freshwater Fish Sampling Protocols (Part 1): Wadeable rivers and streams.* Palmerston North, New Zealand: Massey University.

IBI with salmonids as negative indicator

Value	Ecosystem health	
Freshwater Body Type	Rivers	
Attribute	**Fish Index of Biotic Integrity (F-IBI)[1]**	
Attribute Unit	Score between 0-60	
Attribute State	**Numeric Attribute State**	**Narrative Attribute State**
	Average	
A	≥34	High integrity of fish community. Habitat has minimal degradation.
B	<34 and ≥26	High-moderate integrity of fish community. Habitat is mildly degraded.
C	<26 and ≥16	Moderate integrity of fish community. Habitat is moderately degraded.
National Bottom Line	**16**	
D	<16	Low integrity of fish community. Habitat highly degraded.

1. The F-IBI as defined by Joy, M. K., & Death, R. G. (2004). Application of the Index of Biotic Integrity Methodology to New Zealand Freshwater Fish Communities. *Environmental Management, 34*(3), 415-428. doi:10.1007/s00267-004-0083-0
2. Applies only to wadeable rivers and fish are to be surveyed at least annually between December and March (inclusive) following the protocols in:
Joy M, David B, and Lake M. 2013. *New Zealand Freshwater Fish Sampling Protocols (Part 1): Wadeable rivers and streams.* Palmerston North, New Zealand: Massey University.

IBI scores are statistically different with and without trout at a positive health indicator.

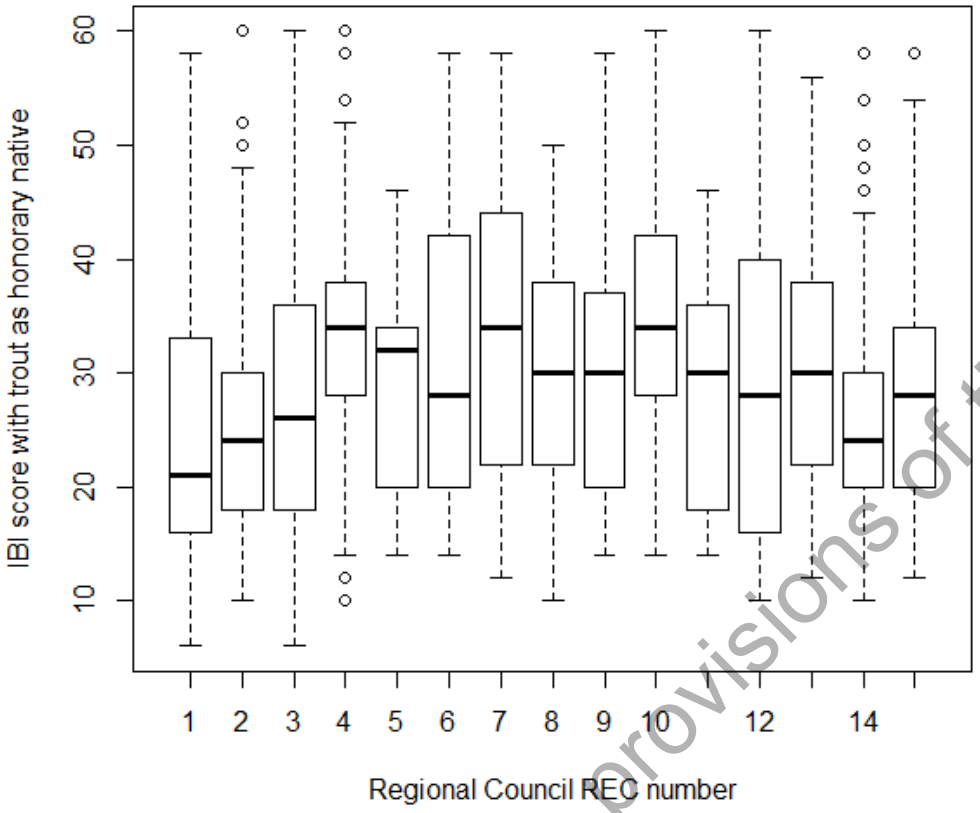
Anova: Single Factor

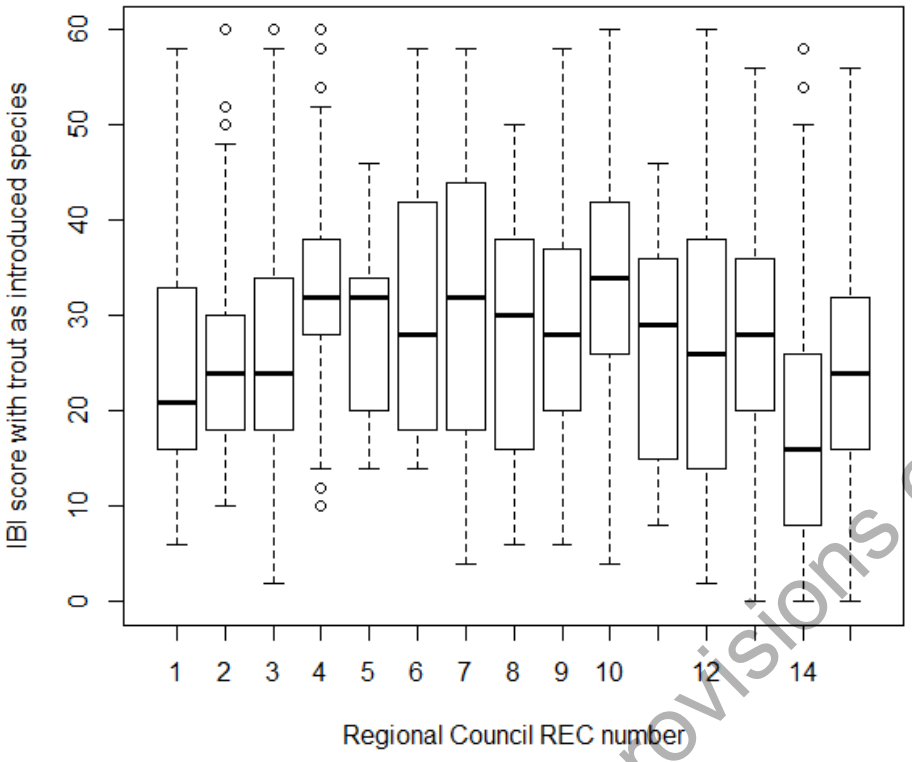
SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	3009	87130	28.95646	121.8867
Column 2	3009	79126	26.29644	161.319

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	10645.4	1	10645.4	75.17785	5.46E-18	3.843005
Within Groups	851882.9	6016	141.6029			
Total	862528.3	6017				





Ecosystem processes

Value	Ecosystem health				
Freshwater	Rivers				
Attribute	Ecosystem metabolism				
Attribute Unit	g O_2 m^{-2} d^{-1} (grams of dissolved oxygen per square metre per day)				
Attribute State	**Numeric Attribute State**				**Narrative Attribute State**
	Gross primary production		Ecosystem respiration		
	Non-wadeable	Wadeable	Non-wadeable	Wadeable	
A	≤3.0	≤3.5	1.6-3.0	1.6-5.8	No evidence of an impact on ecosystem metabolism.
B	>3.0 and <5.5	>3.5 and <5.0	>1.0 and <1.6 Or >3.0 and <8	>1.2 and <1.6 Or >5.8 and <7	Mild effect on ecosystem metabolism.
C	≥5.5 and ≤8.0	≥5.0 and ≤7.0	≥0.6 and ≤1.0 Or ≥8.0 and ≤13.0	≥0.8 and ≤1.2 Or ≥7.0 and ≤9.5	Moderate effect on ecosystem metabolism.
National Bottom Line	**8.0**	**7.0**	**≥0.6 or ≤13.0**	**≥0.8 or ≤9.5**	
D	<8.0	<7.0	<0.6 or >13.0	<0.8 or >9.5	Severely impaired ecosystem metabolism.

1. Derived from 7 consecutive days of continuous dissolved oxygen monitoring, though objective applies year-round.
2. Young, R. G., Matthaei, C. D., & Townsend, C. R. (2008). Organic matter breakdown and ecosystem metabolism: functional indicators for assessing river ecosystem health. Journal of the North American Benthological Society, 27(3), 605-625. doi:10.1899/07-121.1
3. Clapcott JE 2015. Development of management bands for ecosystem metabolism in nonwadeable rivers. Prepared for Waikato Regional Council. Cawthron Report No. 2770. 21 p. plus appendix.

Notes on LakeSPI as a potential Attribute for Lake Ecosystem health for discussion at the STAG

(based on consultations between the DO sub-group, Ian Hawes, Clive Howard-Williams and Marc Schallenberg with input from Paul Champion)

23 April 2019

"The use of lake macrophytes for ecological quality assessments usually seeks to indicate the degree of anthropogenic impact, but few of these schemes implicitly consider impacts of alien weeds. LakeSPI (submerged plant indicators) uses indicators of habitat degradation for macrophytes but also incorporates the degree of impact from alien weeds. Application of LakeSPI to 195 New Zealand lakes provided a dataset to examine how component metrics responded over gradients of anthropogenic pressures, and consider whether weed invasion was merely a 'passenger' of habitat degradation, or represented an additional pressure. As expected, metrics measuring depth, and diversity of native vegetation negatively correlated with independent measures of lake eutrophy and were also relatively well explained (69–78% variation) by multiple regression with lake and catchment attributes that included proxies for anthropogenic pressure. In contrast, metrics for invasive impact were largely de-coupled from eutrophication, and poorly explained (31%) by the multiple regression. The response of native vegetation metrics to invasive impact measures varied, with the strongest detected interaction relating to native displacement by increased weed occupation of the vegetated zone. Interactions between invasion and lake trophic status were also discerned, with the extent of weed occupation having a more substantial outcome for the presence of charophyte meadows in low productivity lakes than in more productive lakes. These results suggest weed invasion should be considered as an additional source of anthropogenic pressure, and incorporated in macrophyte bioassessment schemes for a more complete differentiation of lake ecological condition". deWinton et al. (2012)

LakeSPI is a lake macrophyte index that has been in use for over 20 years. A number of regional councils and the Department of Conservation have undertaken LakeSPI assessments and, to date, LakeSPI assessments have been carried out on > 300 New Zealand lakes. LakeSPI data are collated and reported on the LAWA website as a key indicator of lake health.

The lakeSPI index is composed of two sub-indices:

(i) Native condition index and
(ii) Invasive impact index.

These can be combined with the maximum depth of the macrophyte community to yield the overall LakeSPI score. We refer the STAG to the two LakeSPI reports (Clayton & Edwards 2006a, b) for more detailed background information on the LakeSPI index.

Lake depth is recognised to have an influence on the maximum potential LakeSPI and native Condition Index scores (it does not affect the Invasive Impact scores). Therefore, when applying the first two indices, lake depth needs to be taken into account and this is done with a lake depth classification (Table 1).

Table 1. Table 4 from Clayton & Edwards (2011) showing the lake depth classsification used to "calibrate" LakeSPI scores.

Table 4. 'Depth Calibration Table' showing the maximum potential scores that can be achieved for lakes with different maximum depths.

Max lake depth (m)	Maximum Potential LakeSPI Score	Maximum Potential Native Condition Score	Maximum Potential Invasive Condition Score
1- 2.9	34	14	27
3- 4.9	35	15	27
5- 6.9	40	20	27
7- 8.9	41	21	27
9- 9.9	42	22	27
10- 10.9	43	23	27
11- 12.9	44	24	27
13- 14.9	45	25	27
15- 16.9	47	27	27
17- 18.9	48	28	27
19- 19.9	49	29	27
20+	50	30	27

A full explanation of this table can be found in section 8.4 of the LakeSPI Technical Report).

Table 1 allows the LakeSPI scores to be converted into an O/E approach, which we have developed into a NOF-type framework based on the percentage of the maximal potential scores.

CONDITION OF THE NATIVE MACROPHYTE COMMUNITY

In Table 2, we present guidelines for the use of the LakeSPI Native Condition Index as a **Monitoring Requirement** for lake ecosystem health.

Table 2. Proposed native plant community condition Monitoring Requirement based on LakeSPI native condition scores.

Value	Ecosystem health	
Freshwater Body Type	Lakes	
Attribute	Lake Submerged Plant Index (LakeSPI)[1] - **Native Condition Index**	
Attribute Unit	LakeSPI Scores as a percentage of maximum potential score (%)	
Attribute State	**Numeric Attribute State (% of maximum potential score)**	**Narrative Attribute State**
A	>75%	Excellent ecological condition. Native submerged plant communities are almost completely intact

B	50 - 75%	High ecological condition. Native submerged plant communities are largely intact
C	20 – 50%	Moderate ecological condition. Native submerged plant communities are moderately impacted
National Bottom Line	20%	
D	<20%	Poor ecological condition. Native submerged plant communities are largely degraded or absent

NOTES:

1. To be calculated annually following:
   Clayton J, and Edwards T. 2006. LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual Version 2. Hamilton, New Zealand: National Institute of Water & Atmospheric Research Ltd p57.
2. Lakes in a devegetated state receive LakeSPI scores of 0.
3. Percentages used in Table 2 are the same as the narrative categories developed by the NIWA LakeSPI team for interpretation of LakeSPI scores:

LakeSPI Index score		**Category**
>75%	=	Excellent
>50-75%	=	High
>20-50%	=	Moderate
>0-20%	=	Poor
0%	=	Non-vegetated

4. Using the above bottom line of 20% of the maximum potential Native Condition score, 38% of lakes in which LakeSPI assessments have been made breached the bottom line.

CAVEATS:

1.Factors other than lake depth which can influence LakSPI scores: LakeSPI is not an appropriate method for situations where vegetation development in lakes is strongly constrained by…

- High altitude (i.e. > 1300m a.s.l),
- Strong geothermal influence,
- Extremely low pH (e.g., < 4.5)
- water level fluctuation (e.g., > 10m)
- salinity (i.e. ICOLLs)
- Lakes to which grass carp have been added

…as specified in the LakeSPI user manual (section 9.2). Thus, lakes with some extreme conditions may not be appropriately assessed using LakeSPI.

2. Improving the narratives: It would be useful to look at component LakeSPI metrics in driving the band distinctions, so these can be used in the 'Narrative Attribute State' description. For example, 'cover' categories for invasive plants are described e.g., occasional (very few invasive species found e.g., <10 plants in a profile), or 'invasive ratio' is a subjective estimate of the percentage of invasive vegetation over an entire depth profile. This will need some work to define.

INVASIVE MACROPHYTE IMPACT

In Table 3, we present guidelines for the use of the LakeSPI Invasive Impact Index as a **Monitoring Requirement** for lake ecosystem health.

Table 3. Proposed LakeSPI Attribute table based on LakeSPI Invasive condition scores

Value	Ecosystem health	
Freshwater Body Type	Lakes	
Attribute	Lake Submerged Plant Index (LakeSPI)[1] – **Invasive Impact Index**	
Attribute Unit	% of maximum potential impact (Note higher III is more invaded)	
Attribute State	**Numeric Attribute State (% of maximum potential score)**	**Narrative Attribute State**
	Suggested scores are indicative and may need some work to define	
A	0%	No impact from invasive plants.
B	1 - 25%	Impact from invasive plants is minor.
C	26 - 90%	Impact from invasive plants is moderate to high.
National Bottom Line	90%	
D	>90%	Impact from invasive plants is extreme.

1. To be calculated annually following:
Clayton J, and Edwards T. 2006. *LakeSPI: A method for monitoring ecological condition in New Zealand lakes. User Manual Version 2.* Hamilton, New Zealand: National Institute of Water & Atmospheric Research Ltd p57.

ECOLOGICALLY SIGNIFICANT CHANGE IN LAKESPI

Change can also be assessed over longer time frames and multiple surveys. Guidelines (Figure 3) based on expert judgement suggest a scale of probabilities for determining the ecologically significance of change in lake condition, using averaged LakeSPI indices over repeated surveys. These guidelines have considered variation by different observers and the response of LakeSPI scores to major ecological events in lakes. The significance for the various levels of change are:

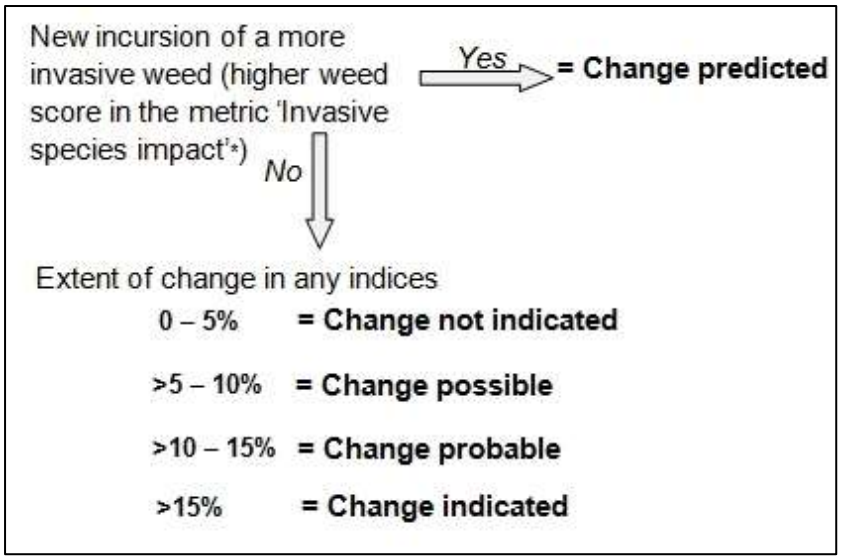


Figure 1: Guidelines assessing the significance of change in LakeSPI Indices over multiple surveys of a lake.

POINTS FOR DISCUSSION WITH STAG

1. We would like to propose the LakeSPI indices as Monitoring Requirements. Some refinements may still be made to the narratives. Does the STAG agree with this?
2. Should we also include the overall LakeSPI score as a Monitoring Requirement as this additionally incorporates the measurement of the maximum depth of the macrophyte community?
3. Is the STAG OK with all devegetated lakes failing the bottom line? Do we need to make some allowance for lakes with extreme conditions, as describe above?

Notes for discussion on a Dissolved Oxygen attribute for lake ecosystems

(Based on the STAG Lake DO sub-group consultation (Ian Hawes, Clive Howard-Williams, Marc Schallenberg). 26 April 2019

The value of including lake DO in the NOF is that it may capture lakes that are in the A – C bands for trophic state (according to the current Attributes in the NOF), but may still have issues regarding internal nutrient feedbacks and fish habitat that indicate a compromised lake ecosystem.

DO depletion in lakes is to a large extent driven by phytoplankton biomass, but is also affected strongly by lake morphology (Fig. 1; Schallenberg & Burns 1999). The model in Fig. 1 predicting DO depletion rate in the hypolimnia of lakes includes chlorophyll a, euphotic depth and lake mean depth. The phytoplankton biomass produced in the euphotic zone drives respiration (DO consumption) in the bottom waters and in the sediment. The extent to which respiration affects the bottom water DO depletion rate (and hence the DO concentration) is in part dependent on the pool of DO in the bottom waters. **In lakes with shallow hypolimnia, the DO pool is relatively small and, thus, DO can be rapidly depleted, resulting in hypoxia or anoxia.**

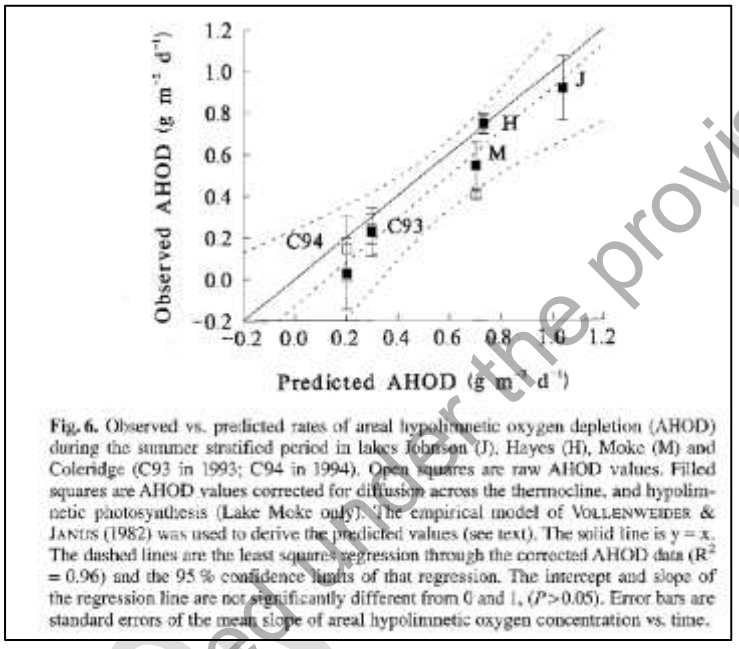


Fig. 6. Observed vs. predicted rates of areal hypolimnetic oxygen depletion (AHOD) during the summer stratified period in lakes Johnson (J), Hayes (H), Moke (M) and Coleridge (C93 in 1993; C94 in 1994). Open squares are raw AHOD values. Filled squares are AHOD values corrected for diffusion across the thermocline, and hypolimnetic photosynthesis (Lake Moke only). The empirical model of VOLLENWEIDER & JANUS (1982) was used to derive the predicted values (see text). The solid line is $y = x$. The dashed lines are the least squares regression through the corrected AHOD data ($R^2 = 0.96$) and the 95 % confidence limits of that regression. The intercept and slope of the regression line are not significantly different from 0 and 1, ($P > 0.05$). Error bars are standard errors of the mean slope of areal hypolimnetic oxygen concentration vs. time.

Fig. 1. Predicted hypolimnetic oxygen depletion rates (from a model by Janus and Vollenweider (1982)) for New Zealand lakes. Variables in the model are chlorophyll a, euphotic depth and lake mean depth. From Schallenberg & Burns (1999).

A previous discussion at the STAG pointed to two separate aspects of lake ecosystem health that are affected by dissolved oxygen depletion in the hypolimnion. These are Biogeochemistry and Habitat and we have explored potential attributes and monitoring requirements for both these aspects.

Biogeochemistry:

We need to consider bottom water oxygen to safeguard phosphorus binding capacity and minimise nutrient (phosphate and ammonium) release and internal nutrient loading from lake sediments. In theory, biogeochemical aspects of lake health could be covered by two bands separated by a 'national bottom line' (oxic/acceptable and anoxic/unacceptable), or we could incorporate more bands by accounting for "risk of anoxia developing". We have taken this latter approach.

Habitat:

Protecting bottom water oxygen for biogeochemistry should also improve habitat for fish and invertebrates that live in or utilise the hypolimnetic zone. The evidence base supporting the oxygen concentrations needed to protect invertebrates is not strong enough to propose Attribute bands for habitat for these organisms. So, we propose a habitat narrative to protect fish by safeguarding an oxygenated thermal refuge in cooler (and by definition deeper) waters. So, a DO attribute to safeguard fish aims to ensure that sufficient DO exists in the cooler waters to allow the most sensitive fish species (e.g., salmonids and sensitive natives) to thrive if the surface waters become inhospitably warm. This is a clear and simple narrative which is evidence-based because we know a lot about DO effects on fish in both rivers and lakes.

We have come to the conclusion that the different requirements for biogeochemical and habitat aspects of lake ecosystems may necessitate having two DO attributes/monitoring requirements. More analysis is needed to determine whether protecting for biogeochemistry alone would also adequately protect thermal refuges in most lakes.

Tables 1 and 2 show proposed Lake DO ***attributes*** or ***monitoring requirements*** for discussion. Table 1 is for bottom water DO to specifically protect against adverse effects of lake biogeochemistry, and Table 2 specifically protects thermal refuge for sensitive fish species.

Table 1. Proposed safeguards for Lake Bottom DO (Biogeochemistry). This protects against bottom water anoxia and associated internal nutrient loads.

Value	**Ecosystem Health**	
Freshwater body type	**All Lakes**	
Attribute	Bottom* dissolved oxygen (Lake biogeochemistry)	
Attribute State	**Numeric attribute state**	**Narrative attribute state**
Attribute Unit	mg/L (milligrams/litre)	
Time period	Measured or estimated annual minimum	
A	>= 7.5	No risk from bottom DO of biogeochemical conditions causing nutrient release from sediments.
B	2.0 - 7.5	No risk from bottom DO of biogeochemical conditions causing nutrient release from sediments.
C	0.5 – 2.0	Risk from bottom DO of biogeochemical conditions causing nutrient release from sediments.
National Bottom line	**0.5**	
D	0.5	Likelihood from bottom DO of biogeochemical conditions resulting in nutrient release from sediments.

NOTES:

- *recorded *ca.* <1m above sediment surface at the deepest part of the lake
- For seasonally stratified lakes, minimum oxygen concentrations are likely to occur in late summer and autumn. For polymictic lakes, minimum oxygen concentrations are more likely to occur transiently, anytime from spring to autumn.

CAVEAT TABLE 1:

1. Lakes with naturally low bottom water DO concentrations: Some lakes may exhibit naturally low bottom water DO concentrations (even though they are minimally degraded). Such lakes include those with:

- unusual chemical conditions (eg Lake Tikitapu),
- high natural organic loading (some peat lakes and forested lakes rich in DOC)
- a small hypolimnetic volume relative to lake volume.

We currently do not know how many naturally low DO lakes there are in New Zealand but the current, monitored database (biased in favour of lowland lakes) suggest there may be a few of them, especially in the class of lakes with a max. depth between 10m and 50m. ***We suggest that the proposed DO bottom line should not apply to lakes which can be shown to have had naturally hypoxic or anoxic conditions. The onus would be on Regional Councils to demonstrate this for specific lakes in order for the lakes to be exempt from the bottom line.***

Table 2. Proposed safeguards for lake habitat (mid-hypolimnetic DO). This protects thermal refuges for fish in seasonally stratifying lakes.

Value	**Ecosystem Health**	
Freshwater body type	**Lakes (seasonally stratifying)**	
Attribute	Mid-hypolimnetic dissolved oxygen (Lake habitat)	
Attribute State	**Numeric attribute state**	**Narrative attribute state**
Attribute Unit	mg/L (milligrams/litre)	
Time	Measured or estimated annual minimum	
A	>= 7.5	No stress caused to any fish species by low dissolved oxygen.
B	5.0 – 7.5	Minor stress on sensitive fish seeking thermal refuge in the hypolimnion. Minor risk of reduced abundance of sensitive fish and macro-invertebrate species.
C	4.0 -5 .0	Moderate stress on sensitive fish seeking thermal refuge in the hypolimnion. Risk of sensitive fish species being lost.
National Bottom line	**4.0**	
D	< 4.0	Significant stress on a range of fish species seeking thermal refuge in the hypolimnion. Likelihood of local extinctions of fish species and loss of ecological integrity.

NOTES:

- Band thresholds align with the River DO attribute bands
- Minimum oxygen concentrations are likely to occur in late summer and autumn. Determination of mid-hypolimnetic DO requires that temperature and oxygen profiles are recorded. Different lake types (depths, areas, exposure, altitude and latitude) have significantly different thermal stratification profiles and this can add some complexity to the definition which requires the assessment of the mid-point of the hypolimnion.

CAVEATS TABLE 2:

1. Lakes with naturally low bottom water DO concentrations: Some lakes may exhibit naturally low bottom water DO concentrations (even though they are minimally degraded). Such lakes include those with:

- unusual chemical conditions (eg Lake Tikitapu),
- high natural organic loading (some peat lakes and forested lakes rich in DOC)
- a small hypolimnetic volume relative to lake volume.

We currently do not know how many of these naturally low DO lakes there are but the current, monitored database (biased in favour of lowland lakes) suggest there may be a few of them, especially in the class of lakes with a max. depth between 10m and 50m.

We suggest that the proposed DO bottom line should not apply to lakes which can be shown to have had naturally hypoxic or anoxic conditions. The onus would be on Regional Councils to demonstrate this for specific lakes in order for the lakes to be exempt from the bottom line.

2. Thermal refuge: This is requirement is mostly relevant to salmonids, which tend to be sensitive to high temperature and low DO, but will also ensure suitable habitat conditions are available for all fish and invertebrate species.

We have chosen the mid-point of the hypolimnion as the site to ensure a suitable thermal refuge is available. This is somewhat arbitrary and may need further refinement (e.g., bottom of metalimnion may be less conservative and more suitable for the NOF?).

APPLICATION TO MONITORED LAKES:

In Table 3, we show how some currently monitored lakes would be classified according to the proposed DO attributes/monitoring requirements.

Table 3. Example lakes with lake bands based on the proposed attributes/monitoring requirements:

Lake	Chl *a* median mg m^{-3}	Depth (m)	Mid-hypolimnetic DO (Band)	Bottom water DO (Band)	Characteristics
Wanaka	1		A	A	Oligo deep (>50m)
Wakatipu	<1		A	A	Oligo deep (>50m)
Waikaremoana	0.8	120	A	A	Oligo deep (>50m)
Brunner	1.2	110	A	B	Oligo, deep (>50m)
Taupo	0.9	140	B	B	Oligo, deep (>50m)
Tarawera	1.4	90	B	A	Oligo/Meso, deep (>50m)
Okataina	2.1	65	C	D	Meso, deep (>50m)
Rotoiti	5.8	126	D	D	Eutrophic deep (>50m)
Hayes	15	30	D	D	Eutrophic (<50m)
Johnson		28	D	D	Eutrophic (<50m)
Rotorua	11	45	D	D	Eutrophic, Polymictic (<50m)
Kai-Iwi	2.3	16	D	D	Meso trophic (<50m)
Tutira	4	45	D	D	Meso/Eutrophic (<50m)
Ellesmere/Te Waihora	~150	2.8	D	D	Eutrophic, polymictic (<50m)
Forsyth/Wairewa	~100		D	D	Eutrophic, polymictic (<50m)
Alexandrina	1.45	30	D	D	Oligo/mesotrophic Small hypolimnion (<50m)
Tikitapu	1.47	28	D	D	Oligotrophic, small hypoliomnion (<50m)

Many lakes fall into the D category and the percentages of Ds are presented in Table 4. From these tests, it seems apparent that the proposed DO framework is stricter that the current NOF attributes (Chla, TN and TP). This may be due to the fact that bottom water DO is also driven by sediment DO uptake, which can be seen as a "legacy effect" (i.e., historical excess nutrient inputs and phytoplankton overproduction contribute to current bottom water DO depletion rates). **Thus, it is sensible that DO attributes/monitoring requirements will be stricter than current trophic state.**

Table 4. Percentages of lakes in our (limited) dataset that meet the Bands for Bottom DO (Biogeochemistry). Some lakes in the D band may have naturally low bottom water DO concentrations, however the number or proportion of these is not presently known.

	Lake Depth category			
NOF Band	**<10m**	**10-50m**	**>50m**	**All lakes**
A	4	4	9	2
B	27	0	64	14
C	27	27	0	13
D	32	68	27	50

OPTIONS TO DISCUSS WITH STAG:

1. DO Biogeochemistry is proposed as a national Attribute or Monitoring Requirement

- Given the importance of legacy effects and in-lake factors (e.g., lake depth), should this be an Attribute (subject to limit-setting) or a Monitoring Requirement?
- Is the bottom-line opt-out provision for lakes with naturally low bottom water DO an acceptable solution to the issue of natural variation in bottom water DO concentrations? An alternative would be to do some more analysis to develop a classification based on lake depth and dissolved organic carbon to refine the bands and bottom line.

2. DO Habitat is proposed as a national Attribute or Monitoring Requirement

- Is the STAG happy with our definition of thermal refuge (i.e., based on salmonid DO tolerances and set at the mid-point of the hypolimnion)?
- Given the importance of legacy effects and in-lake factors (e.g., lake depth), should this be an Attribute (subject to limit-setting) or a Monitoring Requirement?
- Is the bottom-line opt-out provision for lakes with naturally low bottom water DO an acceptable solution to the issue of natural variation in bottom water DO concentrations? An alternative would be to do some more analysis to develop a classification based on lake depth and dissolved organic carbon to refine the bands and bottom line.

STAG Paper – National Default Source Water Risk Management Zones

Background

The Three Waters Review is proposing system-wide reforms to the drinking water regulatory framework to address the issues identified by the Havelock North Inquiry (the Inquiry). The Inquiry made a number of recommendations for changes to how drinking water supply was regulated, including protection of the sources of drinking water.

At present source waters are regulated under the Resource Management Act (RMA) and the National Environmental Standard for Sources of Human Drinking Water (Drinking Water NES). These impose requirements on regional councils and territorial authorities when making decisions that could affect the quality of drinking water. Drinking water suppliers are also required to 'contribute to' the protection of drinking water sources under the Health Act. This paper focused on proposed changes to the Drinking Water NES.

The **Drinking Water NES** essentially requires regional councils to:

- decline discharge or water permits 'upstream' or 'up-gradient' of an abstraction point that pose certain risks to the quality of a drinking water supply serving 500 or more people
- be satisfied that permitted activities rules in regional plans will not pose certain risks to the quality of a drinking water supply serving 500 or more people.

Note: *There is no definition of upstream/up-gradient specifying the spatial area to which the regulations apply. There is also no requirement for consenting authorities to inform water suppliers of RMA decisions with a potential to pose risks to drinking water sources.*

The Havelock North Inquiry found that these provisions in the Drinking Water NES were insufficient as they do not cover all types of land-use activities that pose contaminations risks to drinking water sources or provide any specific protection for water supplies serving less than 500 people.

The Havelock North Inquiry recommended these issues be addressed through amendments to the drinking water NES, including:

- using source protection zones to define the spatial area to which the regulations apply;
- extending the scope of the regulations so they apply to:
  - land-use activities that pose a risk to drinking water sources, including activities governed by district plans, controlled activities, and consented activities; and
  - drinking-water supplies serving 25 or more people
- requiring regional councils to inform drinking-water suppliers and local health authorities of any consent applications with a potential to pose a risk to drinking water sources
- redrafting the regulations so they are easier to interpret and apply.

The Inquiry also recommended legislative changes to ensure water suppliers and local authorities each have clearly defined responsibilities for source protection and be required to work together to proactively identify and manage contamination risks in source waters.

Proposal One – Introduce Default National Source Water Risk Management Zones

The Ministry for the Environment (MfE) contracted Pattle Delamore Partners to develop a proposal to include spatial criterion in the Drinking Water NES based on appropriately robust methods for delineating source protection zones.

S 9(2)(f)(iv) Figure 1 provides a worked example of the source water risk management zones.

S 9(2)(f)(iv)

Proposal Two

S 9(2)(f)(iv)

S 9(2)(f)(iv) S 9(2)(f)(iv)

S 9(2)(f)(iv)

What we need from you

We would like your feedback on the following aspects of our proposals:

- S 9(2)(f)(iv)
-
-
-

FOR STAG CONSIDERATION ONLY NOT GOVERNMENT POLICY

Table 1: Proposed specifications for default Source Water Risk Management Zones S 9(2)(f)(iv) [redacted]

Zone	*Surface Water Source*	*Groundwater Source*	*Conjunctive Source*	S 9(2)(f)(iv) [redacted]
1. Intake/Wellhead Protection Zone *This represents the immediate zone around the drinking water supply intake or wellhead, where contaminants could directly impact on the intake structure.* *For groundwater supplies this zone is defined on the basis that the well is properly constructed and sited to avoid rainwater and floodwaters from directly entering the well casing.*	<u>Streams/Rivers</u> • 5m landward of the water's edge (flood plain edge) on both sides of the stream for the 1000m upstream reach of the intake and 100m downstream, including all tributaries within that distance. <u>Lakes</u> • 500m radius from the intake should apply, and 5m landward of the water's edge. Any tributaries within the 500m radius would be included (5m landward and up to 1000m upstream).	• 5m radius around wellhead.	• For galleries and wells within a river bed, the same intake zone as for a surface water take would apply. • For springs, the same intake zone as for a groundwater source would apply.	S 9(2)(f)(iv) [redacted]

S 9(2)([redacted]

Zone	*Surface Water Source*	*Groundwater Source*	*Conjunctive Source*	S 9(2)(f)(iv)
				S 9(2)(f)(iv)
2. Intermediate Zone *This intermediate zone is focused on specific land-use activities or discharges that might directly contaminate the water source.* *For surface water sources, the extent of the zone is based on providing an early warning of a potential contamination event and to limit the concentrations of microbial pathogens in surface water prior to abstraction and treatment.* *For groundwater sources, the zone's primary purpose is to*	<u>Streams/Rivers</u> • 8 hours travel time to intake (assuming a river water velocity of 1m/s if no site specific information is available), 100 m downstream and 100 m landward of the water's edge (buffer strip) for the reach of surface water described in the preceding point, including all tributaries within that distance. <u>Lakes</u> • For lakes, the whole lake, plus any tributaries (8 hours travel time and 100 m buffer strip).	• 1 year time of travel to the well intake (based on microbial attenuation via the migration pathway), out to a maximum distance of 2.5 km, with a conservative allowance for parameter variability and uncertainty. • If no information is available on the groundwater flow direction then the zone shall be defined by an area of 2.5 km radius around the well. • For aquifers where long travel distances with little attenuation are known to occur (such as karst aquifers), the Zone 2 definition could be replaced with Zone 3.	• For wells where Zone 2 intersects a surface waterway, both the surface water and groundwater protection zones should apply. • For springs and small groundwater fed lakes, the same zones as for wells should be applied.	S 9(2)(f)(iv) [redacted]

Zone	*Surface Water Source*	*Groundwater Source*	*Conjunctive Source*	S 9(2)(f)(iv) [redacted]
limit the potential for microbial contaminants to reach the water supply in an infective state.				S 9(2)(f)(iv) [redacted]
3. Entire Catchment/ Capture Zone *This zone encompasses the entire upper catchment (surface water) and/or the entire capture zone (groundwater).* *Within this zone non-point sources arising from general land use, cumulative effects from small point sources and large scale discharges may need to be managed.* *This zone is also intended to address*	The entire surface water catchment upstream of a point 100 m downstream of the intake.	• The total capture zone for the well or catchment that could contribute water to the well, with a conservative allowance for parameter variability and uncertainty. • In the unlikely event that no information is available on the groundwater flow direction then the zone shall be defined as the entire groundwater catchment. • In addition, where a number of wells draw from the same groundwater system, it may be more pragmatic to	The total extent of the groundwater and surface water catchments contributing to the well or surface waterway.	S 9(2)(f)(iv) [redacted]

Zone	*Surface Water Source*	*Groundwater Source*	*Conjunctive Source*	S 9(2)(f)(iv) [redacted]
persistent contaminants that may not attenuate significantly before reaching a water supply intake, such as nitrate, pesticides and some emerging contaminants.		make Zone 3 the entire groundwater catchment.		

Figure 2: Example of default source water risks management zones for a river abstraction point

Table 2: Maximum Acceptable values for inorganic determinands of health significance

Name	MAV (mg/L)	Remarks
antimony	0.02	
arsenic	0.01	For excess lifetime skin cancer risk of 6×10^{-4}. PMAV, because of analytical difficulties
barium	0.7	
boron[1]	1.4	
bromate	0.01	For excess lifetime cancer risk of 7×10^{-5}. PMAV
cadmium	0.004	
chlorate	0.8	PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chlorine	5	Free available chlorine expressed in mg/L as Cl_2. ATO. Disinfection must never be compromised
chlorite	0.8	Expressed in mg/L as ClO_2. PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chromium	0.05	PMAV. Total. Limited information on health effects
copper	2	ATO
cyanide	0.6	Total cyanides, short-term only
cyanogen chloride	0.4	Expressed in mg/L as CN total. DBP (chloramination)
fluoride[2]	1.5	
lead	0.01	
manganese	0.4	ATO
mercury	0.007	Inorganic mercury
molybdenum	0.07	
monochloramine	3	DBP (chlorination)
nickel	0.08	
nitrate, short-term[3]	50	Expressed in mg/L as NO_3. The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs must not exceed one
nitrite, long-term	0.2	Expressed in mg/L as NO_2. PMAV (long term)
nitrite, short-term[3]	3	Expressed in mg/L as NO_2. The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs must not exceed one
selenium	0.01	
uranium	0.02	PMAV

Improving monitoring metrics for wastewater and stormwater service performance and environmental impacts

1. Background

Through the Three Waters Review, the Department of Internal Affairs, the Ministry of Health and the Ministry of the Environment are developing policy options to improve the regulatory frameworks for drinking water, wastewater and stormwater services. The review has highlighted several problems related to the transparency and quality of information on the performance of these networks, including:

1. Robust and comparable monitoring data on the environmental performance and compliance of wastewater and stormwater networks is not readily available. This has resulted in poor understanding of how these networks contribute to negative environmental and public health outcomes, and the scale of these problems.
2. Existing monitoring requirements are not 'useful' to network providers. The monitoring requirements within the existing regulatory framework do not effectively support or incentivise wastewater and stormwater providers to optimise the performance of these networks to achieve the best outcomes for people and the environment.

The lack of consistent monitoring information between regions/cities and a system for centralised reporting is a key contributor to these identified problems.

The Three Waters Review is exploring options to develop a new set of comprehensive monitoring requirements that would simultaneously serve two purposes:

a) Clarifying the impacts of these activities on the environment and the quality of the wastewater/stormwater services themselves (eg. efficiency and effectiveness).
b) Establishing a clear set of monitoring metrics that can answer both of these questions allows for more strategic infrastructure planning and investment to improve levels of service.

2. What are the current monitoring and reporting requirements?

Monitoring and reporting requirements for wastewater and stormwater services are set out within different statutes. The Local Government Act (LGA) requires annual reporting of some performance metrics, comparing actual with intended performance (as described in the Long Term Plan). The LGA prescribes a set of mandatory performance measures for stormwater, wastewater and water supply services, though none of these relate to environmental impacts. The measures do provide some comparability across Territorial and Local Authorities (TLAs) regarding economic regulation, measuring aspects of network performance against stated levels of service. Annual reports are audited by the Office of the Auditor General (OAG). In a recent report, the OAG concluded that these metrics could be improved.

Section 35 (2) of the Resource Management Act (RMA) gives regional and unitary councils the authority to carry out monitoring of the state of the environment. At present, there is little consistency in the State of the Enviornment monitoring in relation to wastewater and stormwater discharges. Councils tend to interpret this requirement very broadly, to give a mandate to undertake a range of environmental monitoring programmes, and while they do not specifically report on stormwater and wastewater, they do report the state of environments impacted by these. Considering that these council datasets are often the source of information for national reporting under the

Environment Reporting Act (ERA), improving consistency of information would be beneficial. S 9(2)(f)(iv) [redacted]

Councils set rules, objectives and policies in their regional or district plans, and define which activities require what class of resource consent. These consents invariably require monitoring of performance, using both primary (water quality) and secondary (operational performance) measures. Wastewater discharges require resource consents from regional councils. These consents are subject to conditions, often including monitoring and performance reporting, so holders can demonstrate their compliance (or otherwise) with their consents. This data is used to report on overall performance. Some stormwater networks operate subject to network discharge consents which are subject to performance monitoring and reporting.

Some service providers go above and beyond the regulated monitoring requirements. For example Watercare Services Limited have a Wastewater treatment performance report detailing the performance of individual treatment plants. Another reporting mechanism is the national benchmarking analysis undertaken by Water New Zealand. Water NZ collates a range of performance information from all service providers and publishes an annual report. However participation in this benchmarking is voluntary and the diversity of metrics monitored across the country creates significant challenges for producing a complete and reliable picture of performance.

3. What is proposed?

The Three Waters Review is currently considering the development of a new and comprehensive set of measures focussing on the environmental outcomes and service performance of wastewater and stormwater networks. Officials are exploring a wide range of metrics that might be feasible to include based on domestic and international best practice (see appendix 1). S 9(2)(f)(iv) [redacted]

S 9(2)(f)(iv) [redacted]

4. Questions for discussion

Using the draft list of possible monitoring metrics in Appendix 1, we would like feedback on the following:

- S 9(2)(f)(iv) [redacted]
- [redacted]
- [redacted]

Appendix 1 – Possible Wastewater and Stormwater Monitoring Metrics (Draft)

Possible Metrics (options to standardise metadata, methods etc)	S 9(2)(f)(iv) [redacted]	[redacted]
Primary Variables (Environmental impact)		
Temperature	S [redacted]	[redacted]
Colour/Clarity	S [redacted]	[redacted]
Odour	S 9(2)(f)(iv) [redacted]	[redacted]
Suspended Solids	S [redacted] S 9 [redacted]	[redacted]
Conductivity	S [redacted]	[redacted]
Alkalinity	S [redacted]	[redacted]
pH	S [redacted]	[redacted]
Redox potential (ORP)	S [redacted] 9(2 [redacted]	[redacted]
Dissolved Oxygen (DO)	S [redacted] 9(2)(f) (iv)	[redacted]
Nutrients	S 9(2)(f)(iv) [redacted]	[redacted]
Ammonia	S [redacted]	[redacted]
Nitrate/Nitrite	S [redacted]	[redacted]

Organic nitrogen	S	[redacted]
Phosphorus	S	[redacted]
Organic Matter		
Total Organic Carbon (TOC)	S 9(2)(f)(iv) [redacted]	[redacted]
Chemical Oxygen Demand (COD)	S 9(2)(f)(iv) [redacted]	[redacted]
Biological Oxygen Demand (BOD)	S 9(2)(f)(iv) [redacted]	[redacted]
Fluoride	S	[redacted]
Boron	S 9(2)(f)(iv)	[redacted]
Trace Elements		
Aluminium	S	[redacted]
Cadmium	S	[redacted]
Chromium	S	[redacted]
Copper	S	[redacted]
Iron	S	[redacted]
Lead	S	[redacted]
Mercury	S	[redacted]
Zinc	S	[redacted]
Arsenic	S	[redacted]
Selenium	S	[redacted]
Microbiological Indicators		
Faecal coliforms		
E. coli	S	[redacted]
Network connection and level of service metrics (secondary)		

The number of dry weather sewerage overflows from the territorial authority's sewerage system, expressed per 1000 sewerage connections to that sewerage system.	S	[redacted]
Compliance with the territorial authority's resource consents for discharge from its sewerage system measured by the number of: a) abatement notices; b) infringement notices; c) enforcement orders; and d) convictions, received by the territorial authority in relation those resource consents.	S	[redacted]
The total number of complaints received by the territorial authority about any of the following: a) sewage odour; b) sewerage system faults; c) sewerage system blockages; and the territorial authority's response to issues with its sewerage system, expressed per 1000 connections to the territorial authority's sewerage system	S	[redacted]
Attendance time: from the time that the territorial authority receives notification to the time that service personnel reach the site; and Resolution time: from the time that the territorial authority receives notification to the time that service personnel confirm resolution of the blockage or other fault.	S	[redacted]
The number of flooding events that occur in a territorial authority district. For each flooding event, the number of habitable floors affected. (Expressed per 1000 properties connected to the territorial authority's stormwater system.)	S	[redacted]

Compliance with the territorial authority's resource consents for discharge from its stormwater system, measured by the number of: a) abatement notices; and b) infringement notices; and c) enforcement orders; and d) successful prosecutions, received by the territorial authority in relation those resource consents.	S	[redacted]
The median response time to attend a flooding event, measured from the time that the territorial authority receives notification to the time that service personnel reach the site.	S	[redacted]
The number of complaints received by a territorial authority about the performance of its stormwater system, expressed per 1000 properties connected to the territorial authority's stormwater system	S	[redacted]
The extent to which the local authority's drinking water supply complies with: (a) part 4 of the drinking-water standards (bacteria compliance criteria); and (b) part 5 of the drinking-water standards (protozoal compliance criteria).	S	[redacted]
The percentage of real water loss from the local authority's networked reticulation system (including a description of the methodology used to calculate this).	S	[redacted]

Where the local authority attends a call-out in response to a fault or unplanned interruption to its networked reticulation system, the following median response times are measured: a) attendance for urgent call-outs: from the time that the local authority receives notification to the time that service personnel reach the site; b) resolution of urgent call-outs: from the time that the local authority receives notification to the time that service personnel confirm resolution of the fault or interruption; c) attendance for non-urgent call-outs: from the time that the local authority receives notification to the time that service personnel reach the site; and d) resolution of non-urgent call-outs: from the time that the local authority receives notification to the time that service personnel confirm resolution of the fault or interruption.	S	
No. of WWTP's not complying with resource consent conditions	S	
S 9(2)(f)(iv)		
AECOM Canadian benchmarking measures		
#, frequency and cause of WW blockages per connected property	S	
% of network inspected for maintenance per annum	S	
Length and % of SW, WS, WW network replaced per annum	S	
Breakdown of # of reported overflows by cause	S	
Length and % of scheduled maintenance work completed	S	