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Ref: Setting nutrients to support the Southland periphyton targets

MEMORANDUM

To whom it may concern,

In this memorandum, I provide my views on the debate between Southland Regional Council and DairyNZ on the appropriate derivation of nutrient criteria to support achieving Southland's periphyton targets for rivers. I do not comment on the appropriateness of the chosen periphyton objectives nor the appropriateness of the derived nutrient criteria to support ecosystem health objectives other than periphyton, such as for macroinvertebrates and fish.

In my opinion, nutrient criteria to support periphyton targets that are based on Snelder, Moore and Kilroy (2019), as recalibrated in Ministry for the Environment (Ministry for the Environment, 2020), are the most robust and defensible currently available. While the methodology is sound, the final nutrient criteria adopted would be dependent on (a) the level of risk of periphyton target exceedance that decision makers are willing to accept, and (b) the nutrient criteria needs to support other ecosystem health objectives (e.g., macroinvertebrates and downstream environments).

Snelder, Moore and Kilroy (2019) is a published, internationally peer reviewed, journal article that presents total nitrogen (TN) and dissolved reactive phosphorus (DRP) target concentrations to support achieving desired periphyton objectives across New Zealand. The authors used a national dataset of monthly nutrient concentrations and periphyton biomass, temperature, flow, flood frequency, substrate size, solar radiation and absorption, water clarity and riparian shade to model and validate the probability of achieving (and risk of not achieving) desired periphyton targets. The models were then used to derive nutrient criteria look-up tables to identify suitable nutrient criteria, dependent on the desired periphyton target, the river class (groups rivers based on like climatic and topographical characteristics), and the level of risk of not achieving the desired periphyton targets that decision makers are willing to accept. As periphyton communities are biological they have inherent uncertainty, that means they cannot be modelled in a deterministic (or mechanistic) way to reliably predict a guaranteed

outcome in response to management actions, such as nutrient reductions. Modelling the probability of outcome is a sensible, pragmatic way of deriving nutrient criteria, though it also relies on decision makers making a socio-political judgement on the acceptable level of precaution. More stringent nutrient criteria have lower risks of periphyton non-compliance.

In doing so, I have reviewed the following relevant items:

- Norton, N. & Wilson, K. (2019). *Developing draft freshwater objectives for Southland*. Environment Southland Regional Council. Invercargill, New Zealand.
- Wilson, K., McLachlan, S., & Davie, T. (2020). *Community values for Southland's freshwater management units*. Environment Southland Regional Council. Invercargill, New Zealand.
- Depree, C. & Thiange, C. (2021). *Technical review of work undertaken to inform nutrient reduction requirements to achieve freshwater objectives in Southland catchments.* DairyNZ. Hamilton, New Zealand.
- De Silva, N., & Hodson, R. (2020). *Drivers of periphyton in the Southland region.* Environment Southland Regional Council. Invercargill, New Zealand.
- Ministry for the Environment (2020) Action for healthy waterways: Guidance on look-up tables for setting nutrient targets for periphyton. Wellington, New Zealand.
- Snelder, T. H., Moore, C. & Kilroy, C. (2019) 'Nutrient Concentration Targets to Achieve Periphyton Biomass Objectives Incorporating Uncertainties', JAWRA Journal of the American Water Resources Association. John Wiley & Sons, Ltd (10.1111), 0(0). doi: 10.1111/1752-1688.12794.
- Snelder, T. (2020). *Assessment of nutrient load reductions to achieve freshwater objectives in the rivers, lakes and estuaries of Southland: To inform the Southland Regional Forum process.* Land Water People. Lyttleton, New Zealand.
- Zoom meeting recording discussing DairyNZ's feedback on Southland's proposed nutrient criteria to support periphyton. File: "Zoom_peripyton_20201113.mp3".
- Cox, T., Kerr, T., Snelder, T., Rodway, E., & Wilson, K. (2020). *Southland region catchment nutrient models: Supporting the Southland Regional Forum process*. LWP. Lyttleton, New Zealand.
- Wilson, K. & Norton, N. (2021). *Memorandum: Recommended actions arising from stakeholder feedback on science reports estimating nutrient load reductions to achieve freshwater objectives.* Environment Southland Regional Council. Invercargill, New Zealand.

I outline the main arguments presented by DairyNZ and my response:

Issue one: Nutrient criteria for periphyton should not be applied to lowland soft-bed streams

There is an increasing view that nutrient criteria should not exist for soft-bed streams as periphyton requires a hard substrate to grow on, effectively seen as a "get out of jail free card" for those opposed to nutrient regulation. This view, however, demonstrates a misunderstanding of what periphyton is and where it grows. Periphyton is defined as "the microfloral community living attached to the surfaces of

submerged objects in water" (Wetzel, 2001; Azim *et al.*, 2005). Periphyton can be sub-classified depending where it grows: termed 'epiphyton' if it is attached to aquatic plants, 'epipelon' if attached to sedment/mud/silt, 'epixylon' if attached to wood, 'epilithon' if attached to rock or 'epipsammon' if attached to sand (Wetzel, 2001; Azim *et al.*, 2005). The argument here incorrectly assumes that periphyton and epilithon are exactly the same, rather epilithon is a category periphyton. Furthermore, although state of environment monitoring typically uses a method that measures epilithon, it does not negate the presence of other categories that are unmeasured. Periphyton is present in all rivers, regardless of whether it is bound to rocks, plants, mud or other substrates. The National Policy Statement for Freshwater Management (NPS-FM) 2020 also does not make the distinction soft and hard bottomed rivers.

While the nutrient criteria derived use only data from epilithon surveys, it is the only periphyton-nutrient relationship to date, and should be used as a precaution and alongside nutrient criteria for other objectives (such as for the estuary, dissolved oxygen, ecosystem metabolism and macroinvertebrates).

Issue two: Models have poor predictive performance and require regional validation

The models provided by Snelder, Moore and Kilroy (2019) have already been validated nationally including data from Southland. Overall, the models performed well. If further work were to be undertaken to improve the models, then this work could: (1) incorporate new data from across the country as it collected; (2) examine different nutrient summary statistics, beyond the median; (3) use more nuanced hydrological data, accounting for the days of accrual; and (4) use data collected from all forms of periphyton, not just that growing on rocks. Some may be of the view that only data from the Southland region should be used, however, I do not share that view. When modelling it is best use data across the spectrum of environmental conditions where the model will be used. If only regional data is used, then it is probable that some river classes will not have periphyton survey data collected at numerous sites across the nutrient gradient. As a result, there would be low confidence in a model that was required to extrapolate nutrient criteria beyond the range of the data that informed it. If the right climatic, geological and hydrological variables are included in the model, then national datasets allow for more data to be included and more environmental gradients to be captured, minimising the need for gross extrapolation.

Issue three: Nutrient criteria for a broader range of risk levels for periphyton non-compliance should be considered

Deciding the level of risk for periphyton non-compliance is ultimately a normative decision that depends on the values being managed for and the ambition of objectives. It can and should, however, be informed by science as the risk of non-compliance needs to be weighed against the ecological impacts of non-compliance. Furthermore, choosing a high-risk level may, given the logarithmic relationship between periphyton and nutrients, lead to nutrient criteria that are ineffectual at driving improvements in periphyton biomass. In my view, nutrient criteria should rely on multiple lines of evidence, considering all the objectives that could be affected by nutrients. Nutrient criteria for other objectives may need to

be more stringent than those required for periphyton and/or have parity with an acceptable risk of periphyton non-compliance. For example, suitable nutrient criteria for an MCI score of 100 would be ~0.4 mg DIN/L (Canning, Joy and Death, 2021), which is slightly more stringent than (but very close to), the ~0.5 mg N/L required to support achieving a 20% risk of periphyton non-compliance using a chlorophyll *a* objective of 200 mg/m^2 at the 92nd percentile, in a cool dry lowland river (such as the Oreti). If a 30% risk of non-compliance was chosen, then ~1.5 mg N/L would be adopted, grossly exceeding that required for a healthy macroinvertebrate community. Choosing a risk-level that gives nutrient criteria on par with those needed for other components of the ecosystem can give confidence that protection is adequate.

In addition to being a normative decision, I have low confidence in the predictions for high risk levels because the nutrient criteria derived at a 30% non-compliance level have very high concentrations that indicate extrapolations beyond the range of most of the data.

Issue four: The random forest model by Kilroy et al (2019) *should be considered for setting nutrient criteria*

Even with the inclusion of many potential explanatory variables, the random forest models by Kilroy et al (2019) performed poorly in predicting the chlorophyll *a* biomass at the 92nd percentile, having R^2 values at 0.37, and random forests are unable to predict outside the range of data use to inform the models (the authors highlight the biases in the dataset used and suggest alternative methods). The report by Kilroy et al (2019) has also not calculated nutrient criteria from their random forests, so values are not readily available and would require further work. Given the uncertainty in predicting periphyton, the approach already adopted allows for uncertainty in periphyton compliance to be considered in decision making.

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Literature cited

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Canning, A.D., Joy, M.K. and Death, R.G. (2021) “Nutrient criteria to achieve New Zealand’s riverine macroinvertebrate targets,” *PeerJ*, 9, p. e11556. doi:10.7717/peerj.11556.
Kilroy, C. *et al.* (2019) *Modelling periphyton in New Zealand rivers. 1. An analysis of current data and development of national predictions*. Christchurch, New Zealand.
Ministry for the Environment (2020) *Action for healthy waterways: Guidance on look-up tables for setting nutrient targets for periphyton*. Wellington, New Zealand.
Snelder, T.H., Moore, C. and Kilroy, C. (2019) “Nutrient Concentration Targets to Achieve Periphyton Biomass Objectives Incorporating Uncertainties,” *JAWRA Journal of the American Water Resources Association*, 0(0). doi:10.1111/1752-1688.12794.
Wetzel, R.G. (2001) *Limnology: lake and river ecosystems*. Gulf Professional Publishing.