Setting instream nutrient outcomes

Numbers are compulsory for species to survive!

Our NPS-FM position in a nutshell

You need to set nutrient concentrations and/or loads and exceedance criteria ('nutrient outcomes') for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorous (DRP) that will support fish and insect life and manage periphyton growth[1]. These are functionally the same as target attribute states (TAS).

You must achieve these desired nutrient outcomes through limits, delivered as rules in your regional plan. This may require land use input controls (like stocking rate or fertiliser application controls) and restrictions on land use intensification. If you do not currently collect land use input control information, you will need to set more conservative limits as your current inputs will be unknown.

You must set nutrient outcomes for DIN and DRP levels that support ecosystem health. Outcomes for DIN concentrations should be set at around 0.3 - 0.6mg/L and median DRP concentrations should be set at around 0.01 - 0.03mg/L[2,3]. You will need to have a comprehensive and regular monitoring regime to ensure these concentrations are being achieved throughout the year, not just monitored as an annual sample or three yearly reporting exercise.

The NPS-FM directive

Clause 3.13 of the NPS-FM now directs you to set instream nutrient outcomes to recognise the ecosystem-wide impacts of nutrients, not just 'toxicity' levels. This is a key change for instream nutrient requirements since earlier versions of the NPS-FM.

Clause 3.13 instructs you to set '*instream concentrations and exceedance criteria, or instream loads, for nitrogen and phosphorous*'. This is the same step as setting your target attribute states for other attributes under the NPS-FM - but it has been identified through this explicit part of the NPS-FM. To reference the term, '*instream concentrations and exceedance criteria, or instream loads, for nitrogen and phosphorous*' more easily, we have called them 'nutrient outcomes' as this is the term used in 3.12(1) when referring to them.

You must set nutrient criteria in your regional plan to achieve the target attribute state for any *'nutrient attribute'*, such as ammonia and for any '*attribute affected by nutrients*'[4]. For example, you must set nutrient outcomes at levels that will ensure that you can achieve the target attribute states for periphyton and macroinvertebrates (MCI) (these are identified '*attributes affected by nutrients*')[5]. In some cases, nutrient attributes, like total nitrogen, will require nutrient

[1] Canning, A. (2018). Predicting New Zealand riverine fish reference assemblages. *PeerJ*, 6, e4890.

[2] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556.

[3] Canning, A. D., Death, R. G. (2023). Establishing riverine nutrient criteria using individual taxa thresholds. *Water Research, 246*, 120731. https://doi.org/10.1016/j.watres.2023.120731.

[4] Link to: Clause 3.13(1) of the NPS-FM

[5] Examples of nutrient-affected attributes are given in clause 3.13(5), and include periphyton (appendix 2A, table 2, applicable to rivers), dissolved oxygen (appendix 2A, table 7 and appendix 2B, table 17, applicable to rivers and appendix 2B tables, 18 and 19, applicable to lakes), submerged plants (invasive species) (appendix 2B, table 12,

outcomes set to achieve them, for example the nutrient outcome for DIN must also ensure the nutrient attribute for total nitrogen is not exceeded in a downstream receiving environment.

You will need to adopt an integrated management approach (ki uta ki tai)[6]. For example, nutrient outcomes must be set at a level that achieves the target attribute states for that waterbody, while also achieving the environmental outcomes for nutrient sensitive receiving environments downstream of that waterbody. This means the nutrient outcomes for rivers or streams feeding into lakes and wetlands must be set at a level that will achieve the goals set for those lakes and wetlands. In many cases this means that nutrient outcomes for rivers or streams feeding into sensitive receiving environments need to be set at more stringent levels to protect that sensitive receiving environment than would otherwise be necessary to achieve the target attribute states in the stream itself. If a downstream receiving environment is already polluted with nutrients, that means more will need to be done to address the pollution, rather than it no longer being considered as 'nutrient sensitive'.

Section 15(1)(a) and (b) of the RMA states that no person may discharge any contaminant or water into water; or to land, unless it is expressly allowed by a national environmental standard, rule in a regional plan or resource consent.

Nutrient outcomes are treated the same way as Appendix 2A attributes – limits are required in order to achieve nutrient outcomes[7]. These limits must be expressed as rules in your regional plan.

What do we want to see?

We want to see nutrient outcomes identified in your regional plans for dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) that protect ecosystem health and all attributes impacted by nutrient enrichment (including macroinvertebrates).

The Science and Technical Advisory Group (STAG)[8] to government stated that:

> *"the inclusion of both DIN and DRP attributes is recommended because both impact the structure and functioning of healthy ecosystems.*
>
> *Reducing DIN and DRP will contribute to improvements in ecosystem health by potentially reducing the prevalence of macrophytes, organic matter processing, conspicuous and non-conspicuous periphyton, changes in trophic structure and function, assimilation efficiency, and changes in fish and invertebrate communities"*[9].

There was a thorough analysis and a significant body of work undertaken by the STAG to determine their recommendation and this has contributed to the weight of evidence supporting the need for low DIN and DRP values to protect ecosystem health.

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applicable to lakes), fish (rivers) (appendix 2B, table 13, applicable to wadeable rivers), macroinvertebrates (appendix 2B, tables 14 and 15, applicable to wadeable rivers), ecosystem metabolism (appendix 2B, table 21, applicable to rivers. (https://environment.govt.nz/assets/publications/Freshwater/A-guide-to-implementing-clause-3.13-of-the-NPS-FM-2020.pdf)

[6] Link to: Clause 3.5 of the NPS-FM

[7] Link to: Clause 3.12 of the NPS-FM

[8] A group made up of 19 leading freshwater scientists, primarily freshwater ecologists.

[9] Freshwater Science and Technical Advisory Group. (June 2019). STAG Report to the Minister for the Environment.

If you have robust, regional specific monitoring and modelling that allows you to define the relationship between nutrients and attributes like dissolved oxygen, MCI and periphyton, you should use that to inform setting your nutrient outcomes. If you do not, the best information available[10] is research from Canning & Death[11], and Canning, Joy, and Death[12]. To protect the majority of macroinvertebrate species and meet the bottom-line Macroinvertebrate Community Index (MCI) attribute states in the NPS-FM (Tables 14 & 15: MCI, QMCI, ASPM)[13] this peer reviewed research concludes that:

- Mean and median DIN concentrations should be set at around 0.3 - 0.6 mg/L
- Mean and median DRP concentrations should be set at around 0.01 - 0.02 mg/L

These levels were determined utilising robust datasets from across Aotearoa New Zealand and provide an appropriate and robust guideline for councils to set nutrient outcomes for DIN and DRP to contribute to improving ecosystem health.

Figures 1 and 2 below illustrates the different DIN and DRP levels that would be needed to protect different percentages of macroinvertebrate species in different river classifications, and to achieve different MCI targets.

[10] Link to: Best information available PN

[11] Canning, A. D., Death, R. G. (2023). Establishing riverine nutrient criteria using individual taxa thresholds. *Water Research, 246*, 120731. https://doi.org/10.1016/j.watres.2023.120731.

[12] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556.

[13] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556

Nutrient	River classification	80%	85%	90%	95%	Number of reaches
DIN	High order rivers (HO)	0.57	0.44	0.3	0.25	30,485
	Mid order rivers (MO)	0.76	0.56	0.35	0.25	111,733
	Low order rivers in warm climates (LO/W)	0.86	0.63	0.39	0.27	104,509
	Low order rivers in cool climates with plutonic geology (LO/C/Pl)	1.09	0.77	0.45	0.3	287,780
	Low order rivers in cool climates with all other geology (LO/C/Al, HS, SS, M, VA, VB)	1.32	0.89	0.45	0.3	27,048
DRP	High order rivers in low and mid gradient valleys (HO/LG, MG)	0.019	0.016	0.013	0.012	29,683
	Low and mid order rivers in low and mid gradient valleys (LO, MO/LG, MG)	0.024	0.018	0.014	0.012	232,367
	Rivers in high gradient valleys with cool wet and extra wet climates (HG/CW, CX)	0.029	0.02	0.016	0.012	94,813
	Rivers in high gradient valleys with all other climates (HG/CD, WD, WW, WX)	0.033	0.022	0.016	0.014	204,692

Figure 1: *The mean DIN and DRP concentrations (mg/L) predicted to protect a given proportion of macroinvertebrate taxa from a 20% change in occurrence probability across Aotearoa New Zealand's rivers and streams, as classified (with regression trees) into river environment classes following Snelder et al., 2010. (Canning & Death, 2023).*

Table 2 Nutrient criteria to support New Zealand's national bottom line riverine macroinvertebrate targets. Statistics summarizing the DIN and DRP criteria (mg/L) produced using the minimization-of-mismatch method to support New Zealand's three macroinvertebrate national bottom lines set out in the NPS-FM 2020.

Nutrient dataset	Metric	Nutrient	Statistic					
			Min	Lower quartile	Median	Mean	Upper quartile	Max
Measured	MCI	DIN	0.93	1.04	1.07	1.07	1.10	1.21
		DRP	0.025	0.027	0.028	0.028	0.028	0.030
	QMCI	DIN	0.46	0.57	0.63	0.62	0.67	0.77
		DRP	0.015	0.017	0.018	0.018	0.019	0.020
	ASPM	DIN	1.01	1.09	1.12	1.13	1.16	1.29
		DRP	0.026	0.028	0.028	0.028	0.029	0.032
Modelled	MCI	DIN	0.60	0.63	0.64	0.64	0.65	0.68
		DRP	0.020	0.021	0.021	0.021	0.021	0.021
	QMCI	DIN	0.01	0.02	0.02	0.02	0.02	0.02
		DRP	0.019	0.020	0.020	0.020	0.020	0.021
	ASPM	DIN	0.59	0.62	0.63	0.63	0.64	0.65
		DRP	0.020	0.020	0.021	0.021	0.021	0.021

Figure 2: *Nutrient criteria to support Aotearoa New Zealand's national bottom line riverine macroinvertebrate targets. Statistics summarizing the DIN and DRP criteria (mg/L) produced using the minimization-of-mismatch method to support Aotearoa New Zealand's three macroinvertebrate national bottom lines set out in the NPS-FM 2020[14].*

[14]Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556.

These levels are more stringent than the levels previous recommended in the STAG report[15], because they are based on more recent peer reviewed science[16].

If your target attribute states for MCI are more stringent than national bottom lines, your nutrient outcomes may need to be more stringent than these minimums. In rivers and streams that feed into nutrient sensitive lakes, wetlands and estuaries you will need to set more stringent nutrient outcomes than these minimums.

Table 20 of the NPS-FM requires identification of a target attribute state for DRP, with a lower level (D band) of >0.018[17]. The D band represents a degraded ecosystem with significant changes in invertebrate and fish communities, including loss of some species. Target attribute states for DRP should align with the nutrient outcomes for DRP and should be set in the C band or above.

Clause 3.13 of the NPS-FM requires you to set nutrient outcomes for ecosystem health. Table 6, Nitrate Toxicity, should not be used to set bottom lines or target states. More stringent levels must be set to achieve ecosystem health outcomes in line with the research by Canning & Death[18], and Canning, Joy, and Death[19].

Table 6 of the NPS-FM contains an attribute table with target bands that only relate to nitrate toxicity. These values are of no ecological relevance to freshwater bodies – ecosystems will collapse as a result of other nutrient-induced effects well before toxicity values are reached. The 'bottom line' values in this attribute table at annual median 2.4mg and ≤6.9 NO_3-N/L (milligrams nitrate-nitrogen per litre) and annual 95th percentile >3.5 and ≤9.8 NO_3-N/L[20], are not stringent enough to maintain ecosystem health.

If your current regional plan already includes more stringent DIN and DRP levels than the defaults set out above, you should set your nutrient outcomes at or above those existing levels. For example, Horizons Regional Council already uses a DIN target of 0.44 mg/L for some catchments and Hawkes Bay Regional Council uses a DIN target 0.8 mg/L in its Tukituki catchment.

Where water quality already exceeds (i.e., is better than) these DIN and DRP levels, we would expect the nutrient outcomes to be more stringent than the values suggested above. We expect councils to set nutrient outcomes above the baseline states for DIN and DRP, in the same way that target attribute states must be set at a level great than baseline states. This is consistent with Policy 5 of the NPS-FM[21].

Where the water quality of a catchment is degrading or there is uncertainty about an activity's adverse effects on freshwater, we expect resource consents to be granted for a shorter term (5

[15] Freshwater Science and Technical Advisory Group. (June 2019). STAG Report to the Minister for the Environment.

[16] Recommendation 13 of the STAG report suggested a median bottom line of 1.0 mg/L and 95th percentile bottom line of 2.05 mg/L for DIN.

[17] Link to: Table 20 of the NPS-FM

[18] Canning, A. D., Death, R. G. (2023). Establishing riverine nutrient criteria using individual taxa thresholds. *Water Research, 246*, 120731. https://doi.org/10.1016/j.watres.2023.120731.

[19] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556.

[20] Link to: Appendx 2A - Table 6 of NPS-FM

[21] Link to: Policy 5 of the NPS-FM

year) with monitoring and reporting conditions linked to adaptative management conditions that require a change in the activity if trigger levels are exceeded. Where there is uncertainty about effects, conditions should require more frequent reviews of the consent conditions[22].

How should the NPS-FM be implemented?

Include meaningful nutrient outcomes to protect ecosystem health in all rivers and streams

Nutrient outcomes should be set for all waterbodies, not just those that are currently hard bottomed. Periphyton can grow in all rivers and streams, and can impact ecosystem health in all waterbodies, because it does not rely on a rocky bottom to grow. Nutrients can also have direct adverse effects on ecosystem health - periphyton is not the only cause of problems[23].

The term “conspicuous” has been removed from the NPS-FM 2020 (previously in the 2017 version). Conspicuous periphyton had been interpreted to mean “growing on rocks”. Because of this, approximately 25% of the nation’s rivers (naturally soft-bottom reaches) were excluded from consideration for nutrient outcomes to control periphyton in the NPS-FM 2017.

Periphyton doesn’t just grow in streams with rocky bottoms. It can also grow on logs in streams, on fine sediments and on other aquatic plants. The removal of “conspicuous” means soft-bottom streams and other periphyton types must be taken into consideration and instream nutrient concentrations set to achieve periphyton target attribute states for naturally soft-bottom river reaches as well as hard-bottomed reaches[24].

The definition of periphyton is “Organisms attached to or clinging to the stems and leaves of plants or other objects projecting above the bottom sediments of freshwater”[25]. Ecologically, periphyton can be sub-classified depending on where it grows:

- *Epilithon* - growing on rocks
- *Epiphyton* - growing on plants (including filamentous algae)
- *Epidendron* - growing on woods and detritus
- *Epipelon* growing on fine sediments
- *Epipsammon* growing on sand
- *Epizoon* - growing on aquatic animals.

Changes in periphyton abundance and frequency of blooms can be expected to increase as a result of climate change impacts. Warmer weather, longer periods of low flow, and less frequent ‘flushing flows’ to remove periphyton can be expected in many parts of the country. As such,

[22] Link to: Consent terms and activity status PN

[23] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand’s riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556.

[24] Link to: Clause 3.13 of the NPS-FM

[25] Allaby, M. (2015). *A dictionary of ecology* (Fifth edition. ed.). Oxford University Press.

you can expect increased periphyton growth during these conditions[26]. This means controls on nutrients to limit periphyton growth will become even more important in the future.

Additional monitoring during high-risk periods (e.g., during low flows at the height of summer) should be provided for in plans (including action plans) to ensure periphyton issues are recognised and addressed.

Do not delay - use the best information available

The Science and Technical Advisory Group to government[27] (STAG) stated that:

> *While there may not always be a direct link and well-defined mechanistic models between nutrients and components of a healthy ecosystem, ecosystems are dominated by indirect relationships and the framework for managing the health of fresh water must account for this."*

All attribute tables, including periphyton, in the NPS-FM have been derived at national-scale for application at catchment-scale.

If your council does not have enough regionally specific data, you should use the national data sets that are available. The work of Canning & Death[28], and Canning, Joy and Death[29] is new, best information available for you to make decisions for DIN and DRP levels to support macroinvertebrates and MCI attributes.

You cannot delay setting nutrient outcomes. Avoiding setting nutrient outcomes to achieve ecosystem health now will drive conflict and ultimately lead to poor decision-making and stranded investments (as has happened to date).

How we know the NPS-FM is being achieved

Your regional plan will apply instream numerical nutrient concentration targets to all river reaches. The median DIN concentrations will be set at around 0.3 – 0.6 mg/L and the median DRP concentrations will be set at around 0.01 - 0.03 mg/L, and lower where this is necessary to support sensitive receiving environments.

[26] Biggs, B.J.F. (2000). New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams. Ministry for the Environment, Wellington.

[27] A group made up of 19 leading freshwater scientists, primarily freshwater ecologists.

[28] Canning, A. D., Death, R. G. (2023). Establishing riverine nutrient criteria using individual taxa thresholds. *Water Research, 246*, 120731. https://doi.org/10.1016/j.watres.2023.120731.

[29] Canning, A. D., Joy, M. K., and Dealth, R. G. (2021). Nutrient criteria to achieve New Zealand's riverine macroinvertebrate targets. *PeerJ.* 9: e11556. https://doi.org/10.7717/peerj.11556

Implementation Toolbox

The toolbox will continue to be developed as new information becomes available:

Tools:	are helpful diagrams, processes, or ways to support how you should implement the NPS-FM.
Examples:	provide text suggestions to help draft objectives (values and environmental outcomes), policies, and rules (limits) in your regional plans, including how and monitoring could be achieved. It includes examples of how attributes and base line states, target attribute states, environmental flows and levels, and other criteria, where appropriate, can be written or presented help to achieve environmental outcomes.
Case studies:	illustrate where the NPS-FM has been well applied (or not) throughout the country and provides national or international lessons to help implement the NPS-FM.
Evidence:	provides relevant case law to support how the NPS-FM must be applied.
Resources:	provide links to supporting literature and best information available to implement the NPS-FM.

Tools

[When available]

Examples

[When available]

Case studies

[When available]

Evidence

[When available]

Resources

Allaby, M. (2015). *A dictionary of ecology* (Fifth edition. ed.). Oxford University Press.

Biggs, B.J.F. (2000). New Zealand periphyton guideline: detecting, monitoring and managing enrichment of streams. Ministry for the Environment, Wellington.

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Schmutz, S. and Sendzimir, J. (2018). Riverine Ecosystem Management: Science for Governing Towards a Sustainable Future. *Institute for Biodiversity and Ecosystem Dynamics, University of Amsterdam, Amsterdam, The Netherlands.* Vol. 8. Source: Springer Open: *https://doi.org/10.1007/978-3-319-73250-3*

Fish & Game and Forest & Bird and Choose Clean Water have written this practice note to communicate their expectation on how regional councils should implement the National Policy Statement for Freshwater Management 2020 (NPS-FM) into their regional plans. This is one in a series of practice notes which have been prepared on various topics relating to NPS-FM implementation.