

## Response to public submissions on draft default guideline values for nitrate in freshwater

June 2025

Draft default guideline values (DGVs) for nitrate in freshwater were published on the Water Quality Guidelines website for a 3-month public consultation period. During this period, comments for the draft DGVs for nitrate in freshwater were received via public submission.

All submissions were reviewed by the Water Quality Guidelines Improvement Program technical manager. The revised technical brief was subject to re-approval by the relevant jurisdictional committees. Responses to comments are outlined in this report for public record, with the identity of submissions omitted.

Following public consultation and re-review, the default guideline values for nitrate in freshwater are now published as final. For additional information on the publication process, please refer to the pathway for toxicant default guideline value publication.

The Water Quality Guidelines Improvement Program thanks all submissions for their valuable contribution to the development of water quality assessment for the protection of ecosystem health.

Submitter	Issue	Response	Action taken
1.	a) The proposed DGVs for soft waters are more stringent than the nitrate toxicity attribute state value ( $>1 - \leq 2.4$ mg/L $\text{NO}_3\text{-N}$ ) in the current New Zealand National Policy Statement for Freshwater Management (NPS FM). Expert advice ... indicates that if the draft nitrate DGV was finalized and published, as the first official nitrate guideline adopted by ANZG since the ANZECC (2000) values was retracted, the more conservative nature of the proposed DGVs means future compliance with this guideline could impact discharge consenting and compliance .... going forward.	<p>The current draft DGVs now provide some ability to tailor the DGV to local water quality conditions. Although there are several uncertainties associated with the DGVs (as clearly acknowledged in the technical brief), the evidence is strong that nitrate toxicity at low hardness/ionic strength is higher than at higher hardness/ionic strength. Thus, having more conservative DGVs for low hardness/ionic strength waters would appear to be appropriate.</p> <p>Ultimately, if or how the hardness-based DGVs are implemented for regulatory purposes will be a matter for local jurisdictions and subject to additional processes. For example, any amendment to the NPS-FM would be subject to wider Government objectives and agreement; would need to comply with relevant legislative requirements; and would be informed by analysis of impacts and the feasibility of implementation (among other matters).</p>	No changes to the DGVs technical brief.
	b) The applicability of the high-hardness nitrate DGV warrants further exploration. Although the high-hardness DGV may be under-protective for high-hardness low-chloride waters, applying an overly conservative intermediate value is not considered appropriate. This approach could result in technical non-compliance events despite reduced toxicity of nitrate offered by elevated water hardness in site-specific circumstances. ... this points to the relevance and usefulness of site-specific assessments rather than reliance on general ANZG guidelines	<p>Noted. Any further research (see response to issue 2 h), below) would help inform the high hardness DGV. However, the current recommendation for the moderate hardness DGVs to be applied for high hardness waters in NZ (and anywhere else where hardness and chloride are not well correlated) effectively means that the current status for NZ is retained, given that the DGVs for moderate hardness are very similar to the current nitrate toxicity attribute state values in the NPS FM. Moreover, in the absence of further certainty, a precautionary approach is appropriate.</p> <p>The comment regarding site-specific assessments is well made. It is worth emphasising that ANZG (2018) recommends site-specific GVs over generic DGVs (noting</p>	No changes to the DGVs technical brief.

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		that any intention to derive site-specific DGVs would require consultation with/agreement of jurisdictions). This point is already included in Section 4.3 of the DGVs technical brief.	
2.	<b>Note:</b> Submission 2 was supported by a review undertaken of a 'pre-release' draft version of the nitrate freshwater DGVs technical brief (Hickey 2024) under permission of the NZ Ministry for the Environment. The scope of the review was broader than just a direct review of the draft nitrate DGVs released for public comment. Consequently, only those aspects of the review that are relevant to the draft nitrate freshwater DGVs are addressed here.		
	<p>a) <i>Use of water hardness as basis of toxicity criteria</i></p> <p>Our understanding is that the mechanism of toxicity reduction based on hardness has not been definitively established. Hickey (2016) suggests that the reduction in nitrate toxicity may be associated with increasing chloride ion concentration via a competitive inhibition mechanism (Hickey 2016).</p> <p>This uncertainty is acknowledged by the authors of the nitrate DGV document stating:</p> <ul style="list-style-type: none"> <li>“... important to note that all the published studies on the effect of hardness on nitrate toxicity are confounded by the presence of several other ions at elevated concentrations (e.g. bicarbonate, chloride), so it is not possible to fully discern which variable was the main toxicity modifier.”</li> <li>“... more research is required on the effects of chloride on nitrate toxicity to freshwater species to understand its importance relative to hardness and if it needs to be incorporated as a factor that modifies nitrate toxicity.”</li> </ul> <p>The authors state that although uncertain, because hardness is often correlated with other major ion variables, “any ameliorative effects associated with one or more of them would likely be captured by focusing on hardness as the critical variable”. In other words, it is not necessary to know the exact mechanism if water hardness is a good</p>	<p>As noted in Section 3 of the technical brief, the evidence for chloride as a key toxicity modifying factor (TMF) for nitrate toxicity is equivocal, although there are limited data available to assess this. Notably, Soucek &amp; Dickinson (2016) concluded that chloride-dependent nitrate sensitivity is not universal among freshwater crustaceans and is not as strong as the effect of hardness.</p> <p>As noted by the submitter, the technical brief acknowledged that there is uncertainty over this issue and that it is important to address the uncertainty, but that the hardness-based DGVs still represent a significant improvement over the previous ANZECC/ARMCANZ (2000) DGVs. Even if chloride is a more important TMF than hardness, the current hardness-based DGVs will be relevant in many cases, as was detailed in the analysis of the hardness v chloride relationship for NZ waters in Appendix D of the technical brief. As is also stated in Appendix D, where the DGVs are not applicable, it would be expected that conservative DGVs would be applied or that site-specific DGVs would need to be derived. This is considered acceptable and consistent with the guiding principles of ANZG (2018).</p>	No changes to the DGVs technical brief.

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	<p>proxy for the other factors (i.e. chloride concentrations co-vary with hardness). However, the analysis presented in Appendix D (p.27-30)<sup>Error! Bookmark not defined.</sup>, based on New Zealand river water shows a poor relationship between chloride and water hardness.</p> <p>This weak relationship means that hardness is unlikely to be a suitable proxy for chloride concentrations. And so, if chloride is the main ‘modifier’ of nitrate toxicity (not hardness), then this calls into question the technical rigour of developing DGVs based on water hardness. This issue was acknowledged by the authors who state:</p> <ul style="list-style-type: none"> <li>• <i>“This is of potential concern for the nitrate DGVs, given that chloride is the most likely alternative candidate to act as a significant modifier of nitrate toxicity.”</i></li> </ul> <p>Accordingly, if chloride is the main nitrate toxicity modifier and this is poorly related to hardness, then nitrate DGVs based on water hardness lack technical rigour. Our understanding is that if an analysis was repeated based on chloride, then it would likely generate significantly different categories to those based on water hardness.</p> <p>In addition, Hickey (2024) outlines concerns around a lack of validation data for key species to establish whether hardness or chloride concentration are protective of chronic nitrate toxicity. Hickey (2024) asserts that testing should be undertaken with native NZ species to justify the decreased nitrate toxicity DGVs that would apply in low hardness (i.e. soft) waters in NZ if the proposed updated guideline is adopted.</p> <p>Given this, the proposed nitrate DGVs based on water hardness is not supported.</p> <p><sup>1</sup> ... about 50% of NZ freshwaters would fall into the “low hardness” category meaning that the national bottom-line for nitrate-N toxicity</p>	<p>Comments regarding a lack of validation of key TMFs for local species are relevant, as already noted in the technical brief. See response to issue 2 h, below, for further details.</p>	

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	<i>would decrease from 2.4 mg/l to 1.1 mg/l for approximately half of NZ's stream and rivers.</i>		
	<p>b) <i>Arbitrary nature of hardness thresholds used to categorise nitrate toxicity DGVs</i></p> <p>If there was robust data supporting incorporation of a toxicity modify, then DairyNZ would support this being incorporated as a 'continuous correction factor' rather than a categorical approach. For example, pH is a modifier of ammonia toxicity, and is corrected for using the observed pH value. We consider that if hardness (or chloride) is a significant modifier of nitrate toxicity, then toxicity should be corrected based on the concentrations of the modifier via an algorithm, as opposed to a categorical approach used in the proposed nitrate DGVs – especially when the category 'break points' are not effects-based (i.e. based on sample size requirements).</p> <p>We note the authors mention efforts to develop an algorithm that could be used to adjust a nitrate site specific guideline value but concluded the approach had too many limitations.<sup>2</sup></p> <p>We understand that the thresholds defining the water hardness categories were based on a requirement to meet a statistically robust sample size (discussed in greater detail by Hickey 2024<sup>Error! Bookmark not defined.</sup>). Guided by the limitations of the size of toxicity dataset, the authors grouped the data into three bins with water hardness thresholds of 30 and 150 mg/L defining 'soft', 'moderately hard' and 'hard' categories.</p> <p>We note that there is considerable overlap in chronic nitrate toxicity values between the hardness classes, indicating that the arbitrary hardness ranges do not clearly separate all species sensitivities (refer to Hickey 2024). In practice, this mean that there will be different nitrate toxicity DGVs applied to rivers with comparable hardness</p>	<p>The preference for a continuous TMF adjustment is acknowledged. Ultimately, this would be the preferred approach; however, the current data do not allow for such an approach to be developed, and what has been developed instead is considered to be the next best approach. Indeed, the categorical approach that has been taken is considered to be better than deriving DGVs based on a single dataset that spans a very wide range of hardness/ionic strength when it is clear that nitrate toxicity does vary across this range.</p> <p>The reasons for not developing an algorithm (multiple linear regression) approach were outlined in the technical brief, but also in more detail in van Dam et al. (2022).</p> <p>With regards to the overlap in toxicity values between the hardness categories, this is not surprising. A full separation of species sensitivities between the categories would not necessarily be expected, nor is it required. It would not be unusual for toxicity values for insensitive species and sensitive species to overlap between different hardness levels. Notably, data across at least two hardness levels were available for seven species. Rather than focusing on overlap at the bottom and/or top end of the datasets, it is the entire distribution of the dataset (and its species sensitivity distribution) for each of the hardness categories that is most important. As was evident in the technical brief (Appendix D and Figure 1), these distributions were markedly different for the three selected hardness levels.</p>	No changes to the DGVs technical brief.

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	<p>values that are not supported by robust science. That is, a river with hardness of 28 mg/L will have a 2.5-times more stringent nitrate national bottom-line applied compared to a river with 35 mg/L (i.e. 95% protection level NBLs of 1.1 and 2.6 mg/L, respectively).</p> <p>DairyNZ are concerned about the regulatory issues (i.e. limit setting) created by these different nitrate thresholds based on arbitrary hardness categories. It is difficult to see how the arbitrary categorical approach adopted could have addressed the limitations of an algorithm adjustment approach.</p> <p><sup>2</sup> <i>We suspect the limitations of the algorithm approach may reflect limitations of using hardness as a proxy for the main nitrate toxicity modifier (as discussed in previous section and in Hickey 2024).</i></p>	<p>The criticism that “...there will be different nitrate toxicity DGVs applied to rivers with comparable hardness values that are not supported by robust science.” is not accepted. The DGVs are based on the best available science. The analysis of the data demonstrated that there are differences in the toxicity of nitrate at different hardness/ionic strength, even if the direct causal mechanism is not yet fully understood. Although the categorical approach is not the preferred option, it is the option that was able to be implemented based on the available data and it represents a better approach than providing a single DGV for all water types. As noted in the response to issue 1 a), nitrate toxicity at low hardness/ionic strength is clearly higher than at higher hardness/ionic strength (irrespective of the causal mechanism), and it would have been inappropriate for the current derivation to have ignored this.</p>	
	<b>Responses to specific comments in Hickey (2024).</b>		
	c) The proposed hardness categories were based on an arbitrary split of the distribution to provide the same number of species in each category.	<p>This is incorrect - the classes were determined by examining the range/distribution of the hardness levels for which nitrate toxicity has been assessed, to look for natural clusters, checking that there were apparent differences in toxicity between the classes, and ensuring that each class had sufficient (not necessarily the same) sample size to result in a high reliability SSD (assuming a good fit of the SSD to the data).. This is explained in Appendix B of the draft DGV technical brief.</p>	No changes to the DGVs technical brief.
	d) The draft guideline report (ANZG 2023) states that there were chronic toxicity data available for 38 species covering eight taxonomic groups, comprising three microalgae, nine crustaceans, two bivalve molluscs,	<p>Noted. Thank you for picking up this error. The submitter was correct that there were data for 37 species, not 38 species. This has been corrected.</p>	Error has been corrected in the Summary and Section 4.1 of the technical brief.

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	two gastropod molluscs, three insects, one cnidarian, 13 fish and five amphibians. Note that the data summarised in Table 2 and Appendix 1 from the ANZG (2023) report have only 37 species from seven taxonomic groups.		
	e) There are seven species in the database which have sensitivity data in two or more hardness classes, including two of the five fish species (rainbow trout and fathead minnow) which have sensitivity data in all three hardness classes and thus provide an ability to validate the toxicity modifier response for individual species (Table 3). Only fish sensitivity data is available for both low and moderate hardness classes, with a mean toxicity reduction of 17-fold (range 0.13- to 55-fold, Table 3). The fathead minnow showed an increase in toxicity (by 8-fold) with increasing hardness, while the native common bully showed comparable sensitivity in both low and moderate hardness classes. The native inanga, however, showed a 13-fold reduction in toxicity between the low and moderate hardness classes. There are no comparable invertebrate species in the low and moderate hardness classes, which are most relevant to NZ, however the three invertebrate species each showed a reduction in toxicity between the moderate and high hardness classes (mean 11-fold, range 2.8- to 21-fold, Table 3). This very limited database for species in the various hardness classes provides only a minimal basis for assessing species validation for hardness as the toxicity modifier, and for the level of ecological protection afforded to freshwater aquatic species for reduction in nitrate toxicity associated with the three water hardness classes. This database provides minimal certainty for the level of protection afforded to native species by increasing water hardness.	<p>The uncertainties associated with the derivation were clearly articulated in the technical brief; however, on balance, the available evidence was deemed to be sufficient to warrant proceeding with the hardness-based derivations. The technical brief acknowledges that further research on nitrate TMFs is desirable and will further help to reduce the uncertainty in the DGVs. Also see response to issue 2 h, below.</p> <p>Notably, 12 of the species represented across the three nitrate datasets (low, moderate, high hardness) are known to occur in Australian and/or NZ freshwaters, which represents a reasonable proportion of regionally-relevant species for the purposes of deriving ANZG DGVs. It should be noted that, where particular ecosystems or species are identified, ANZG (2018) recommends site-specific GVs.</p> <p>While further research is important and will be valuable, it is not considered essential that such research is completed prior to the publication of the nitrate freshwater DGVs. Jurisdictions are responsible for implementing the DGVs as they determine to be appropriate.</p>	No changes to the DGVs technical brief.
	f) <i>Technical concerns with using hardness as a toxicity modifier</i>	(i) See response to issue 2(a).	No changes to the DGVs technical brief.

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	<p>(i) The conceptual difficulty with the use of hardness as a toxicity modifier is that the mechanism of toxicity reduction based on hardness has not been definitively established. Rather, it is potentially increasing chloride concentrations which may mitigate chronic nitrate toxicity with the mechanism being competitive inhibition of nitrite toxicity (Hickey 2016).</p> <p>(ii) There remains a lack of validation data for key species for chronic toxicity tests undertaken to establish whether hardness (i.e., calcium and magnesium) or chloride concentrations are protective of chronic nitrate toxicity. Such definitive testing should be undertaken with native NZ species to justify the decreased nitrate toxicity DGVs which would apply in low hardness waters if this proposed updated guideline is adopted.</p>	<p>(ii) This data gap is consistent with what has been stated in the DGVs technical brief. Further research in this area would be useful for both Australia and NZ (see further response to issue i) below).</p>	
	<p>g) There remains a lack of validation data for key species for chronic toxicity tests undertaken to establish whether hardness (i.e., calcium and magnesium) or chloride concentrations are protective of chronic nitrate toxicity. Such definitive testing should be undertaken with native NZ species to justify the decreased nitrate toxicity DGVs which would apply in low hardness waters if this proposed updated guideline is adopted.</p>	<p>This data gap is consistent with what has been stated in the DGVs technical brief. Further research in this area would be useful. See further response to issue 2 h below.</p>	<p>No changes to the DGVs technical brief.</p>
	<p><i>h) Recommendations for additional species for chronic nitrate toxicity assessment</i></p> <p>(i) Six additional fish species/life-stages and four additional macroinvertebrate species are recommended for chronic testing to provide a more robust sensitivity database for native species.</p> <p>(ii) Toxicity Modifying Factor (TMF) validations for selected native species should also be undertaken to provide surety that ecological protection is provided by increasing water</p>	<p>(i) While it is always useful to obtain more toxicity data for native species, it is considered that there are sufficient (12) native species represented in the current derivation to not require further testing of native species for nitrate toxicity alone, prior to the DGVs being published. If there are regional or site-specific concerns, then regional/site-specific research could be undertaken and regional/site-specific GVs derived or</p>	<p>No changes to the DGVs technical brief. However, research to better understand the key TMFs for nitrate toxicity is expected to be commissioned.</p>



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	hardness, or some other water quality factor, such as chloride.	<p>the DGVs potentially adapted for regional or site-specific purposes.</p> <p>(ii) It is considered worthwhile to focus any future research effort on better understanding the nitrate TMFs rather than just increasing the nitrate toxicity database <i>per se</i>. Such research should be undertaken, but it is not considered essential to have completed this research prior to publication of the DGVs; the DGVs can be updated in the future if the research results indicate this is necessary.</p>	

## References

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