Otago Regional Council

Water Quality Baseline State

Otago Regional Council
Private Bag 1954, Dunedin 9054
70 Stafford Street, Dunedin 9016
Phone 03 474 0827
www.orc.govt.nz

ISBN
Report writer: Jason Augspurger
Data and statistical analyses performed by: Land, Water, People; Jason Augspurger; Hugo Borges; Rachel Ozanne
Reviewed by: Rachel Ozanne (internal), Helen Manly (interal), Dean Olsen (external)
Published: February 2024

Contents

Executive Summary

Under the NPSFM 2020, regional councils must set baseline and target attribute states to achieve environmental outcomes. This report identifies challenges related to the baseline and target attribute state provisions in the NPSFM. To provide a target attribute state framework that complies with both the “site” and wider FMU-based clauses in the NPSFM, a hybrid approach that uses both site and river network-based target attribute states is required.

The report also identifies the “state” and trends of compulsory ecosystem health attributes (Appendix 2 A, B of the NPSFM) and nutrient concentrations in relation to periphyton (3.13) on 7 September 2017, where possible, for the Otago Region to inform the “baseline” state and setting of target attribute states. Both site-based state and trends and river network state are provided. To indicate the environmental variability (i.e., both natural and anthropogenic) present at each site, where possible, rolling yearly attribute states have been analysed and are provided.

The report also suggests a pathway for deriving draft target attribute states:

1. determine initial network-based targets for each FMU that align with the visions and outcomes and consider potential natural limits on what may be achieved

2. apply these network targets to sites as a new “regional bottom line” and

3. Having derived draft targets for each site based on the network targets, the site targets can then be considered in their local context to determine if the network target is suitable in that location.

List of Figures

List of Tables

The National Policy Statement for Freshwater Management 2020 (NPS-FM 2020) Requirements

The National Policy Statement for Freshwater Management (NPSFM) 2020 sets out the objectives and policies for freshwater management under the Resource Management Act (1991). Under subpart 2, the National Objective Framework, regional councils must follow a process which includes:

1. Identify attributes for each value and set baseline state for those attributes (3.7.2(d), 3.10); and
2. Set target attribute states, environmental flows and levels, and other criteria to support the achievement of the environmental outcomes (3.7.2(e), 3.11, 3.13, 3.16).

Baseline state

Under the NPSFM, baseline state is defined as:

1. The state of the attribute on the date it is first identified by a regional council under clause 3.10(1)(b) or (c)
2. The state of the attribute on the date on which a regional council set a freshwater objective for the attribute under the NPSFM 2014 (as amended in 2017)
3. The state of the attribute on 7 September 2017.

Sub-clause (4) of clause 3.10 states "attribute states and baseline states may be expressed in a way that accounts for natural variability and sampling error".

The purpose of baseline state, under clause 3.11.2 is to provide a threshold for which "target attribute state for every value with attributes (except the value human contact) must be set at or above the baseline state of that attribute". Therefore, future state must be maintained at, or above, the identified baseline state.

Clause 3.11.3 applies to human health contact attributes (i.e., *Escherichia coli* Tables 9 and 22) and states "the target attribute state for the value human contact must be set above the baseline state of that attribute, unless the baseline state is already within the A-band of Table 9 or 10 in Appendix 2A, as applicable". Therefore, target attribute state of human contact attributes must be set above the baseline state unless already compliant with the A-band.

Target attribute state

Under section 3.7 of the NPSFM, councils must "set target attribute states, environmental flows and levels, and other criteria to support the achievement of environmental outcomes". To do so, the NPSFM requires councils to (clauses 3.11.1a, 3.11.1b):

1. Set a target attribute state of every attribute identified for a value; and
2. Identify the site or sites to which the target attribute state applies.

Under clause 3.11.7, “every regional council must ensure the target attribute states are set in such a way that they will achieve the environmental outcomes for the relevant values, and the relevant long-term vision.” To do so, council must have regard to the following (clause 3.11.8):

1. The environmental outcomes and target attribute states of any receiving environment
2. Connections between water bodies
3. The connection of water bodies to receiving environments

The long-term visions, under clause 3.3.2, may be set at freshwater management unit (FMU), part of FMU, or catchment level. However, in practice, visions and environmental outcomes are often linked to whole FMUs.

This suite of provisions linking long-term visions, environmental outcomes, and target attributes states results in conflicting requirements for regional councils. While clause 3.11.1b requires identifying site-based target attribute states (TAS), visions and outcomes may be set a higher spatial scale. To do so, regional councils must be able to link the outcome of site-based results to the wider FMU vision.

Site-based target attribute states

For many attributes (particularly biological response attributes such as periphyton, macroinvertebrates and fish) monitoring data from a site has limited informative value about other locations up, or downstream, of the monitoring site. This causes a disconnect between site and FMU outcomes. While a monitored river reach may comply with the target attribute state, reaches immediately up, or downstream may fail to comply with the target attribute state; a site may be compliant with a nutrient concentration criterion, but this does not necessarily mean that other locations within the catchment are similarly compliant.

Further, biological response outcomes (periphyton, macroinvertebrates, fish, etc.) vary over a wide range of spatial scales. While they are influenced by water quality, they also have a strong association with reach scale physical habitat. This means the response of biotic communities to drivers such as nutrients may vary on a reach level. Therefore, the state of a monitoring site is an uncertain estimate of state at an FMU scale. This leads to difficulty in determining a site-based target attribute that achieves the desired outcome across the rest of the catchment, or FMU, potentially failing to comply with clause 3.11.7.

Developing site-based target attribute states which provide for these outcomes and visions without further modelling, requires a monitoring network representative of the FMU and an understanding of how “monitored sites” link to other areas. Site-based results presented in this baseline analysis are provided for sites with available data. These sites are not, nor are intended to be, representative of the overall state of the FMU; some FMUs have very few sites. Instead, Otago Regional Council’s existing monitoring network is stratified by river class to provide the state of the region as a whole.

River network-based target attribute states

To estimate the state across larger spatial scales such as a catchment, FMU, or region, river-network modelling can be used (Whitehead 2018). With sufficient input data, river-network models are better able to incorporate spatial variation to portray broadscale outcomes that are more representative of true "state" than simple aggregations of monitoring sites. If applied to a single segment (i.e., to predict a site-based outcome), the models have high uncertainty and are not appropriate for informing site-based attribute states. While it is possible to set target attribute states for the river network without named sites, targets that apply to every river segment may not be considered as applying to sites and potentially fail to comply with clauses 3.11.1a and 3.11.1b.

Hybrid approach

To provide a target attribute state framework that complies with the "site-based" clause 3.11.1a/b and the wider FMU-based clause 3.11.7, a hybrid approach using both site and river network-based target attribute states is required. In this hybrid approach, river network-based targets apply to every river segment within an FMU or catchment, and the site-based targets apply to their respective monitoring site. To assess progress toward the river-network target attribute state, models are re-produced by pooling up-to-date site-based monitoring data as samples of the overall population. Results are then compared with prior modelling results. To assess progress of a site toward its site-based target attribute state, state and trends are calculated at a future date. Notably, in the hybrid approach, network models are not used to assess compliance of individual monitoring sites which removes potential conflicting results.

Special provisions for attributes affected by nutrients (clause 3.13)

Under clause 3.13, the NPSFM states "to achieve the target attribute state of any nutrient attribute, and any attribute affected by nutrients, regional councils must also set, at a minimum, appropriate instream concentrations or exceedance criteria for nitrogen and phosphorus". Attributes affected by nutrients include but are not limited to, periphyton, dissolved oxygen, submerged plants, fish, macroinvertebrates, and ecosystem metabolism. Nitrogen and phosphorus are nutrients that may contribute to both primary (i.e., algae/phytoplankton growth), and secondary (macroinvertebrates), production in freshwater. Nitrogen and phosphorus concentrations tend to be higher in landscapes with land-use intensification than concentrations in natural systems (MFE 2023).

While conceptual links between nutrients and attributes such as periphyton, macroinvertebrates, fish and others are well understood, direct relationships between concentrations of nitrogen and phosphorus and affected attribute band thresholds are difficult to determine with appropriate levels of certainty for planning purposes (i.e., a nutrient concentration of x provides for an MCI score of y). This difficulty is partially due to affected attributes also being influenced by other factors such as sunlight, hydrological regime, habitat type and others. For instance, periphyton biomass may be limited by the consistent occurrence of flushing flows, which scour periphyton from the riverbed, instead of nutrient concentrations. When moving up trophic levels in the food web from primary to secondary consumers (i.e., algae to macroinvertebrates), links to nutrients become less direct and may break down altogether. For instance, in headwater catchments dominated by natural land cover,

such as forest or tussocks, production is often driven by external inputs such as leaf litter (termed allochthonous production). The combination of shading and external inputs with lower nutrient uptake can result in higher instream nutrient concentrations than might be expected. Response of invertebrates to nutrients in these systems is likely to be lower than in systems, or downstream reaches, where shading is less prevalent.

In systems where production is driven by primary producers (termed autochthonous), periphyton represents the lowest trophic level in river ecosystems taking up nitrogen and phosphorus directly. Attributes in higher trophic levels, such as macroinvertebrates and fish, may be influenced by periphyton biomass through its influence on food availability, food quality and habitat. As a result of the direct linkage between periphyton and nutrient concentrations, the relationship between periphyton biomass and nutrient concentration is likely to be the strongest of the nutrient-affected attributes (MFE 2023). While linkages in allochthonous reaches are likely to be weaker, autochthonous reaches often occur downstream. Further, whether a river is autochthonous or allochthonous may vary temporally. Therefore, it is important to consider the response of autochthonous reaches, even where allochthonous production may dominate. As a result, to meet clause 3.13, we evaluate nutrient concentrations that provide for periphyton biomass outcomes by using previously published periphyton-nutrient criteria (Snelder 2023). These tables provide nutrient concentrations to meet the A, B and C periphyton biomass bands.

The user must select a level of under-protection risk to use the periphyton biomass-nutrient look-up tables. The under-protection risk is the proportion of the river network which is likely to exceed the biomass objective despite being compliant with the associated nutrient criteria. Therefore, if all segments comply with the nutrient criteria, a 20% under-protection risk would result in 80% of segments complying with the biomass objective. As a result, by selecting the under-protection risk, the user selects the proportion of segments that will not comply with the biomass objective. Lower under-protection risks are associated with lower, and therefore more stringent, nutrient criteria (Snelder 2023). The ORC Policy Team has previously selected a 20% under-protection risk for the periphyton biomass objective and therefore a 20% under-protection risk is used here[1].

As the relationship between periphyton and nutrient concentrations is influenced by multiple factors and is subject to a degree of uncertainty, nutrient concentrations for attributes in higher trophic levels (macroinvertebrates, fish) or with less data (ecosystem metabolism, aquatic plants), have not been modelled. These attributes are likely to have nutrient relationships that are more uncertain, weak, or may not exist compared with the link between nutrients and periphyton. As a result, these higher trophic level relationships currently have limited utility in setting instream nutrient concentration targets as the affected attribute outcome would widely vary.

Determining “baseline state”

This report provides the “state” of compulsory ecosystem health attributes (Appendix 2 A, B of the NPSFM) and nutrient concentrations in relation to periphyton (clause 3.13) on 7 September 2017,

[1] De Pelsemaeker, T., 2024. Selecting Under-protection Risk. Otago Regional Council Memo.

where possible, for the Otago Region to inform the "baseline" state and setting of target attribute states. Both site-based state and network state are provided to enable a hybrid approach.

For lake attributes, the baseline state is best represented by the results previously published in Ozanne et al. (2023). This report uses an alternative analysis period of 2017-2022. The alternative period is used for lakes because a monitoring programme review in 2017 resulted in changes to sites and measurements. The changes were made to better represent state and compliance with NPSFM requirements. Some attributes, including lake SPI (NPSFM table 11 and 12), dissolved oxygen (NPSFM table 18 and 19), and cyanobacteria (NPSFM table 10) have insufficient data to evaluate attribute state. Interim results for lake SPI (Ozanne 2022), dissolved oxygen (Appendix 1), and cyanobacteria (Appendix 1) are available in the respective references.

Site-based baseline state

Natural variability and sample error

Sub-clause (4) of clause 3.10 states "attribute states and baseline states may be expressed in a way that accounts for natural variability and sampling error". Natural variability relating to NOF attributes, is variation in an attribute "state" due to natural processes such as climate cycles, weather events, or other natural factors. Natural variations can occur on sub-daily to decadal timescales. Sample error is a statistical term meaning the difference between the unknown, actual, population statistic and the sample statistic. It is not related to a lab or field-based error while taking a sample. The sample error is generally quantified using confidence intervals (Milne et al. 2023).

Currently, no statistically robust method is available for determining baseline state and accounting for natural variability and sample error (Milne et al. 2023). Accounting for natural variability is inherently difficult; NPSFM "state" is generally calculated over periods of five, or less, years. This time period does not fully incorporate factors that result in water quality being non-stationary such as climate cycles, which occur over decades or longer time scales, or other factors that are known to influence water quality. For example, the five-year period of observations includes part of a climate cycle; the next five-year period captures a different portion of the climate cycle. Therefore, when the five-year periods are isolated, they can be considered to represent different populations. Due to the non-stationary nature of most water quality parameters, underlying assumptions of confidence intervals are often violated making their results difficult to interpret; the confidence interval derived from the first five-year period would indicate only the confidence of the statistic in that period. It would not indicate confidence in a future period under a different climate cycle.

While it is possible to use a longer timeframe to represent state which would incorporate natural variation due to climate cycles, such as a 10- or 20-year period, these timeframes include both natural and anthropogenic-induced change. Separating natural variation from anthropogenic-induced change over this period is not possible.

Rolling yearly attribute states have been analysed and provided where possible for an indication of the environmental variability (i.e., both natural and anthropogenic) present at each site. The rolling analysis begins in September 1, 2012, to August 30, 2017, and ends in the period September 1, 2017, to

August 30, 2022. This analysis is not a formal quantification of natural variability or sample error, but it provides an indication of the variability in attribute state at a particular site.

To meet the "baseline state" definition, the state for the five-year period leading to 7 September, 2017 is calculated for river attributes defined by the NPSFM. These include ammonia toxicity (Table 5), nitrate toxicity (Table 6), suspended fine sediment (Table 8), *E. coli* (Table 9), dissolved reactive phosphorus (Table 20), fish index of biotic integrity (IBI; Table 13), macroinvertebrate community index (MCI; Table 14), average score per metric (ASPM; Table 15), and nutrients in relation to periphyton biomass (Table 2). Required sample numbers for each attribute were relaxed slightly in alignment with ORC's most recent state of the environment report (Ozanne et al. 2023).

ORC's State of the Environment (SoE) monitoring programme was reviewed and significantly improved following the 2017 SoE report and NPSFM release. This review added a large number of sites as well as implementing periphyton and additional macroinvertebrate monitoring. As a result of the monitoring programme review, "state" is not available for all attributes on the 7 September 2017 date specified in the NPSFM. Due to the availability of monitoring data, an alternative period of 1 July 2019 to 30 June 2022 was used for periphyton biomass (Table 2) which requires three years of sampling to calculate a score. Full current-state results for sites implemented after the 2017 network review are available in this report (Ozanne et al. 2023) and have not been presented here as they do not align with the 2012-2017 baseline period.

For some attributes, including deposited sediment (NPSFM Table 16), dissolved oxygen (NPSFM Table 17), and ecosystem metabolism (NPSFM Table 21), the sample record does not have enough observations to provide five-year NOF scores. Interim scores for deposited sediment (Ozanne 2022) and dissolved oxygen (Fraser 2022) are available. The ecosystem metabolism attribute does not yet have a table of grades but requires monitoring. A monitoring programme is currently being implemented to gather data on ecosystem metabolism across a number of sites in Otago.

Detecting site-based degradation

As a result of sample error and natural variability, changes in "state" scores over differing time periods do not necessarily indicate progression towards a target attribute state or degradation. Changes in score also do not indicate the likely cause.

Trend analyses indicate changes in state at an individual site (i.e., the probability a site is improving or degrading) and are recommended as the primary means to determine whether a site is progressing towards its target (Milne et al. 2023). Trend analyses themselves do not indicate causation. As a result, additional analysis must be used to interpret trends such as land-use and climate data, patterns at natural reference sites, and consenting information.

Results of trend analyses and changes in NOF score can conflict. For instance, an individual site can have an improving trend and a decline in NOF score. Similarly, a site can have a declining trend and an improvement in NOF score. This occurs as the trend and NOF score represent different things. A NOF score based on a 95th percentile is influenced by a small number of samples (5 out of 60 samples). If the most recent 5-year period has 5 samples with higher values than the previous 5-year period, the 95th percentile will increase and may result in a lower NOF score. These samples could be due to

increased anthropogenic inputs. However, they could also be due to sample error where random monthly sampling happened to sample more rainfall/rising limb events leading to higher values. If most observations are similar or lower values, the 10-year trend may be improving or stable. This would result in conflicting results between NOF score and trend and create a challenge when assessing whether a site is maintaining or improving.

To provide context on current patterns at monitored sites, 10 and 20-year long-term trends are provided in this report, where possible. Trends are presented based on their probability of improvement and percent annual change (Table 1).

Table 1: Trend categories based on probability of improving trend.

Category	Probability
Exceptionally unlikely	0-1
Extremely unlikely	1-5
Very unlikely	5-10
Unlikely	10-33
As likely as not	33-67
Likely	67-90
Very likely	90-95
Extremely likely	95-99
Virtually certain	99-100

Network state

Available network modelling was used to enable assessment of the wider river-network state. This included nitrate toxicity (Table 6) (Snelder and Fraser 2023), suspended fine sediment (Table 8) (Whitehead 2018), *E. coli* (Table 9) (Snelder and Fraser 2021), MCI (Table 14) (Whitehead 2018), and, through nutrient criteria, periphyton biomass (Table 2) (Snelder and Fraser 2023). Model results are provided as the percent of river segments complying with relevant NOF bands to provide consistency in interpretations. The methods and details of network models are presented in their own reports, noted above.

Water quality, ecological communities, hydrology, and other characteristics naturally vary from headwaters to lower elevation reaches. To encompass these variations, an alteration of the River Environment Classification (REC;(Snelder and Biggs 2007)) was used to classify river segments in Otago (Figure 1) in to one of five management classes (Mountain, Hill, Lowland, Lower Lake, and

Upper Lake) using the second (source of flow) level (Snelder and Fraser 2023)[2] . This alteration reduces the number of management classes from the original REC and allows for justifiable and specific plan provisions which incorporate natural river heterogeneity and maintain a manageable, and understandable, level of detail. The percentage of segments complying are presented for each management class.

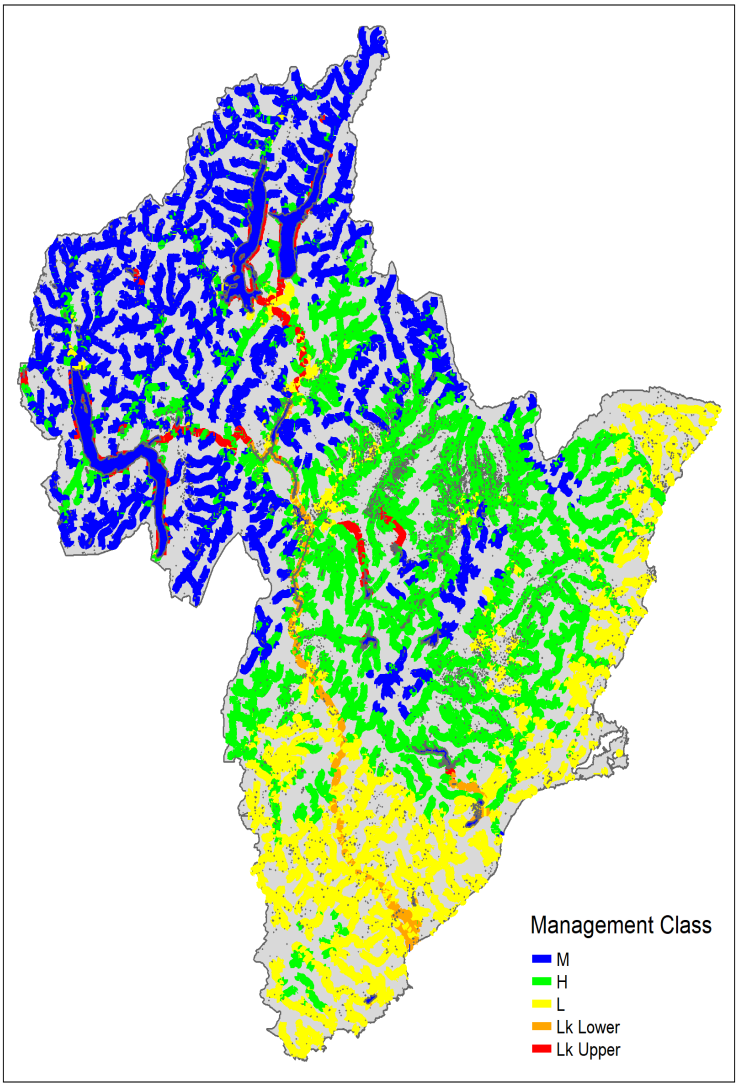

Figure 1: Management class distribution across the Otago Region

Results are presented by FMU/Rohe (Figure 2).

[2] Modifications to the original REC Source-of-flow categories were made. First, the 'Glacial Mountain' and 'Mountain' Source-of-flow categories were combined and called 'Mountain' (M), the Lake-fed Source-of-flow category was subdivided into upper lakes (Lk Upper) and lower lakes (Lk Lower). The other two river management classes were defined by the Hill (H) and Lowland (L) Source-of-flow categories (Snelder and Fraser, 2023).

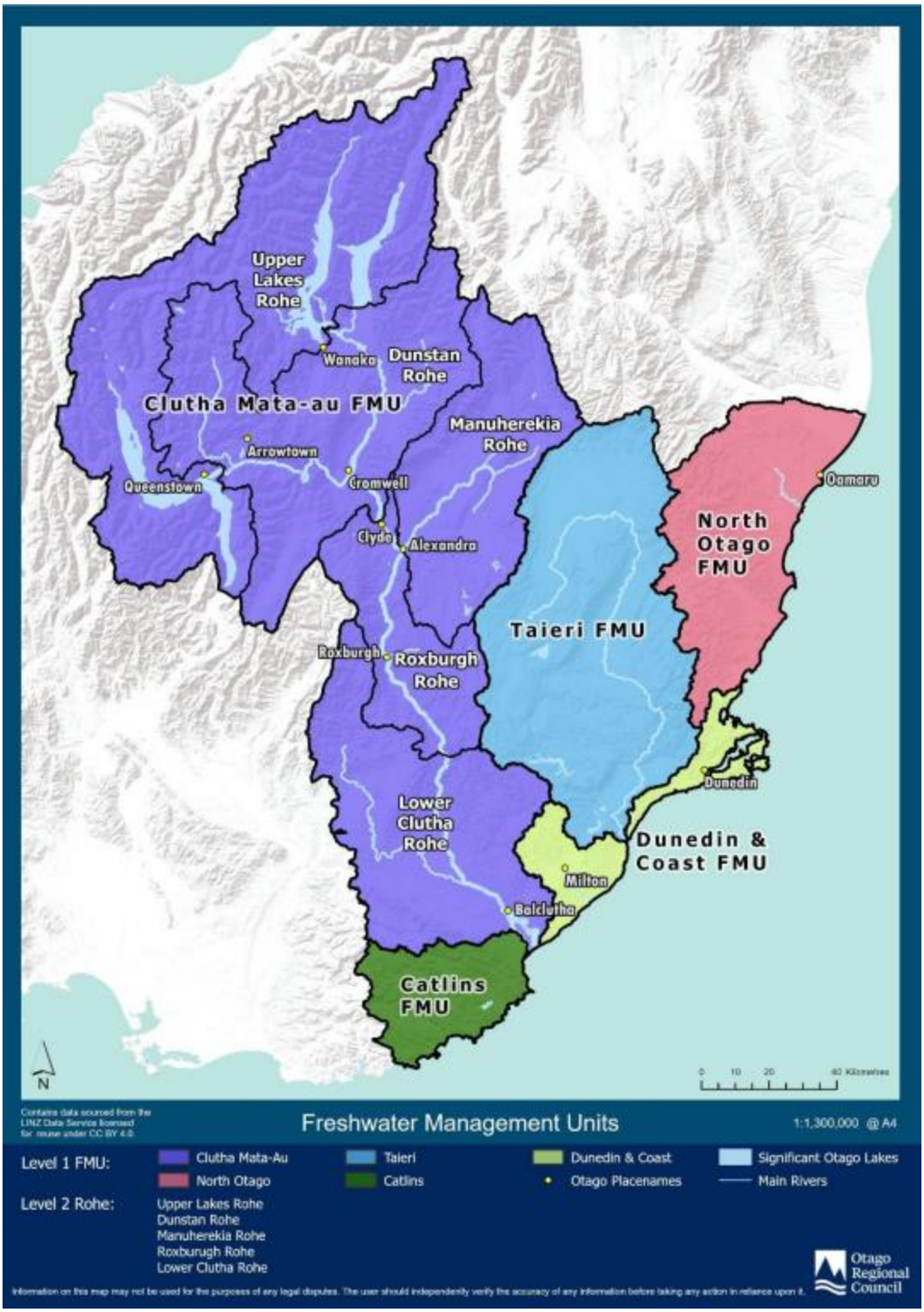

Figure 2: Otago's FMUs and Rohe

North Otago FMU

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

No sites in the North Otago FMU fall below the national bottom line (bottom of B-band) for the ammoniacal nitrogen toxicity attribute (Table 2). All sites comply with the A-band for the median statistic with most sites also complying with the 95th percentile A-band. Awamoko at SH83 and Waiareka creek at Taipo Road comply with the B-band.

Table 2: North Otago FMU ammonia toxicity (NH) state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (five-year period ending August 2017- to five-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in superscript. The values in paratheses are not confidence intervals. Instead, they provide a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Awamoko at SH83	CDL	0.021 (0.004^{2021} - 0.021^{2017})	A (A - A)	0.224 (0.052^{2022} - 0.224^{2017})	B (B - B)
Kakanui at Clifton Falls Bridge	CDH	0.004 (0.001^{2019} - 0.004^{2017})	A (A - A)	0.012 (0.004^{2022} - 0.017^{2019})	A (A - A)
Kakanui at McCones	CDH	0.004 (0.003^{2020} - 0.004^{2017})	A (A - A)	0.013 (0.009^{2020} - 0.013^{2017})	A (A - A)
Kauru at Ewings	CDH	0.003 (0.001^{2019} - 0.003^{2017})	A (A - A)	0.009 (0.005^{2022} - 0.009^{2017})	A (A - A)
Shag at Craig Road	CDH	0.004 (0.002^{2019} - 0.004^{2017})	A (A - A)	0.013 (0.005^{2022} - 0.013^{2017})	A (A - A)
Shag at Goodwood Pump	CDL	0.005 (0.003^{2019} - 0.005^{2017})	A (A - A)	0.011 (0.008^{2020} - 0.011^{2017})	A (A - A)
Trotters Creek at Mathesons	CDL	0.006 (0.005^{2019} - 0.007^{2021})	A (A - A)	0.013 (0.013^{2017} - 0.029^{2022})	A (A - A)
Waianakarua at Browns	CDH	0.003 (0.001^{2019} - 0.003^{2017})	A (A - A)	0.011 (0.004^{2022} - 0.011^{2017})	A (A - A)
Waiareka Creek at Taipo Road	CDL	0.023 (0.008^{2022} - 0.023^{2018})	A (A - A)	0.104 (0.081^{2022} - 0.112^{2020})	B (B - B)

Site-based trends

Over the 20-year trend period (Table 3), the majority of sites have improving trends with the exception of Trotters Creek at Mathesons which is *unlikely* to be improving. This site also has an *unlikely* to be improving trend result in the 10-year period (Table 4) indicating ammoniacal nitrogen levels have increased at this site.

Table 3: North Otago FMU 20-year trends for ammoniacal nitrogen (NHx-N) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	115	0.00	1.00	Virtually certain
Kakanui at McCones	BiMonth	115	0.00	0.98	Extremely likely
Shag at Craig Road	BiMonth	115	0.00	1.00	Virtually certain
Shag at Goodwood Pump	BiMonth	115	0.00	1.00	Virtually certain
Trotters Creek at Mathesons	Qtr	64	0.00	0.13	Unlikely
Waianakarua at Browns	BiMonth	115	0.00	1.00	Virtually certain
Waiareka Creek at Taipo Road	BiMonth	115	-5.53	1.00	Virtually certain

Table 4: North Otago FMU 10-year trends for ammoniacal nitrogen (NHx-N) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	103	0	0.77	Likely
Kakanui at Clifton Falls Bridge	Month	111	0	0.92	Very likely
Kakanui at McCones	Qtr	40			Not Analysed
Kauru at Ewings	Month	107	0	0.85	Likely
Shag at Craig Road	Month	115	0	0.96	Extremely likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Shag at Goodwood Pump	Month	114	0	0.81	Likely
Trotters Creek at Mathesons	Month	109	0	0.17	Unlikely
Waianakarua at Browns	Month	112	0	0.90	Likely
Waiareka Creek at Taipo Road	Month	111	0	0.99	Virtually certain

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the FMU comply with the national bottom line and most sites have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line. To comply with the A-band, some reduction is required as two sites fail to comply with the A-band.

Nitrate Toxicity (NPSFM Table 6)

Sites-based baseline state

No sites in the North Otago FMU fall below the national bottom line for the nitrate toxicity attribute (Table 5). All sites comply with the A-band for the median statistic with most sites also complying with the 95th percentile A-band. Awamoko at SH83 and Trotters Creek at Mathesons comply with the B-band with rolling results ranging from B to A-band. Nitrate concentrations in Waiareka Creek at Taipo Road comply with the B-band.

Table 5: North Otago FMU NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Awamoko at SH83	CDL	0.19 (0.19^{2017} - 0.49^{2021})	A (A - A)	1.908 (1.086^{2021} - 1.908^{2017})	B (A - B)

Site	Class	Median	Median Band	95th	95th Band
Kakanui at Clifton Falls Bridge	CDH	0.017 (0.015^{2018} - 0.024^{2022})	A (A - A)	0.127 (0.1^{2022} - 0.127^{2017})	A (A - A)
Kakanui at McCones	CDH	0.255 (0.255^{2017} - 0.38^{2021})	A (A - A)	0.705 (0.683^{2019} - 0.848^{2022})	A (A - A)
Kauru at Ewings	CDH	0.012 (0.012^{2017} - 0.014^{2021})	A (A - A)	0.112 (0.045^{2022} - 0.112^{2017})	A (A - A)
Shag at Craig Road	CDH	0.075 (0.075^{2017} - 0.108^{2021})	A (A - A)	0.576 (0.472^{2022} - 0.576^{2017})	A (A - A)
Shag at Goodwood Pump	CDL	0.22 (0.21^{2018} - 0.24^{2021})	A (A - A)	0.904 (0.574^{2022} - 0.904^{2017})	A (A - A)
Trotters Creek at Mathesons	CDL	0.47 (0.42^{2018} - 0.495^{2021})	A (A - A)	2.185 (1.194^{2022} - $.185^{2017}$)	B (A - B)
Waianakarua at Browns	CDH	0.2 (0.2^{2018} - 0.3^{2022})	A (A - A)	0.53 (0.52^{2018} - 0.53^{2017})	A (A - A)
Waiareka Creek at Taipo Road	CDL	0.41 (0.41^{2017} - 0.61^{2021})	A (A - A)	2 (1.941^{2022} - 2^{2017})	B (B - B)

Site-based trends

Over the 20-year trend period, the majority of sites have degrading trends, indicating nitrate levels have increased, with the exception of the Kauru at Ewings (Table 6). Over the 10-year period, the Kauru at Ewings, Shag at Craig Road, Shag at Goodwood Pump, and Waiareka Creek at Taipo Road have improving trends indicating decreased nitrate levels (Table 7).

Table 6: North Otago FMU 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	115	4.45	0.00	Exceptionally unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at McCones	BiMonth	114	7.77	0.00	Exceptionally unlikely
Kauru at Ewings	Qtr	64	-0.93	0.74	Likely
Shag at Craig Road	BiMonth	115	4.33	0.00	Exceptionally unlikely
Shag at Goodwood Pump	BiMonth	114	1.37	0.12	Unlikely
Trotters Creek at Mathesons	Qtr	64	6.53	0.00	Exceptionally unlikely
Waianakarua at Browns	BiMonth	112	6.07	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	BiMonth	115	6.55	0.00	Exceptionally unlikely

Table 7: North Otago FMU 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	103	2.76	0.02	Extremely unlikely
Kakanui at Clifton Falls Bridge	Month	111	1.48	0.27	Unlikely
Kakanui at McCones	Month	109	2.70	0.29	Unlikely
Kauru at Ewings	Month	107	-4.84	0.87	Likely
Shag at Craig Road	Month	115	-3.89	0.90	Very likely
Shag at Goodwood Pump	Month	114	-8.17	1.00	Virtually certain
Trotters Creek at Mathesons	Month	109	4.32	0.13	Unlikely
Waianakarua at Browns	Month	112	7.24	0.00	Exceptionally unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waiareka Creek at Taipo Road	Month	111	-5.18	0.99	Extremely likely

Network state

All segments in the mountain and hill management classes (100%; 100-100) comply with the nitrate toxicity A-band (Table 8). In the lowland management class, 95% (76-100) of segments comply with the A-band and 100% (99-100) comply with the B-band. To improve compliance with the A-band in the lowland class, nitrate reductions would be required. To comply with the national bottom line, no reductions would be required.

Table 8: Percent of river segments in the North Otago FMU complying with potential nitrate toxicity attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	51
M	B	100 (100 - 100)	51
M	C	100 (100 - 100)	51
H	A	100 (100 - 100)	806
H	B	100 (100 - 100)	806
H	C	100 (100 - 100)	806
L	A	95 (76 - 100)	254
L	B	100 (99 - 100)	254
L	C	100 (100 - 100)	254

Nitrate toxicity state summary

All sites and segments in the North Otago FMU comply with the national bottom line for nitrate toxicity. However, many sites have probabilities of *unlikely* to be improving, or lower, over both the 10 and 20-year trend periods. To maintain baseline state, measures which stop further nitrate increases, and potentially reverse trends, may be required. Nearly all segments and sites also comply with the A-band. However, three monitoring sites and approximately 5% of segments fail to comply with the A-band. If an A-band target attribute state is set, reductions may be required.

Suspended Fine Sediment (NPSFM Table 8)

Sites-based baseline state

All sites with sufficient data in the North Otago FMU comply with the suspended fine sediment A-band (Table 9).

Table 9: North Otago FMU Clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Awamoko at SH83	CDL		
Kakanui at Clifton Falls Bridge	CDH	5.333 (5.261^{2018} - 7.216^{2022})	A (A - A)
Kakanui at McCones	CDH		
Kauru at Ewings	CDH		
Shag at Craig Road	CDH		
Shag at Goodwood Pump	CDL	4.573 (4.381^{2021} - 4.573^{2020})	A (A - A)
Trotters Creek at Mathesons	CDL		
Waianakarua at Browns	CDH	5.524 (5.157^{2018} - 6.317^{2022})	A (A - A)
Waiareka Creek at Taipo Road	CDL	1.966 (1.966^{2017} - 2.269^{2022})	A (A - A)

Site-based trends

Over the 20-year trend period, the Kakanui at Clifton Falls and the Kauru at Ewings are *as likely as not* to be improving which indicates an ambiguous trend which is neither classed as improving or degrading. The other sites in the FMU have trends which indicate degradation (Table 10).

Over the 10-year period, all sites have trends which have *likely,* or higher, probabilities of improving (

Table 11). The contradicting results in the 10 and 20-year trend period could be due to either improvement in land use practice and/or because of natural variability.

Table 10: North Otago FMU 20-year trends for turbidity for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	115	-0.28	0.66	As likely as not
Kakanui at McCones	BiMonth	115	0.80	0.22	Unlikely
Kauru at Ewings	Qtr	64	0.45	0.37	As likely as not
Shag at Craig Road	BiMonth	115	1.49	0.04	Extremely unlikely
Shag at Goodwood Pump	BiMonth	115	1.16	0.11	Unlikely
Trotters Creek at Mathesons	Qtr	64	0.84	0.15	Unlikely
Waianakarua at Browns	BiMonth	115	3.18	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	BiMonth	115	2.73	0.00	Exceptionally unlikely

Table 11: North Otago FMU 10-year trends for turbidity for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	102	-8.02	1.00	Virtually certain
Kakanui at Clifton Falls Bridge	Month	111	-6.50	1.00	Virtually certain
Kakanui at McCones	Month	107	-7.15	1.00	Virtually certain
Kauru at Ewings	Month	107	-4.52	0.99	Extremely likely
Shag at Craig Road	Month	109	-2.74	0.92	Very likely
Shag at Goodwood Pump	Month	113	-3.92	0.98	Extremely likely
Trotters Creek at Mathesons	Month	109	-2.77	0.97	Extremely likely
Waianakarua at Browns	Month	112	-2.76	0.94	Very likely
Waiareka Creek at Taipo Road	Month	111	-5.45	1.00	Virtually certain

Network state

Network modelling results show 100% mountain segments comply with the suspended sediment A-band (Table 12). For the hill class, 68% comply with the A-band, 77% comply with the B-band and 86% comply with C-band. Therefore approximately 15% of the segments in this class may not meet the C-band. This is likely to be within the model uncertainty but may indicate reductions are required for all segments to comply with the national bottom line. In the lowland class, 96% of segments comply with the A-band, 99% comply with the B-band and 100% of segments comply with the C-band.

Table 12: Percent of segments complying with potential A, B, and C suspended fine sediment attribute bands split by management class in 2017 based on Whitehead (2018) for the North Otago FMU.

Management Class	Band	Segment %	# of Segments
M	A	100	48
M	B	100	48
M	C	100	48
H	A	68	835

Management Class	Band	Segment %	# of Segments
H	B	77	835
H	C	86	835
L	A	96	704
L	B	99	704
L	C	100	704

Suspended sediment state summary

All sites and nearly all segments in the FMU comply with the national bottom line. However, approximately 15% of hill-fed segments may not comply with the C-band. All sites also have improving trends over the 10-year period. Over the 20-year period, degrading trends are present indicating a decline in state over this period. Reductions may be required for all hill class segments to comply with the national bottom line.

Escherichia coli (NPSFM Table 9)

Sites-based baseline state

Compliance with *E. coli* attribute bands in the North Otago FMU is variable both between sites, and within a site's rolling analysis (Table 13). All monitoring site results span more than a band for at least one of the *E. coli* metrics with the exception of Waiareka Creek at Taipo Road. This monitoring site fails to comply with the national bottom line across the entire rolling analysis. The Kakanui at Clifton Falls Bridge, Waianakarua at Browns, and Waiareka at Taipo Road fail to comply with the national bottom line within the rolling analysis. At least some level of improvement is required at these sites.

Table 13: North Otago FMU E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Awamoko at SH83	CDL								
Kakanui at Clifton Falls Bridge	CDH	92 (92^{2017} - 216.5^{2022})	A (A - D)	635.1 (635.1^{2017} - 1118^{2022})	B (B - C)	0.211 (0.211^{2017} - 0.385^{2022})	B (B - D)	0.07 (0.07^{2017} - 0.308^{2022})	B (B - E)
Kakanui at McCones	CDH								
Kauru at Ewings	CDH								
Shag at Craig Road	CDH	47 (46^{2020} - 54.5^{2022})	A (A - A)	424 (424^{2017} - 667.7^{2022})	A (A - B)	0.107 (0.093^{2022} - 0.125^{2018})	A (A - A)	0.018 (0.018^{2019} - 0.056^{2022})	A (A - B)
Shag at Goodwood Pump	CDL	68.5 (67^{2019} - 126^{2022})	A (A - A)	308 (308^{2017} - 1125.6^{2022})	A (A - C)	0.125 (0.125^{2017} - 0.245^{2022})	A (A - B)	0.018 (0.018^{2017} - 0.113^{2022})	A (A - C)
Trotters Creek at Mathesons	CDL								

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Waianakarua at Browns	CDH	39 (39^{2017} - 110^{2021})	A (A - A)	315 (315^{2017} - 1539.1^{2022})	A (A - D)	0.055 (0.055^{2017} - 0.212^{2022})	A (A - B)	0.018 (0.018^{2017} - 0.115^{2022})	A (A - C)
Waiareka Creek at Taipo Road	CDL	230 (180^{2020} - 240^{2018})	D (D - D)	1595 (858.5^{2021} - 1595^{2017})	D (B - D)	0.439 (0.439^{2017} - 0.491^{2018})	D (D - D)	0.263 (0.216^{2022} - 0.263^{2017})	D (D - D)

Site-based trends

Over the 20-year trend period, the only site with a *likely* to be improving trend probability, or higher, for *E. coli* is the Shag at Craig Road. All other sites have *unlikely,* or lower, probabilities of improving indicating degrading trends, and increased *E. coli* levels, over the 20-year period (Table 14).

Over the 10-year period the Awamoko at SH 83, Shag at Craig Road, and Waiareka Creek at Taipo Road sites have *likely* to be improving, or higher, probabilities indicating E. coli concentrations have decreased (

Table 15). The Kakanui at McCones and Shag at Goodwood Pump are *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading. The remaining sites have *unlikely*, or lower, probabilities to be improving over this period indicating *E. coli* levels have increased.

Table 14: North Otago FMU 20-year trends for E. coli for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	117	1.15	0.02	Extremely unlikely
Kakanui at McCones	BiMonth	115	3.01	0.00	Exceptionally unlikely
Kauru at Ewings	Qtr	64	4.42	0.03	Extremely unlikely
Shag at Craig Road	BiMonth	113	-1.51	0.86	Likely
Shag at Goodwood Pump	BiMonth	114	1.12	0.21	Unlikely
Trotters Creek at Mathesons	Qtr	64	4.99	0.00	Exceptionally unlikely
Waianakarua at Browns	BiMonth	114	8.38	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	BiMonth	115	4.96	0.00	Exceptionally unlikely

Table 15: North Otago FMU 10-year trends for E. coli for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	103	-0.62	0.67	Likely
Kakanui at Clifton Falls Bridge	Month	112	2.19	0.01	Extremely unlikely
Kakanui at McCones	Month	107	0.00	0.51	As likely as not
Kauru at Ewings	Month	107	7.22	0.00	Exceptionally unlikely
Shag at Craig Road	Month	113	-2.63	0.82	Likely
Shag at Goodwood Pump	Month	112	1.06	0.34	As likely as not
Trotters Creek at Mathesons	Month	107	5.31	0.05	Very unlikely
Waianakarua at Browns	Month	110	8.92	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	Month	111	-2.49	0.88	Likely

Network state

Network modelling results in the mountain management class indicate 62% (4-100) of segments comply with the A-band criteria, 86% (19-100) comply with the B-band criteria and 85% (12-100) comply with the C-band criteria (Table 16). In the hill management class, compliance is lower with 31% (4-60) complying with the A-band, 56% (23-87) complying with the B-band and 66% (32-97) complying with the C-band. In the lowland management class, 10% (1-22) comply with the A-band 23% (7-42) comply with the B-band and 33% (18-62) comply with the C-band. In the hill and lowland classes, confidence intervals do not overlap 100% indicating there is a 95% probability that a reduction is required for all segments to comply with the national bottom line. Compliance in these classes may require reductions in upstream mountain segments.

Table 16: Percent of river segments in the North Otago FMU complying with potential E. coli attribute band with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	62 (4 - 100)	51

Management Class	Band	Current	Count
M	B	86 (19 - 100)	51
M	C	85 (12 - 100)	51
H	A	31 (4 - 60)	842
H	B	56 (23 - 87)	842
H	C	66 (32 - 97)	842
L	A	10 (1 - 22)	706
L	B	23 (7 - 42)	706
L	C	33 (18 - 62)	706

E. coli state summary

When the rolling *E. coli* analysis is considered, three sites in the North Otago FMU fail to comply with the national bottom line. Trend analyses show increasing *E. coli* levels are common in the 20-year period. About half of sites have degrading trends in the 10-year analysis period whereas the others have improving trends. Network modelling indicates hill and lowland class confidence intervals do not overlap 100%. This indicates, with 95% confidence, that a reduction is required for all segments to comply with the national bottom line. Compliance in these classes may require reductions in upstream mountain segments. For the entire FMU to comply with the national bottom line, measures which reduce *E. coli* levels are required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Two sites, the Awamoko at SH83 and Waiareka Creek at Taipo Road, in the North Otago FMU fail to comply with the C-band for the DRP attribute (Table 17). No bottom line exists for this attribute. However, the attribute does affect periphyton biomass which has a national bottomline which must be considered. All other sites comply with A-band and remain in the A-band through the rolling analysis, except for the Shag at Goodwood Pump which ranges between the B and A-band.

Table 17: North Otago FMU DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence

intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Awamoko at SH83	CDL	0.05 (0.05^{2017} - 0.058^{2020})	D (D - D)	0.219 (0.146^{2022} - 0.219^{2017})	D (D - D)
Kakanui at Clifton Falls Bridge	CDH	0.003 (0.001^{2022} - 0.003^{2017})	A (A - A)	0.009 (0.004^{2022} - 0.01^{2020})	A (A - A)
Kakanui at McCones	CDH	0.003 (0.003^{2022} - 0.004^{2019})	A (A - A)	0.008 (0.008^{2017} - 0.014^{2021})	A (A - A)
Kauru at Ewings	CDH	0.004 (0.002^{2022} - 0.004^{2018})	A (A - A)	0.009 (0.006^{2020} - 0.009^{2017})	A (A - A)
Shag at Craig Road	CDH	0.005 (0.003^{2022} - 0.005^{2017})	A (A - A)	0.013 (0.01^{2022} - 0.013^{2017})	A (A - A)
Shag at Goodwood Pump	CDL	0.007 (0.004^{2022} - 0.007^{2017})	B (A - B)	0.013 (0.013^{2018} - 0.014^{2021})	A (A - A)
Trotters Creek at Mathesons	CDL	0.005 (0.004^{2022} - 0.005^{2017})	A (A - A)	0.009 (0.008^{2022} - 0.009^{2021})	A (A - A)
Waianakarua at Browns	CDH	0.004 (0.002^{2022} - 0.005^{2018})	A (A - A)	0.009 (0.009^{2017} - 0.012^{2021})	A (A - A)
Waiareka Creek at Taipo Road	CDL	0.11 (0.11^{2017} - 0.19^{2022})	D (D - D)	0.263 (0.263^{2017} - 0.37^{2022})	D (D - D)

Site-based trends

Across the 20-year trend period, the majority of sites have *virtually certain* to be improving trends (Table 18). The Shag at Goodwood Pump has an *as likely as not* trend which is an ambiguous result and is not classed as improving or degrading. The Waiareka Creek at Taipo Road has a *very unlikely* to be improving trend indicating an increase in DRP levels.

Across the 10-year period, all sites have improving trends except for the Awamoko at SH83 and Waiareka Creek at Taipo Road which are *exceptionally unlikely* to be improving (Table 19). This indicates DRP levels have increased at these sites over this time-period.

Table 18: North Otago FMU 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	113	0.00	1.00	Virtually certain
Kakanui at McCones	BiMonth	115	0.00	1.00	Virtually certain
Shag at Craig Road	BiMonth	114	0.00	1.00	Virtually certain
Shag at Goodwood Pump	BiMonth	112	0.00	0.36	As likely as not
Waianakarua at Browns	BiMonth	104	0.00	1.00	Virtually certain
Waiareka Creek at Taipo Road	BiMonth	114	1.01	0.08	Very unlikely

Table 19: North Otago FMU 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	102	3.71	0.01	Exceptionally unlikely
Kakanui at Clifton Falls Bridge	Month	110	0.00	1.00	Virtually certain
Kakanui at McCones	Month	106	0.00	0.94	Very likely
Kauru at Ewings	Month	106	0.00	1.00	Virtually certain
Shag at Craig Road	Month	115	0.00	1.00	Virtually certain
Shag at Goodwood Pump	Month	114	-6.94	1.00	Virtually certain
Trotters Creek at Mathesons	Qtr	40	-0.63	0.99	Virtually certain
Waianakarua at Browns	Month	112	0.00	1.00	Virtually certain
Waiareka Creek at Taipo Road	Month	110	10.15	0.00	Exceptionally unlikely

Dissolved reactive phosphorus state summary.

Most monitoring sites in the North Otago FMU comply with the DRP A-band and have improving trends over both the 20 and 10-year trend periods. Whether phosphorus reductions are required depends upon the target attribute state set for this table and the periphyton biomass target.

Periphyton (NPSFM Table 2)

All sites with periphyton biomass data fail to comply with the national bottom line in the North Otago FMU (Table 20). A rolling analysis is not possible due to insufficient data.

Sites-based baseline state

Table 20: North Otago FMU Periphyton state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Kakanui at McCones	464	D	30
Oamaru Creek at SH1	569	D	34
Shag at Goodwood Pump	372	D	32
Waianakarua at Browns	220	D	33

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, the Awamoko at SH83, Trotters Creek at Mathesons, and Waiareka Creek at Taipo Road fail to comply with the C-band nutrient criteria (Table 21). The remaining sites comply with the C-band nutrient criteria. Kakanui at Clifton Falls Bridge and Kauru at Ewings comply with the B-band criteria.

For total phosphorus, all sites except for the Awamoko at SH83 and Waiareka Creek at Taipo Road comply with the C-band 20% under-protection risk periphyton nutrient criteria (Table 21).

Table 21: North Otago FMU total nitrogen and total phosphorus compliance with the 20% under protection risk periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are

presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Awamoko at SH83	CDL	0.715 (0.715^{2017} - 1.09^{2021})	D (D - D)	0.069 (0.069^{2017} - 0.079^{2020})	D (D - D)
Kakanui at Clifton Falls Bridge	CDH	0.115 (0.113^{2018} - 0.146^{2022})	B (B - B)	0.006 (0.004^{2022} - 0.006^{2017})	C (C - C)
Kakanui at McCones	CDH	0.405 (0.405^{2017} - 0.52^{2021})	C (C - C)	0.008 (0.008^{2017} - 0.011^{2020})	C (C - C)
Kauru at Ewings	CDH	0.12 (0.12^{2017} - 0.135^{2022})	B (B - B)	0.008 (0.005^{2022} - 0.008^{2018})	C (C - C)
Shag at Craig Road	CDH	0.255 (0.255^{2017} - 0.29^{2021})	C (C - C)	0.008 (0.007^{2022} - 0.008^{2020})	C (C - C)
Shag at Goodwood Pump	CDL	0.38 (0.37^{2018} - 0.445^{2021})	C (C - C)	0.013 (0.009^{2021} - 0.013^{2017})	C (C - C)
Trotters Creek at Mathesons	CDL	0.62 (0.62^{2018} - 0.74^{2021})	D (D - D)	0.012 (0.012^{2017} - 0.014^{2021})	C (C - C)
Waianakarua at Browns	CDH	0.29 (0.29^{2017} - 0.395^{2022})	C (C - C)	0.006 (0.004^{2022} - 0.006^{2019})	C (B - C)
Waiareka Creek at Taipo Road	CDL	1.3 (1.21^{2022} - 1.44^{2020})	D (D - D)	0.16 (0.16^{2017} - 0.23^{2022})	D (D - D)

Site-based trends

Over the 20-year trend period considered, all sites have *unlikely* to *exceptionally unlikely* probabilities of an improving trend. This indicates total nitrogen levels which have increased across the FMU during this period (Table 22).

Over the 10-year trend period the Shag at Craig Road, Shag at Goodwood Pump, and Waiareka Creek at Taipo Road have *very likely,* or higher, probabilities of improving trends indicating total nitrogen levels have decreased (Table 23). The rest of the FMU maintains *unlikely,* or lower, probabilities of improving indicating total nitrogen levels have increased over the ten-year period analysis.

Table 22: North Otago FMU 20-year trends for total nitrogen for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	115	0.00	0.25	Unlikely
Kakanui at McCones	BiMonth	114	5.61	0.00	Exceptionally unlikely
Kauru at Ewings	Qtr	64	0.15	0.24	Unlikely
Shag at Craig Road	BiMonth	115	2.57	0.00	Exceptionally unlikely
Shag at Goodwood Pump	BiMonth	114	0.91	0.13	Unlikely
Trotters Creek at Mathesons	Qtr	64	4.87	0.00	Exceptionally unlikely
Waianakarua at Browns	BiMonth	112	3.74	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	BiMonth	115	2.38	0.00	Exceptionally unlikely

Table 23: North Otago FMU 10-year trends for total nitrogen for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	103	2.41	0.03	Extremely unlikely
Kakanui at Clifton Falls Bridge	Month	111	0.00	0.02	Extremely unlikely
Kakanui at McCones	Month	107	2.99	0.04	Extremely unlikely
Kauru at Ewings	Month	107	0.34	0.06	Very unlikely
Shag at Craig Road	Month	115	-2.17	0.91	Very likely
Shag at Goodwood Pump	Month	114	-4.10	0.98	Extremely likely
Trotters Creek at Mathesons	Month	109	3.40	0.11	Unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waianakarua at Browns	Month	112	5.44	0.00	Exceptionally unlikely
Waiareka Creek at Taipo Road	Month	111	-2.71	0.96	Extremely likely

Over the 20-year total phosphorus trend period, only two sites have trend analysis results due to the number of observations which fall below the detection level (Table 24). The Kakanui at Clifton Falls Bridge is *virtually certain* to be improving and the Waiareka Creek at Taipo Road is *as likely as not* to be improving.

Over the 10-year trend period the Awamoko at SH83 and Waiareka Creek at Taipo Road have very *unlikely*, or lower, probabilities of improving indicating total phosphorus levels have increased (

Table 25). Trotters Creek at Mathesons is *as likely as not* to be improving. The rest of the FMU has *likely*, or higher, probabilities of improving trends indicating total phosphorus levels have decreased.

Table 24: North Otago FMU 20-year trends for total phosphorus for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at Clifton Falls Bridge	BiMonth	113	-3.24	1.0	Virtually certain
Kakanui at McCones	BiMonth	115			Not Analysed
Shag at Craig Road	BiMonth	113			Not Analysed
Shag at Goodwood Pump	BiMonth	112			Not Analysed
Waianakarua at Browns	BiMonth	104			Not Analysed
Waiareka Creek at Taipo Road	BiMonth	114	0.00	0.5	As likely as not

Table 25: North Otago FMU 10-year trends for total phosphorus for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Awamoko at SH83	Month	103	1.55	0.10	Very unlikely
Kakanui at Clifton Falls Bridge	Month	111	-5.54	1.00	Virtually certain
Kakanui at McCones	Month	107	0.00	0.59	As likely as not
Kauru at Ewings	Month	107	-5.10	0.99	Virtually certain
Shag at Craig Road	Month	115	-2.06	0.90	Likely
Shag at Goodwood Pump	Month	114	-4.61	1.00	Virtually certain
Trotters Creek at Mathesons	Month	109	0.00	0.59	As likely as not
Waianakarua at Browns	Month	112	-7.19	1.00	Virtually certain
Waiareka Creek at Taipo Road	Month	111	7.28	0.00	Exceptionally unlikely

Network state

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results show 100% (100-100) of mountain class segments complying with the B-band nutrient criteria (

Table 26). For hill class segments, 65% (39-91) comply with the B-band criteria and 100% (100-100) comply with the C-band criteria. In lowland segments, few segments comply with the B-band criteria and 82% (68-96) of segments comply with the C-band criteria. Few to no segments comply with the A-band criteria in any class with the exception of mountain segments.

For total phosphorus in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results show 93% (76-100) of mountain segments complying with the B-band nutrient criteria and 100% (100-100) of segments complying with the C-band criteria (

Table 26). In the hill management class, 10% (0-32) of segments comply with the B-band criteria and 96% (84-100) of segments comply with the C-band criteria. In the lowland class, 3% (0-13) of segments comply with the B-band criteria and 90% (77-99) of segments comply with the C-band criteria.

Network results indicate nitrogen and phosphorus reductions are required for 100% of segments to comply with the C-band nutrient criteria with further reductions required if the B-band was selected as the target attribute state for all management classes.

Table 26: Percent of river segments in the North Otago FMU complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	21 (0 - 88)	0 (0 - 0)	51
M	B	100 (100 - 100)	93 (76 - 100)	51
M	C	100 (100 - 100)	100 (100 - 100)	51
H	A	4 (0 - 19)	0 (0 - 0)	806
H	B	65 (39 - 91)	10 (0 - 32)	806
H	C	100 (100 - 100)	96 (84 - 100)	806
L	A	1 (0 - 6)	0 (0 - 0)	254
L	B	1 (0 - 5)	3 (0 - 13)	254
L	C	82 (68 - 96)	90 (77 - 99)	254

Periphyton biomass state summary

In the North Otago FMU, all sites with monitored periphyton biomass fail to comply with the national bottom line. When compared to the 20% under-protection risk periphyton nutrient criteria, three sites also fail to comply with the C-band for total nitrogen and two sites fail to comply with C-band total phosphorus. Total nitrogen trends indicate increasing total nitrogen levels for many sites over both the 20 and 10-year trend periods. Total phosphorus trends indicate decreasing total phosphorus levels at many sites over both the 20 and 10-year periods.

Network modelling fails to overlap 100% in the confidence interval for the C-band in lowland segments which indicates with 95% confidence that total nitrogen and total phosphorus reductions are required for all segments to comply with the C-band criteria. As all periphyton biomass sites fail to comply with the national bottom line, network modelling indicates not all lowland segments comply, and degrading nitrogen trends are present, reductions in total nitrogen and total phosphorus are required.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

For MCI, the Kakanui at McCones, Shag at Goodwood Pump, Trotters Creek at Mathesons, and Waiareka Creek at Taipo Road monitoring sites fail to comply with the national bottom line (Table 27). The Shag at Craig Road and Waianakarua at Browns comply with the C-band. The Kakanui at Clifton Falls Bridge and the Kauru at Ewings comply with the B-band but range from the C to B-band in the rolling analysis.

For ASPM, Trotters Creek at Mathesons and Waiareka Creek at Taipo Road fail to comply with the national bottom line (Table 27). All other sites comply with the B-band. However, the Kakanui at Clifton Falls, Kakanui at McCones, and Shag at Craig Road range from C to B-band in the rolling analysis.

Table 27: North Otago FMU Macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Awamoko at SH83	CDL				
Kakanui at Clifton Falls Bridge	CDH	113.64 (99.826^{2022} - 113.64^{2018})	B (C - B)	0.55 (0.376^{2022} - 0.55^{2017})	B (C - B)
Kakanui at McCones	CDH	90 (86.92^{2022} - 90^{2017})	D (D - D)	0.41 (0.31^{2020} - 0.41^{2017})	B (C - B)
Kauru at Ewings	CDH	118 (109.52^{2020} - 119.2^{2018})	B (C - B)	0.56 (0.454^{2022} - 0.56^{2017})	B (B - B)
Shag at Craig Road	CDH	98.67 (94^{2020} - 98.67^{2017})	C (C - C)	0.45 (0.36^{2021} - 0.45^{2017})	B (C - B)
Shag at Goodwood Pump	CDL	86 (83.64^{2020} - 87.62^{2021})	D (D - D)	0.45 (0.41^{2020} - 0.45^{2017})	B (B - B)
Trotters Creek at Mathesons	CDL	87.37 (80.235^{2022} - 87.37^{2017})	D (D - D)	0.22 (0.21^{2019} - 0.23^{2022})	D (D - D)
Waianakarua at Browns	CDH	105.6 (105.6^{2017} - 106.09^{2021})	C (C - C)	0.47 (0.47^{2017} - 0.5^{2021})	B (B - B)

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Waiareka Creek at Taipo Road	CDL	71.67 (71.67[2018] - 74.59[2021])	D (D - D)	0.16 (0.15[2020] - 0.16[2017])	D (D - D)

Site-based trends

Over the 20-year trend period, the Kakanui at McCones has an *as likely as not* probability of improving which is an ambiguous result not classed as improving or degrading (Table 28). The Shag at Goodwood Pump and Waianakarua at Browns are *very unlikely* to improving indicating the MCI score has likely decreased at this site over the 20-year period.

Over the 10-year trend period, all sites have *unlikely* to be improving probabilities, or lower, indicating MCI score is decreasing over this period (Table 29). For ASPM, the Kakanui at McCones and Shag at Goodwood Pump are *very unlikely* to be improving whereas the Waianakarua at Browns is *extremely likely* to be improving (

Table 30).

Table 28: North Otago FMU 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at McCones	Year	16	-0.06	0.64	As likely as not
Shag at Goodwood Pump	Year	17	-0.48	0.93	Very unlikely
Waianakarua at Browns	Year	16	-0.45	0.93	Very unlikely

Table 29: North Otago FMU 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at McCones	Year	10	-1.10	0.99	Exceptionally unlikely
Shag at Goodwood Pump	Year	10	-0.71	0.79	Unlikely
Waianakarua at Browns	Year	10	-0.80	0.86	Unlikely

Table 30: North Otago FMU 10-year trends for the average score per metric (APSM) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kakanui at McCones	Year	9	-6.24	0.94	Very unlikely
Shag at Goodwood Pump	Year	9	-2.08	0.94	Very unlikely
Waianakarua at Browns	Year	9	2.01	0.02	Extremely likely

Network state

Network modelling results for MCI show 100% of mountain class segments complying with the B-band. For the hill management class, 49% comply with the B-band and 100% comply with the C band. In the lowland management class, 12% comply with the B-band and 56% comply with the C-band. This indicates that factors which influence MCI, such as fine sediment deposition, nutrients, and others, must be improved for all segments to comply with the national bottom line.

Table 31: Percent of segments complying with potential A, B and C macroinvertebrate community index (MCI) attribute band split by management class in 2017 based on Whitehead (2018) in the North Otago FMU.

Management Class	Band	Segment %	# of Segments
M	A	0	48
M	B	100	48
M	C	100	48
H	A	0	834
H	B	49	834
H	C	100	834
L	A	0	703
L	B	12	703

Management Class	Band	Segment %	# of Segments
L	C	56	703

Macroinvertebrate state summary

Four monitoring sites in the North Otago FMU fail to comply with the national bottom line and approximately 44% of lowland segments fail to comply with the national bottom line. Over the 10 and 20-year trend periods degrading trends also occur. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. While the local factors that contribute to low scores is not known and is likely to be a combination of multiple factors, management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish Index of Biotic Integrity (IBI; NPSFM Table 13)

Site-based baseline state

For fish IBI, all four sites with monitoring available in the 2017 baseline period comply with the A-band. However, the Kakanui at Clifton Falls and Shag at Craig Road range from complying with B to A-band in the rolling analysis (Table 32).

Table 32: North Otago FMU annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (period ending 2012- period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Kakanui at Clifton Falls	52 (28^{2012} - 52^{2017})	A (B - A)	A (A - A)
Kakanui at McCones	46 (42^{2012} - 50^{2013})	A (A - A)	A (A - A)
Shag at Craig Road	42 (32^{2013} - 46^{2012})	A (B - A)	A (A - A)
Waianakarua at Browns Pump	54 (50^{2012} - 54^{2014})	A (A - A)	A (A - A)
Waikouaiti 500m d/s of DCC Intake	NA (42^{2019} - 50^{2016})	NA (A - A)	NA (A - A)
Waikouaiti at Orbells Crossing	NA (30^{2012} - 50^{2014})	NA (B - A)	NA (A - A)

Dunedin & Coast FMU

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

No sites in the Dunedin & Coast FMU fall below the national bottom line for the ammoniacal nitrogen toxicity attribute (Table 33). All sites comply with the A-band for the median statistic with most sites also complying with the 95th percentile A-band. Kaikorai Stream at Brighton Road and the Leith at Dundas Street Bridge comply with the B-band over the 2012-2017 period but range from B to A-band in the rolling analysis.

Table 33: Dunedin & Coast FMU NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (five-year period ending August 2017- five-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Kaikorai Stream at Brighton Road	CDL	0.011 (0.006^{2022} - 0.011^{2019})	A (A - A)	0.145 (0.042^{2021} - 0.184^{2019})	B (A - B)
Leith at Dundas Street Bridge	CWL	0.009 (0.005^{2021} - 0.009^{2017})	A (A - A)	0.09 (0.013^{2022} - 0.09^{2017})	B (A - B)
Lindsays Creek at North Road Bridge	CDL	0.009 (0.006^{2022} - 0.009^{2017})	A (A - A)	0.031 (0.011^{2022} - 0.031^{2017})	A (A - A)
Tokomairiro at Blackbridge	CDL	0.011 (0.008^{2020} - 0.011^{2017})	A (A - A)	0.03 (0.027^{2019} - 0.038^{2022})	A (A - A)
Tokomairiro at Lisnatunny	CDL	0.006 (0.002^{2022} - 0.006^{2020})	A (A - A)	0.01 (0.003^{2022} - 0.011^{2020})	A (A - A)
Tokomairiro at West Branch Bridge	CDL	0.004 (0.003^{2022} - 0.004^{2017})	A (A - A)	0.011 (0.008^{2021} - 0.011^{2017})	A (A - A)
Waikouaiti at Confluence d/s	CDL	0.005 (0.002^{2022} - 0.005^{2017})	A (A - A)	0.016 (0.003^{2022} - 0.017^{2019})	A (A - A)

Site-based trend

Over the 20-year trend period, all sites have improving trends (Table 34). Over the 10-year trend period, Kaikorai Stream at Brighton Road and Tokomairiro at Blackbridge are *unlikely* to be improving indicating ammoniacal nitrogen levels have increased (Table 35). All other sites have *likely to be* improving, or higher, probabilities indicating ammoniacal nitrogen has decreased.

Table 34: Dunedin & Coast FMU 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	116	0	0.99	Extremely likely
Leith at Dundas Street Bridge	BiMonth	116	0	1.00	Virtually certain
Tokomairiro at West Branch Bridge	BiMonth	108	0	1.00	Virtually certain

Table 35: Dunedin & Coast FMU 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	110	0.00	0.28	Unlikely
Leith at Dundas Street Bridge	Month	109	0.00	0.96	Extremely likely
Lindsays Creek at North Road Bridge	Month	110	0.00	0.99	Virtually certain
Tokomairiro at Blackbridge	BiMonth	48	2.47	0.21	Unlikely
Tokomairiro at West Branch Bridge	BiMonth	60	0.00	0.84	Likely

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Dunedin & Coast FMU comply with the national bottom line and some sites have improving trends. However, two sites potentially have degrading trends over the 10-year period. To maintain state, measures which stop any further increase of ammoniacal nitrogen inputs are required. To comply with the A-band, reduction is required as two

sites fail to comply with the A-band. Both sites are urban and therefore urban controls which reduce ammoniacal nitrogen inputs may be considered.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

No sites in the Dunedin & Coast FMU fail to comply with the nitrate toxicity national bottom line (Table 36). All sites comply with the A-band for the median statistic. All sites, expect for the Tokomairiro at Black Bridge, comply with the 95th percentile A-band. The Tokomairiro at Black Bridge complies with the B-band.

Table 36: Dunedin & Coast FMU NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Kaikorai Stream at Brighton Road	CDL	0.31 (0.31^{2018} - 0.43^{2020})	A (A - A)	1.082 (0.958^{2022} - 1.144^{2020})	A (A - A)
Leith at Dundas Street Bridge	CWL	0.51 (0.44^{2022} - 0.525^{2018})	A (A - A)	0.996 (0.726^{2022} - 0.996^{2017})	A (A - A)
Lindsays Creek at North Road Bridge	CDL	0.735 (0.58^{2022} - 0.735^{2017})	A (A - A)	1.38 (1.016^{2022} - 1.38^{2017})	A (A - A)
Tokomairiro at Blackbridge	CDL	0.39 (0.375^{2019} - 0.43^{2021})	A (A - A)	1.795 (1.795^{2017} - 2.84^{2022})	B (B - B)
Tokomairiro at Lisnatunny	CDL	0.24 (0.133^{2022} - 0.24^{2017})	A (A - A)	1.064 (0.906^{2018} - 1.083^{2020})	A (A - A)
Tokomairiro at West Branch Bridge	CDL	0.265 (0.194^{2022} - 0.28^{2020})	A (A - A)	1.18 (1.084^{2022} - 1.18^{2017})	A (A - A)
Waikouaiti at Confluence d/s	CDL	0.012 (0.008^{2019} - 0.028^{2022})	A (A - A)	0.465 (0.21^{2022} - 0.465^{2017})	A (A - A)

Site-based trends

Over the 20-year trend period, all three monitoring sites have *unlikely,* or lower, probabilities of improving trend indicating long-term increases in nitrate levels (Table 37). Over the 10-year period, the Leith at Dundas Street Bridge, Lindsays Creek at North Road Bridge, and Tokomairiro at West Branch Bridge have *very likely,* or higher, probabilities of improving trends indicating nitrate levels

have decreased in this period (Table 38). The Kaikorai Stream at Brighton Road is *extremely unlikely* to be improving across both the 10- and 20-year trend period indicating nitrate levels have increased.

Table 37: Dunedin & Coast FMU 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	116	1.85	0.04	Extremely unlikely
Leith at Dundas Street Bridge	BiMonth	116	1.97	0.00	Exceptionally unlikely
Tokomairiro at West Branch Bridge	BiMonth	108	0.29	0.31	Unlikely

Table 38: Dunedin & Coast FMU 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	110	4.73	0.01	Extremely unlikely
Leith at Dundas Street Bridge	Month	109	-2.16	0.95	Very likely
Lindsays Creek at North Road Bridge	Month	110	-3.40	1.00	Virtually certain
Tokomairiro at Blackbridge	BiMonth	48	0.99	0.44	As likely as not
Tokomairiro at West Branch Bridge	Month	110	-3.45	1.00	Virtually certain

Network state

Network modelling results indicate 100% (100-100) of segments in the hill management class comply with the nitrate toxicity A-band (Table 39). In the lowland class, 94% (74-100) of segments comply with the A-band and 100% (100-100) of segments comply with the B-band. This indicates no nitrate reductions are required to meet the national bottom line. However, nitrate reductions may be required to comply with the A-band in all segments.

Table 39: Percent of river segments in the Dunedin & Coast FMU complying with potential nitrate toxicity attribute band, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
H	A	100 (100 - 100)	29
H	B	100 (100 - 100)	29
H	C	100 (100 - 100)	29
L	A	94 (74 - 100)	322
L	B	100 (100 - 100)	322
L	C	100 (100 - 100)	322

Nitrate toxicity state summary

All sites and segments in the Dunedin FMU comply with the national bottom line for nitrate toxicity. Degrading trends occurred over the 20-year trend period but, over the 10-year period, most trends are improving. For all segments and sites to comply with the A-band, some reduction may be necessary as approximately 6% of segments, and two monitoring sites, fail to comply with the A-band.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

No sites in the Dunedin & Coast FMU fail to comply with the national bottom line for suspended fine sediment. The Kaikorai Stream at Brighton Road, Leith at Dundas Street Bridge, Tokomairiro at Lisnatunny and Waikouaiti at Confluence d/s all comply with the A-band (Table 40). The Tokomairiro at West Branch Bridge complies with the B-band and ranges from the B- to A-band in the rolling analysis. Lindsays Creek at North Road Bridge complies with the C-band and ranges from the C- to B-band in the rolling analysis.

Table 40: Dunedin & Coast FMU suspended fine sediment state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are

presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Kaikorai Stream at Brighton Road	CDL	1.502 (1.42^{2022} - 1.52^{2020})	A (A - A)
Leith at Dundas Street Bridge	CWL	1.841 (1.841^{2017} - 1.966^{2022})	A (A - A)
Lindsays Creek at North Road Bridge	CDL	1.502 (1.502^{2017} - 1.685^{2021})	C (C - B)
Tokomairiro at Blackbridge	CDL		
Tokomairiro at Lisnatunny	CDL	1.236 (1.236^{2017} - 1.375^{2022})	A (A - A)
Tokomairiro at West Branch Bridge	CDL	1.619 (1.619^{2017} - 1.785^{2022})	B (B - A)
Waikouaiti at Confluence d/s	CDL	3.618 (3.26^{2021} - 3.738^{2022})	A (A - A)

Site-based trends

Over the 20-year trend period, no degrading trends are present (Table 41). The Tokomairiro at West Branch Bridge is *as likely as not* to be improving indicating an ambiguous trend classed as neither increasing nor decreasing over this period. The Leith at Dundas Street Bridge is *virtually certain* to be improving, and the Kaikorai Stream at Brighton Road is *likely* to be improving indicating clarity has increased.

Over the 10-year period, two sites have degrading trends (

Table 42). The Kaikorai Stream at Brighton Road is *very unlikely* to be improving, and the Tokomairiro at Black Bridge is *exceptionally unlikely* to be improving, indicating clarity has decreased at these sites. Whether this is due to natural variability or anthropocentric inputs is unknown.

Table 41: Dunedin & Coast FMU 20-year trends for turbidity for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	116	-0.83	0.83	Likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Leith at Dundas Street Bridge	BiMonth	116	-1.77	0.99	Extremely likely
Tokomairiro at West Branch Bridge	BiMonth	107	0.00	0.51	As likely as not

Table 42: Dunedin & Coast FMU 10-year trends for turbidity for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	110	2.72	0.06	Very unlikely
Leith at Dundas Street Bridge	Month	109	0.20	0.41	As likely as not
Lindsays Creek at North Road Bridge	Month	110	0.00	0.59	As likely as not
Tokomairiro at Blackbridge	BiMonth	48	7.25	0.00	Exceptionally unlikely
Tokomairiro at West Branch Bridge	Month	110	-2.84	0.93	Very likely

Network state

Network modelling results for clarity show 10% of segments in the hill management class comply with the A and B-band (Table 43). Sixty two percent of segments in the hill management class comply with the C-band. In the lowland class, 47% of segments comply with the A-band, 61% comply with the B-band and 73% comply with the C-band. Network modelling indicates reductions in sediment inputs are necessary for all segments to comply with the national bottom line.

Table 43: Percent of segments in the Dunedin & Coast FMU complying with potential A, B, and C suspended fine sediment attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
H	A	10	29
H	B	10	29

Management Class	Band	Segment %	# of Segments
H	C	62	29
L	A	47	445
L	B	61	445
L	C	73	445

Suspended sediment state summary

All monitored sites in the Dunedin & Coast FMU comply with the national bottom line. Over the 10 and 20- year period a mix of degrading and improving trends occur in the FMU. Network modelling indicates approximately 27% of lowland and 38% of hill segments fail to comply with the national bottom line. For all segments to comply, and to reverse degrading trends, controls which manage sediment inputs are required in this FMU.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

Compliance with *E. coli* attribute bands in the Dunedin & Coast FMU is variable both between sites and within an individual site's rolling analysis (Table 44). All site results span more than one band for at least one of the *E. coli* metrics. When the rolling analysis is taken into account, all sites fail to comply with the national bottom line. Results are not available for many sites due to the requirement of having 54 observations over a five-year period.

Table 44: Dunedin & Coast FMU E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Kaikorai Stream at Brighton Road	CDL								
Leith at Dundas Street Bridge	CWL								
Lindsays Creek at North Road Bridge	CDL								
Tokomairiro at Blackbridge	CDL								
Tokomairiro at Lisnatunny	CDL	175 (175^{2017} - 360^{2022})	D (D - E)	2280 (937^{2019} - 2500^{2022})	D (B - D)	0.389 (0.386^{2019} - 0.6^{2022})	D (D - E)	0.185 (0.15^{2021} - 0.2^{2022})	C (C - C)
Tokomairiro at West Branch Bridge	CDL	139.5 (139.5^{2017} - 236^{2021})	D (D - D)	2760 (2760^{2017} - 3131.5^{2021})	D (D - D)	0.352 (0.328^{2019} - 0.446^{2022})	D (C - D)	0.259 (0.241^{2018} - 0.316^{2021})	D (D - E)
Waikouaiti at Confluence d/s	CDL	35 (26.5^{2019} - 50^{2021})	A (A - A)	350 (350^{2017} - 6000^{2022})	A (A - D)	0.074 (0.074^{2017} - 0.19^{2021})	A (A - A)	0.019 (0.019^{2017} - 0.111^{2022})	A (A - C)

Site-based trends

Across the 20-year trend period, all sites have *unlikely,* or lower, probabilities of an improving trend indicating *E. coli* levels have increased across the FMU over this period (Table 45).

Across the 10-year period all sites, except for the Tokomairiro at West Branch Bridge, have *unlikely,* or lower, probabilities of an improving trend indicating that *E. coli* levels have increased across the FMU over this period (Table 46). The Tokomairiro at West Branch Bridge is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading.

Table 45: Dunedin & Coast FMU 20-year trends for E. coli for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	116	2.72	0.04	Extremely unlikely
Leith at Dundas Street Bridge	BiMonth	116	1.78	0.08	Very unlikely
Tokomairiro at West Branch Bridge	BiMonth	108	0.48	0.25	Unlikely

Table 46: Dunedin & Coast FMU 10-year trends for E. coli for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	108	14.98	0.00	Exceptionally unlikely
Leith at Dundas Street Bridge	Month	108	3.17	0.12	Unlikely
Lindsays Creek at North Road Bridge	Month	109	1.07	0.28	Unlikely
Tokomairiro at Blackbridge	BiMonth	48	6.64	0.02	Extremely unlikely
Tokomairiro at West Branch Bridge	Month	110	-0.21	0.52	As likely as not

Network state

Network modelling results for *E. coli* show, in the hill management class, 35% (0-90) of segments comply with the A-band, 59% (0-97) comply with the B-band, and 79% (27-97) comply with the C-band (Table 47). In the lowland class, 4% (0-12) comply with the A-band, 14% (3-34) comply with the B-band and 24% (11-57) comply with the C-band. While confidence intervals are wide, due to the highly variable nature of *E. coli*, they do not overlap 100%. This indicates with 95% confidence that a reduction is required to comply with the national bottom line in all segments.

Table 47: Percent of river segments in the Dunedin & Coast FMU complying with potential E. coli attribute band with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
H	A	35 (0 - 90)	29
H	B	59 (0 - 97)	29
H	C	79 (27 - 97)	29
L	A	4 (0 - 12)	447
L	B	14 (3 - 34)	447
L	C	24 (11 - 57)	447

E. coli state summary

All three sites in the Dunedin & Coast FMU fail to comply with the national bottom line in the rolling analysis. Trend analyses show increasing *E. coli* levels are common in both the 10 and 20-year trend periods. Network modelling indicates that hill and lowland class confidence intervals do not overlap 100%. This indicates that there is a 95% probability that a reduction is required to for all segments to comply with the national bottom line. Compliance in these classes may require reductions in upstream segments. For the entire FMU to comply with the national bottom line, measures which reduce *E. coli* levels will be required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Two sites in the Dunedin & Coast FMU fail to comply with the median C-band in the 2012-2017 period, Leith at Dundas Street Bridge and the Tokomairiro at Blackbridge (Table 48). Both sites range from the D to C-band in the rolling analysis. The Tokomairiro at Lisnatunny, Tokomairiro at West Branch Bridge,

and Lindsays Creek at North Road Bridge comply with median C-band, with the Tokomairiro sites ranging from C to B-band in the rolling analysis. The Kaikorai Stream at Brighton Road complies with the B-band and the Waikouaiti at Confluence d/s complies with the A-band.

For the 95th percentile, all sites comply with the C-band or better. The Tokomairiro at Black Bridge and Leith at Dundas Street comply with the C-band, with the Leith site ranging from C to B-band in the rolling analysis. The Kaikorai Stream at Brighton Road, Lindsays Creek at North Road, and Tokomairiro at Lisnatunny comply with the B-band, with the Kaikorai site ranging from B to A-band in the rolling analysis. The Tokomairiro at West Branch Bridge and Waikouaiti at Confluence d/s comply with the A-band.

Table 48: Dunedin & Coast FMU DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Kaikorai Stream at Brighton Road	CDL	0.01 (0.008^{2022} - 0.01^{2017})	B (B - B)	0.022 (0.021^{2022} - 0.025^{2021})	B (A - B)
Leith at Dundas Street Bridge	CWL	0.02 (0.017^{2021} - 0.02^{2017})	D (C - D)	0.038 (0.029^{2021} - 0.038^{2017})	C (B - C)
Lindsays Creek at North Road Bridge	CDL	0.018 (0.015^{2022} - 0.018^{2017})	C (C - C)	0.027 (0.024^{2022} - 0.028^{2019})	B (B - B)
Tokomairiro at Blackbridge	CDL	0.023 (0.016^{2021} - 0.023^{2017})	D (C - D)	0.038 (0.035^{2020} - 0.049^{2022})	C (C - C)
Tokomairiro at Lisnatunny	CDL	0.017 (0.009^{2022} - 0.017^{2018})	C (B - C)	0.027 (0.025^{2021} - 0.028^{2019})	B (B - B)
Tokomairiro at West Branch Bridge	CDL	0.011 (0.007^{2022} - 0.011^{2017})	C (B - C)	0.02 (0.014^{2022} - 0.02^{2017})	A (A - A)
Waikouaiti at Confluence d/s	CDL	0.003 (0.002^{2022} - 0.003^{2021})	A (A - A)	0.008 (0.004^{2022} - 0.008^{2017})	A (A - A)

Site-based trends

Over the 20-year trend period, the Kaikorai Stream at Brighton Road is *likely* to be improving indicating DRP levels have decreased (Table 49). The Leith at Dundas Street Bridge is *as likely as not* to be improving. The Tokomairiro at West Branch Bridge is *unlikely* to be improving indicating DRP levels have increased at this site.

Over the 10-year trend period, the Lindsays Creek at North Road Bridge, Tokomairiro at Black Bridge, and Tokomairiro at West Branch Bridge have probabilities of *likely* to be improving, or higher, indicating DRP levels have decreased at these sites over the 10-year period (Table 50). The Leith at Dundas Street Bridge is *as likely as not* to be increasing which is an ambiguous result classed as neither improving nor degrading. The Kaikorai Stream at Brighton Road is *unlikely* to be improving indicating DRP levels have increased at this site.

Table 49: Dunedin & Coast FMU 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	115	0	0.80	Likely
Leith at Dundas Street Bridge	BiMonth	115	0	0.48	As likely as not
Tokomairiro at West Branch Bridge	BiMonth	108	0	0.22	Unlikely

Table 50: Dunedin & Coast FMU 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	109	1.83	0.12	Unlikely
Leith at Dundas Street Bridge	Month	108	-0.14	0.66	As likely as not
Lindsays Creek at North Road Bridge	Month	109	-1.18	0.91	Very likely
Tokomairiro at Black Bridge	BiMonth	48	-2.20	0.88	Likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Tokomairiro at West Branch Bridge	Month	110	-2.86	0.99	Virtually certain

Dissolved reactive phosphorus state summary

State of DRP in the Dunedin & Coast FMU is variable. Two sites fail to comply with the C-band. Over the 10 and 20-year period both improving and degrading trends occur. Whether phosphorus reductions are required depends upon the target attribute state set for this table and the periphyton biomass target.

Periphyton (NPSFM Table 2)

In the Dunedin & Coast FMU, the Kaikorai Stream at Brighton Road fails to comply with the national bottom line (Table 51). The two other periphyton biomass monitoring sites in the FMU, Akatore Creek at Akatore Creek Road and Tokomairiro at West Branch Bridge, comply with the C-band. A rolling analysis is not possible because periphyton biomass sampling started in 2019.

Site-based baseline state

Table 51: Dunedin & Coast FMU periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Akatore Creek at Akatore Creek Road	147	C	32
Kaikorai Stream at Brighton Road	503	D	31
Tokomairiro at West Branch Bridge	175	C	30

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, three sites fail to comply with the C-band criteria including Lindsays Creek at North Road Bridge, Tokomairiro at Black Bridge, and Tokomairiro at West Branch Bridge (Table 52). The remaining sites comply with the C-band criteria. For total phosphorus in relation to the periphyton biomass 20% under-protection risk nutrient criteria, three sites fail to comply with the C-band criteria including the Lindsays Creek at North Road Bridge, Tokomairiro at Black Bridge and Tokomairiro at Lisnatunny. Therefore, periphyton biomass may exceed the national bottom line in many locations across the FMU.

Table 52: Dunedin & Coast FMU total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of

environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Kaikorai Stream at Brighton Road	CDL	0.51 (0.51^{2017} - 0.76^{2021})	C (C - D)	0.023 (0.023^{2017} - 0.025^{2021})	C (C - C)
Leith at Dundas Street Bridge	CWL	0.67 (0.64^{2022} - 0.69^{2020})	C (C - C)	0.032 (0.028^{2022} - 0.032^{2017})	C (C - C)
Lindsays Creek at North Road Bridge	CDL	0.925 (0.785^{2022} - 0.925^{2017})	D (D - D)	0.03 (0.026^{2022} - 0.03^{2017})	D (C - D)
Tokomairiro at Blackbridge	CDL	0.79 (0.74^{2019} - 0.87^{2021})	D (D - D)	0.054 (0.054^{2017} - 0.057^{2022})	D (D - D)
Tokomairiro at Lisnatunny	CDL	0.53 (0.465^{2022} - 0.53^{2017})	C (C - C)	0.038 (0.038^{2017} - 0.051^{2022})	D (D - D)
Tokomairiro at West Branch Bridge	CDL	0.57 (0.515^{2022} - 0.57^{2018})	D (C - D)	0.029 (0.029^{2017} - 0.034^{2020})	C (C - D)
Waikouaiti at Confluence d/s	CDL	0.17 (0.17^{2017} - 0.21^{2021})	C (C - C)	0.008 (0.006^{2022} - 0.008^{2019})	C (C - C)

Site-based trends

Over the 20-year trend period for total nitrogen, both the Kaikorai Stream at Brighton Road and the Tokomairiro at West Branch Bridge are *unlikely* to be improving indicating total nitrogen levels have increased (Table 53). The Leith at Dundas Street Bridge is *as likely as not* which is an ambiguous result classed as neither improving nor degrading.

Over the 10-year trend period for total nitrogen two sites, Kaikorai Stream at Brighton Road and Tokomairiro at Black Bridge, have probabilities of *extremely unlikely* to be improving, or lower, indicating total nitrogen levels have increased at these sites (Table 54). The remaining sites in the FMU have *very likely*, or higher, probabilities to be improving indicating total nitrogen levels have likely decreased at these sites.

Table 53: Dunedin & Coast FMU 20-year trends for total nitrogen for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	116	1.13	0.07	Very unlikely
Leith at Dundas Street Bridge	BiMonth	116	0.00	0.58	As likely as not
Tokomairiro at West Branch Bridge	BiMonth	108	0.90	0.08	Very unlikely

Table 54: Dunedin & Coast FMU 10-year trends for total nitrogen for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	110	4.59	0.00	Exceptionally unlikely
Leith at Dundas Street Bridge	Month	109	-1.30	0.94	Very likely
Lindsays Creek at North Road Bridge	Month	110	-2.38	1.00	Virtually certain
Tokomairiro at Black Bridge	BiMonth	48	3.48	0.04	Extremely unlikely
Tokomairiro at West Branch Bridge	Month	110	-1.17	0.91	Very likely

Over the 20-year trend period for total phosphorus, both the Kaikorai Stream at Brighton Road and the Leith at Dundas Street Bridge have probabilities of *extremely likely* to be improving, or higher, indicating total phosphorus levels have decreased at these sites (Table 55). The Tokomairiro at West Branch Bridge is *unlikely* to be improving over the 20-year trend period indicating total phosphorus levels have probably increased (Table 56).

Over the 10-year trend period for total phosphorus two sites, Kaikorai Stream at Brighton Road and Tokomairiro at Black Bridge, have trend probabilities of *unlikely* to be improving, or lower, indicating total phosphorus levels have increased at these sites (Table 56). The remaining sites in the FMU have *as likely as not* which is an ambiguous result classed as neither improving nor degrading.

Table 55: Dunedin & Coast FMU 20-year trends for total phosphorus for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	BiMonth	115	-1.93	0.98	Extremely likely
Leith at Dundas Street Bridge	BiMonth	115	-2.43	1.00	Virtually certain
Tokomairiro at West Branch Bridge	BiMonth	108	0.26	0.33	Unlikely

Table 56: Dunedin & Coast FMU 10-year trends for total phosphorus for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Month	110	2.95	0.04	Extremely unlikely
Leith at Dundas Street Bridge	Month	109	0.00	0.56	As likely as not
Lindsays Creek at North Road Bridge	Month	110	0.00	0.51	As likely as not
Tokomairiro at Blackbridge	BiMonth	48	1.20	0.13	Unlikely
Tokomairiro at West Branch Bridge	Month	110	0.00	0.49	As likely as not

Network state

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results show 72% (10-100) of the hill management class segments comply with the B-band criteria whereas 100% (100-100) comply with the C-band criteria (Table 57). For the lowland class, 1% (0-3) of segments comply the B-band criteria and 54% (32-87) comply with the C-band criteria.

For total phosphorus in relation to the periphyton biomass 20% under-protection risk nutrient criteria, 16% of hill management class segments comply with the B-band criteria and 97% (100-100) comply with the C-band criteria. The B-band total phosphorus criteria is complied with in 3% (0-7) of the lowland management class segments and the C-band is complied with in 64% (39-93). As confidence intervals in the lowland class do not overlap 100%, there is 95% confidence that some

level of nitrogen and phosphorus reduction is required for all segments to comply with the 20% under-protection risk nutrient criteria.

Table 57: Percent of river segments in the Dunedin & Coast FMU complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Nitrogen	Phosphorus	Total segments
H	A	1 (0 - 0)	0 (0 - 0)	29
H	B	72 (10 - 100)	16 (7 - 97)	29
H	C	100 (100 - 100)	97 (100 - 100)	29
L	A	0 (0 - 0)	0 (0 - 0)	322
L	B	1 (0 - 3)	3 (0 - 7)	322
L	C	54 (32 - 87)	64 (39 - 93)	322

Periphyton biomass state summary

In the Dunedin & Coast FMU, periphyton biomass fails to comply with the national bottom line at one monitoring site and complies with the C-band at the other two sites. When compared to the 20% under-protection risk periphyton nutrient criteria, half of the monitoring sites also fail to comply with the C-band criteria for total nitrogen and total phosphorus. Trend results are mixed with both improving and degrading trends across the 10 and 20-year trend periods.

Network modelling fails to overlap 100% in the confidence interval for the C-band in lowland segments which indicates 95% confidence that nitrogen and phosphorus reduction is required for all segments to comply with the C-band criteria. To improve state and comply with national bottom lines, measures which reduce nitrogen and phosphorus are required.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

For MCI, all but one site in the Dunedin & Coast FMU fail to comply with the national bottom line. The Tokomairiro at West Branch Bridge complies with the B-band over the 2012-2017 period and ranges from C- to B-band in the rolling analysis (Table 58). Results for ASPM are similar, with two sites, the Kaikorai Stream at Brighton Road and Lindsays Creek at North Road, failing to comply with the national bottom line. The Leith at Dundas Street complies with the national bottom line in the 2012-2017 baseline period but fails to comply in the rolling analysis. The Tokomairiro at West Branch Bridge complies with the B-band. As few sites comply with the national bottom line, factors which influence invertebrate communities such as sediment and nutrients must be managed to achieve the national bottom lines for macroinvertebrate attributes in the Dunedin & Coast FMU.

Table 58: Dunedin & Coast FMU macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Kaikorai Stream at Brighton Road	CDL	68.33 (68^{2022} - 68.33^{2017})	D (D - D)	0.135 (0.13^{2018} - 0.14^{2020})	D (D - D)
Leith at Dundas Street Bridge	CWL	90 (85.186^{2022} - 91.925^{2018})	D (D - C)	0.32 (0.265^{2021} - 0.32^{2017})	C (D - C)
Lindsays Creek at North Road Bridge	CDL	89.52 (89.09^{2020} - 89.52^{2017})	D (D - D)	0.25 (0.224^{2022} - 0.26^{2019})	D (D - D)
Tokomairiro at Blackbridge	CDL				
Tokomairiro at Lisnatunny	CDL				
Tokomairiro at West Branch Bridge	CDL	113.91 (104.67^{2022} - 113.91^{2017})	B (C - B)	0.46 (0.46^{2017} - 0.535^{2022})	B (B - B)
Waikouaiti at Confluence d/s	CDL	88.6 (87.66^{2021} - 92.085^{2019})	D (D - C)		

Site-based trends

Over the 20-year MCI trend period, the Kaikorai Stream at Brighton Road is *likely* to be improving indicating MCI have *likely* increased over this period (Table 59). The Tokomairiro at West Branch Bridge is *extremely unlikely* to be improving which indicates MCI has decreased at this site over this period.

Over the 10-year MCI trend period, the Kaikorai Stream at Brighton Road is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading (Table 60). The Tokomairiro at West Branch Bridge is *exceptionally unlikely* to be improving indicating that the MCI score decreased at this site over this period. Over the 10-year ASPM period, the Kaikorai at Brighton Road Bridge is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading (Table 61).

Table 59: Dunedin & Coast FMU 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Year	18	0.29	0.16	Likely
Tokomairiro at West Branch Bridge	Year	17	-0.63	0.97	Extremely unlikely

Table 60: Dunedin & Coast FMU 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Year	10	0.55	0.43	As likely as not
Tokomairiro at West Branch Bridge	Year	10	-1.80	1.00	Exceptionally unlikely

Table 61: Dunedin & Coast FMU 10-year trends for the average score per metric (APSM) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kaikorai Stream at Brighton Road	Year	9	0	0.46	As likely as not

Network state

Network modelling results for MCI show 28% of the hill management class comply with the B-band and 100% comply with the C-band (Table 62). In the lowland management class, 4% of segments comply with the B-band and 68% comply with the C-band. For all segments to comply with the national bottom line, factors which influence MCI, such as sediment, nutrients, and others, will need to be improved. Compliance with the national bottom line may not occur even under natural conditions.

Table 62: Percent of segments in the Dunedin & Coast FMU complying with A, B and C macroinvertebrate community index (MCI) attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
H	A	0	29
H	B	28	29
H	C	100	29
L	A	0	445
L	B	4	445
L	C	68	445

Macroinvertebrate state summary

Four of five sites in the Dunedin & Coast FMU fail to comply with the national bottom line for macroinvertebrate indices and approximately 32% of lowland segments also fail to comply. Over the 20 and 10-year trend periods, degrading trends also occur. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. While localised causation of low scores is not known, management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Results for the 2017 fish IBI baseline period are available for one site in the Dunedin FMU, Kaikorai Stream at Brighton Road, which complies with the B-band and ranges from B- to A-band in the rolling analysis (Table 63). Lindsays Creek at North Road does not have results from the baseline period but ranges from D to B-band and the Tokomairiro at West Branch Bridge complies with the B-band.

Table 63: Dunedin & Coast FMU annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (period ending 2012- period ending 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional band
Kaikorai Stream at Brighton Road	32 (32^{2015} - 36^{2019})	B (B - A)	A (A - A)
Lindsay's Creek at North Road	NA (16^{2015} - 30^{2016})	NA (D - B)	NA (C - A)
Tokomairiro at West Branch Bridge	NA (28^{2012} - 28^{2012})	NA (B - B)	NA (A - A)

Taieri

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

No sites in the Taieri FMU fall below the ammoniacal nitrogen toxicity national bottom line (Table 64). All sites comply with the A-band for the median statistic and all but one site comply with the 95th percentile A-band. The Silver Stream at Taieri Depot complies with the B-band 95th percentile. The Contour Channel at No. 4 Bridge complies with the A-band in the 2012-2017 period but ranges from B to A-band in the rolling analysis.

Table 64: Taieri FMU NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017- 5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Contour Channel at No. 4 Bridge	CDL	0.01 (0.008^{2021} - 0.01^{2022})	A (A - A)	0.038 (0.032^{2018} - 0.062^{2022})	A (A - B)
Deep Stream at SH87	CDH	0.002 (0.001^{2019} - 0.002^{2017})	A (A - A)	0.008 (0.002^{2022} - 0.008^{2017})	A (A - A)
Kye Burn at SH85 Bridge	CDH	0.003 (0.001^{2019} - 0.003^{2017})	A (A - A)	0.007 (0.003^{2021} - 0.007^{2017})	A (A - A)
Nenthorn at Mt Stoker Road	CDH	0.004 (0.002^{2020} - 0.004^{2017})	A (A - A)	0.013 (0.004^{2021} - 0.013^{2017})	A (A - A)
Silver Stream at Taieri Depot	CDL	0.007 (0.002^{2021} - 0.007^{2018})	A (A - A)	0.072 (0.072^{2017} - 0.095^{2020})	B (B - B)
Taieri at Allanton Bridge	CDH	0.006 (0.004^{2022} - 0.006^{2017})	A (A - A)	0.019 (0.013^{2021} - 0.019^{2019})	A (A - A)
Taieri at Linnburn Runs Road	CDH	0.003 (0.001^{2020} - 0.003^{2017})	A (A - A)	0.009 (0.002^{2022} - 0.009^{2017})	A (A - A)
Taieri at Outram	CDH	0.005 (0.001^{2020} - 0.005^{2017})	A (A - A)	0.01 (0.005^{2022} - 0.01^{2017})	A (A - A)
Taieri at Stonehenge	CDH	0.003 (0.001^{2019} - 0.003^{2017})	A (A - A)	0.007 (0.004^{2021} - 0.007^{2019})	A (A - A)
Taieri at Sutton	CDL	0.004 (0.002^{2020} - 0.004^{2017})	A (A - A)	0.019 (0.008^{2021} - 0.019^{2018})	A (A - A)
Taieri at Tiroiti	CDH	0.004 (0.002^{2021} - 0.004^{2017})	A (A - A)	0.011 (0.008^{2021} - 0.011^{2017})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Taieri at Waipiata	CDH	0.004 (0.003[2020] - 0.004[2017])	A (A - A)	0.021 (0.011[2021] - 0.021[2020])	A (A - A)
Waipori at Waipori Falls Reserve	CDL	0.003 (0.001[2019] - 0.003[2017])	A (A - A)	0.008 (0.004[2022] - 0.008[2017])	A (A - A)

Site-based trends

Over the 20-year trend period, the majority of sites have improving trends with the exception of Taieri at Sutton (Table 65). This site has an *as likely as not* to be improving trend which is an ambiguous result classed as neither improving nor degrading. Over the 10-year period, the majority of sites have *likely* to be improving probabilities, or higher, indicating ammoniacal nitrogen levels tend to have decreased across the FMU (Table 66). However, the Taieri at Stonehenge is *unlikely* to be improving indicating ammoniacal nitrogen levels have likely increased at this site.

Table 65: Taieri FMU 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	97	0	0.99	Extremely likely
Silver Stream at Taieri Depot	BiMonth	117	0	0.94	Very likely
Taieri at Allanton Bridge	BiMonth	119	0	1.00	Virtually certain
Taieri at Linnburn Runs Road	BiMonth	113	0	1.00	Virtually certain
Taieri at Stonehenge	BiMonth	120	0	1.00	Virtually certain
Taieri at Sutton	Qtr	64	0	0.67	As likely as not
Taieri at Waipiata	Qtr	80	0	0.97	Extremely likely
Waipori at Waipori Falls Reserve	Qtr	64	0	1.00	Virtually certain

Table 66: Taieri FMU 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	-6.42	0.83	Likely
Deep Stream at SH87	Month	106	0.00	1.00	Virtually certain
Kye Burn at SH85 Bridge	Month	112	0.00	0.99	Extremely likely
Nenthorn at Mt Stoker Road	BiMonth	48	0.00	1.00	Virtually certain
Silver Stream at Taieri Depot	Month	112	0.00	0.97	Extremely likely
Taieri at Allanton Bridge	BiMonth	60	0.00	0.98	Extremely likely
Taieri at Linnburn Runs Road	Month	111	0.00	1.00	Virtually certain
Taieri at Outram	Month	98	0.00	1.00	Virtually certain
Taieri at Stonehenge	BiMonth	60	0.00	0.26	Unlikely
Taieri at Sutton	Qtr	40	0.00	0.94	Very likely
Taieri at Tiroiti	Month	97	0.00	0.99	Extremely likely
Taieri at Waipiata	Month	118	0.00	0.34	As likely as not
Waipori at Waipori Falls Reserve	Month	112	0.00	0.71	Likely

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Taieri FMU comply with the national bottom line and most sites have improving trends. To maintain state, measures which stop any further inputs of ammoniacal nitrogen are required. To comply with the A-band, some reduction will be required as one site fails to comply with the A-band.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

All sites in the Taieri FMU comply with the A-band nitrate toxicity for both the median and 95th percentile statistics (Table 67).

Table 67: Taieri FMU NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017-5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Contour Channel at No. 4 Bridge	CDL	0.13 (0.13^{2018} - 0.23^{2021})	A (A - A)	0.979 (0.475^{2022} - 0.979^{2017})	A (A - A)
Deep Stream at SH87	CDH	0.001 (0.001^{2018} - 0.001^{2021})	A (A - A)	0.092 (0.053^{2022} - 0.122^{2019})	A (A - A)
Kye Burn at SH85 Bridge	CDH	0.032 (0.032^{2017} - 0.071^{2021})	A (A - A)	0.27 (0.19^{2018} - 0.272^{2019})	A (A - A)
Nenthorn at Mt Stoker Road	CDH	0.001 (0.001^{2018} - 0.001^{2022})	A (A - A)	0.059 (0.014^{2019} - 0.059^{2017})	A (A - A)
Silver Stream at Taieri Depot	CDL	0.33 (0.33^{2017} - 0.41^{2021})	A (A - A)	0.69 (0.66^{2018} - 0.873^{2022})	A (A - A)
Taieri at Allanton Bridge	CDH	0.06 (0.06^{2017} - 0.074^{2021})	A (A - A)	0.3 (0.205^{2022} - 0.3^{2017})	A (A - A)
Taieri at Linnburn Runs Road	CDH	0.003 (0.002^{2019} - 0.003^{2017})	A (A - A)	0.007 (0.007^{2018} - 0.012^{2022})	A (A - A)
Taieri at Outram	CDH	0.048 (0.046^{2020} - 0.052^{2021})	A (A - A)	0.274 (0.153^{2022} - 0.274^{2017})	A (A - A)
Taieri at Stonehenge	CDH	0.005 (0.005^{2019} - 0.009^{2022})	A (A - A)	0.05 (0.03^{2018} - 0.05^{2017})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Taieri at Sutton	CDL	0.021 (0.021^{2017} - 0.039^{2021})	A (A - A)	0.252 (0.123^{2022} - 0.252^{2017})	A (A - A)
Taieri at Tiroiti	CDH	0.027 (0.022^{2019} - 0.037^{2022})	A (A - A)	0.106 (0.087^{2018} - 0.128^{2021})	A (A - A)
Taieri at Waipiata	CDH	0.016 (0.012^{2019} - 0.023^{2022})	A (A - A)	0.09 (0.067^{2018} - 0.093^{2022})	A (A - A)
Waipori at Waipori Falls Reserve	CDL	0.014 (0.014^{2017} - 0.023^{2021})	A (A - A)	0.078 (0.076^{2018} - 0.129^{2022})	A (A - A)

Site-based trends

Over the 20-year trend period, five sites have *very unlikely* to be improving, or lower, trend probabilities indicating nitrate levels have increased at the Kye Burn at SH85 Bridge, Silver Stream at Taieri Depot, Taieri at Allanton Bridge, Taieri at Sutton, and Taieri at Waipiata (Table 68). The Waipori at Waipori Falls Reserve is *virtually certain* to be improving indicating nitrate levels have decreased and the Taieri at Stonehenge is *as likely as not* which is an ambiguous result that does not indicating an improving or degrading trend.

Over the 10-year trend period, the Contour Channel at No.4 Bridge, Kye Burn at SH85 Bridge, Taieri at Stonehenge, and Taieri at Tiroiti are unlikely to be improving with the Waipori at Waipori Falls Reserve very unlikely indicating nitrate levels have likely increased at these sites (

Table 69). The Taieri at Allanton Bridge and Taieri at Outram are *likely* to be improving indicating nitrate levels have likely decreased. The remaining sites are *as likely as not* to be improving which is an ambiguous result that does not indicating an improving or degrading trend.

Table 68: Taieri FMU 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	97	5.46	0.00	Exceptionally unlikely
Silver Stream at Taieri Depot	BiMonth	117	3.72	0.00	Exceptionally unlikely
Taieri at Allanton Bridge	BiMonth	119	2.63	0.00	Exceptionally unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Taieri at Linnburn Runs Road	BiMonth	114			Not Analysed
Taieri at Stonehenge	BiMonth	120	0.00	0.40	As likely as not
Taieri at Sutton	Qtr	64	1.71	0.04	Extremely unlikely
Taieri at Waipiata	BiMonth	120	1.00	0.06	Very unlikely
Waipori at Waipori Falls Reserve	Qtr	64	-10.40	1.00	Virtually certain

Table 69: Taieri FMU 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	0.70	0.17	Unlikely
Deep Stream at SH87	Qtr	36			Not Analysed
Kye Burn at SH85 Bridge	Month	112	3.46	0.13	Unlikely
Nenthorn at Mt Stoker Road	BiMonth	48			Not Analysed
Silver Stream at Taieri Depot	Month	112	0.00	0.50	As likely as not
Taieri at Allanton Bridge	Month	116	-1.24	0.70	Likely
Taieri at Linnburn Runs Road	Month	111			Not Analysed
Taieri at Outram	Month	98	-1.81	0.82	Likely
Taieri at Stonehenge	Month	118	0.00	0.25	Unlikely
Taieri at Sutton	Month	117	0.00	0.65	As likely as not
Taieri at Tiroiti	Month	97	1.49	0.24	Unlikely
Taieri at Waipiata	Month	118	0.00	0.55	As likely as not

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipori at Waipori Falls Reserve	Month	112	5.40	0.06	Very unlikely

Network state

Network modelling results indicate 100% (100-100) of mountain and hill class segments in the Taieri FMU comply with the nitrate toxicity A-band (Table 70). In the lowland management class, 96% (78-100) of segments comply with the A-band and 100% (100-100) comply with the B-band indicating all segments comply with the national bottom line.

Table 70: Percent of river segments in the Taieri FMU complying with nitrate toxicity attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	352
M	B	100 (100 - 100)	352
M	C	100 (100 - 100)	352
H	A	100 (100 - 100)	2,076
H	B	100 (100 - 100)	2,076
H	C	100 (100 - 100)	2,076
L	A	96 (78 - 100)	241
L	B	100 (100 - 100)	241
L	C	100 (100 - 100)	241

Nitrate toxicity state summary

All sites and segments in the Taieri FMU comply with the national bottom line for nitrate toxicity. However, many sites have probabilities of *unlikely* to be improving, or lower, over both the 10 and 20-year trend periods. To maintain state, restrictions on intensification which stop, and potentially reverse trends, may be required. All monitoring sites, and nearly all segments, also comply with the A-band. However, approximately 4% of segments fail to comply with the A-band. If an A-band target attribute state is set, reductions may be required.

Suspended Fine Sediment (NPSFM Table 8)

Many waterways in the Taieri FMU are naturally stained by tannins and thus the national bottom line for this attribute may not apply to all sites in this FMU.

Site-based baseline state

For sites with sufficient monitoring data, the Taieri at Allanton Bridge, Taieri at Linnburn Runs Road, Taieri at Sutton, Taieri at Waipiata and Waipori at Waipori Falls Reserve fail to comply with the national bottom line (Table 71). All of these sites are affected by tannin staining. The Kye Burn at SH85 Bridge, Taieri at Linnburn Runs Road, and Taieri at Stonehenge comply with the C-band. The mainstem sites range from C to B-band in the rolling analysis. The Kye Burn at SH85 Bridge ranges from C to A-band in the rolling analysis. The Silver Stream at Taieri Depot complies with the A-band.

Table 71: Taieri FMU clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Contour Channel at No. 4 Bridge	CDL		
Deep Stream at SH87	CDH		
Kye Burn at SH85 Bridge	CDH	2.354 (2.354^{2017} - 3.283^{2020})	C (C - A)
Nenthorn at Mt Stoker Road	CDH		
Silver Stream at Taieri Depot	CDL	2.391 (2.391^{2017} - 3.754^{2022})	A (A - A)
Taieri at Allanton Bridge	CDH	1.118 (1.1^{2021} - 1.126^{2020})	D (D - D)
Taieri at Linnburn Runs Road	CDH	2.504 (2.504^{2017} - 2.889^{2022})	C (C - B)
Taieri at Outram	CDH		
Taieri at Stonehenge	CDH	2.504 (2.504^{2017} - 2.839^{2020})	C (C - B)
Taieri at Sutton	CDL	1.214 (1.135^{2021} - 1.295^{2018})	D (D - D)
Taieri at Tiroiti	CDH		
Taieri at Waipiata	CDH	1.52 (1.485^{2022} - 1.64^{2019})	D (D - D)
Waipori at Waipori Falls Reserve	CDL	2.196 (2.196^{2017} - 2.338^{2018})	D (D - C)

Site-based trends

Over the 20-year trend period two sites, the Silver Stream at Taieri Depot and Waipori at Waipori Falls Reserve have probabilities of *very likely* to be improving, or higher, indicating clarity has increased at these sites (Table 72). The Taieri at Waipiata is *as likely as not* to be improving over the 20-year period which is an ambiguous result that is not classed as degrading or improving. The remaining sites have an *unlikely,* or lower, probability of improving and thus clarity has likely decreased.

Over the 10-year trend period, most sites have a *likely,* or higher, probability of improving indicating clarity has increased (Table 73). The Contour Channel at No.4 Bridge is the only site where clarity is *likely* to be decreased as it has a probability of *unlikely* to be improving.

Table 72: Taieri FMU 20-year trends for turbidity for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Silver Stream at Taieri Depot	BiMonth	117	-1.49	0.93	Very likely
Taieri at Allanton Bridge	BiMonth	119	2.75	0.00	Exceptionally unlikely
Taieri at Linnburn Runs Road	BiMonth	109	0.63	0.16	Unlikely
Taieri at Stonehenge	BiMonth	115	0.91	0.06	Very unlikely
Taieri at Waipiata	BiMonth	115	-0.25	0.65	As likely as not
Waipori at Waipori Falls Reserve	Qtr	64	-4.29	1.00	Virtually certain

Table 73: Taieri FMU 10-year trends for turbidity for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	5.78	0.13	Unlikely
Deep Stream at SH87	Month	106	-3.08	0.99	Extremely likely
Kye Burn at SH85 Bridge	Month	112	-4.46	0.94	Very likely
Nenthorn at Mt Stoker Road	BiMonth	48	-6.55	0.99	Virtually certain

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Silver Stream at Taieri Depot	Month	112	-6.42	1.00	Virtually certain
Taieri at Allanton Bridge	Month	116	-2.16	0.94	Very likely
Taieri at Linnburn Runs Road	Month	111	-1.46	0.90	Very likely
Taieri at Outram	Month	98	0.00	0.51	As likely as not
Taieri at Stonehenge	Month	118	-1.99	0.96	Extremely likely
Taieri at Sutton	Month	117	-0.56	0.59	As likely as not
Taieri at Tiroiti	Month	97	-2.79	0.79	Likely
Taieri at Waipiata	Month	118	-2.86	0.94	Very likely
Waipori at Waipori Falls Reserve	Month	112	-0.17	0.64	As likely as not

Network state

Network modelling results for clarity in the Taieri FMU show 61% of mountain segments comply with the A-band, 85% comply with the B-band and 97% comply with the C-band (Table 74). For the hill management class, 8% comply with the A-band, 28% comply with the B-band and 59% comply with the C-band. In the lowland class, 44% of segments comply with the A-band, 68% of segments comply with the B band and 81% of segments comply with the C band. Not all segments in this FMU are likely to comply with the national bottom line due to the natural characteristics of the FMU. The proportion of the river network capable of complying is unknown.

Table 74: Percent of segments in the Taieri FMU complying with A, B, and C suspended fine sediment attribute band split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	61	355
M	B	85	355
M	C	97	355
H	A	8	2,432
H	B	28	2,432
H	C	59	2,432
L	A	44	407
L	B	68	407
L	C	81	407

Suspended sediment state summary.

Most of the Taieri FMU, including mainstem sites, are affected by natural occurring processes that result in tannin staining. Tanin naturally reduces water clarity by absorbing light as it travels through the water. While mainstem sites fall below the national bottom line, at least some component of this is likely to be natural. Trend analysis indicates most sites having improving trends over the 10-year period. Appropriate targets are difficult to determine without a better understanding of the natural state in these systems. In the interim, to ensure sites maintain state, measures which manage sediment are required.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

Compliance with *E. coli* attribute bands in the Taieri FMU is variable both between sites and within an individual site's rolling analysis (Table 75). Most site results span more than one band for at least one of the *E. coli* metrics with the exception of the Kye Burn at SH85 Bridge, the Taieri at Stonehenge, and Waipori at Waipori Falls Reserve. These three sites comply with the A-band across all statistics and all periods in the rolling analysis. When the rolling analysis is considered, two sites fall below the national bottom line, the Silver Stream at Taieri Depot and the Taieri at Allanton Bridge. To comply with the national bottom line, measures must be taken to reduce *E. coli* levels at these sites.

Table 75: Taieri FMU E.coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Contour Channel at No. 4 Bridge	CDL								
Deep Stream at SH87	CDH								
Kye Burn at SH85 Bridge	CDH	26 (25^{2018} - 73^{2022})	A (A - A)	500 (270^{2020} - 500^{2018})	A (A - A)	0.13 (0.052^{2020} - 0.13^{2017})	A (A - A)	0.019 (0.017^{2019} - 0.036^{2022})	A (A - A)
Nenthorn at Mt Stoker Road	CDH								
Silver Stream at Taieri Depot	CDL	140 (101^{2020} - 150^{2022})	D (A - D)	2025 (2025^{2017} - 2350^{2018})	D (D - D)	0.273 (0.254^{2020} - 0.321^{2022})	B (B - C)	0.091 (0.091^{2017} - 0.232^{2022})	B (B - D)
Taieri at Allanton Bridge	CDH	120 (105.5^{2020} - 129^{2022})	A (A - A)	941.5 (935^{2018} - 2120.2^{2022})	B (B - D)	0.254 (0.224^{2020} - 0.283^{2018})	B (B - B)	0.119 (0.119^{2017} - 0.155^{2021})	C (C - C)
Taieri at Linnburn Runs Road	CDH	43 (43^{2017} - 64^{2022})	A (A - A)	894 (703.15^{2021} - 894^{2017})	B (B - B)	0.222 (0.185^{2022} - 0.222^{2017})	B (A - B)	0.093 (0.069^{2020} - 0.093^{2017})	B (B - B)
Taieri at Outram	CDH								
Taieri at Stonehenge	CDH	42 (38^{2018} - 59^{2022})	A	223 (223^{2017} - 290^{2022})	A	0.034 (0.034^{2017} - 0.055^{2022})	A (A - A)	0.034 (0.017^{2018} - 0.036^{2022})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
			(A - A)		(A - A)				
Taieri at Sutton	CDL	100 (100[2018] - 149[2022])	A (A - D)	766 (642[2018] - 1101.9[2022])	B (B - C)	0.207 (0.155[2018] - 0.25[2022])	B (A - B)	0.103 (0.053[2020] - 0.125[2022])	C (B - C)
Taieri at Tiroiti	CDH								
Taieri at Waipiata	CDH	87 (87[2017] - 110[2022])	A (A - A)	812.325 (311.1[2020] - 915[2022])	B (A - B)	0.237 (0.102[2019] - 0.237[2017])	B (A - B)	0.102 (0[2020] - 0.102[2017])	C (A - C)
Waipori at Waipori Falls Reserve	CDL	10 (10[2017] - 15[2022])	A (A - A)	54 (51.2[2021] - 82.9[2022])	A (A - A)	0 (0[2020] - 0[2020])	A (A - A)	0 (0[2018] - 0[2018])	A (A - A)

Site-based trends

Over the 20-year trend period, all sites have probabilities of *unlikely* to be improving, or lower, indicating that *E. coli* levels have increased across the FMU over the 20-year trend period (Table 76). Similar patterns are present in the 10-year trend period where the majority of sites have probabilities of *unlikely* to be improving, or lower, indicating that *E. coli* levels have increased over this period (Table 77). The exceptions are the Taieri at Tiroiti and Taieri at Waipiata which are *likely* to be improving indicating that *E. coli* levels have decreased at these sites. Over the 10-year period the Silver Stream at Taieri Depot, Taieri at Allanton Bridge, Taieri at Stonehenge, and Waipori at Waipori Falls Reserve are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Table 76: Taieri FMU 20-year trends for E. coli for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	97	1.31	0.25	Unlikely
Silver Stream at Taieri Depot	BiMonth	117	3.11	0.02	Extremely unlikely
Taieri at Allanton Bridge	BiMonth	119	1.80	0.04	Extremely unlikely
Taieri at Linnburn Runs Road	BiMonth	113	2.39	0.01	Exceptionally unlikely
Taieri at Stonehenge	BiMonth	119	1.46	0.04	Extremely unlikely
Taieri at Sutton	Qtr	64	4.67	0.00	Exceptionally unlikely
Taieri at Waipiata	Month	202	1.42	0.01	Extremely unlikely
Waipori at Waipori Falls Reserve	Qtr	64	2.23	0.16	Unlikely

Table 77: Taieri FMU 10-year trends for E. coli for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	20.67	0.00	Exceptionally unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Deep Stream at SH87	Month	106	4.69	0.04	Extremely unlikely
Kye Burn at SH85 Bridge	Month	111	1.72	0.19	Unlikely
Nenthorn at Mt Stoker Road	BiMonth	48	3.47	0.27	Unlikely
Silver Stream at Taieri Depot	Month	112	0.27	0.42	As likely as not
Taieri at Allanton Bridge	Month	116	0.21	0.45	As likely as not
Taieri at Linnburn Runs Road	Month	110	0.60	0.27	Unlikely
Taieri at Outram	Month	106	2.10	0.15	Unlikely
Taieri at Stonehenge	Month	117	-0.27	0.58	As likely as not
Taieri at Sutton	Month	117	2.11	0.21	Unlikely
Taieri at Tiroiti	Month	97	-1.03	0.68	Likely
Taieri at Waipiata	Month	117	-0.72	0.68	Likely
Waipori at Waipori Falls Reserve	Month	112	0.00	0.50	As likely as not

Network state

Network modelling for *E. coli* results show 59% (0-100) of mountain class segments comply with the A-band, 85% (5-100) comply with the B-band and 85% (2-100) comply with the C-band. In the hill management class, 30% (0-94) comply with the A-band, 57% (0-100) comply with the B-band and 61% (0-100) comply with the C-band. For the lowland class, 14% (0-60) comply with the A-band, 33% (0-76) comply with the B-band and 40% (0-95) comply with the C-band. As confidence intervals for the lowland class C-band do not overlap 100%, there is 95% confidence that a reduction in *E. coli* concentrations is required for 100% of segments to comply with the national bottom line.

Table 78: Percent of river segments in the Taieri FMU complying with E. coli target attribute bands with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	59 (0 - 100)	357
M	B	85 (5 - 100)	357
M	C	85 (2 - 100)	357
H	A	30 (0 - 94)	2,448
H	B	57 (0 - 100)	2,448
H	C	61 (0 - 100)	2,448
L	A	14 (0 - 60)	407
L	B	33 (0 - 76)	407
L	C	40 (0 - 95)	407

Escherichia coli *state summary*

When the rolling *E. coli* analysis is considered, two sites in the Taieri FMU fail to comply with the national bottom line. Trend analyses show increasing *E. coli* levels are common in the 10 and 20-year period. Network modelling indicates lowland class confidence intervals do not overlap 100% resulting in 95% confidence that a reduction is required to for all segments to comply with the national bottom line. Compliance in these classes may require reductions in upstream mountain segments. For the entire FMU to comply with the national bottom line, controls which reduce *E. coli* levels are required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Two sites in the Taieri FMU fail to comply with the C-band DRP attribute, the Contour Channel at No.4 Bridge and Taieri at Waipiata (Table 79). The Deep Stream at SH87, Kye Burn at SH85 Bridge, Taieri at Linnburn Runs Road, and Waipori at Waipori Falls Reserve comply with the A-band across both statistics and the rolling analysis. The remaining sites span multiple bands in the rolling analysis with results varying between the B and C-bands.

Table 79: Taieri FMU DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Contour Channel at No. 4 Bridge	CDL	0.025 (0.017^{2020} - 0.025^{2017})	D (C - D)	0.056 (0.044^{2020} - 0.079^{2022})	D (C - D)
Deep Stream at SH87	CDH	0.003 (0.002^{2022} - 0.003^{2019})	A (A - A)	0.006 (0.004^{2022} - 0.006^{2018})	A (A - A)
Kye Burn at SH85 Bridge	CDH	0.005 (0.003^{2022} - 0.005^{2017})	A (A - A)	0.008 (0.005^{2022} - 0.008^{2018})	A (A - A)
Nenthorn at Mt Stoker Road	CDH	0.008 (0.006^{2022} - 0.008^{2017})	B (A - B)	0.023 (0.018^{2022} - 0.025^{2018})	B (A - B)
Silver Stream at Taieri Depot	CDL	0.006 (0.003^{2022} - 0.006^{2018})	A (A - A)	0.012 (0.012^{2017} - 0.025^{2022})	A (A - B)
Taieri at Allanton Bridge	CDH	0.013 (0.008^{2022} - 0.013^{2017})	C (B - C)	0.022 (0.022^{2017} - 0.026^{2022})	B (B - B)
Taieri at Linnburn Runs Road	CDH	0.004 (0.002^{2022} - 0.004^{2017})	A (A - A)	0.008 (0.005^{2022} - 0.009^{2019})	A (A - A)
Taieri at Outram	CDH	0.011 (0.006^{2022} - 0.011^{2017})	C (B - C)	0.018 (0.018^{2018} - 0.021^{2022})	A (A - B)
Taieri at Stonehenge	CDH	0.007 (0.004^{2022} - 0.007^{2017})	B (A - B)	0.014 (0.011^{2022} - 0.014^{2017})	A (A - A)
Taieri at Sutton	CDL	0.011 (0.008^{2022} - 0.011^{2017})	C (B - C)	0.03 (0.026^{2018} - 0.03^{2020})	B (B - C)

Site	Class	Median	Median Band	95th	95th Band
Taieri at Tiroiti	CDH	0.015 (0.01[2022] - 0.015[2017])	C (C - C)	0.027 (0.027[2018] - 0.037[2021])	B (B - C)
Taieri at Waipiata	CDH	0.024 (0.017[2021] - 0.024[2018])	D (C - D)	0.06 (0.048[2022] - 0.062[2018])	D (C - D)
Waipori at Waipori Falls Reserve	CDL	0.002 (0.002[2017] - 0.003[2019])	A (A - A)	0.005 (0.004[2019] - 0.008[2022])	A (A - A)

Site-based trends

Over the 20-year trend period, three sites in the Taieri FMU show increased DRP levels, with probabilities of *unlikely* to be improving, or lower. These sites are the Taieri at Allanton Bridge, Taieri at Stonehenge and Taieri at Waipiata (Table 80). The remaining sites in the FMU have trend probabilities of *likely* to be improving, or higher, indicating DRP has decreased over the 20-year period.

Over the 10-year trend period, all sites have trend probabilities which indicate DRP has decreased except for the Waipori at Waipori falls reserve which is *exceptionally unlikely* to be improving (Table 81). This indicates DRP has increased over the 10-year period at this site.

Table 80: Taieri FMU 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	96	-4.23	1.00	Virtually certain
Silver Stream at Taieri Depot	BiMonth	114	0.00	0.99	Extremely likely
Taieri at Allanton Bridge	BiMonth	119	1.57	0.02	Extremely unlikely
Taieri at Linnburn Runs Road	BiMonth	114	0.00	0.90	Likely
Taieri at Stonehenge	BiMonth	120	0.00	0.27	Unlikely
Taieri at Sutton	Qtr	64	-2.55	0.96	Extremely likely
Taieri at Waipiata	BiMonth	120	0.93	0.09	Very unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipori at Waipori Falls Reserve	Qtr	64			Not Analysed

Table 81: Taieri FMU 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	-4.17	0.88	Likely
Deep Stream at SH87	Month	106	0.00	1.00	Virtually certain
Kye Burn at SH85 Bridge	Month	112	0.00	1.00	Virtually certain
Nenthorn at Mt Stoker Road	BiMonth	48	-7.15	0.99	Virtually certain
Silver Stream at Taieri Depot	Month	112	0.00	0.98	Extremely likely
Taieri at Allanton Bridge	Month	116	-3.19	0.97	Extremely likely
Taieri at Linnburn Runs Road	Month	111	0.00	1.00	Virtually certain
Taieri at Outram	Month	98	-6.11	1.00	Virtually certain
Taieri at Stonehenge	Month	118	0.00	0.97	Extremely likely
Taieri at Sutton	Month	117	-1.13	0.77	Likely
Taieri at Tiroiti	Month	97	-4.31	0.99	Virtually certain
Taieri at Waipiata	Month	118	-2.70	0.97	Extremely likely
Waipori at Waipori Falls Reserve	Month	112	0.00	0.01	Exceptionally unlikely

Dissolved reactive phosphorus state summary.

DRP concentrations at two sites in the Taieri FMU relative to the attribute bands in Table 20 of the NPSFM fail to comply with the C-band. Over the 10-year trend period, most sites have improving trends. Whether phosphorus reductions are required depends upon the target attribute state set for this table and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

In the Taieri FMU, the Silver Stream at Taieri Depot fails to comply with the national bottom line for periphyton biomass. The Kye Burn at SH85 Bridge complies with the A-band (Table 82).

Table 82: Taieri FMU periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Kye Burn at SH85 Bridge	33	A	26
Silver Stream at Taieri Depot	273	D	31

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, all sites comply with the C-band criteria and four sites comply with the B-band criteria including Deep Stream at SH87, Kye Burn at SH85 Bridge, Taieri at Linnburn Runs Road, and Taieri at Stonehenge (Table 83). For total phosphorus, five sites fail to comply with the C-band 20% under-protection risk periphyton nutrient criteria including the Contour Channel at No. 4 Bridge, Taieri at Allanton Bridge, Taieri at Sutton, Taieri at Waipiata, and Taieri at Tiroiti. Therefore, periphyton biomass may exceed the national bottom line in many locations across the FMU including the mainstem of the Taieri River.

Table 83: Taieri FMU total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Contour Channel at No. 4 Bridge	CDL	0.41 (0.41^{2017} - 0.53^{2021})	C (C - C)	0.059 (0.046^{2020} - 0.059^{2017})	D (D - D)
Deep Stream at SH87	CDH	0.188 (0.182^{2018} - 0.194^{2019})	B (B - B)	0.012 (0.01^{2022} - 0.012^{2019})	C (C - C)

Site	Class	TN	TN Band	TP	TP Band
Kye Burn at SH85 Bridge	CDH	0.14 (0.14^{2017} - 0.17^{2021})	B (B - B)	0.01 (0.006^{2022} - 0.01^{2017})	C (C - C)
Nenthorn at Mt Stoker Road	CDH	0.34 (0.34^{2017} - 0.41^{2022})	C (C - C)	0.026 (0.022^{2020} - 0.026^{2022})	C (C - C)
Silverstream at Taieri Depot	CDL	0.49 (0.49^{2017} - 0.57^{2020})	C (C - D)	0.012 (0.007^{2022} - 0.012^{2017})	C (C - C)
Taieri at Allanton Bridge	CDH	0.35 (0.345^{2022} - 0.375^{2021})	C (C - C)	0.034 (0.031^{2022} - 0.034^{2019})	D (C - D)
Taieri at Linnburn Runs Road	CDH	0.18 (0.15^{2021} - 0.18^{2017})	B (B - B)	0.013 (0.011^{2021} - 0.013^{2019})	C (C - C)
Taieri at Outram	CDH	0.31 (0.3^{2022} - 0.32^{2018})	C (C - C)	0.03 (0.023^{2022} - 0.03^{2017})	C (C - C)
Taieri at Stonehenge	CDH	0.21 (0.21^{2020} - 0.255^{2022})	B (B - C)	0.021 (0.019^{2018} - 0.021^{2021})	C (C - C)
Taieri at Sutton	CDL	0.295 (0.29^{2018} - 0.31^{2021})	C (C - C)	0.034 (0.03^{2022} - 0.034^{2017})	D (D - D)
Taieri at Tiroiti	CDH	0.26 (0.26^{2017} - 0.3^{2021})	C (C - C)	0.039 (0.031^{2022} - 0.039^{2017})	D (C - D)
Taieri at Waipiata	CDH	0.33 (0.32^{2018} - 0.34^{2022})	C (C - C)	0.054 (0.045^{2022} - 0.054^{2017})	D (D - D)
Waipori at Waipori Falls Reserve	CDL	0.21 (0.21^{2017} - 0.26^{2022})	C (C - C)	0.013 (0.013^{2020} - 0.013^{2020})	C (C - C)

Site-based trends

Over the 20-year trend period for total nitrogen, most sites have probabilities of *unlikely* to be improving, or lower, indicating total nitrogen levels have increased across the FMU (Table 84). The only exception is the Taieri at Sutton which is *as likely as not* to improving which is an ambiguous result not classed as improving or degrading.

Over the 10-year trend period, results are more varied (Table 85). Five sites, including the Deep Stream at SH87, Kye Burn at SH85 Bridge, Silver Stream at Taieri Depot, Taieri at Outram, and Taieri at Sutton, are *as likely as not* to be improving which is an ambiguous result that does not indicating improving or degrading trends. The Contour Channel at No. 4 Bridge, Taieri at Stonehenge, Taieri at Tiroiti, Taieri at Waipiata, and Waipori at Waipori Fall Reserve all have trend probabilities of *unlikely* to be improving,

or lower, indicating total nitrogen levels have increased at these sites. The Taieri at Allanton Bridge, Nenthorn at Mt. Stoker Road and Taieri at Linnburn Runs Road are *likely* to be improving indicating total nitrogen levels have decreased at these sites.

Table 84: Taieri FMU 20-year trends for total nitrogen for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	97	0.00	0.32	Unlikely
Silver Stream at Taieri Depot	BiMonth	117	2.13	0.00	Exceptionally unlikely
Taieri at Allanton Bridge	BiMonth	119	0.98	0.04	Extremely unlikely
Taieri at Linnburn Runs Road	BiMonth	114	0.00	0.16	Unlikely
Taieri at Stonehenge	BiMonth	120	1.20	0.01	Extremely unlikely
Taieri at Sutton	Qtr	64	0.00	0.61	As likely as not
Taieri at Waipiata	BiMonth	120	0.83	0.02	Extremely unlikely
Waipori at Waipori Falls Reserve	Qtr	64	0.36	0.25	Unlikely

Table 85: Taieri FMU 10-year trends for total nitrogen for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	1.02	0.32	Unlikely
Deep Stream at SH87	Month	106	0.21	0.35	As likely as not
Kye Burn at SH85 Bridge	Month	112	0.00	0.48	As likely as not
Nenthorn at Mt Stoker Road	BiMonth	48	-1.99	0.82	Likely
Silver Stream at Taieri Depot	Month	112	0.44	0.37	As likely as not
Taieri at Allanton Bridge	Month	116	-0.57	0.70	Likely
Taieri at Linnburn Runs Road	Month	111	0.00	0.70	Likely
Taieri at Outram	Month	98	0.00	0.51	As likely as not

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Taieri at Stonehenge	Month	118	2.77	0.00	Exceptionally unlikely
Taieri at Sutton	Month	117	0.00	0.47	As likely as not
Taieri at Tiroiti	Month	97	2.14	0.03	Extremely unlikely
Taieri at Waipiata	Month	118	1.24	0.08	Very unlikely
Waipori at Waipori Falls Reserve	Month	112	3.64	0.00	Exceptionally unlikely

Over the 20-year trend period for total phosphorus, most sites have *likely*, or higher, probabilities of improving trend including the Kye Burn as SH85 Bridge, Silver Stream at Taieri Depot, Taieri at Sutton, Taieri at Waipiata, and Waipori at Waipori Falls Reserve (Table 86). This indicates total phosphorus has decreased at these sites. The Taieri at Allanton bridge and Taieri at Stonehenge have probabilities of *unlikely* to be improving, or lower, indicating total phosphorus has increased over the 20-year period at these sites. The Taieri at Linnburn Runs Road is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Table 86: Taieri FMU 20-year trends for total phosphorus for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	BiMonth	96	0.00	0.84	Likely
Silver Stream at Taieri Depot	BiMonth	114	0.00	0.72	Likely
Taieri at Allanton Bridge	BiMonth	119	0.49	0.24	Unlikely
Taieri at Linnburn Runs Road	BiMonth	114	0.00	0.34	As likely as not
Taieri at Stonehenge	BiMonth	120	0.00	0.01	Extremely unlikely
Taieri at Sutton	Qtr	64	-2.21	0.98	Extremely likely
Taieri at Waipiata	BiMonth	120	-0.35	0.81	Likely
Waipori at Waipori Falls Reserve	Qtr	64	0.00	1.00	Virtually certain

Over the 10-year trend period, all sites except for the Taieri at Stonehenge and Waipori at Waipori Falls Reserve have trend probabilities of *likely* to be improving or better indicating total phosphorus levels have decreased over the 10-year trend period (Table 87). This may be due to improved land use practice, natural variability, or a component of both. The Taieri at Stonehenge and Waipori at Waipori Falls Reserve are *unlikely* to be improving indicating total phosphorus levels have increased at these sites over the 10-year period.

Table 87: Taieri FMU 10-year trends for total phosphorus for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Contour Channel at No. 4 Bridge	BiMonth	48	-1.70	0.69	Likely
Deep Stream at SH87	Month	106	-1.52	0.91	Very likely
Kye Burn at SH85 Bridge	Month	112	-9.92	1.00	Virtually certain
Nenthorn at Mt Stoker Road	BiMonth	48	-2.10	0.81	Likely
Silver Stream at Taieri Depot	Month	112	-4.52	0.98	Extremely likely
Taieri at Allanton Bridge	Month	116	-2.43	0.96	Extremely likely
Taieri at Linnburn Runs Road	Month	111	-2.87	0.98	Extremely likely
Taieri at Outram	Month	98	-4.80	0.99	Extremely likely
Taieri at Stonehenge	Month	118	1.19	0.13	Unlikely
Taieri at Sutton	Month	117	-1.43	0.79	Likely
Taieri at Tiroiti	Month	97	-3.45	0.96	Extremely likely
Taieri at Waipiata	Month	118	-1.52	0.93	Very likely
Waipori at Waipori Falls Reserve	Month	112	0.00	0.18	Unlikely

Network state

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results show 100% (100-100) of mountain class segments comply with the B-band criteria (Table 88). For the hill class, 61% (15-100) comply with the B-band criteria and 100% (100-100)

comply with the C-band criteria. In the lowland class, 1% (0-1) comply with the B-band criteria and 74% (25-100) comply with the C-band criteria. As the confidence interval overlaps 100%, there is less than 95% confidence a reduction is required. Very few segments comply with the A-band criteria across the management classes although the outcome for mountain segments has a wide confidence interval.

For total phosphorus in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results show 76% (56-100) of mountain class segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria (Table 88). For the hill class segments, 11% (7-33) comply with the B-band criteria and 85% (38-100) comply with the C-band. The lowland class has 2% (0-15) compliance with the B-band criteria and 70% (27-94) compliance with the C-band criteria. As confidence intervals in the lowland class do not overlap 100%, there is 95% confidence that some level of phosphorus reduction is required for all segments to comply with the 20% under-protection risk nutrient criteria.

Table 88: Percent of river segments in the Taieri FMU complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	8 (0 - 79)	0 (0 - 0)	352
M	B	100 (100 - 100)	76 (56 - 100)	352
M	C	100 (100 - 100)	100 (100 - 100)	352
H	A	2 (0 - 9)	0 (0 - 0)	2,076
H	B	61 (15 - 100)	11 (7 - 33)	2,076
H	C	100 (100 - 100)	85 (38 - 100)	2,076
L	A	1 (0 - 1)	0 (0 - 0)	241
L	B	1 (0 - 1)	2 (0 - 15)	241
L	C	74 (25 - 100)	70 (27 - 94)	241

Periphyton biomass state summary

In the Taieri FMU, one site fails to comply with the national bottom line and the other site complies with the A-band. When compared to the 20% under-protection risk periphyton nutrient criteria, all sites comply with the C-band for total nitrogen. However, four sites fail to comply for total phosphorus. Total nitrogen trends indicate increasing total nitrogen levels for many sites over both the 20 and 10-year trend periods. Total phosphorus trends indicate decreasing total phosphorus levels at many sites over both the 20 and 10-year periods. Network modelling fails to overlap 100% in the confidence interval for the C-band in lowland segments which indicates 95% confidence that some level of phosphorus reduction is required for all segments to comply with the C-band criteria. To improve periphyton biomass in the Taieri FMU and comply with national bottom lines, reductions in phosphorus are required and reductions in nitrogen may be required.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

Three sites in the Taieri FMU have sufficient information for MCI and ASPM NOF score calculations in the baseline period (Table 89). For MCI, the Kye Burn at SH85 Bridge and Waipori at Waipori Falls Reserve comply with the C-band whereas the Silver Stream at Taieri Depot fails to comply with the C-band. This site ranges from D to C-band in the rolling analysis. For ASPM, the Silver Stream at Taieri Depot also fails to comply with the national bottom line and ranges from D to C-band in the rolling analysis. The Kyeburn at SH85 Bridge complies with the B-band and the Waipori at Waipori Falls Reserve complies with the C-band.

Table 89: Taieri FMU macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (five-year period ending August 2017- five-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Contour Channel at No. 4 Bridge	CDL				
Deep Stream at SH87	CDH				
Kye Burn at SH85 Bridge	CDH	105 (100^{2022} - 105^{2020})	C (C - C)	0.55 (0.51^{2022} - 0.55^{2018})	B (B - B)
Nenthorn at Mt Stoker Road	CDH				

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Silver Stream at Taieri Depot	CDL	89.41 (89.41[2017] - 90.43[2020])	D (D - C)	0.26 (0.26[2017] - 0.322[2022])	D (D - C)
Taieri at Allanton Bridge	CDH				
Taieri at Linnburn Runs Road	CDH				
Taieri at Outram	CDH				
Taieri at Stonehenge	CDH				
Taieri at Sutton	CDL				
Taieri at Tiroiti	CDH				
Taieri at Waipiata	CDH				
Waipori at Waipori Falls Reserve	CDL	108.57 (93.85[2021] - 108.57[2017])	C (C - C)	0.34 (0.34[2017] - 0.39[2022])	C (C - C)

Site-based trend

Over the 20-year MCI trend period, the Silver Stream at Taieri Depot is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (Table 90). Over the 10-year MCI trend period, both the Kye Burn at SH85 Bridge and Silver Stream at Taieri Depot have trend probabilities of *unlikely* to be improving, or worse, indicating MCI scores have decreased (Table 91).

Over the 10-year ASPM trend period, the Kye Burn at SH85 Bridge is *very unlikely* to be improving indicating ASPM score has likely decreased (Table 92). The Silver Stream at Taieri Depot is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Table 90: Taieri FMU 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Silver Stream at Taieri Depot	Year	17	0.04	0.45	As likely as not

Table 91: Taieri FMU 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	Year	10	-1.61	0.91	Very unlikely
Silver Stream at Taieri Depot	Year	10	-0.43	0.76	Unlikely

Table 92: Taieri FMU 10-year trends for the average score per metric (ASPM) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kye Burn at SH85 Bridge	Year	9	-2.64	0.91	Very unlikely
Silver Stream at Taieri Depot	Year	9	1.61	0.38	As likely as not

Network state

Network modelling results for MCI indicate 16% of mountain class segments comply with the B-band and 100% of segments comply with the C-band (Table 93). For the hill class, 8% of segments comply with the B-band and 100% comply with the C-band. In the lowland class, 10% of segments comply with the B-band and 80% of segments comply with the C-band. For all segments to comply with the national bottom-line sediment, management of nutrients and other factors which can lower MCI may be required.

Table 93: Percent of segments in the Taieri FMU complying with potential A, B and C macroinvertebrate community index (MCI) target attribute band split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	353
M	B	16	353
M	C	100	353
H	A	0	2,351

Management Class	Band	Segment %	# of Segments
H	B	8	2,351
H	C	100	2,351
L	A	0	404
L	B	10	404
L	C	80	404

Macroinvertebrate state summary

One out of three sites in the Taieri FMU fails to comply with the national bottom line and modelling suggests approximately 20% of lowland segments fail to comply with the national bottom line. Over the 10-year trend period degrading trends also occur. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish Index of Biotic Integrity (IBI, NPSFM Table 13)

Site-based baseline state

Fish IBI is monitored at two sites in the Taieri FMU with one site over the baseline period (Table 94). The Kye Burn at SH85 complies with the C-band over the baseline period and ranged from C to A-band in the rolling analysis. The Silver Stream at Riccarton Road also ranged from C to A-band in the rolling analysis.

Table 94: Taieri FMU annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Kye Burn at SH85	22 (18^{2019} - 34^{2022})	C (C - A)	B (B - A)
Silver Stream at Riccarton Road	NA (26^{2014} - 38^{2015})	NA (C - A)	NA (A - A)

Upper Lakes Rohe

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

Both sites with long-term monitoring data in the Upper Lakes Rohe comply with the A-band for ammoniacal nitrogen statistics (Table 95).

Table 95: Upper Lakes Rohe NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017-5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dart at The Hillocks	CXH	0.003 (0.001[2019] - 0.003[2017])	A (A - A)	0.015 (0.003[2022] - 0.015[2017])	A (A - A)
Matukituki at West Wanaka	CXGM	0.004 (0.002[2020] - 0.004[2017])	A (A - A)	0.016 (0.006[2022] - 0.018[2020])	A (A - A)

Site-based trends

Over the 20-year trend period for ammoniacal nitrogen, the Matukituki at West Wanaka is *very likely* to be improving, indicating that ammoniacal nitrogen levels have decreased (Table 96). Over the 10-year trend period, both the Dart at the Hillocks and Matukituki at West Wanaka are *virtually certain* to be improving indicating ammoniacal nitrogen levels have decreased over this period (Table 97).

Table 96: Upper Lakes Rohe 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Matukituki at West Wanaka	BiMonth	96	0	0.93	Very likely

Table 97: Upper Lakes Rohe 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	105	0	1.00	Virtually certain
Matukituki at West Wanaka	Month	112	0	1.00	Virtually certain

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Rohe comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

Both sites with long-term data in the Upper Lakes Rohe comply with the nitrate toxicity A-band (Table 98).

Table 98: Upper Lakes Rohe NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dart at The Hillocks	CXH	0.023 (0.023^{2017} - 0.028^{2022})	A (A - A)	0.05 (0.044^{2022} - 0.054^{2018})	A (A - A)
Matukituki at West Wanaka	CXGM	0.048 (0.047^{2018} - 0.06^{2022})	A (A - A)	0.083 (0.083^{2018} - 0.096^{2022})	A (A - A)

Site-based trends

Twenty-year trends for nitrate are not available in this Rohe. Over the 10-year trend period, the Matukituki at West Wanaka is *exceptionally unlikely* to be improving indicating nitrate levels have

increased. The Dart at the Hillocks is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (Table 99).

Table 99: Upper Lakes Rohe 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	106	0.00	0.44	As likely as not
Matukituki at West Wanaka	Month	112	4.10	0.00	Exceptionally unlikely

Network state

Network modelling results indicate all segments in the Rohe comply with the A-band for nitrate toxicity (Table 100).

Table 100: Percent of river segments in the Upper Lakes Rohe complying with potential nitrate toxicity target attribute band, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	3,399
M	B	100 (100 - 100)	3,399
M	C	100 (100 - 100)	3,399
H	A	100 (100 - 100)	581
H	B	100 (100 - 100)	581
H	C	100 (100 - 100)	581
L	A	100 (100 - 100)	18
L	B	100 (100 - 100)	18
L	C	100 (100 - 100)	18

Nitrate toxicity state summary

All sites and segments in the Upper Lakes Rohe comply with the national bottom line and A-band for nitrate toxicity. One site had a degrading 10-year trend. To maintain state, measures to reduce nitrogen concentrations may be required.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

Both long-term monitored sites in the Upper Lakes Rohe are influenced by glacial flour and are exempt from the suspended sediment baseline. The Matukituki at West Wanaka complies with the A-band and ranges from D to A-band in the rolling analysis (Table 101).

Table 101: Upper Lakes Rohe clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Dart at The Hillocks	CXH		
Matukituki at West Wanaka	CXGM	1.813 (1.295^{2021} - 2.196^{2019})	A (D - A)

Site-based trends

Over the 20-year trend period, the Matukituki at West Wanaka is *unlikely* to be improving (Table 102) indicating that turbidity has increased. Over the 10-year trend period, the Dart at the Hillocks is *extremely likely* to be improving while the Matukituki at West Wanaka is *as likely as not* to be improving (Table 103).

Table 102: Upper Lakes Rohe 20-year trends for turbidity for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Matukituki at West Wanaka	BiMonth	96	1.81	0.15	Unlikely

Table 103: Upper Lakes Rohe 10-year trends for turbidity for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	106	-8.51	0.99	Extremely likely
Matukituki at West Wanaka	Month	112	0.00	0.49	As likely as not

Network state

Network analyses for clarity result in 75% of mountain segments complying with the A-band, 87% of segments complying with the B-band, and 97% complying with the C-band (Table 104). For the hill class, 65% of segments comply with the A-band, 84% comply with the B band and 91% comply with the C-band. For the lowland class, 44% comply with the A-band, 52% comply with B-band and 68% comply with the C-band.

Table 104: Percent of segments in the Upper Lakes Rohe complying with potential A, B, and C suspended fine sediment target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	75	3,397
M	B	87	3,397
M	C	97	3,397
H	A	65	590
H	B	84	590
H	C	91	590
L	A	44	50
L	B	52	50
L	C	68	50

Suspended sediment state summary.

The two long-term monitoring sites in this FMU are affected by natural sources of high concentrations of suspended sediment (i.e., glacial flour) and are therefore exempt from the national bottom line. The proportion of the FMU that would naturally comply with the bottom line is unknown. Additional monitoring data is available from sites more recently implemented following a network review

(Ozanne et al. 2023). Data from these sites indicate much of the FMU currently complies with the A-band. To maintain state, controls on sediment inputs and intensification are required.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

E. coli results are available for one site in the Upper Lakes Rohe (Table 105). The Matukituki at West Wanaka complies with variable bands across the statistics with the rolling analysis ranging from the C to A-band.

Table 105: Upper Lakes Rohe E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Dart at The Hillocks	CXH								
Matukituki at West Wanaka	CXGM	23 (23^{2019} - 26^{2022})	A (A - A)	1200 (243^{2020} - 1200^{2018})	C (A - C)	0.143 (0.035^{2020} - 0.143^{2017})	A (A - A)	0.071 (0.017^{2019} - 0.071^{2017})	B (A - B)

Site-based trends

Across the 20-year trend period the Matukituki at West Wanaka is *extremely unlikely* to be improving indicating *E. coli* levels have increased (Table 106). Across the 10-year trend period, both the Dart at the Hillocks and Matukituki at West Wanaka are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (Table 107).

Table 106: Upper Lakes Rohe 20-year trends for E. coli for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Matukituki at West Wanaka	BiMonth	96	3.93	0.02	Extremely unlikely

Table 107: Upper Lakes Rohe 10-year trends for E. coli for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	104	0	0.59	As likely as not
Matukituki at West Wanaka	Month	110	0	0.50	As likely as not

Network state

Network modelling results for *E. coli* show 66% (0-100) of mountain segments comply with the A-band, 86% (9-100) comply with the B-band and 94% (49-100) comply with the C-band (Table 108). In the hill class, 45% (0-99) of segments comply with the A-band, 68% (3-100) comply with the B-band and 86% (17-100) comply with the C-band. In the lowland class, 15% (0-100) comply with the A-band, 36% (0-100) comply with the B-band and 57% (0-100) comply with the C-band. As the confidence interval overlaps 100% in all classes it is unclear whether a reduction is required to comply with the national bottom line. However, as *E. coli* is increasing over the 20-year period, *E. coli* mitigation measures should be considered.

Table 108: Percent of river segments in the Upper Lakes Rohe complying with potential E. coli target attribute bands with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	66 (0 - 100)	1,001
M	B	86 (9 - 100)	1,001
M	C	94 (49 - 100)	1,001

Management Class	Band	Current	Count
H	A	45 (0 - 99)	306
H	B	68 (3 - 100)	306
H	C	86 (17 - 100)	306
L	A	15 (0 - 100)	22
L	B	36 (0 - 100)	22
L	C	57 (0 - 100)	22

E. coli state summary

The one monitoring site with available scores complies with the C-band for *E. coli*. Trend analyses indicate that *E. coli* levels have increased at this site over the 20-year period. Network modelling indicates hill and lowland class confidence intervals overlap 100%. This indicates there is less than 95% confidence that a reduction is required to for all segments to comply with the national bottom line. Further, Ozanne et al. (2023), which incorporates monitoring sites which have data outside the baseline period, indicates much of the Rohe currently complies with the B or A-band for *E. coli*. To maintain state, controls on *E. coli* inputs would be required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Both sites in the Upper Lakes Rohe comply with the DRP A-band for both statistics (Table 109).

Table 109: Upper Lakes Rohe DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dart at The Hillocks	CXH	0.003 (0.002^{2022} - 0.003^{2017})	A (A - A)	0.006 (0.003^{2022} - 0.006^{2017})	A (A - A)
Matukituki at West Wanaka	CXGM	0.003 (0.002^{2022} - 0.003^{2018})	A (A - A)	0.006 (0.004^{2022} - 0.006^{2019})	A (A - A)

Site-based trends

Twenty-year trends are not available for the DRP trends as the majority of samples fall below the detection limit (Table 110).

Table 110: Upper Lakes Rohe 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Matukituki at West Wanaka	Qtr	64			Not Analysed

Over the 10-year trend period, both the Dart at the Hillocks and Matukituki at West Wanaka have trend probabilities of *virtually certain* to be improving indicating DRP levels have decreased over the 10-year period (Table 111).

Table 111: Upper Lakes Rohe 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	106	0	1	Virtually certain
Matukituki at West Wanaka	Month	112	0	1	Virtually certain

Dissolved reactive phosphorus state summary.

Both monitoring sites in the Upper Lakes comply with the A-band for DRP. Both sites also have improving trends over the 10-year trend period. Whether phosphorus reductions are required depends upon the target attribute state set for this table, requirements of the downstream lake receiving environment, and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

For periphyton biomass, the majority of monitored sites in the Upper Lakes Rohe comply with the A-band (Table 112). Bullock Creek at Dunmore Street Footbridge fails to comply with the national bottom line. The Motatapu at Wanaka Mt. Aspiring Road and Turner Creek at Kinlock Road comply with the B-band.

Table 112: Upper Lakes Rohe periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019, to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
12 Mile Creek at Glenorchy Queenstown Road	9	A	29
25 Mile Creek at Glenorchy Queenstown Road	32	A	29
Arrow at Morven Ferry Road	34	A	23
Bullock Creek at Dunmore Street Footbridge	323	D	32
Dart at The Hillocks	6	A	20
Greenstone at Greenstone Station Road	7	A	29
Matukituki at West Wanaka	4	A	24
Motatapu at Wanaka Mt Aspiring Road	50	B	28
Precipice Creek at Glenorchy Paradise Road	14	A	32
The Neck Creek at Meads Road	32	A	31
Turner Creek at Kinloch Road	72	B	29

For total nitrogen in relation to the 20% under-protection risk periphyton biomass nutrient criteria, both long-term sites comply with the B-band 20% (Table 113), though the Dart site ranges to the A-band in the rolling analysis. For total phosphorus, both sites comply with the B-band criteria.

Table 113: Upper Lakes Rohe total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Dart at The Hillocks	CXH	0.084 (0.04^{2022} - 0.084^{2017})	B (A - B)	0.03 (0.014^{2022} - 0.03^{2017})	B (B - B)
Matukituki at West Wanaka	CXGM	0.095 (0.078^{2019} - 0.095^{2017})	B (B - B)	0.01 (0.006^{2022} - 0.01^{2017})	B (B - B)

Site-based trends

Twenty-year total nitrogen trends are not available for total nitrogen in this Rohe. Over the 10-year trend period, the Dart at the Hillocks is *virtually certain* to be improving, indicating total nitrogen levels have decreased (Table 114).

Table 114: Upper Lakes Rohe 10-year trends for total nitrogen for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	105	0	1	Virtually certain
Matukituki at West Wanaka	Qtr	40			Not Analysed

Over the 20-year total phosphorus trend period, the Matukituki at West Wanaka is *extremely likely* to be improving (Table 115). Over the 10-year period, both sites are *virtually certain* to be improving indicating total phosphorus levels have decreased at these sites (

Table 116).

Table 115: Upper Lakes Rohe 20-year trends for total phosphorus for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Matukituki at West Wanaka	BiMonth	96	-3.94	0.98	Extremely likely

Table 116: Upper Lakes Rohe 10-year trends for total phosphorus for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dart at The Hillocks	Month	106	-15.58	1	Virtually certain
Matukituki at West Wanaka	Month	112	-9.37	1	Virtually certain

Network state

Network modelling results for total nitrogen in relation to the 20% under-protection risk periphyton biomass nutrient criteria show 100% (100-100) of mountain segments comply with the B-band criteria (Table 117). For the hill management class, 98% (92-100) of segments comply with the B-band criteria and 100% (100-100) of segments comply with the C-band criteria. In the lowland class, 58% (50-84) of segments comply with the B-band criteria and 97% (89-100) of segments comply with the C-band criteria. Few hill or lowland segments comply with the A-band criteria. Compliance with the A-band criteria is very uncertain with wide confidence intervals. As confidence intervals and mean percentages overlap 100%, no nitrogen reductions would be required to comply with the national bottom line. Reductions may be required if target attribute state is set above this level.

Network modelling results for total phosphorus in relation to the 20% under-protection risk periphyton biomass nutrient criteria show 100% of mountain class segments comply with the B-band criteria (Table 117). For the hill management class, 86% (83-94) of segments comply with the B-band criteria and 100% (99-100) comply with the C-band criteria. In the lowland class, 51% (17-78) of segments comply with the B-band criteria and 99% (89-100) comply with the C-band criteria. Few segments comply with the A-band criteria across all classes. As confidence intervals and mean percentages overlap, or are near, 100%, no reductions are required in this Rohe to comply with the national bottom line.

Table 117: Percent of river segments in the Upper Lakes Rohe complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	47 (0 - 100)	0 (0 - 0)	3,399
M	B	100 (100 - 100)	100 (100 - 100)	3,399
M	C	100 (100 - 100)	100 (100 - 100)	3,399
H	A	30 (0 - 85)	0 (0 - 0)	581
H	B	98 (92 - 100)	86 (83 - 94)	581
H	C	100 (100 - 100)	100 (99 - 100)	581
L	A	24 (0 - 61)	0 (0 - 0)	18
L	B	58 (50 - 84)	51 (17 - 78)	18
L	C	97 (89 - 100)	99 (89 - 100)	18

Periphyton biomass state summary

In the Upper Lakes Rohe, one site fails to comply with the national bottom line, two sites comply with the B-band and eight sites comply with the A-band. When compared to the 20% under-protection risk periphyton nutrient criteria, the two long term sites comply with the B-band for total nitrogen and for total phosphorus. Trend analysis indicates both total nitrogen and total phosphorus are improving over the 10-year trend period. Network modelling confidence intervals and means overlap, or are near, 100% for the C-band in all classes indicating no reduction is required to comply with the national bottom line.

Macroinvertebrates (NPSFM Table 14-15)

No sites in the Upper Lakes Rohe have long-term macroinvertebrate monitoring data with sufficient samples for a NOF score in the baseline period. More recent periods are quantified in Ozanne et al. (2023).

Network state

Network modelling for MCI shows 99% of mountain segments comply with the B-band and 100% of segments comply with the C-band (Table 118). For the hill management class, 90% of segments comply with the B-band and 100% of segments comply with the C-band. In the lowland class, 45% of segments comply with the B-band and 100% of segments comply with the C-band. As 100% of segments comply with the C-band no improvements are necessary to comply with the national bottom line in this Rohe.

Table 118 Percent of segments in the Upper Lakes Rohe complying with potential A, B and C macroinvertebrate community index (MCI) target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	3,275
M	B	99	3,275
M	C	100	3,275
H	A	5	455
H	B	90	455
H	C	100	455
L	A	0	38
L	B	45	38
L	C	100	38

Macroinvertebrate state summary

All segments in the Upper Lakes Rohe comply with the national bottom line. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Site-based baseline state

No sites in the Rohe have fish IBI data during the baseline period (Table 119). More recent monitoring data results in 12 Mile Creek and 25 Mile Creek comply with the B-band.

Table 119: Upper Lakes Rohe annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
12 Mile Creek	NA (28^{2020} - 28^{2020})	NA (B - B)	NA (A - A)
25 Mile Creek	NA (28^{2020} - 28^{2020})	NA (B - B)	NA (A - A)

Dunstan Rohe

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

All sites in the Dunstan Rohe comply with A-band ammoniacal nitrogen for both the median and 95th statistics (Table 120).

Table 120: Dunstan Rohe NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017- 5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Bannockburn at Lake Dunstan	CDH	0.005 (0.002^{2019} - 0.005^{2017})	A (A - A)	0.016 (0.005^{2022} - 0.016^{2017})	A (A - A)
Cardrona at Mt Barker	CDH	0.004 (0.002^{2019} - 0.004^{2017})	A (A - A)	0.011 (0.004^{2022} - 0.011^{2017})	A (A - A)
Clutha @ Luggate Br	CXLk	0.003 (0.003^{2020} - 0.003^{2022})	A (A - A)	0.009 (0.008^{2022} - 0.009^{2020})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Hawea at Camphill Bridge	CXLk	0.001 (0^{2018} - 0.001^{2017})	A (A - A)	0.015 (0.002^{2022} - 0.015^{2017})	A (A - A)
Kawarau @ Chards Rd	CWLk	0.002 (0.002^{2017} - 0.003^{2019})	A (A - A)	0.005 (0.005^{2017} - 0.008^{2020})	A (A - A)
Lindis at Ardgour Road	CDH	0.003 (0.002^{2018} - 0.003^{2017})	A (A - A)	0.008 (0.004^{2022} - 0.008^{2018})	A (A - A)
Lindis at Lindis Peak	CDH	0.002 (0.001^{2018} - 0.002^{2017})	A (A - A)	0.01 (0.003^{2021} - 0.01^{2017})	A (A - A)
Luggate Creek at SH6 Bridge	CWM	0.002 (0.001^{2018} - 0.002^{2017})	A (A - A)	0.007 (0.003^{2022} - 0.007^{2017})	A (A - A)
Mill Creek at Fish Trap	CDH	0.007 (0.003^{2020} - 0.007^{2017})	A (A - A)	0.022 (0.014^{2020} - 0.022^{2017})	A (A - A)
Nevis at Wentworth Station	CWM	0.001 (0^{2019} - 0.001^{2017})	A (A - A)	0.014 (0.002^{2022} - 0.014^{2017})	A (A - A)
Shotover @ Bowens Peak	CWM	0.002 (0.002^{2022} - 0.002^{2017})	A (A - A)	0.006 (0.005^{2021} - 0.006^{2019})	A (A - A)

Site-based trends

Over the 20-year trend period, no sites have degrading trends (Table 121). The Cardrona at Mt. Barker, Clutha at Luggate Bridge, Kawarau at Chards Road and Shotover at Bowens Peak have probabilities of *likely* to be improving or higher, indicating ammoniacal nitrogen levels have decreased. Luggate Creek at SH6 Bridge and Hawea at Camphill Bridge are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Over the 10-year trend period, all sites have *very likely*, or higher probabilities of improving trends (Table 122). As a result, ammoniacal nitrogen levels have likely decreased across the Rohe.

Table 121: Dunstan Rohe 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	119	0.00	0.78	Likely
Clutha @ Luggate Br	Month	237	-4.17	1.00	Virtually certain
Hawea at Camphill Bridge	BiMonth	96	0	0.47	As likely as not

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Kawarau @ Chards Rd	Month	236	0.00	0.99	Virtually certain
Lindis at Ardgour Road	BiMonth	100			Not Analysed
Lindis at Lindis Peak	BiMonth	114			Not Analysed
Luggate Creek at SH6 Bridge	BiMonth	96	0.00	0.60	As likely as not
Mill Creek at Fish Trap	Qtr	80			Not Analysed
Shotover @ Bowens Peak	Month	238	-4.68	1.00	Virtually certain

Table 122: Dunstan Rohe 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54			Not Analysed
Cardrona at Mt Barker	Month	111	0.00	0.93	Very likely
Clutha @ Luggate Br	Month	117	-12.61	1.00	Virtually certain
Hawea at Camphill Bridge	Month	112	0	0.99	Virtually certain
Kawarau @ Chards Rd	Month	116	-4.42	1.00	Virtually certain
Lindis at Ardgour Road	Month	116	0.00	0.94	Very likely
Lindis at Lindis Peak	Month	111			Not Analysed
Luggate Creek at SH6 Bridge	Month	111	0.00	0.99	Extremely likely
Mill Creek at Fish Trap	Qtr	40			Not Analysed
Nevis at Wentworth Station	BiMonth	50	0.00	1.00	Virtually certain
Shotover @ Bowens Peak	Month	118	-16.90	1.00	Virtually certain

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Rohe comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

All sites in the Dunstan Rohe comply with A-band nitrate toxicity for both the median and 95th percentile statistics (Table 123).

Table 123: Dunstan Rohe NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Bannockburn at Lake Dunstan	CDH	0.001 (0^{2019} - 0.001^{2017})	A (A - A)	0.006 (0.004^{2019} - 0.012^{2022})	A (A - A)
Cardrona at Mt Barker	CDH	0.066 (0.066^{2017} - 0.079^{2020})	A (A - A)	0.164 (0.164^{2017} - 0.21^{2022})	A (A - A)
Clutha @ Luggate Br	CXLk	0.032 (0.026^{2019} - 0.032^{2017})	A (A - A)	0.132 (0.049^{2020} - 0.132^{2017})	A (A - A)
Hawea at Camphill Bridge	CXLk	0.012 (0.01^{2018} - 0.018^{2022})	A (A - A)	0.03 (0.03^{2017} - 0.041^{2022})	A (A - A)
Kawarau @ Chards Rd	CWLk	0.006 (0.006^{2017} - 0.02^{2022})	A (A - A)	0.093 (0.032^{2022} - 0.093^{2017})	A (A - A)
Lindis at Ardgour Road	CDH	0.072 (0.032^{2022} - 0.072^{2017})	A (A - A)	0.205 (0.13^{2020} - 0.205^{2017})	A (A - A)
Lindis at Lindis Peak	CDH	0.015 (0.014^{2018} - 0.019^{2022})	A (A - A)	0.117 (0.077^{2022} - 0.117^{2017})	A (A - A)
Luggate Creek at SH6 Bridge	CWM	0.002 (0.002^{2018} - 0.004^{2022})	A (A - A)	0.015 (0.014^{2018} - 0.016^{2021})	A (A - A)
Mill Creek at Fish Trap	CDH	0.32 (0.32^{2018} - 0.35^{2022})	A (A - A)	0.465 (0.465^{2017} - 0.49^{2020})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Nevis at Wentworth Station	CWM	0.002 (0.002[2019] - 0.002[2020])	A (A - A)	0.01 (0.007[2019] - 0.012[2020])	A (A - A)
Shotover @ Bowens Peak	CWM	0.028 (0.014[2022] - 0.028[2017])	A (A - A)	0.222 (0.031[2021] - 0.222[2017])	A (A - A)

Site-based trends

Over the 20-year trend period six sites, including the Cardrona at Mt. Barker, Clutha at Luggate Bridge, Hawea at Camphill Bridge, Kawarau at Chard Road, Lindis at Lindis Peak, and Luggate Creek at SH6 Bridge, have trend probabilities of *unlikely* to be improving, or lower, indicating nitrate has increased over this period (Table 124). Two sites, the Lindis at Ardgour Road and Shotover at Bowens Peak, have *extremely likely,* or higher, probabilities of improving trends indicating nitrate has decreased at these sites.

Over the 10-year trend period, six sites, including the Cardrona at Mt. Barker, Hawea at Camphill Bridge, Kawarau at Chard Road, Lindis at Lindis Peak, Luggate Creek at SH6 Bridge, and Mill Creek at Fish Trap have *unlikely*, or lower, probabilities of improving, indicating nitrate levels have increased over this period (Table 125). Three sites: Bannockburn at Lake Dunstan, Lindis at Ardgour Road, and Shotover at Bowens Peak, have *likely,* or higher, probabilities of improving indicating nitrate levels have decreased at these sites.

Table 124: Dunstan Rohe 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	118	3.34	0.00	Exceptionally unlikely
Clutha @ Luggate Br	Month	237	3.36	0.00	Exceptionally unlikely
Hawea at Camphill Bridge	BiMonth	96	5.61	0	Exceptionally unlikely
Kawarau @ Chards Rd	Month	236	0.95	0.09	Very unlikely
Lindis at Ardgour Road	BiMonth	99	-3.47	0.98	Extremely likely
Lindis at Lindis Peak	BiMonth	114	0.79	0.21	Unlikely
Luggate Creek at SH6 Bridge	Qtr	64	0.00	0.01	Extremely unlikely
Mill Creek at Fish Trap	BiMonth	118	0.00	0.62	As likely as not

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Shotover @ Bowens Peak	Month	238	-2.18	1.00	Virtually certain

Table 125: Dunstan Rohe 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	0.00	0.83	Likely
Cardrona at Mt Barker	Month	111	6.37	0.00	Exceptionally unlikely
Clutha @ Luggate Br	Month	117	0.00	0.40	As likely as not
Hawea at Camphill Bridge	Month	112	3.61	0.00	Exceptionally unlikely
Kawarau @ Chards Rd	Month	116	8.34	0.00	Exceptionally unlikely
Lindis at Ardgour Road	Month	116	-12.40	1.00	Virtually certain
Lindis at Lindis Peak	Month	111	1.88	0.14	Unlikely
Luggate Creek at SH6 Bridge	Month	111	0.00	0.01	Extremely unlikely
Mill Creek at Fish Trap	Month	112	1.68	0.00	Exceptionally unlikely
Nevis at Wentworth Station	BiMonth	50	0.00	0.61	As likely as not
Shotover @ Bowens Peak	Month	118	-14.52	1.00	Virtually certain

Network state

Network modelling results for nitrate toxicity (Table 126) indicate all segments in the Rohe comply with A-band nitrate toxicity (100%; 100-100).

Table 126: Percent of river segments in the Dunstan Rohe complying with potential nitrate toxicity target attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	1,827

Management Class	Band	Current	Count
M	B	100 (100 - 100)	1,827
M	C	100 (100 - 100)	1,827
H	A	100 (100 - 100)	869
H	B	100 (100 - 100)	869
H	C	100 (100 - 100)	869
L	A	100 (100 - 100)	25
L	B	100 (100 - 100)	25
L	C	100 (100 - 100)	25

Nitrate toxicity state summary

All sites and segments in this Rohe comply with the A-band for nitrate toxicity. However, many sites have probabilities of *unlikely* to be improving, or lower, over both the 10 and 20-year trend periods. To maintain baseline state, measures which reduce nitrate concentrations may be required.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

Many waterways in the Dunstan Rohe, such as the Shotover River, are naturally turbid due to high natural sediment loads.

For sites with sufficient monitoring data, the Clutha at Luggate Bridge, Mill Creek at Fish Trap, and Shotover at Bowens fail to comply with the national bottom line (Table 127). The Lindis at Lindis Peak and Kawarau at Chard Road comply with the C-band but fail to comply with the national bottom line in the rolling analysis. The Lindis at Ardgour Road complies with the B-band and ranges from the C- to B-band in the rolling analysis. The Cardrona at Mt. Barker complies with the A-band during the baseline period and ranges from C to A-band in the rolling analysis. Both the Hawea at Camphill Bridge and Luggate Creek at SH6 Bridge comply with the A-band.

Table 127: Dunstan Rohe clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Bannockburn at Lake Dunstan	CDH		
Cardrona at Mt Barker	CDH	3.111 (2.228^{2022} - 3.131^{2018})	A (C - A)
Clutha @ Luggate Br	CXLk	1.61 (1.61^{2017} - 4.086^{2021})	D (D - A)
Hawea at Camphill Bridge	CXLk	6.209 (6.209^{2017} - 7.141^{2020})	A (A - A)
Kawarau @ Chards Rd	CWLk	2.523 (1.554^{2022} - 2.619^{2018})	C (D - B)
Lindis at Ardgour Road	CDH	2.702 (2.328^{2021} - 2.702^{2017})	B (C - B)
Lindis at Lindis Peak	CDH	2.463 (1.87^{2022} - 2.463^{2017})	C (D - C)
Luggate Creek at SH6 Bridge	CWM	3.353 (3.032^{2022} - 3.353^{2017})	A (A - A)
Mill Creek at Fish Trap	CDH	1.389 (1.173^{2022} - 1.389^{2017})	D (D - D)
Nevis at Wentworth Station	CWM		
Shotover @ Bowens Peak	CWM	1.159 (0.613^{2021} - 1.159^{2017})	D (D - D)

Site-based trends

Over the 20-year trend analysis period nearly all sites have an *unlikely,* or lower¸ probability of improving trend indicating turbidity has increased across the Rohe (Table 128). The exception is the Clutha at Luggate bridge which is *virtually certain* to be improving.

Over the 10-year trend period six sites have probabilities of *unlikely* to be improving, or lower, indicating turbidity has increased. These sites include the Cardrona at Mt. Barker, Kawarau at Chards Road, Lindis at Lindis Peak, Luggate Creek at SH6 Bridge, Mill Creek at Fish Trap and Shotover at Bowens Peak (Table 129). Four sites, including the Lindis at Ardgour Road, Clutha at Luggate Bridge, Hawea at Camphill Bridge, and Nevis at Wentworth Station, have probabilities of *likely* to be improving, or higher, indicating turbidity has decreased.

Table 128: Dunstan Rohe 20-year trends for turbidity for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	119	1.10	0.07	Very unlikely
Clutha @ Luggate Br	Month	236	-5.00	1.00	Virtually certain
Hawea at Camphill Bridge	BiMonth	96	0.89	0.14	Unlikely
Kawarau @ Chards Rd	Month	236	5.07	0.00	Exceptionally unlikely
Lindis at Ardgour Road	BiMonth	100	1.19	0.09	Very unlikely
Lindis at Lindis Peak	BiMonth	114	0.76	0.14	Unlikely
Luggate Creek at SH6 Bridge	BiMonth	96	4.41	0.00	Exceptionally unlikely
Mill Creek at Fish Trap	BiMonth	117	3.61	0.00	Exceptionally unlikely
Shotover @ Bowens Peak	Month	236	8.82	0.00	Exceptionally unlikely

Table 129: Dunstan Rohe 10-year trends for turbidity for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	1.92	0.43	As likely as not
Cardrona at Mt Barker	Month	111	1.34	0.30	Unlikely
Clutha @ Luggate Br	Month	116	-42.33	1.00	Virtually certain
Hawea at Camphill Bridge	Month	112	-4.12	1.00	Virtually certain
Kawarau @ Chards Rd	Month	116	3.87	0.12	Unlikely
Lindis at Ardgour Road	Month	116	-1.46	0.79	Likely
Lindis at Lindis Peak	Month	111	3.40	0.04	Extremely unlikely
Luggate Creek at SH6 Bridge	Month	111	2.69	0.02	Extremely unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Mill Creek at Fish Trap	Month	112	5.15	0.00	Exceptionally unlikely
Nevis at Wentworth Station	BiMonth	50	-1.44	0.68	Likely
Shotover @ Bowens Peak	Month	116	8.80	0.01	Extremely unlikely

Network state

Network modelling results for water clarity show 90% of mountain segments comply with A-band, 97% comply with the B-band and 99% comply with the C-band (Table 130). In the hill management class, 42% of segments comply with the A-band, 69% comply with the B-band and 83% comply with the C-band. For the lowland class, 39% comply with the A-band 56% comply with the B-band and 67% comply with the C-band.

Table 130: Percent of segments in the Dunstan Rohe complying with potential A, B, and C suspended fine sediment target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	90	1,818
M	B	97	1,818
M	C	99	1,818
H	A	42	942
H	B	69	942
H	C	83	942
L	A	39	122
L	B	56	122
L	C	67	122

Suspended sediment state summary.

Many streams in the Dunstan Rohe, such as the Shotover, Kawarau, and potentially some Clutha mainstem sites, are affected by natural occurring process (such as glacial flour) which naturally result in lower water clarity. While Clutha and Kawarau mainstem sites and the Shotover fall below the national bottom line, at least some component of this is likely to be due to natural process. Trends

analysis indicates mixed patterns with some sites having improving trends and others having degraded trends over the 10-year period. Over the 20-year period, degrading trends are common. Appropriate targets are difficult to determine without a better understanding of natural state in these systems and the processes leading to the variability of suspended sediment concentrations. In the interim, to ensure sites maintain state, controls on sediment are required to ensure no further increase.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

Compliance with *E. coli* attribute bands in the Dunstan Rohe is variable, both between sites and within an individual site's rolling analysis (Table 131). Two sites fail to comply with the national bottom line including the Kawarau at Chards Road and Mill Creek at Fish Trap. All other sites comply with the A or B-band with many sites ranging between the A and B-band in the rolling analysis.

Table 131: Dunstan Rohe E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Bannockburn at Lake Dunstan	CDH								
Cardrona at Mt Barker	CDH	36 (36^{2017} - 72.5^{2022})	A (A - A)	269 (267.5^{2019} - 652.2^{2022})	A (A - B)	0.054 (0.051^{2019} - 0.111^{2022})	A (A - A)	0.036 (0.034^{2019} - 0.056^{2022})	A (A - B)
Clutha @ Luggate Br	CXLk	63.85 (3.1^{2021} - 63.85^{2017})	A (A - A)	602.65 (48.01^{2021} - 602.65^{2017})	B (A - B)	0.15 (0^{2022} - 0.15^{2017})	A (A - A)	0.05 (0^{2021} - 0.05^{2017})	B (A - B)
Hawea at Camphill Bridge	CXLk	1.157 (1.157^{2017} - 2^{2022})	A (A - A)	29.2 (18.55^{2022} - 34.85^{2020})	A (A - A)	0.018 (0^{2022} - 0.018^{2017})	A (A - A)	0 (0^{2021} - 0^{2021})	A (A - A)
Kawarau @ Chards Rd	CWLk	143.9 (5.75^{2022} - 143.9^{2017})	D (A - D)	1439.07 (272.24^{2022} - 1439.07^{2017})	D (A - D)	0.288 (0.058^{2022} - 0.288^{2017})	B (A - B)	0.136 (0.019^{2022} - 0.136^{2017})	C (A - C)
Lindis at Ardgour Road	CDH	26.5 (26^{2018} - 79^{2022})	A (A - A)	215.5 (215.5^{2017} - 502.85^{2022})	A (A - A)	0.033 (0.033^{2017} - 0.113^{2022})	A (A - A)	0 (0^{2017} - 0.038^{2022})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Lindis at Lindis Peak	CDH	20.5 (19.75[2019] - 79[2022])	A (A - A)	147 (147[2017] - 507.75[2022])	A (A - A)	0 (0[2017] - 0.132[2022])	A (A - A)	0 (0[2017] - 0.038[2022])	A (A - A)
Luggate Creek at SH6 Bridge	CWM	25 (25[2017] - 72.5[2022])	A (A - A)	351 (296.2[2020] - 659[2022])	A (A - B)	0.054 (0.054[2017] - 0.13[2022])	A (A - A)	0.018 (0.018[2017] - 0.056[2022])	A (A - B)
Mill Creek at Fish Trap	CDH	135 (87.5[2021] - 135[2017])	D (A - D)	544 (544[2017] - 1340.5[2022])	B (B - D)	0.315 (0.22[2020] - 0.315[2017])	C (B - C)	0.056 (0.051[2019] - 0.164[2022])	B (B - C)
Nevis at Wentworth Station	CWM								
Shotover @ Bowens Peak	CWM	50.9 (6.3[2021] - 50.9[2017])	A (A - A)	704.6 (77.115[2020] - 704.6[2017])	B (A - B)	0.1 (0.018[2020] - 0.1[2017])	A (A - A)	0.05 (0[2020] - 0.05[2017])	B (A - B)

Site-based trends

Over the 20-year trend period four sites, including the Cardrona at Mt. Barker, Lindis at Ardgour, Lindis at Lindis Peak, and Luggate at SH6 Bridge, have trend probabilities of *unlikely* to be improving, or lower, indicating *E. coli* levels have increased (Table 132). Three sites, the Clutha at Luggate Bridge, Kawarau at Chard Road, and Shotover at Bowens, are *virtually certain* to be improving indicating *E. coli* levels have decreased.

Over the 10-year trend period six sites, including the Bannockburn at Lake Dunstan, Cardrona at Mt. Barker, Lindis at Ardgour Road, Lindis at Lindis Peak, Luggate Creek at SH6 Bridge, and Nevis at Wentworth Station, have *very unlikely,* or lower, probabilities of improving indicating that *E. coli* levels have increased (Table 133). Four sites, the Clutha at Luggate Bridge, Kawarau at Chards Road, Mill Creek at Fish Trap, and Shotover at Bowens Peak, have probabilities of *likely* to be improving, or higher, indicating that *E. coli* levels have decreased.

Table 132: Dunstan Rohe 20-year trends for E. coli for the 2002-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	119	1.67	0.12	Unlikely
Clutha @ Luggate Br	Month	202	-14.03	1.00	Virtually certain
Hawea at Camphill Bridge	Qtr	64	0.00	0.50	As likely as not
Kawarau @ Chards Rd	Month	202	-7.95	1.00	Virtually certain
Lindis at Ardgour Road	BiMonth	100	3.57	0.02	Extremely unlikely
Lindis at Lindis Peak	BiMonth	113	5.10	0.00	Exceptionally unlikely
Luggate Creek at SH6 Bridge	BiMonth	96	4.37	0.00	Exceptionally unlikely
Mill Creek at Fish Trap	BiMonth	118	0.00	0.50	As likely as not
Shotover @ Bowens Peak	Month	202	-8.50	1.00	Virtually certain

Table 133: Dunstan Rohe 10-year trends for E. coli for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	9.89	0.00	Exceptionally unlikely
Cardrona at Mt Barker	Month	111	8.37	0.00	Exceptionally unlikely
Clutha @ Luggate Br	Month	114	-108.79	1.00	Virtually certain
Hawea at Camphill Bridge	Qtr	40	0	0.55	As likely as not
Kawarau @ Chards Rd	Month	113	-23.08	1.00	Virtually certain
Lindis at Ardgour Road	Month	115	10.00	0.00	Exceptionally unlikely
Lindis at Lindis Peak	Month	110	14.28	0.00	Exceptionally unlikely
Luggate Creek at SH6 Bridge	Month	111	2.66	0.06	Very unlikely
Mill Creek at Fish Trap	Month	110	-1.99	0.85	Likely
Nevis at Wentworth Station	BiMonth	50	11.86	0.02	Extremely unlikely
Shotover @ Bowens Peak	Month	114	-26.97	1.00	Virtually certain

Network state

Network modelling results for *E. coli* indicate that 63% (0-100) of segments in the mountain class comply with the A-band, 83% (7-100) comply with the B-band and 93% (49-100) comply with the C-band (Table 134). In the hill management class 34% (0-96) comply with the A-band, 57% (1-100) comply with the B-band and 77% (5-100) comply with the C-band. For the lowland class, the A-band is complied with in 11% (0-63), the B-band is complied with in 31% (0-100) and the C-band is complied with in 54% (2-100). Confidence intervals are wide and, for the C-band, and overlap 100% in all classes. This indicates there is less than 95% confidence that a reduction in *E. coli* concentrations is required to comply with the national bottom line. However, the mean percentage is well below 100% in both hill and lowland classes and many sites have trends which indicate increasing *E. coli* levels. As a result, management measures may be required to ensure the national bottom line is met, or continues to be met, across the FMU.

Table 134: Percent of river segments in the Dunstan Rohe complying with potential E. coli target attribute stats (TAS) with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	63 (0 - 100)	1,619
M	B	83 (7 - 100)	1,619
M	C	93 (49 - 100)	1,619
H	A	34 (0 - 96)	934
H	B	57 (1 - 100)	934
H	C	77 (5 - 100)	934
L	A	11 (0 - 63)	116
L	B	31 (0 - 100)	116
L	C	54 (2 - 100)	116

E. coli state summary

Two monitoring sites in the Dunstan Rohe fail to comply with the *E. coli* national bottom line. Trend results are mixed with some sites improving over the 10 and 20-year periods and others degrading. Network modelling indicates hill and lowland class confidence intervals overlap 100%. The upper confidence interval indicates that there is less than 95% confidence that a reduction is required to for all segments to comply with the national bottom line. However, the lower confidence interval fails to overlap 100% indicating there is also less than 95% confidence all segments in the FMU comply with the national bottom line. To maintain state, measures which allow no further *E. coli* inputs would be required. To improve from the current state, reductions in *E. coli* concentrations are required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

All sites in the Dunstan Rohe comply with the A-band criteria for dissolved reactive phosphorus except for the Clutha at Luggate Bridge which complies with the B-band and the Luggate Creek at SH6 Bridge which complies with the C-band (Table 135).

Table 135: Dunstan Rohe DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Bannockburn at Lake Dunstan	CDH	0.005 (0.003^{2022} - 0.005^{2018})	A (A - A)	0.008 (0.005^{2022} - 0.008^{2017})	A (A - A)
Cardrona at Mt Barker	CDH	0.004 (0.002^{2022} - 0.004^{2017})	A (A - A)	0.006 (0.004^{2022} - 0.006^{2017})	A (A - A)
Clutha @ Luggate Br	CXLk	0.008 (0^{2022} - 0.008^{2017})	B (A - B)	0.022 (0.001^{2021} - 0.022^{2017})	B (A - B)
Hawea at Camphill Bridge	CXLk	0.002 (0.001^{2021} - 0.002^{2020})	A (A - A)	0.004 (0.003^{2022} - 0.004^{2018})	A (A - A)
Kawarau @ Chards Rd	CWLk	0.005 (0.001^{2022} - 0.005^{2017})	A (A - A)	0.008 (0.006^{2022} - 0.008^{2017})	A (A - A)
Lindis at Ardgour Road	CDH	0.003 (0.002^{2022} - 0.003^{2017})	A (A - A)	0.005 (0.004^{2022} - 0.006^{2019})	A (A - A)
Lindis at Lindis Peak	CDH	0.004 (0.002^{2022} - 0.004^{2018})	A (A - A)	0.006 (0.005^{2022} - 0.007^{2020})	A (A - A)
Luggate Creek at SH6 Bridge	CWM	0.011 (0.009^{2022} - 0.011^{2017})	C (B - C)	0.017 (0.011^{2022} - 0.017^{2017})	A (A - A)
Mill Creek at Fish Trap	CDH	0.006 (0.004^{2022} - 0.006^{2018})	A (A - A)	0.013 (0.009^{2019} - 0.013^{2017})	A (A - A)
Nevis at Wentworth Station	CWM	0.005 (0.003^{2022} - 0.005^{2017})	A (A - A)	0.007 (0.005^{2022} - 0.007^{2018})	A (A - A)
Shotover @ Bowens Peak	CWM	0.005 (0^{2021} - 0.005^{2017})	A (A - A)	0.014 (0.002^{2022} - 0.014^{2017})	A (A - A)

Site-based trends

Over the 20-year trend period, all sites have *likely,* or higher, probabilities of improving trends for DRP, indicating DRP levels have decreased across the Rohe (Table 136). Over the 10-year trend period all sites have *extremely likely*, or higher, trend probabilities of improving, indicating DRP has decreased across the Rohe (Table 137).

Table 136: Dunstan Rohe 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	115	0.00	1.00	Virtually certain
Clutha @ Luggate Br	Month	237	-10.69	1.00	Virtually certain
Hawea at Camphill Bridge	Qtr	64			Not Analysed
Kawarau @ Chards Rd	Month	229	-3.96	1.00	Virtually certain
Lindis at Ardgour Road	BiMonth	97	0.00	1.00	Virtually certain
Lindis at Lindis Peak	BiMonth	109	0.00	1.00	Virtually certain
Mill Creek at Fish Trap	BiMonth	118	0.00	0.67	Likely
Shotover @ Bowens Peak	Month	238	-8.33	1.00	Virtually certain

Table 137: Dunstan Rohe 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	0.00	0.97	Extremely likely
Cardrona at Mt Barker	Month	111	0.00	1.00	Virtually certain
Clutha @ Luggate Br	Month	117	-142.40	1.00	Virtually certain
Hawea at Camphill Bridge	Month	112			Not Analysed
Kawarau @ Chards Rd	Month	109	-19.18	1.00	Virtually certain
Lindis at Ardgour Road	Month	115	0.00	1.00	Virtually certain
Lindis at Lindis Peak	Month	110	0.00	1.00	Virtually certain

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Luggate Creek at SH6 Bridge	Month	111	-3.29	1.00	Virtually certain
Mill Creek at Fish Trap	Month	111	0.00	0.99	Extremely likely
Nevis at Wentworth Station	BiMonth	50	-15.88	1.00	Virtually certain
Shotover @ Bowens Peak	Month	118	-62.69	1.00	Virtually certain

Dissolved reactive phosphorus state summary

Most sites in the Dunstan Rohe comply with the DRP A-band. All sites also have improving trends over the 10- and 20-year trend period. Whether phosphorus reductions are required depends upon the target attribute state set for this table, requirements of the downstream lake receiving environment requirements and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

The three periphyton biomass monitoring sites in the Dunstan Rohe all comply with the B-band. A rolling analysis is not possible due to insufficient data (Table 138).

Table 138: Dunstan Rohe periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Cardrona at Mt Barker	56	B	28
Lindis at Ardgour Road	115	B	23
Luggate Creek at SH6 Bridge	97	B	32

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, all sites comply with the C-band criteria, or better, therefore meeting the national bottom line (Table 139). All sites except for Mill Creek at Fish Trap also comply with the B-band criteria. One site, the Hawea at Camphill Bridge, complies with the A-band criteria.

For total phosphorus in relation to the periphyton biomass 20% under-protection, all sites comply with the C-band criteria (Table 139). The Clutha at Luggate Bridge, Hawea at Camphill Bridge, Luggate Creek at SH6 Bridge, Nevis at Wentworth Station and Shotover at Bowens Peak comply with the B-band criteria.

No monitored sites fail to comply with the C-band criteria for total nitrogen or phosphorus, indicating the majority of the FMU would be expected to comply.

Table 139: Dunstan Rohe total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Bannockburn at Lake Dunstan	CDH	0.072 (0.072^{2017} - 0.086^{2022})	B (B - B)	0.01 (0.006^{2022} - 0.01^{2018})	C (C - C)
Cardrona at Mt Barker	CDH	0.14 (0.14^{2018} - 0.151^{2022})	B (B - B)	0.008 (0.006^{2021} - 0.008^{2017})	C (C - C)
Clutha @ Luggate Br	CXLk	0.275 (0.065^{2022} - 0.275^{2017})	B (B - B)	0.03 (0.002^{2021} - 0.03^{2017})	B (B - B)
Hawea at Camphill Bridge	CXLk	0.043 (0.037^{2020} - 0.043^{2017})	A (A - A)	0.004 (0.001^{2018} - 0.004^{2017})	B (B - B)
Kawarau @ Chards Rd	CWLk	0.239 (0.062^{2022} - 0.239^{2017})	B (B - B)	0.019 (0.018^{2022} - 0.019^{2018})	C (C - C)
Lindis at Ardgour Road	CDH	0.155 (0.109^{2021} - 0.155^{2017})	B (B - B)	0.008 (0.006^{2022} - 0.008^{2019})	C (C - C)
Lindis at Lindis Peak	CDH	0.083 (0.078^{2021} - 0.083^{2018})	B (B - B)	0.01 (0.006^{2022} - 0.01^{2017})	C (C - C)
Luggate Creek at SH6 Bridge	CWM	0.074 (0.068^{2019} - 0.074^{2017})	B (B - B)	0.018 (0.016^{2022} - 0.019^{2020})	B (B - B)
Mill Creek at Fish Trap	CDH	0.51 (0.488^{2020} - 0.51^{2017})	C (C - C)	0.024 (0.019^{2022} - 0.024^{2017})	C (C - C)
Nevis at Wentworth Station	CWM	0.057 (0.055^{2021} - 0.058^{2019})	B (B - B)	0.008 (0.006^{2022} - 0.008^{2019})	B (B - B)
Shotover @ Bowens Peak	CWM	0.284 (0.05^{2022} - 0.284^{2017})	B (B - B)	0.028 (0.028^{2018} - 0.032^{2022})	B (B - C)

Site-based trends

Over the 20-year total nitrogen trend period two sites, the Cardrona at Mt. Barker and Luggate Creek at SH6, have *extremely unlikely*, or lower, probabilities of improving trend indicating total nitrogen has increased at these sites (Table 140). All other sites have *likely,* or higher, probabilities of improving trend indicating total nitrogen levels have decreased with the exception of Mill Creek at Fish Trap. This site is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Over the 10-year total nitrogen trend period six sites, including the Bannockburn at Lake Dunstan, Clutha at Luggate Bridge, Kawarau at Chards Road, Lindis at Ardgour, Luggate Creek at SH6 Bridge and Shotover at Bowens Peak have *likely* to be improving trend probabilities, or higher, indicating total nitrogen levels have decreased at these sites (Table 141). The Cardrona at Mt. Barker and Mill Creek at Fish Trap are *exceptionally unlikely* to be improving which suggests total nitrogen levels have increased at these sites.

Table 140: Dunstan Rohe 20-year trends for total nitrogen for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	118	1.85	0.00	Exceptionally unlikely
Clutha @ Luggate Br	Month	237	-5.64	1.00	Virtually certain
Hawea at Camphill Bridge	BiMonth	96			Not Analysed
Kawarau @ Chards Rd	Month	237	-4.29	1.00	Virtually certain
Lindis at Ardgour Road	BiMonth	99	0.00	0.83	Likely
Lindis at Lindis Peak	Qtr	76			Not Analysed
Luggate Creek at SH6 Bridge	BiMonth	96	0.00	0.04	Extremely unlikely
Mill Creek at Fish Trap	BiMonth	118	0.00	0.60	As likely as not
Shotover @ Bowens Peak	Month	238	-5.80	1.00	Virtually certain

Table 141: Dunstan Rohe 10-year trends for total nitrogen for the 2012-2022 period

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	0.00	0.79	Likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	Month	110	4.26	0.00	Exceptionally unlikely
Clutha @ Luggate Br	Month	117	-43.71	1.00	Virtually certain
Hawea at Camphill Bridge	Month	111			Not Analysed
Kawarau @ Chards Rd	Month	117	-14.61	1.00	Virtually certain
Lindis at Ardgour Road	Month	115	-7.59	1.00	Virtually certain
Lindis at Lindis Peak	Qtr	40			Not Analysed
Luggate Creek at SH6 Br	Month	111	0.00	0.78	Likely
Mill Creek at Fish Trap	Month	111	1.51	0.00	Exceptionally unlikely
Nevis at Wentworth Station	BiMonth	50			Not Analysed
Shotover @ Bowens Peak	Month	118	-45.49	1.00	Virtually certain

Over the 20-year total phosphorus trend period, all sites have *likely*, or higher, probabilities of improving, indicating total phosphorus has decreased across the Rohe (Table 142). This pattern is also present over the 10-year period for total phosphorus trend (Table 143).

Table 142: Dunstan Rohe 20-year trends for total phosphorus for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	BiMonth	115	0.00	0.84	Likely
Clutha @ Luggate Br	Month	237	-8.50	1.00	Virtually certain
Kawarau @ Chards Rd	Month	234	-0.31	0.69	Likely
Lindis at Ardgour Road	BiMonth	97			Not Analysed
Lindis at Lindis Peak	BiMonth	109	0.00	0.93	Very likely
Mill Creek at Fish Trap	BiMonth	118	-0.37	0.73	Likely
Shotover @ Bowens Peak	Month	238	-0.49	0.76	Likely

Table 143: Dunstan Rohe 10-year trends for total phosphorus for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Bannockburn at Lake Dunstan	BiMonth	54	-3.10	0.82	Likely
Cardrona at Mt Barker	Month	111	-7.15	1.00	Virtually certain
Clutha @ Luggate Br	Month	117	-145.01	1.00	Virtually certain
Hawea at Camphill Bridge	Month	112	0.00	1	Virtually certain
Kawarau @ Chards Rd	Month	114	-3.86	0.96	Extremely likely
Lindis at Ardgour Road	Month	116	-8.34	1.00	Virtually certain
Lindis at Lindis Peak	Month	111	-7.13	1.00	Virtually certain
Luggate Creek at SH6 Br	Month	111	-1.48	0.97	Extremely likely
Mill Creek at Fish Trap	Month	112	-0.77	0.73	Likely
Nevis at Wentworth Station	BiMonth	50	-2.25	0.88	Likely
Shotover @ Bowens Peak	Month	118	-1.91	0.76	Likely

Network state

For total nitrogen in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results show 100% (100-100) of mountain segments comply with the B-band criteria (Table 144). In the hill management class, 86% (23-100) comply with the B-band criteria and 100% (100-100) comply with the C-band criteria. For the lowland class, 0% (0-0) comply with the B-band criteria and 91% (60-100) comply with the C-band criteria. Few segments comply with the A-band criteria in any management class.

For total phosphorus in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results show 95% (84-100) of mountain segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria (Table 144). In the hill management class, 14% (8-54) comply with the B-band criteria and 99% (97-100) comply with the C-band criteria. For the lowland class, 3% (0-20) comply with the B-band criteria and 95% (68-100) comply with the C-band criteria. Few segments comply with the A-band criteria in any management class.

Table 144: Percent of river segments in the Dunstan Rohe complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Nitrogen	Phosphorus	Total segments
M	A	29 (0 - 88)	0 (0 - 0)	1,827
M	B	100 (100 - 100)	94 (83 - 100)	1,827
M	C	100 (100 - 100)	100 (100 - 100)	1,827
H	A	7 (0 - 30)	0 (0 - 0)	869
H	B	87 (54 - 100)	13 (9 - 33)	869
H	C	100 (100 - 100)	99 (92 - 100)	869
L	A	1 (0 - 0)	0 (0 - 0)	25
L	B	3 (0 - 40)	1 (0 - 0)	25
L	C	89 (64 - 100)	91 (48 - 100)	25

Periphyton biomass state summary

In the Dunstan Rohe, all three periphyton biomass monitoring sites comply with the B-band. When compared to the 20% under-protection risk periphyton nutrient criteria, all monitoring sites comply with the C-band criteria for total nitrogen and total. Total nitrogen trends indicate increasing total nitrogen levels for many sites over both the 20 and 10-year trend periods. Total phosphorus trends indicate decreasing total phosphorus levels at most sites over both the 20 and 10-year periods. Network modelling confidence intervals overlap the 100% in the confidence interval for the C-band in all classes indicating less than 95% confidence that nitrogen and phosphorus reduction is required for all segments to comply with the C-band criteria. To maintain the baseline state, measure which allow no further increase in total nitrogen are required to stop degrading trends. If the B-band is set as the target attribute state, reductions will be required for all segments, and monitoring sites, to comply.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

Four sites in the Dunstan Rohe have sufficient information for macroinvertebrate NOF score calculations in the baseline period (Table 145). For MCI, the Cardrona at Mt. Barker, Lindis at Ardgour and Luggate Creek at SH6- Bridge comply with the C-band whereas Mill Creek at Fish Trap fails to comply with the C-band. As a result, this site fails to comply with the national bottom line. For APSM,

two sites: the Cardrona at Mt. Barker and Luggate Creek at SH6 Bridge comply with the B-band. The Lindis at Ardgour complies with the C-band and ranges from C to B-band in the rolling analysis. Mill Creek at Fish Trap complies with the C-band but ranges from D- to C-band in the rolling analysis, thus failing to comply with the national bottom line.

Table 145: Dunstan Rohe macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Bannockburn at Lake Dunstan	CDH				
Cardrona at Mt Barker	CDH	107.62 (105.9^{2022} - 107.6^{2017})	C (C - C)	0.53 (0.46^{2021} - 0.53^{2017})	B (B - B)
Clutha @ Luggate Br	CXLk				
Hawea at Camphill Br	CXLk				
Kawarau @ Chards Rd	CWLk				
Lindis at Ardgour Road	CDH	103.16 (101.25^{2018} - 106.32^{2022})	C (C - C)	0.38 (0.32^{2019} - 0.42^{2021})	C (C - B)
Lindis at Lindis Peak	CDH				
Luggate Creek at SH6 Bridge	CWM	108.42 (106.32^{2021} - 108.42^{2018})	C (C - C)	0.52 (0.47^{2020} - 0.52^{2017})	B (B - B)
Mill Creek at Fish Trap	CDH	86.67 (83.26^{2021} - 86.67^{2017})	D (D - D)	0.33 (0.26^{2020} - 0.36^{2022})	C (D - C)
Nevis at Wentworth St	CWM				
Shotover @ Bowens	CWM				

Site-based trends

Over the 20-year MCI trend period, the Cardrona at Mt. Barker is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading. Both the Lindis at Ardgour Road and Luggate Creek at SH6 Bridge have *likely,* or higher, probabilities of improving trend indicating MCI has increased at these sites (Table 146).

Over the 10-year trend period, the Cardrona Mt. Barker is *unlikely* to be improving indicating MCI has decreased over this period. The Lindis at Ardgour is *likely* to be improving indicating MCI has increased and the Luggate Creek at SH6 Bridge is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading(Table 147).

Table 146: Dunstan Rohe 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	Year	18	0.05	0.41	As likely as not
Lindis at Ardgour Road	Year	17	0.25	0.27	Likely
Luggate Creek at SH6 Bridge	Year	17	0.37	0.05	Extremely likely

Table 147: Dunstan Rohe 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	Year	10	-0.45	0.70	Unlikely
Lindis at Ardgour Road	Year	10	0.49	0.24	Likely
Luggate Creek at SH6 Bridge	Year	10	-0.18	0.50	As likely as not

Over the 20-year ASPM trend period, the Cardrona at Mt. Barker and Luggate Creek at SH6 Bridge have *very likely* or higher probabilities of improving trend indicating ASPM has increased (Table 148). The Lindis at Ardgour Road is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Over the 10-year ASPM trend period, the Cardrona at Mt. Barker is *unlikely* to be improving indicating that the ASPM has decreased. The Lindis at Ardgour Road and Luggate Creek at SH6 Bridge are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (Table 149).

Table 148: Dunstan Rohe 20-year trends for the average score per metric (ASPM) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	Year	16	2.29	0.06	Very likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Lindis at Ardgour Road	Year	16	0.18	0.45	As likely as not
Luggate Creek at SH6 Bridge	Year	16	3.25	0.02	Extremely likely

Table 149: Dunstan Rohe 10-year trends for the average score per metric (ASPM) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Cardrona at Mt Barker	Year	9	-2.97	0.87	Unlikely
Lindis at Ardgour Road	Year	9	2.16	0.46	As likely as not
Luggate Creek at SH6 Bridge	Year	9	-0.77	0.58	As likely as not

Network state

Network modelling results for MCI show 81% of mountain segments comply with the B-band and 100% of segments comply with the C-band (Table 150). In the hill management class 35% of segments comply with the B-band and 100% of segments comply with the C-band. For the lowland class, 0% of segments comply with the B-band and 100% of segments comply with the C-band.

Table 150: Percent of segments in the Dunstan Rohe complying with potential A,B and C macroinvertebrate community index (MCI) target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	1,813
M	B	81	1,813
M	C	100	1,813
H	A	0	907
H	B	35	907
H	C	100	907
L	A	0	100
L	B	0	100

Management Class	Band	Segment %	# of Segments
L	C	100	100

Macroinvertebrate state summary

One out of four macroinvertebrate monitoring sites in the Dunstan Rohe fails to comply with the national bottom line for MCI and ASPM across the rolling analysis. Network results show all segments comply with the national bottom line. Over the 10-year trend period, one site is *unlikely* to be improving trend. Over the 20-year trend period, trends are neutral or improving. To comply with the national bottom line, improvements across the Rohe are generally not required. Instead, localized response may be needed for non-complying sites. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Site-based baseline state

Fish IBI is available in the baseline period for three sites (Table 151). The Cardrona at Mt. Barker complies with the C-band and ranges from C to A-band in the rolling analysis. The Lindis at Ardgour Road fails to comply with the C-band and ranges from D to C-band in the rolling analysis. Lindis at Lindis Crossing fails to comply with the C-band across the rolling analysis.

Table 151: Dunstan Rohe annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Cardrona at Mount Barker	18 (18^{2017} - 42^{2018})	C (C - A)	B (B - A)
Lindis at Ardgour Road	16 (16^{2016} - 20^{2022})	D (D - C)	C (C - B)
Lindis at Lindis Crossing	16 (16^{2013} - 16^{2013})	D (D - D)	C (C - C)
Lindis at Lindis Peak	NA (18^{2022} - 18^{2022})	NA (C - C)	NA (B - B)
Luggate Creek at SH6 Br	NA (12^{2013} - 12^{2013})	NA (D - D)	NA (C - C)
Mill Creek at Fish Trap	NA (18^{2014} - 38^{2016})	NA (C - A)	NA (B - A)

Roxburgh Rohe

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

Both monitoring sites in the Roxburgh Rohe comply with A-band nitrate toxicity (Table 152).

Table 152: Roxburgh Rohe NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017- 5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Benger burn at SH8	CDH	0.006 (0.002^{2022} - 0.006^{2017})	A (A - A)	0.014 (0.003^{2022} - 0.014^{2017})	A (A - A)
Clutha @ Millers Flat	CWLk	0.002 (0.001^{2022} - 0.002^{2017})	A (A - A)	0.005 (0.003^{2022} - 0.005^{2017})	A (A - A)

Site-based trends

Over the 20-year trend period the Clutha at Millers Flat is *unlikely* to be improving indicating ammoniacal nitrogen has increased at this site (Table 153). Over the 10-year period the site is *very likely* to be improving indicating ammoniacal nitrogen has decreased (Table 154).

Table 153: Roxburgh Rohe 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	238	0	0.3	Unlikely

Table 154: Roxburgh Rohe 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	119	0	0.91	Very likely

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Roxburgh Rohe comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

Both sites in the Roxburgh Rohe comply with A-band nitrate toxicity (Table 155).

Table 155: Roxburgh Rohe NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017 to 5-year period ending August end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Benger burn at SH8	CDH	0.22 (0.22^{2017} - 0.26^{2022})	A (A - A)	1.236 (1.236^{2017} - 1.48^{2022})	A (A - A)
Clutha @ Millers Flat	CWLk	0.027 (0.027^{2017} - 0.03^{2021})	A (A - A)	0.067 (0.05^{2022} - 0.067^{2017})	A (A - A)

Site-based trends

Over the 20-year trend period, the Clutha at Millers Flat is *extremely likely* to improving indicating nitrate levels have decreased (Table 156). Similar patterns are present in the 10-year trend period (Table 157).

Table 156: Roxburgh Rohe 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	238	-0.6	0.98	Extremely likely

Table 157: Roxburgh Rohe 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	119	-1.04	0.93	Very likely

Network state

Network analysis indicates all segments in all classes comply with the B-band (100%; 100-100) thus complying with the national bottom line (Table 158). All segments in the mountain and hill management classes also comply with the A-band criteria. In the lowland class, 99% (91-100) of segments comply with the A-band.

Table 158: Percent of river segments in the Roxburgh Rohe complying with potential nitrate toxicity target attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	200
M	B	100 (100 - 100)	200
M	C	100 (100 - 100)	200
H	A	100 (100 - 100)	541
H	B	100 (100 - 100)	541
H	C	100 (100 - 100)	541
L	A	99 (91 - 100)	64
L	B	100 (100 - 100)	64

Management Class	Band	Current	Count
L	C	100 (100 - 100)	64

Nitrate toxicity state summary

All sites and nearly all segments in the Roxburgh Rohe comply with the A-band for nitrate toxicity. The trend in the Clutha mainstem is unlikely to be indicative of overall trends in this FMU. To maintain the baseline state, a precautionary approach with measures to restrict intensification to flatten trends may be required.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

The Clutha at Miller Flat fails to comply with the national bottom line for clarity and ranges D to C-band over the rolling period (Table 159). However, this site is exempt from the national bottom line due to natural process such as glacial flour.

Table 159: Roxburgh Rohe clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Benger burn at SH8	CDH		
Clutha @ Millers Flat	CWLk	2.145 (2.145^{2017} - 2.343^{2018})	D (D - C)

Site-based trends

Over the 20-year trend period, the Clutha at Millers Flat is *unlikely* to be improving, indicating turbidity has increased (Table 160). In the 10-year trend period, the Clutha at Millers flat is *very likely* to be improving, indicating turbidity has decreased (Table 161).

Table 160: Roxburgh Rohe 20-year trends for turbidity for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	238	0.98	0.12	Unlikely

Table 161: Roxburgh Rohe 10-year trends for turbidity for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	119	-3.77	0.94	Very likely

Network state

Network modelling results for clarity show 80% of mountain segments in the Rohe comply with the A-band, 93% comply with the B-band and 100% comply with the C-band (Table 162). In the hill management class, 4% comply with the A-band, 32% comply with the B-band and 65% comply with the C-band. For the lowland class, 28% comply with the A-band 58% comply with the B-band and 65% comply with the C-band. A portion of both the hill and lowland class therefore fails to comply with the national bottom line.

Table 162: Percent of segments in the Roxburgh Rohe complying with potential A, B, and C suspended fine sediment target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	80	200
M	B	93	200
M	C	100	200
H	A	4	600
H	B	32	600
H	C	65	600
L	A	28	151
L	B	58	151
L	C	65	151

Suspended sediment state summary

Clutha mainstem sites, are affected by natural occurring process (such as glacial flour) which naturally result in lower clarity. While mainstem sites fail to comply with the national bottom line, a large component of this is likely to be due to natural process. Trends analysis indicates mixed patterns with an improving trend over the 10-year period and degrading trend over the 20-year period. Appropriate targets are difficult to determine without a better understanding of natural state in these systems. In the interim, to ensure sites maintain state, controls on sediment are required.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

The Clutha at Millers Flat complies with the A-band for *E. coli* (Table 163).

Table 163: Roxburgh Rohe E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017-5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Benger burn at SH8	CDH								
Clutha @ Millers Flat	CWLk	9.7 (9.7^{2018} - 14.275^{2022})	A (A - A)	60.3 (60.3^{2017} - 166.49^{2022})	A (A - A)	0.017 (0.017^{2017} - 0.036^{2022})	A (A - A)	0.017 (0.017^{2017} - 0.018^{2022})	A (A - A)

Site-based trends

Over both the 20-year (Table 164) and 10-year (Table 165) trend periods the Clutha at Millers Flat is *unlikely* to be improving indicating that *E. coli* levels have increased.

Table 164: Roxburgh Rohe 20-year trends for E. coli for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	207	1.46	0.12	Unlikely

Table 165: Roxburgh Rohe 10-year trends for E. coli for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	119	2.49	0.25	Unlikely

Network state

E. coli network modelling results show that 60% (0-100) of mountain segments comply with the A-band, 81% (0-100) comply with the B-band and 93% (66-100) comply with the C-band (Table 166). In the hill class, 24% (0-85) comply with the A-band, 46% (0-100) comply with the B-band and 68% (5-100) comply with the C-band. For the lowland management class, 9% (0-46) comply with the A-band, 25% (0-99) comply with the B-band and 46% (0-100) comply with the C-band. Confidence intervals are wide and, for the C-band, overlap 100% in all classes. This indicates less than 95% confidence that a reduction in *E. coli* is required to comply with the national bottom line. However, the mean percentage is well below 100% in both hill and lowland classes suggesting that management measures may be required to ensure the national bottom line is, or continues to be, met across the FMU.

Table 166: Percent of river segments in the Roxburgh Rohe complying with potential E. coli target attribute bands with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	60 (0 - 100)	200
M	B	81 (0 - 100)	200
M	C	93 (66 - 100)	200
H	A	24 (0 - 85)	602
H	B	46 (0 - 100)	602
H	C	68 (5 - 100)	602
L	A	9 (0 - 46)	151
L	B	25 (0 - 99)	151
L	C	46 (0 - 100)	151

E. coli state summary

The single monitoring site in the Roxburgh Rohe complies with the A-band for *E. coli*. Trend analysis suggests a potential degrading trend over both the 10 and 20-year periods. Network modelling indicates hill and lowland class confidence intervals overlap 100%. The upper confidence interval indicates there is less than 95% confidence that a reduction is required to for all segments to comply with the national bottom line. However, the lower confidence interval fails to overlap 100% indicating there is less than 95% confidence all segments in the FMU comply. To maintain baseline state, measures which allow no further increase in *E. coli* inputs would be required. To improve state, measures which result in reductions in *E. coli* concentrations are required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

For DRP, the Benger Burn at SH8 complies with the C-band with a median statistic ranging from C to B-band in the rolling analysis and the Clutha at Millers Flat complies with the A-band (Table 167).

Table 167: Roxburgh Rohe DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Benger burn at SH8	CDH	0.017 (0.01^{2022} - 0.017^{2017})	C (B - C)	0.038 (0.038^{2017} - 0.045^{2022})	C (C - C)
Clutha @ Millers Flat	CWLk	0.001 (0.001^{2017} - 0.001^{2022})	A (A - A)	0.003 (0.003^{2021} - 0.003^{2019})	A (A - A)

Dissolved reactive phosphorus state summary

Both sites in the Roxburgh Rohe comply with DRP C-band, or better. DRP trends are not available for these sites. Whether reductions in phosphorus inputs are required depends upon the target attribute state set for this table, requirements of the downstream lake receiving environment requirements and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

No periphyton biomass monitoring is available for this FMU.

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria all sites comply with the C-band criteria, or better, therefore are expected to meet the national bottom line (Table 168). The Benger Burn at SH8 complies with the C-band criteria and the Clutha at Millers Flat complies with the B-band criteria. For total phosphorus, the Benger Burn at SH8 fails to comply with the C-band criteria and the Clutha at Millers Flat complies with the B criteria.

Table 168: Roxburgh Rohe total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Benger burn at SH8	H	0.6 (0.6^{2021} - 0.72^{2022})	C (C - C)	0.034 (0.024^{2022} - 0.038^{2019})	D (C - D)
Clutha @ Millers Flat	Lk	0.088 (0.077^{2022} - 0.088^{2017})	B (B - B)	0.005 (0.004^{2022} - 0.005^{2017})	B (B - B)

Site-based trends

Over the 20-year total nitrogen trend period the Clutha at Millers flat is *extremely likely* to be improving (Table 169) and over the 10-year period *virtually certain* (Table 170). This indicates total nitrogen levels have decreased at this site.

Table 169: Roxburgh Rohe 20-year trends for total nitrogen for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	234	-0.52	0.97	Extremely likely

Table 170: Roxburgh Rohe 10-year trends for total nitrogen for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	117	-2.12	1	Virtually certain

Over the both 20- and 10-year total phosphorus trend period, the Clutha at Millers flat is *as likely as not* to be improving. This is an ambiguous result classes neither improving nor degrading (Table 171, Table 172).

Table 171: Roxburgh Rohe 20-year trends for total phosphorus for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	236	0	0.53	As likely as not

Table 172: Roxburgh Rohe 10-year trends for total phosphorus for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Millers Flat	Month	118	0	0.42	As likely as not

Network state

For total nitrogen in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results show 100% (100-100) of mountain segments comply with the B-band criteria (Table 173). In the hill management class, 66% (14-99) comply with the B-band criteria and 100% (100-100) comply with the C-band criteria. For the lowland class, few segments comply with the B-band criteria (2% 0-27) and 76% (42-100) comply with the C-band criteria. Few segments comply with the A-band criteria in any class.

For total phosphorus, 74% (24-100) of mountain segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria. In the hill management class, 11% (1-12) comply with the B-band criteria and 90% (45-100) comply with the C-band criteria. For the lowland class, 1% (0-0) comply with the B-band criteria and 81% (34-100) comply with the C-band criteria. No segments comply with the A-band criteria in any class.

Table 173: Percent of river segments in the Roxburgh Rohe complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	5 (0 - 32)	0 (0 - 0)	200
M	B	100 (100 - 100)	74 (24 - 100)	200

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	C	100 (100 - 100)	100 (100 - 100)	200
H	A	1 (0 - 2)	0 (0 - 0)	541
H	B	66 (14 - 99)	11 (1 - 12)	541
H	C	100 (100 - 100)	90 (45 - 100)	541
L	A	1 (0 - 0)	0 (0 - 0)	64
L	B	2 (0 - 27)	1 (0 - 0)	64
L	C	76 (42 - 100)	81 (34 - 100)	64

Periphyton biomass state summary

The Roxburgh Rohe has no periphyton biomass monitoring sites. When compared to the 20% under-protection risk periphyton biomass nutrient criteria, all monitoring sites comply with the C-band criteria for total nitrogen. One site fails to comply with the total phosphorus nutrient criteria. Total nitrogen trends indicate decreasing total nitrogen levels over both the 20 and 10-year trend periods. No trends in total phosphorus concentrations have been detected over both the 20 and 10-year periods.

Network modelling confidence intervals overlap 100% in the confidence interval for the C-band in all classes indicating less than 95% confidence that nitrogen and phosphorus reductions are required for all segments to comply with the C-band criteria. However, the lower confidence interval does not overlap 100% indicating less than 95% confidence that all segments comply. Mean estimates indicate reductions are likely required for all segments to comply. If the B-band is set as the target attribute state, reductions will be required for all segments to comply.

Macroinvertebrates (NPSFM Table 14-15)

No site-based monitoring data is available over the baseline period in the Roxburgh Rohe.

Network modelling results for MCI show 39% of mountain segments comply with the B-band and 100% comply with the C-band (Table 174). In hill-fed segments, 16% comply with the B-band and 100% comply with the C-band. For lowland segments, 5% comply with the B-band and 99% comply with the C-band.

Network state

Table 174: Percent of segments in the Roxburgh Rohe complying with potential A,B and C macroinvertebrate community index (MCI) target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	198
M	B	39	198
M	C	100	198
H	A	0	562
H	B	16	562
H	C	100	562
L	A	0	137
L	B	5	137
L	C	99	137

Macroinvertebrate state summary

No site-based results are available for the Roxburgh Rohe. Network modelling results show nearly all segments comply with the national bottom line suggesting that improvements across the Rohe are generally not required to comply with the national bottom line. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

No monitoring site fish IBI data is available in this Rohe.

Manuherekia

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

All sites in the Manuherekia Rohe comply with the ammoniacal nitrogen toxicity A-band (Table 175).

Table 175: Manuherekia Rohe NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017-5-year period ending August 2022) is presented in the paratheses with the year the min and max

occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dunstan Creek at Beattie Road	CDM	0.003 (0.001[2019] - 0.003[2017])	A (A - A)	0.008 (0.003[2022] - 0.008[2017])	A (A - A)
Manuherekia at Blackstone Hill	CDH	0.001 (0.001[2017] - 0.001[2022])	A (A - A)	0.024 (0.003[2022] - 0.024[2017])	A (A - A)
Manuherekia at Galloway	CDH	0.005 (0.002[2019] - 0.005[2017])	A (A - A)	0.017 (0.005[2022] - 0.017[2018])	A (A - A)
Manuherekia at Ophir	CDH	0.006 (0.003[2021] - 0.006[2017])	A (A - A)	0.019 (0.011[2022] - 0.022[2019])	A (A - A)
Thomsons Creek at SH85	CDH	0.005 (0.004[2020] - 0.005[2017])	A (A - A)	0.033 (0.029[2019] - 0.033[2017])	A (A - A)

Site-based trends

Over the 20-year trend period, both Dunstan Creek at Beattie Road and Manuherekia at Galloway are *virtually certain* to be improving indicating ammoniacal nitrogen levels have decreased (Table 176). The Manuherekia at Ophir is *unlikely* to be improving suggesting that ammoniacal nitrogen levels have increased at this site.

Over the 10-year trend period, all sites have *likely,* or higher, probabilities of improving trend indicating ammoniacal nitrogen has decreased across the Rohe (

Table 177).

Table 176: Manuherekia Rohe 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	BiMonth	100	0	1.00	Virtually certain
Manuherekia at Galloway	BiMonth	119	0	1.00	Virtually certain
Manuherekia at Ophir	Qtr	64	0	0.22	Unlikely

Table 177: Manuherekia Rohe 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	111	0	0.99	Virtually certain
Manuherekia at Blackstone Hill	BiMonth	54	0	1.00	Virtually certain
Manuherekia at Galloway	Month	117	0	1.00	Virtually certain
Manuherekia at Ophir	Month	111	0	0.82	Likely
Thomsons Creek at SH85	Month	105	0	0.76	Likely

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Rohe comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

All monitored sites in the Manuherekia Rohe comply with A-band for nitrate toxicity (Table 178).

Table 178: Manuherekia Rohe NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dunstan Creek at Beattie Road	CDM	0.037 (0.037^{2017} - 0.08^{2022})	A (A - A)	0.196 (0.149^{2022} - 0.196^{2017})	A (A - A)
Manuherekia at Blackstone Hill	CDH	0.004 (0.004^{2017} - 0.004^{2021})	A (A - A)	0.071 (0.069^{2018} - 0.078^{2021})	A (A - A)
Manuherekia at Galloway	CDH	0.025 (0.023^{2018} - 0.048^{2021})	A (A - A)	0.332 (0.19^{2020} - 0.332^{2017})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Manuherekia at Ophir	CDH	0.046 (0.041[2018] - 0.077[2022])	A (A - A)	0.26 (0.251[2018] - 0.286[2021])	A (A - A)
Thomsons Creek at SH85	CDH	0.102 (0.1[2018] - 0.26[2022])	A (A - A)	0.42 (0.42[2017] - 0.618[2022])	A (A - A)

Site-based trends

Over both the 20 and 10-year trend periods all sites have *unlikely* to be improving, or lower, probabilities indicating nitrate levels have increased across the Rohe (Table 179; Table 180).

Table 179: Manuherekia Rohe 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	BiMonth	100	6.49	0.00	Exceptionally unlikely
Manuherekia at Galloway	BiMonth	119	1.23	0.15	Unlikely
Manuherekia at Ophir	Qtr	64	6.66	0.00	Exceptionally unlikely

Table 180: Manuherekia Rohe 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	110	11.50	0.00	Exceptionally unlikely
Manuherekia at Blackstone Hill	BiMonth	54	0.00	0.26	Unlikely
Manuherekia at Galloway	Month	117	4.91	0.19	Unlikely
Manuherekia at Ophir	Month	111	5.16	0.01	Exceptionally unlikely
Thomsons Creek at SH85	Month	105	10.08	0.00	Exceptionally unlikely

Network state

Network modelling indicates all segments in all classes comply with the nitrate toxicity A-band (Table 181).

Table 181: Percent of river segments in the Manuherekia Rohe complying with potential nitrate toxicity target attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	100 (100 - 100)	466
M	B	100 (100 - 100)	466
M	C	100 (100 - 100)	466
H	A	100 (100 - 100)	790
H	B	100 (100 - 100)	790
H	C	100 (100 - 100)	790
L	A	100 (100 - 100)	20
L	B	100 (100 - 100)	20
L	C	100 (100 - 100)	20

Nitrate toxicity state summary

All sites and segments in this Rohe comply with the A-band for nitrate toxicity. However, many sites have probabilities of *unlikely* to be improving, or lower, over both the 10 and 20-year trend periods. To maintain the baseline state, measures to reduce intensification and flatten trends are required.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

Two sites in the Rohe, Manuherekia at Galloway and Manuherekia at Ophir, fail to comply with the suspended fine sediment national bottom line (Table 182). Dunstan Creek at Beattie Road complies with the A-band.

Table 182: Manuherekia Rohe clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence

intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Dunstan Creek at Beattie Road	CDM	3.938 (3.938[2020] - 4.125[2022])	A (A - A)
Manuherekia at Blackstone Hill	CDH		
Manuherekia at Galloway	CDH	1.685 (1.451[2021] - 1.685[2017])	D (D - D)
Manuherekia at Ophir	CDH	1.598 (1.375[2021] - 1.598[2018])	D (D - D)
Thomsons Creek at SH85	CDH		

Site-based trends

Over the 20-year trend period, all three sites have *unlikely*, or lower, probabilities of improving indicating turbidity has increased across the Rohe (Table 183). Over the 10-year trend period the same pattern is present except for Dunstan Creek at Beattie Road which is *likely* to be improving (Table 184). This indicates turbidity has decreased at this site.

Table 183: Manuherekia Rohe 20-year trends for turbidity for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	BiMonth	99	1.52	0.05	Very unlikely
Manuherekia at Galloway	BiMonth	119	2.68	0.00	Exceptionally unlikely
Manuherekia at Ophir	Qtr	64	1.62	0.21	Unlikely

Table 184: Manuherekia Rohe 10-year trends for turbidity for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	111	-1.05	0.78	Likely
Manuherekia at Blackstone Hill	BiMonth	54	1.72	0.31	Unlikely
Manuherekia at Galloway	Month	117	1.46	0.31	Unlikely
Manuherekia at Ophir	Month	111	0.35	0.41	As likely as not
Thomsons Creek at SH85	Month	105	2.16	0.17	Unlikely

Network state

Network modelling results for clarity show 74% of mountain segments comply with the A-band, 97% comply with the B-band and 100% comply with the C-band (Table 185). In the hill management class, 10% of segments comply with the A-band, 42% comply with the B-band and 73% comply with the C-band. For the lowland management class, 79% comply with the A-band, 84% comply with the B-band and 90% comply with the C-band.

Table 185: Percent of segments in the Manuherekia Rohe complying with potential A, B, and C suspended fine sediment target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	74	460
M	B	97	460
M	C	100	460
H	A	10	1,071
H	B	42	1,071
H	C	73	1,071
L	A	79	87
L	B	84	87
L	C	90	87

Suspended sediment state summary

Mainstem sites in the Manuherekia Rohe fail to comply with the national bottom line for clarity. Network modelling indicates that segments in both the lowland and hill categories fail to comply with the national bottom line. Trends analyses indicate degrading trends over the 10 and 20-year period. Appropriate targets are difficult to determine without a better understanding of natural state in these systems. In the interim, to ensure sites maintain the current state, measures to maintain or reduce inputs of sediment are required.

E. coli (NPSFM Table 9)

Site-based baseline state

Compliance with E. coli attribute bands in the Manuherekia is variable both between sites and within an individual site's rolling analysis (Table 186). Dunstan Creek at Beattie Road complies with the A-

band but ranges between A and C-band across the rolling analysis, Manuherekia at Galloway complies with the B-band but ranges from B to D-band and Manuherekia at Ophir complies with the C-band and ranges from C to D in the rolling analysis.

Table 186: Manuherekia Rohe E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Dunstan Creek at Beattie Road	CDM	28.5 (28.5^{2017} - 61^{2022})	A (A - A)	392 (392^{2017} - 1054.8^{2021})	A (A - C)	0.056 (0.056^{2017} - 0.091^{2022})	A (A - A)	0.037 (0.037^{2017} - 0.069^{2021})	A (A - B)
Manuherekia at Blackstone Hill	CDH								
Manuherekia at Galloway	CDH	46 (46^{2017} - 85^{2022})	A (A - A)	620.5 (620.5^{2017} - 1972^{2021})	B (B - D)	0.119 (0.119^{2017} - 0.255^{2022})	A (A - B)	0.068 (0.068^{2017} - 0.119^{2019})	B (B - C)
Manuherekia at Ophir	CDH	91 (91^{2017} - 219^{2022})	A (A - D)	766 (766^{2017} - 4212^{2021})	B (B - D)	0.259 (0.237^{2018} - 0.418^{2022})	B (B - D)	0.111 (0.111^{2017} - 0.236^{2022})	C (C - D)
Thomsons Creek at SH85	CDH								

Site-based trends

Over the 20-year trend period all sites have *unlikely*, or lower, probabilities to be improving indicating that *E. coli* levels have increased over this period (Table 187). Over the 10-year trend period, Dunstan Creek at Beattie Road, Manuherekia at Galloway and Manuherekia at Ophir have *unlikely*, or lower, probabilities of improving trend indicating *E. coli* levels have increased at these sites (Table 188). Manuherekia at Blackstone Hill is *likely* to be improving indicating *E. coli* levels have decreased. Thomsons Creek at SH85 is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading.

Table 187: Manuherekia Rohe 20-year trends for E. coli for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	BiMonth	100	6.65	0.00	Exceptionally unlikely
Manuherekia at Galloway	Month	198	0.43	0.23	Unlikely
Manuherekia at Ophir	Qtr	64	5.14	0.00	Exceptionally unlikely

Table 188: Manuherekia Rohe 10-year trends for E. coli for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	111	10.84	0.00	Exceptionally unlikely
Manuherekia at Blackstone Hill	BiMonth	54	-3.54	0.68	Likely
Manuherekia at Galloway	Month	117	1.07	0.22	Unlikely
Manuherekia at Ophir	Month	111	5.05	0.01	Exceptionally unlikely
Thomsons Creek at SH85	Month	105	0.00	0.50	As likely as not

Network state

Network modelling results for *E. coli* show 60% (0-100) of mountain segments comply with the *E. coli* A-band, 80% (8-100) comply with the B-band and 91% (38-100) comply with the C-band. For the hill management class, 24% (0-72) comply with the A-band, 44% (0-100) comply with the B-band and 63%

(1-100) comply with the C-band. In the lowland management class 5% (0-20) segments comply with the A-band, 18% (0-100) comply with the B-band and 37% (0-100) comply with the C-band.

Table 189: Percent of river segments in the Manuherekia Rohe complying with potential E. coli attribute bands with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	60 (0 - 100)	466
M	B	80 (8 - 100)	466
M	C	91 (38 - 100)	466
H	A	24 (0 - 72)	1,073
H	B	44 (0 - 100)	1,073
H	C	63 (1 - 100)	1,073
L	A	5 (0 - 20)	87
L	B	18 (0 - 100)	87
L	C	37 (0 - 100)	87

Escherichia coli state summary

Two out of three monitoring sites in the Manuherekia Rohe fail to comply with the *E. coli* national bottom line across the rolling analysis. Trend results indicate degrading trends are present in both the 10 and 20-year periods. Network modelling indicates that hill and lowland class confidence intervals overlap 100%. This indicates there is less than 95% confidence that a reduction is required to for all segments to comply with the national bottom line. However, the lower confidence interval does not overlap 100% indicating there is less than 95% confidence that all segments in the FMU comply with the bottom line. As degrading trends are present, to maintain state, controls which allow no increase in *E. coli* inputs would be required. Reductions in *E. coli* concentrations would be required to improve state and comply with national bottom lines.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

In the Manuherekia Rohe one site, Thomsons Creek at SH85, fails to comply with the DRP C-band (Table 190). The Manuherekia at Ophir complies with the C-band. Manuherekia at Galloway complies with the C-band and ranges from C- to B-band in the rolling analysis. Both the Manuherekia at Blackstone and Dunstan Creek at Beattie Road comply with the A-band.

Table 190: Manuherekia Rohe DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Dunstan Creek at Beattie Road	CDM	0.004 (0.003^{2022} - 0.004^{2018})	A (A - A)	0.007 (0.005^{2022} - 0.007^{2018})	A (A - A)
Manuherekia at Blackstone Hill	CDH	0.004 (0.003^{2022} - 0.004^{2018})	A (A - A)	0.011 (0.006^{2022} - 0.011^{2017})	A (A - A)
Manuherekia at Galloway	CDH	0.011 (0.009^{2022} - 0.011^{2017})	C (B - C)	0.024 (0.023^{2019} - 0.028^{2021})	B (B - B)
Manuherekia at Ophir	CDH	0.016 (0.011^{2020} - 0.016^{2017})	C (C - C)	0.048 (0.035^{2021} - 0.05^{2018})	C (C - C)
Thomsons Creek at SH85	CDH	0.021 (0.018^{2021} - 0.023^{2018})	D (C - D)	0.16 (0.105^{2021} - 0.16^{2017})	D (D - D)

Site-based trends

Over both the 20- and 10-year trend periods, all sites have *likely*, or higher, probabilities of an improving trend indicating DRP levels have decreased across the Rohe (Table 191;Table 192).

Table 191: Manuherekia Rohe 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Qtr	66	0.00	1.00	Virtually certain
Manuherekia at Galloway	BiMonth	118	-0.94	0.91	Very likely
Manuherekia at Ophir	Qtr	64	-1.54	0.92	Very likely

Table 192: Manuherekia Rohe 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	111	0.00	1.00	Virtually certain
Manuherekia at Blackstone Hill	BiMonth	54	0.00	0.78	Likely
Manuherekia at Galloway	Month	117	-1.00	0.90	Likely
Manuherekia at Ophir	Month	111	-3.95	1.00	Virtually certain
Thomsons Creek at SH85	Month	105	-2.81	0.95	Very likely

Dissolved reactive phosphorus state summary

In the Manuherekia Rohe, one site fails to comply with the DRP C-band. All sites also have improving trends over the 10- and 20-year trend period. Whether phosphorus reductions are required depends upon the target attribute state set for this table, requirements of the downstream lake receiving environment, and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

Three monitoring sites, the Manuherekia at Blackstone Hill, Manuherekia at Galloway, and Manuherekia at Ophir, comply with the periphyton biomass B-band. (Table 193) Dunstan Creek at Beattie Road complies with the A-band.

Table 193: Manuherekia Rohe periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Dunstan Creek at Beattie Road	48	A	28
Manuherekia at Blackstone Hill	67	B	24
Manuherekia at Galloway	102	B	29
Manuherekia at Ophir	103	B	26

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, all sites comply with the C-band criteria, or better, therefore meeting the national bottom line (Table 194). The Dunstan Creek at Beattie Road, Manuherekia at Blackstone Hill and Manuherekia at Galloway sites comply with the B-band criteria.

For total phosphorus in relation to the periphyton biomass 20% under-protection risk nutrient criteria, four sites comply with the C-band criteria (Table 194). Of these four sites, the Dunstan Creek at Beattie Road site also complies with the B-band criteria. Thomsons Creek at SH85 fails to comply with the C-band criteria.

Table 194: Manuherekia Rohe total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Dunstan Creek at Beattie Road	CDM	0.11 (0.11^{2017} - 0.174^{2021})	B (B - B)	0.007 (0.005^{2022} - 0.007^{2019})	B (B - B)
Manuherikia at Blackstone Hill	CDH	0.11 (0.11^{2019} - 0.112^{2021})	B (B - B)	0.012 (0.009^{2022} - 0.012^{2017})	C (C - C)
Manuherikia at Galloway	CDH	0.22 (0.21^{2018} - 0.255^{2021})	B (B - C)	0.024 (0.022^{2022} - 0.025^{2020})	C (C - C)
Manuherikia at Ophir	CDH	0.285 (0.28^{2018} - 0.32^{2022})	C (C - C)	0.031 (0.03^{2018} - 0.034^{2021})	C (C - D)
Thomsons Creek at SH85	CDH	0.53 (0.53^{2017} - 0.67^{2022})	C (C - C)	0.048 (0.048^{2017} - 0.062^{2022})	D (D - D)

Site-based trends

Over both the 20 and 10-year total nitrogen trend periods all sites, except for Manuherekia at Blackstone Hill, have *unlikely*, or lower, probabilities of improving trends (Table 195; Table 196). This indicates total nitrogen levels have increased at these sites. The Manuherekia at Blackstone Hill monitoring site is *likely* to be improving over the 10-year period indicating total nitrogen levels have decreased.

Table 195: Manuherekia Rohe 20-year trends for total nitrogen for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	BiMonth	100	3.86	0.00	Exceptionally unlikely
Manuherekia at Galloway	BiMonth	119	0.41	0.23	Unlikely
Manuherekia at Ophir	Qtr	64	2.24	0.01	Exceptionally unlikely

Table 196: Manuherekia Rohe 10-year trends for total nitrogen for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	110	5.41	0.00	Exceptionally unlikely
Manuherekia at Blackstone Hill	BiMonth	54	0.00	0.71	Likely
Manuherekia at Galloway	Month	117	1.06	0.13	Unlikely
Manuherekia at Ophir	Month	111	0.64	0.24	Unlikely
Thomsons Creek at SH85	Month	105	2.05	0.05	Very unlikely

Over both the 20 and 10-year total phosphorus trend periods all sites, except for Thomsons Creek at SH85, have *likely*, or higher, probabilities of improving trends (Table 197; Table 198). This indicates total phosphorus levels have decreased at these sites. The Thomsons Creek at SH85 monitoring sites is *as likely as not* to be improving over the 10-year period which is an ambiguous result not classed as improving or degrading.

Table 197: Manuherekia Rohe 20-year trends for total phosphorus for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Qtr	66	-5.28	1.00	Virtually certain
Manuherekia at Galloway	BiMonth	118	-1.28	0.92	Very likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Manuherekia at Ophir	Qtr	64	-0.61	0.72	Likely

Table 198: Manuherekia Rohe 10-year trends for total phosphorus for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Month	111	-4.46	0.99	Extremely likely
Manuherekia at Blackstone Hill	BiMonth	54	-7.78	1.00	Virtually certain
Manuherekia at Galloway	Month	117	-1.19	0.73	Likely
Manuherekia at Ophir	Month	111	-2.38	0.89	Likely
Thomsons Creek at SH85	Month	105	0.00	0.50	As likely as not

Network state

For total nitrogen in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results indicate 100% (100-100) of mountain segments comply with the B-band criteria (Table 199). In the hill management class, 67% (7-100) of segments comply with the B-band criteria and 100% (100-100) comply with C-band criteria. For the lowland management class 1% (0-0) of segments comply with the B-band criteria and 92% (65-100) comply with the C-band. Few segments comply with the A-band criteria in any management class.

For total phosphorus in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results indicate 78% (49-100) of mountain segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria (Table 199). In the hill management class, 1% (0-0) of segments comply with the B-band criteria and 88% (29-100) comply with C-band criteria. For the lowland management class 0% (0-0) of segments comply with the B-band criteria and 83% (5-100) comply with the C-band. Few segments comply with the A-band criteria in any management class.

Table 199: Percent of river segments in the Manuherekia Rohe complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support

periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	12 (0 - 80)	0 (0 - 0)	466
M	B	100 (100 - 100)	78 (49 - 100)	466
M	C	100 (100 - 100)	100 (100 - 100)	466
H	A	2 (0 - 5)	0 (0 - 0)	790
H	B	67 (7 - 100)	1 (0 - 0)	790
H	C	100 (100 - 100)	88 (29 - 100)	790
L	A	0 (0 - 0)	0 (0 - 0)	20
L	B	1 (0 - 0)	0 (0 - 0)	20
L	C	92 (65 - 100)	83 (5 - 100)	20

Periphyton biomass state summary

The Manuherekia Rohe has four periphyton biomass monitoring sites; three comply with the B-band and one complies with the A-band. When compared to the 20% under-protection risk periphyton nutrient criteria, all monitoring sites comply with at least the C-band criteria for total nitrogen and all but one site comply with the total phosphorus C-band nutrient criteria. Total nitrogen trends indicate increasing total nitrogen levels over both the 20 and 10-year trend periods. Total phosphorus trends indicate decreasing total phosphorus levels over both the 20 and 10-year periods. Network modelling confidence intervals overlap 100% for the C-band in all classes indicating less than 95% confidence that nitrogen and phosphorus reduction is required for all segments to comply with the C-band criteria. However, the lower confidence intervals do not overlap 100% indicating less than 95% confidence that all segments comply. As sites in the Rohe have a degrading trend for total nitrogen, to maintain state, measures which allow no further nitrogen inputs are required. If the B-band is set as the target attribute state, reductions will be required in both nitrogen and phosphorus for all segments to comply.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

Site based macroinvertebrate monitoring results in Dunstan Creek complying the B-band for MCI and A-band for ASPM (Table 200). The Manuherekia at Blackstone Road site complies with the MCI C-band and ASPM B-band.

Table 200: Manuherekia Rohe macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Dunstan Creek at Beattie Road	CDM	116 (116^{2017} - 120^{2019})	B (B - B)	0.62 (0.62^{2017} - 0.65^{2020})	A (A - A)
Manuherekia at Blackstone Hill	CDH	97.69 (97.69^{2018} - 101.25^{2022})	C (C - C)	0.55 (0.53^{2021} - 0.55^{2018})	B (B - B)
Manuherekia at Galloway	CDH				
Manuherekia at Ophir	CDH				
Thomsons Creek at SH85	CDH				

Site-based trends

Over the 10-year MCI trend period, Dunstan Creek at Beattie Road and Manuherekia at Ophir are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (Table 201). The Manuherekia at Blackstone Hill is *likely* to be improving indicating that MCI scores have increased over this period.

Over the 10-year ASPM trend period, both sites are *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading (

Table 202).

Table 201: Manuherekia Rohe 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Year	10	0.39	0.43	As likely as not
Manuherekia at Blackstone Hill	Year	10	1.04	0.11	Likely
Manuherekia at Ophir	Year	8	0.27	0.36	As likely as not

Table 202: Manuherekia Rohe 10-year trends for the average score per metric (ASPM) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Dunstan Creek at Beattie Road	Year	9	0.63	0.34	As likely as not
Manuherekia at Blackstone Hill	Year	9	-0.68	0.58	As likely as not

Network state

Network modelling results for MCI show 54% of mountain segments comply with the B-band and 100% comply with the C-band (Table 203). In the hill management class, 4% of segments comply with the B-band and 100% of segments comply with the C-band. For the lowland class, 0% of segments comply with the B-band and 97% comply with the C-band.

Table 203: Percent of segments in the Manuherekia Rohe complying with potential A, B and C macroinvertebrate community index (MCI) target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	454
M	B	54	454
M	C	100	454
H	A	0	1,033
H	B	4	1,033
H	C	100	1,033
L	A	0	87
L	B	0	87
L	C	97	87

Macroinvertebrate state summary

Both the sites in the Manuherekia Rohe comply with the national bottom line for MCI and ASPM across the rolling analysis. Network results show nearly all segments comply with the national bottom line. Over the 10-year and 20-year trend period, trends are neutral or improving. To comply with the national bottom line, improvements across the Rohe are generally not required. Macroinvertebrates

are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Site-based baseline state

Baseline time period monitoring results are available for one site, Thomsons Creek at SH85 which fails to comply with the C-band (Table 204). This site ranges from D to C-band in the rolling analysis.

Table 204: Manuherekia Rohe annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Dunstan Creek at Beattie Road	NA (26^{2016} - 34^{2018})	NA (C - A)	NA (A - A)
Thomsons Creek at SH85	16 (16^{2015} - 22^{2018})	D (D - C)	C (C - B)

Lower Clutha

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

All sites in the Lower Clutha Rohe comply with the national bottom line for the ammoniacal nitrogen toxicity attribute (Table 205). All sites comply with the A-band for the median statistic and all but one site, Wairuna at Millar Road, comply with the 95th percentile A-band.

Table 205: Lower Clutha Rohe NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017-5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Clutha @ Balclutha	CWLk	0.002 (0.002^{2020} - 0.002^{2017})	A (A - A)	0.01 (0.008^{2019} - 0.01^{2017})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Crookston Burn at Kelso Road	CDL	0.011 (0.008[2022] - 0.011[2017])	A (A - A)	0.031 (0.029[2018] - 0.084[2021])	A (A - B)
Heriot Burn at Park Hill Road	CDL	0.013 (0.008[2022] - 0.013[2017])	A (A - A)	0.024 (0.02[2020] - 0.025[2022])	A (A - A)
Lovells Creek at Station Road	CDL	0.009 (0.006[2022] - 0.009[2017])	A (A - A)	0.018 (0.017[2018] - 0.022[2020])	A (A - A)
Pomahaka at Burkes Ford	CDL	0.008 (0.005[2022] - 0.008[2018])	A (A - A)	0.022 (0.016[2022] - 0.023[2021])	A (A - A)
Pomahaka at Glenken	CDH	0.004 (0.002[2020] - 0.004[2017])	A (A - A)	0.012 (0.004[2022] - 0.012[2017])	A (A - A)
Waipahi at Cairns Peak	CDL	0.009 (0.006[2022] - 0.009[2017])	A (A - A)	0.023 (0.013[2022] - 0.023[2017])	A (A - A)
Waipahi at Waipahi	CWL	0.008 (0.004[2022] - 0.008[2017])	A (A - A)	0.029 (0.021[2022] - 0.029[2020])	A (A - A)
Wairuna at Millar Road	CDL	0.023 (0.016[2021] - 0.023[2017])	A (A - A)	0.086 (0.06[2022] - 0.086[2017])	B (B - B)
Waitahuna at Tweeds Bridge	CDL	0.006 (0.004[2022] - 0.007[2019])	A (A - A)	0.01 (0.01[2017] - 0.019[2021])	A (A - A)
Waiwera at Clutha confluence u/s 1km	CDL				
Waiwera at Maws Farm	CDL	0.011 (0.007[2020] - 0.011[2017])	A (A - A)	0.031 (0.022[2022] - 0.031[2017])	A (A - A)

Site-based trends

Over the 10 and 20-year trend periods, the majority of sites have improving trends with probabilities of *likely* to be improving, or higher (Table 206; Table 207). The exception is the Clutha at Balclutha which is *very unlikely* to be improving over the 20-year period. This site has a *likely to* be improving trend over the 10-year period. As a result, ammoniacal nitrogen levels have likely decreased across the Lower Clutha Rohe.

Table 206: Lower Clutha Rohe 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	239	1.11	0.05	Very unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Crookston Burn at Kelso Road	Qtr	68	-5.94	1.00	Virtually certain
Heriot Burn at Park Hill Road	BiMonth	117	-1.93	1.00	Virtually certain
Pomahaka at Burkes Ford	BiMonth	116	0.00	1.00	Virtually certain
Pomahaka at Glenken	BiMonth	117	0.00	1.00	Virtually certain
Waipahi at Cairns Peak	BiMonth	109	0.00	0.58	As likely as not
Waipahi at Waipahi	BiMonth	117	-3.57	1.00	Virtually certain
Waitahuna at Tweeds Bridge	BiMonth	119	0.00	0.86	Likely

Table 207: Lower Clutha Rohe 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	119	-2.29	0.85	Likely
Crookston Burn at Kelso Road	Month	109	0.00	0.74	Likely
Heriot Burn at Park Hill Road	Month	115	-3.71	0.99	Virtually certain
Lovells Creek at Station Road	Month	111	0.00	0.86	Likely
Pomahaka at Burkes Ford	Month	115	0.00	0.78	Likely
Pomahaka at Glenken	Month	109	0.00	1.00	Virtually certain
Waipahi at Cairns Peak	Month	109	-7.63	1.00	Virtually certain
Waipahi at Waipahi	Month	115	0.00	0.88	Likely
Wairuna at Millar Road	Month	115	-1.69	0.86	Likely
Waitahuna at Tweeds Bridge	Month	116	0.00	0.58	As likely as not
Waiwera at Maws Farm	Month	114	0.00	0.53	As likely as not

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the Lower Clutha Rohe comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

All sites in the Lower Clutha Rohe comply with the national bottom line for the nitrate toxicity attribute in the 2012-2017 period (Table 208). However, two sites, including the Wairuna at Millar Road and Lovells Creek at Station Road, fail to comply with the national bottom line in the rolling analysis. Half of monitored sites comply with the A-band median and less than half of sites comply with the A-band 95th percentile.

Table 208: Lower Clutha Rohe NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Clutha @ Balclutha	CWLk	0.05 (0.05^{2018} - 0.062^{2021})	A (A - A)	0.28 (0.28^{2017} - 0.358^{2021})	A (A - A)
Crookston Burn at Kelso Road	CDL	1.5 (1.22^{2022} - 1.5^{2019})	B (B - B)	2.47 (2.4^{2018} - 2.5^{2019})	B (B - B)
Heriot Burn at Park Hill Road	CDL	1.37 (1.31^{2022} - 1.42^{2021})	B (B - B)	2.35 (1.954^{2022} - 2.35^{2017})	B (B - B)
Lovells Creek at Station Road	CDL	0.72 (0.66^{2019} - 1.07^{2021})	A (A - B)	2.48 (2.18^{2018} - 3.67^{2022})	B (B - C)
Pomahaka at Burkes Ford	CDL	0.545 (0.53^{2019} - 0.675^{2021})	A (A - A)	1.51 (1.51^{2017} - 2.485^{2022})	B (B - B)
Pomahaka at Glenken	CDH	0.043 (0.034^{2018} - 0.06^{2021})	A (A - A)	0.417 (0.357^{2022} - 0.417^{2017})	A (A - A)
Waipahi at Cairns Peak	CDL	0.86 (0.73^{2020} - 0.86^{2017})	A (A - A)	2.07 (1.61^{2020} - 2.07^{2017})	B (B - B)
Waipahi at Waipahi	CWL	1.27 (1.135^{2018} - 1.27^{2017})	B (B - B)	2.35 (2.35^{2017} - 2.94^{2022})	B (B - B)
Wairuna at Millar Road	CDL	1.158 (1.065^{2018} - 1.38^{2021})	B (B - B)	3.15 (3.15^{2017} - 6.98^{2022})	B (B - C)
Waitahuna at Tweeds Bridge	CDL	0.183 (0.145^{2019} - 0.183^{2017})	A (A - A)	1.164 (1.154^{2018} - 1.43^{2020})	A (A - A)

Site	Class	Median	Median Band	95th	95th Band
Waiwera at Clutha confluence u/s 1km	CDL				
Waiwera at Maws Farm	CDL	0.85 (0.75[2018] - 1.02[2021])	A (A - B)	2.37 (2.37[2017] - 3.08[2022])	B (B - B)

Site-based trends

Over the 20-year trend period, the majority of sites in the Lower Clutha Rohe, including the Heriot Burn at Park Hill Road, Pomahaka at Burkes Ford, Waipahi at Cairns Peak, Waipahi at Waipahi at Waipahi and Waitahuna at Tweeds Bridge, have *unlikely*, or lower, probabilities of improving trends indicating nitrate levels have increased (Table 209). The Clutha at Balclutha and Crookston Burn at Kelso Road have *likely,* or higher, probabilities of improving trends indicating at these sites nitrate levels have decreased.

Over the 10-year trend period, the majority of sites in the Lower Clutha Rohe, including the Crookston Burn at Kelso Road, Heriot Burn at Parkhill Road, Pomahaka at Glenken, Waipahi at Cairns Peak, Waipahi at Waipahi, Waitahuna at Tweeds Bridge, and Waiwera at Maws Farm have *likely*, or higher, probabilities of improving trends (Table 210). This indicates nitrate levels have decreased at these sites. The Clutha at Balclutha and Lovells Creek at Station Road have *unlikely*, or lower, probabilities of improving trend indicating nitrate levels have increased at these sites.

Table 209: Lower Clutha Rohe 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	239	-0.30	0.71	Likely
Crookston Burn at Kelso Road	Qtr	68	-1.42	0.98	Extremely likely
Heriot Burn at Park Hill Road	BiMonth	117	0.33	0.26	Unlikely
Pomahaka at Burkes Ford	BiMonth	116	0.44	0.15	Unlikely
Pomahaka at Glenken	BiMonth	117	0.00	0.53	As likely as not
Waipahi at Cairns Peak	BiMonth	108	1.23	0.05	Very unlikely
Waipahi at Waipahi	BiMonth	117	0.91	0.06	Very unlikely
Waitahuna at Tweeds Bridge	BiMonth	119	0.89	0.17	Unlikely

Table 210: Lower Clutha Rohe 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	119	1.08	0.11	Unlikely
Crookston Burn at Kelso Road	Month	109	-2.80	0.99	Virtually certain
Heriot Burn at Park Hill Road	Month	115	-2.57	1.00	Virtually certain
Lovells Creek at Station Road	Month	111	3.97	0.01	Exceptionally unlikely
Pomahaka at Burkes Ford	Month	115	-0.65	0.67	As likely as not
Pomahaka at Glenken	Month	109	-2.11	0.88	Likely
Waipahi at Cairns Peak	Month	109	-1.27	0.78	Likely
Waipahi at Waipahi	Month	115	-1.15	0.81	Likely
Wairuna at Millar Road	Month	115	1.41	0.17	Unlikely
Waitahuna at Tweeds Bridge	Month	116	-0.78	0.75	Likely
Waiwera at Maws Farm	Month	114	-1.13	0.83	Likely

Network state

Network modelling results for nitrate toxicity show 99% (98-100) of mountain class segments comply with the nitrate toxicity A-band and 100% (100-100) comply with the B-band (Table 211). For the hill management class, 99% (91-100) of segments comply with the A-band and 100% (100-100) comply with the B-band. In the lowland management class, 79% (17-100) comply with the A-band, 97% (77-100) comply with the B-band and 98% (90-100) comply with the C-band. As the lower confidence interval of B-band compliance is less than 100%, there is less than 95% confidence that all segments in this class comply with the national bottom line.

Table 211: Percent of river segments in the Lower Clutha Rohe complying with potential nitrate toxicity target attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
M	A	99 (98 - 100)	91
M	B	100 (100 - 100)	91
M	C	100 (100 - 100)	91

Management Class	Band	Current	Count
H	A	99 (91 - 100)	612
H	B	100 (100 - 100)	612
H	C	100 (100 - 100)	612
L	A	79 (17 - 100)	979
L	B	97 (77 - 100)	979
L	C	98 (90 - 100)	979

Nitrate toxicity state summary

All sites and nearly all segments in the Lower Clutha Rohe comply with the national bottom line for nitrate toxicity and recent trends indicate nitrate levels are decreasing. However, over the rolling analysis, two sites failed to comply with the national bottom line. Further, the bottom confidence interval for the lowland B-band is 77% indicating with 95% confidence that 77% of segments comply with the national bottom line. To maintain and improve state so all sites and segments comply with the national bottom line, measures to reduce nitrate concentrations are required.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

In the Lower Clutha Rohe, the majority of sites fail to comply with the national bottom line for suspended fine sediment (Table 212). Sites including the Clutha at Balclutha, Crookston Burn at Kelso Road, Heriot Burn at Parkhill Road, Pomahaka at Burkes Ford, Pomahaka at Glenken, Wairuna at Millar Road, and Waitahuna at Tweeds Bridge fail to comply. In the rolling analysis two sites, Pomahaka at Glenken and Waitahuna at Tweeds, ranged from D to C-band. Both the Waipahi at Waipahi and Waiwera at Maws Farm complied with the A-band. The Waipahi at Cairns Peak complied with the C-band and ranges from C to B-band in the rolling analysis.

Table 212: Lower Clutha Rohe clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence

intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Clutha @ Balclutha	CWLk	1.506 (1.267[2021] - 1.566[2018])	D (D - D)
Crookston Burn at Kelso Road	CDL	1.204 (1.038[2022] - 1.214[2019])	D (D - D)
Heriot Burn at Park Hill Road	CDL	0.934 (0.934[2017] - 1.023[2020])	D (D - D)
Lovells Creek at Station Road	CDL		
Pomahaka at Burkes Ford	CDL	1.295 (1.193[2022] - 1.333[2020])	D (D - D)
Pomahaka at Glenken	CDH	1.759 (1.759[2017] - 2.269[2022])	D (D - C)
Waipahi at Cairns Peak	CDL	0.989 (0.989[2017] - 1.259[2022])	C (C - B)
Waipahi at Waipahi	CWL	1.619 (1.619[2017] - 1.841[2021])	A (A - A)
Wairuna at Millar Road	CDL	0.658 (0.658[2017] - 0.779[2019])	D (D - D)
Waitahuna at Tweeds Bridge	CDL	1.145 (1.145[2018] - 1.375[2022])	D (D - C)
Waiwera at Clutha confluence u/s 1km	CDL		
Waiwera at Maws Farm	CDL	1.42 (1.42[2017] - 1.734[2021])	A (A - A)

Site-based trends

Over the 20-year trend period, five sites have trend probabilities of *unlikely* to be improving, or lower, indicating turbidity has increased at these sites (Table 213). The Waipahi at Cairns Peak and Waipahi at Waipahi have *likely*, or higher, probabilities of improving trends indicating turbidity has decreased at these sites.

Over the 10-year trend period, the majority of the Rohe has *likely* to be improving trend probabilities, or higher, indicating turbidity has decreased across the Rohe (Table 214). One site, the Crookston Burn at Kelso Road, has a *very unlikely* trend category which indicates turbidity has increased at this site.

Table 213: Lower Clutha Rohe 20-year trends for turbidity for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	238	1.42	0.05	Extremely unlikely
Crookston Burn at Kelso Road	Qtr	68	0.84	0.17	Unlikely
Heriot Burn at Park Hill Road	BiMonth	117	1.04	0.09	Very unlikely
Pomahaka at Burkes Ford	BiMonth	115	0.12	0.44	As likely as not
Pomahaka at Glenken	BiMonth	116	1.30	0.14	Unlikely
Waipahi at Cairns Peak	BiMonth	105	-0.92	0.87	Likely
Waipahi at Waipahi	BiMonth	116	-1.41	0.94	Very likely
Waitahuna at Tweeds Bridge	BiMonth	119	1.08	0.02	Extremely unlikely

Table 214: Lower Clutha Rohe 10-year trends for turbidity for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	118	-0.18	0.53	As likely as not
Crookston Burn at Kelso Road	Month	109	2.43	0.08	Very unlikely
Heriot Burn at Park Hill Road	Month	115	-2.57	0.97	Extremely likely
Lovells Creek at Station Road	Month	97	-2.71	0.84	Likely
Pomahaka at Burkes Ford	Month	115	-1.32	0.80	Likely
Pomahaka at Glenken	Month	109	-3.66	0.97	Extremely likely
Waipahi at Cairns Peak	Month	109	-5.19	1.00	Virtually certain
Waipahi at Waipahi	Month	115	-2.19	0.85	Likely
Wairuna at Millar Road	Month	115	-1.59	0.81	Likely
Waitahuna at Tweeds Bridge	Month	116	-3.50	1.00	Virtually certain
Waiwera at Maws Farm	Month	114	-5.31	1.00	Virtually certain

Network state

Network modelling results for clarity show 97% of mountain segments comply with the A-band, 98% comply with the B-band and 99% comply with the C-band (Table 215). Compliance is much lower in the hill class with 11% complying the A-band, 33% complying with the B-band and 53% complying with the C-band. In the lowland class, 26% comply with the A-band, 34% comply with the B-band and 59% comply with the C-band.

Table 215: Percent of segments in the Lower Clutha Rohe complying with potential A, B, and C suspended fine sediment target attribute bands, split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	97	93
M	B	98	93
M	C	99	93
H	A	11	635
H	B	33	635
H	C	53	635
L	A	26	1,548
L	B	34	1,548
L	C	59	1,548

Suspended sediment state summary

Clutha mainstem sites and the upper catchment of the Pomahaka River, are affected by naturally occurring process (such as glacial flour or tannin staining) which naturally result in lower water clarity. While mainstem sites fail to comply with the national bottom line, at least some component of this is likely to be due to natural processes. Trend analyses indicate mixed patterns with an improving trend over the 10-year period and degrading trend over the 20-year period. Appropriate targets are difficult to determine without a better understanding of natural state in these systems. In the interim, to ensure sites maintain the baseline state, measures to reduce sediment inputs are required.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

All monitored sites in the Lower Clutha Rohe fail to comply with the national bottom line for *E. coli* (Table 216). Ranging multiple bands in the rolling analysis is common. Most sites fail to comply with more than one statistic.

Table 216: Lower Clutha Rohe E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Clutha @ Balclutha	CWLk	33.5 (33.25^{2020} - 50.4^{2022})	A (A - A)	1218.66 (723.99^{2018} - 1971.52^{2021})	D (B - D)	0.119 (0.102^{2019} - 0.138^{2021})	A (A - A)	0.068 (0.051^{2018} - 0.089^{2022})	B (B - B)
Crookston Burn at Kelso Road	CDL	500 (470^{2020} - 579^{2022})	E (E - E)	7275 (2142.6^{2022} - 7275^{2017})	D (D - D)	0.745 (0.741^{2018} - 0.827^{2022})	E (E - E)	0.455 (0.436^{2020} - 0.577^{2022})	E (E - E)
Heriot Burn at Park Hill Road	CDL	675 (387^{2021} - 675^{2017})	E (E - E)	5245 (2146.5^{2021} - 5245^{2017})	D (D - D)	0.797 (0.6^{2021} - 0.797^{2017})	E (E - E)	0.559 (0.4^{2021} - 0.559^{2017})	E (E - E)
Lovells Creek at Station Road	CDL	330 (236^{2019} - 330^{2017})	E (D - E)	2500 (2433.7^{2019} - 3474^{2022})	D (D - D)	0.537 (0.424^{2019} - 0.559^{2021})	E (D - E)	0.278 (0.222^{2018} - 0.305^{2021})	D (D - E)
Pomahaka at Burkes Ford	CDL	84 (84^{2018} - 120^{2022})	A (A - A)	4755 (1600^{2020} - 4755^{2017})	D (D - D)	0.254 (0.25^{2020} - 0.302^{2022})	B (B - C)	0.169 (0.125^{2020} - 0.189^{2022})	C (C - C)
Pomahaka at Glenken	CDH	210 (156^{2021} - 230^{2018})	D (D - D)	2285 (908^{2022} - 2285^{2017})	D (B - D)	0.404 (0.339^{2020} - 0.441^{2018})	D (C - D)	0.175 (0.057^{2022} - 0.175^{2017})	C (B - C)
Waipahi at Cairns Peak	CDL	235 (188.5^{2021} - 235^{2017})	D (D - D)	5470 (1553^{2022} - 5470^{2017})	D (D - D)	0.482 (0.358^{2022} - 0.482^{2017})	D (D - D)	0.339 (0.226^{2022} - 0.339^{2017})	E (D - E)

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Waipahi at Waipahi	CWL	120 (105[2019] - 192[2022])	A (A - D)	5150 (608.5[2019] - 5894[2021])	D (B - D)	0.25 (0.203[2019] - 0.358[2022])	B (B - D)	0.167 (0.068[2019] - 0.167[2017])	C (B - C)
Wairuna at Millar Road	CDL	655 (480[2019] - 655[2017])	E (E - E)	5650 (3040[2019] - 5650[2017])	D (D - D)	0.783 (0.783[2017] - 0.887[2022])	E (E - E)	0.583 (0.441[2019] - 0.583[2017])	E (E - E)
Waitahuna at Tweeds Bridge	CDL	310 (305[2018] - 330[2020])	E (E - E)	4200 (3145[2020] - 6414[2022])	D (D - D)	0.569 (0.569[2017] - 0.649[2021])	E (E - E)	0.19 (0.19[2017] - 0.316[2021])	C (C - E)
Waiwera at Clutha confluence u/s 1km	CDL								
Waiwera at Maws Farm	CDL	195 (170[2018] - 243[2022])	D (D - D)	1820 (1553[2022] - 1865[2018])	D (D - D)	0.429 (0.339[2019] - 0.446[2022])	D (C - D)	0.196 (0.136[2019] - 0.214[2022])	C (C - D)

Site-based trends

Over the 20-year trend period, three sites have trend probabilities of *unlikely* to be improving, or lower, which indicates *E. coli* levels have increased at the Pomahaka at Glenken, Waipahi at Waipahi and Waitahuna at Tweeds Bridge monitoring sites (Table 217). Three sites, the Clutha at Balclutha, Heriot Burn at Park Hill Road, and Pomahaka at Burkes are *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading. One site, the Waipahi at Cairns Peak, is *very likely* to be improving indicating *E. coli* levels have decreased over the 20-year period.

Over the 10-year trend period only two sites, the Clutha at Balclutha and Waipahi at Waipahi have trend probabilities of unlikely to be improving, or lower, which indicates E. coli levels have increased at these sites (

Table 218). Most sites are *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading. The Heriot Burn at Park Hill Road, Pomahaka at Glenken, Waipahi at Waipahi, and Waitahuna at Tweeds Bridge have probabilities of *likely* to be improving, or higher, indicating that *E. coli* levels have decreased at these sites.

Table 217: Lower Clutha Rohe 20-year trends for E. coli for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	206	0.00	0.48	As likely as not
Heriot Burn at Park Hill Road	BiMonth	116	0.56	0.36	As likely as not
Pomahaka at Burkes Ford	BiMonth	115	0.15	0.44	As likely as not
Pomahaka at Glenken	BiMonth	116	1.78	0.01	Exceptionally unlikely
Waipahi at Cairns Peak	BiMonth	109	-1.64	0.91	Very likely
Waipahi at Waipahi	BiMonth	115	1.20	0.18	Unlikely
Waitahuna at Tweeds Bridge	BiMonth	119	1.89	0.03	Extremely unlikely

Table 218: Lower Clutha Rohe 10-year trends for E. coli for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	118	4.03	0.09	Very unlikely
Crookston Burn at Kelso Road	Month	106	-0.88	0.63	As likely as not

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Heriot Burn at Park Hill Road	Month	114	-5.40	1.00	Virtually certain
Lovells Creek at Station Road	Month	111	-0.45	0.52	As likely as not
Pomahaka at Burkes Ford	Month	114	0.00	0.49	As likely as not
Pomahaka at Glenken	Month	110	-1.45	0.78	Likely
Waipahi at Cairns Peak	Month	109	-3.63	0.98	Extremely likely
Waipahi at Waipahi	Month	115	3.80	0.09	Very unlikely
Wairuna at Millar Road	Month	115	-0.74	0.61	As likely as not
Waitahuna at Tweeds Bridge	Month	116	-1.57	0.80	Likely
Waiwera at Maws Farm	Month	114	0.00	0.52	As likely as not

Network state

Network modelling results for *E. coli* show 49% (0-98) of mountain segments comply with the *E. coli* A-band, 72% (0-98) comply with the B-band and 88% (11-99) comply with the C-band (Table 219). In the hill management class, 21% (0-80) comply with the A-band, 42% (0-100) comply with the B-band and 62% (8-100) comply with the C-band. For the lowland class, 1% (0-8) comply with the A-band, 9% (0-61) comply with the B-band and 18% (0-95) comply with the C-band. As the lowland C-band confidence interval does not overlap 100%, there is 95% confidence a reduction in *E. coli* concentrations is required for all segments to comply with the national bottom line.

Table 219: Lower Clutha Rohe percent of river segments complying with potential E. coli target attribute bands, with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
M	A	49 (0 - 98)	93
M	B	72 (0 - 98)	93
M	C	88 (11 - 99)	93
H	A	21 (0 - 80)	637
H	B	42 (0 - 100)	637

Management Class	Band	Current	Count
H	C	62 (8 - 100)	637
L	A	1 (0 - 8)	1,554
L	B	9 (0 - 61)	1,554
L	C	18 (0 - 95)	1,554

E. coli state summary

All sites in the Lower Clutha Rohe fail to comply with the *E. coli* national bottom line. Over the 10-year period, trends for sites tend to show either neutral or improving trends. Network modelling indicates that the lowland confidence interval does not overlap 100%. This indicates there is 95% confidence that a reduction is required to for all segments to comply with the national bottom line. To improve state, measures to reduce concentrations of *E. coli* are required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Four sites in the Lower Clutha Rohe fail to comply with the C-band DRP attribute, including the Crookston Burn at Kelso Road, Heriot Burn at Park Hill Road, Wairuna at Millar Road, and Waiwera at Maws Farm (Table 220). The Clutha at Balclutha complies with the A-band. The remaining sites often span multiple bands in the rolling analysis with results varying between the B and C-bands.

Table 220: Lower Clutha Rohe DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Clutha @ Balclutha	CWLk	0.001 (0.001^{2020} - 0.001^{2017})	A (A - A)	0.01 (0.005^{2022} - 0.01^{2017})	A (A - A)
Crookston Burn at Kelso Road	CDL	0.034 (0.031^{2020} - 0.034^{2018})	D (D - D)	0.06 (0.059^{2018} - 0.069^{2021})	D (D - D)

Site	Class	Median	Median Band	95th	95th Band
Heriot Burn at Park Hill Road	CDL	0.034 (0.026[2022] - 0.034[2018])	D (D - D)	0.074 (0.045[2022] - 0.074[2017])	D (C - D)
Lovells Creek at Station Road	CDL	0.014 (0.01[2020] - 0.014[2017])	C (B - C)	0.024 (0.024[2017] - 0.034[2022])	B (B - C)
Pomahaka at Burkes Ford	CDL	0.014 (0.011[2022] - 0.014[2017])	C (C - C)	0.024 (0.024[2017] - 0.027[2021])	B (B - B)
Pomahaka at Glenken	CDH	0.008 (0.006[2022] - 0.008[2017])	B (A - B)	0.014 (0.014[2017] - 0.017[2021])	A (A - A)
Waipahi at Cairns Peak	CDL	0.015 (0.011[2022] - 0.015[2017])	C (C - C)	0.028 (0.028[2017] - 0.051[2022])	B (B - C)
Waipahi at Waipahi	CWL	0.017 (0.014[2022] - 0.017[2018])	C (C - C)	0.03 (0.028[2021] - 0.034[2022])	C (B - C)
Wairuna at Millar Road	CDL	0.035 (0.029[2021] - 0.04[2022])	D (D - D)	0.13 (0.13[2017] - 0.194[2022])	D (D - D)
Waitahuna at Tweeds Bridge	CDL	0.015 (0.012[2022] - 0.015[2017])	C (C - C)	0.024 (0.024[2019] - 0.036[2021])	B (B - C)
Waiwera at Clutha confluence u/s 1km	CDL				
Waiwera at Maws Farm	CDL	0.024 (0.021[2020] - 0.025[2018])	D (D - D)	0.038 (0.038[2017] - 0.062[2022])	C (C - D)

Site-based trends

Over the 20-year trend period five sites, including the Crookston Burn at Kelso Road, Heriot Burn at Park Hill Road, Pomahaka at Burkes Ford, Waipahi at Waipahi, and Waitahuna at Tweeds Bridge have trend probabilities of *unlikely* to be improving, or lower, which indicates DRP levels have increased at these sites (Table 221). The Clutha at Balclutha, Pomahaka at Glenken and Waipahi at Waipahi have probabilities of *likely* to be improving or higher which indicates DRP levels have decreased at these sites.

Over the 10-year trend period, the majority of sites have trend probabilities of *likely* to be improving or higher indicating DRP levels have decreased across the FMU (Table 222). The exceptions are the Crookston Burn at Kelso Road which is *as likely as not* to be improving and the Waiwera at Maws Farm which is *unlikely* to be improving indicating DRP has increased at this site.

Table 221: Lower Clutha Rohe 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	239	-1.91	0.99	Extremely likely
Crookston Burn at Kelso Road	Qtr	68	1.87	0.00	Exceptionally unlikely
Heriot Burn at Park Hill Road	BiMonth	117	2.87	0.00	Exceptionally unlikely
Pomahaka at Burkes Ford	BiMonth	116	0.21	0.22	Unlikely
Pomahaka at Glenken	BiMonth	115	0.00	0.71	Likely
Waipahi at Cairns Peak	BiMonth	109	-0.29	0.74	Likely
Waipahi at Waipahi	BiMonth	117	0.95	0.07	Very unlikely
Waitahuna at Tweeds Bridge	BiMonth	119	2.63	0.00	Exceptionally unlikely

Table 222: Lower Clutha Rohe 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	119	-3.91	0.91	Very likely
Crookston Burn at Kelso Road	Month	108	0.00	0.48	As likely as not
Heriot Burn at Park Hill Road	Month	114	-3.32	1.00	Virtually certain
Lovells Creek at Station Road	Month	111	-1.77	0.88	Likely
Pomahaka at Burkes Ford	Month	114	-2.63	0.98	Extremely likely
Pomahaka at Glenken	Month	108	0.00	0.72	Likely
Waipahi at Cairns Peak	Month	109	-3.63	0.99	Virtually certain
Waipahi at Waipahi	Month	115	-0.38	0.70	Likely
Wairuna at Millar Road	Month	115	-0.62	0.72	Likely
Waitahuna at Tweeds Bridge	Month	116	-1.67	0.93	Very likely
Waiwera at Maws Farm	Month	114	1.05	0.20	Unlikely

Dissolved reactive phosphorus state summary

Four sites in the Lower Clutha Rohe fail to comply with the DRP C-band. Most sites have improving trends over the 10-year period. Whether phosphorus reductions are required depends upon the target attribute state set for this table and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

One out of four periphyton biomass monitoring sites (Waipahi at Waipahi) in the Lower Clutha Rohe fails to comply with the national bottom line (Table 223). The remaining three sites comply with the A-band.

Table 223: Lower Clutha Rohe periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Blackcleugh Burn at Rongahere Road	30	A	30
Upper Pomahaka at Aitchison Runs Road	36	A	29
Waipahi at Waipahi	235	D	25
Waitahuna at Tweeds Bridge	31	A	29

For total nitrogen, in relation to the periphyton biomass 20% under-protection risk nutrient criteria, four sites comply with the C-band criteria including the Clutha at Balclutha that complies with the B-band criteria, the Pomahaka at Glenken, Waipahi at Waipahi, and Waitahuna at Tweeds Bridge (Table 224). All other monitored sites fail to comply with the C-band criteria indicating there is potential for periphyton biomass which exceeds the bottom line in the Lower Clutha FMU.

For total phosphorus, in relation to the periphyton biomass 20% under-protection risk nutrient criteria, three sites including the Clutha at Balclutha, Pomahaka at Glenken, and Waipahi at Waipahi comply with the C-band criteria (Table 224). All other sites fail to comply with the C-band criteria.

Table 224: Lower Clutha Rohe total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (end date 2017- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals.

Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Clutha @ Balclutha	CWLk	0.132 (0.119^{2018} - 0.133^{2021})	B (B - B)	0.007 (0.007^{2020} - 0.009^{2021})	B (B - B)
Crookston Burn at Kelso Road	CDL	1.8 (1.6^{2022} - 1.8^{2019})	D (D - D)	0.055 (0.055^{2017} - 0.056^{2021})	D (D - D)
Heriot Burn at Park Hill Road	CDL	1.795 (1.72^{2022} - 1.815^{2021})	D (D - D)	0.07 (0.058^{2022} - 0.071^{2018})	D (D - D)
Lovells Creek at Station Road	CDL	1.29 (1.2^{2019} - 1.53^{2021})	D (D - D)	0.035 (0.03^{2022} - 0.035^{2017})	D (D - D)
Pomahaka at Burkes Ford	CDL	0.87 (0.86^{2019} - 0.98^{2021})	D (D - D)	0.034 (0.032^{2022} - 0.034^{2018})	D (D - D)
Pomahaka at Glenken	CDH	0.26 (0.22^{2020} - 0.26^{2017})	C (B - C)	0.019 (0.017^{2022} - 0.02^{2019})	C (C - C)
Waipahi at Cairns Peak	CDL	1.3 (1.2^{2020} - 1.3^{2017})	D (D - D)	0.044 (0.035^{2022} - 0.044^{2017})	D (D - D)
Waipahi at Waipahi	CWL	1.56 (1.48^{2022} - 1.56^{2017})	C (C - C)	0.038 (0.036^{2021} - 0.04^{2018})	C (C - C)
Wairuna at Millar Road	CDL	1.805 (1.69^{2019} - 1.86^{2021})	D (D - D)	0.092 (0.09^{2019} - 0.093^{2022})	D (D - D)
Waitahuna at Tweeds Bridge	CDL	0.48 (0.43^{2019} - 0.48^{2017})	C (C - C)	0.038 (0.038^{2022} - 0.042^{2021})	D (D - D)
Waiwera at Clutha confluence u/s 1km	CDL				
Waiwera at Maws Farm	CDL	1.24 (1.1^{2018} - 1.44^{2021})	D (D - D)	0.052 (0.046^{2020} - 0.052^{2018})	D (D - D)

Site-based trends

Over the 20-year total nitrogen trend period, five sites have *unlikely*, or lower, probabilities of an improving trend indicating total nitrogen has increased at these sites (Table 225). Two sites, the Clutha at Balclutha and Crookston Burn at Kelso Road have *very likely,* or higher, probabilities of an improving trend indicating total nitrogen has decreased at these sites.

Over the 10-year total nitrogen trend period, the majority of sites have *likely* to be improving, or higher, probabilities indicating total nitrogen levels have decreased at these sites (Table 226). Two sites, Lovells Creek at Station Road and Wairuna at Millar Road, have *unlikely* to be improving probabilities, or lower, indicating total nitrogen concentrations have increased.

Table 225: Lower Clutha Rohe 20-year trends for total nitrogen for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	239	-0.45	0.90	Very likely
Crookston Burn at Kelso Road	Qtr	68	-1.35	0.98	Extremely likely
Heriot Burn at Park Hill Road	BiMonth	117	0.11	0.39	As likely as not
Pomahaka at Burkes Ford	BiMonth	115	0.30	0.32	Unlikely
Pomahaka at Glenken	BiMonth	117	0.31	0.28	Unlikely
Waipahi at Cairns Peak	BiMonth	108	1.03	0.02	Extremely unlikely
Waipahi at Waipahi	BiMonth	117	0.74	0.07	Very unlikely
Waitahuna at Tweeds Bridge	BiMonth	118	0.99	0.03	Extremely unlikely

Table 226: Lower Clutha Rohe 10-year trends for total nitrogen for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	119	0.32	0.40	As likely as not
Crookston Burn at Kelso Road	Month	109	-2.33	0.98	Extremely likely
Heriot Burn at Park Hill Road	Month	115	-2.17	1.00	Virtually certain
Lovells Creek at Station Road	Month	111	3.09	0.01	Exceptionally unlikely
Pomahaka at Burkes Ford	Month	115	-0.99	0.79	Likely
Pomahaka at Glenken	Month	109	0.00	0.43	As likely as not
Waipahi at Cairns Peak	Month	109	-0.93	0.81	Likely
Waipahi at Waipahi	Month	115	-0.51	0.89	Likely
Wairuna at Millar Road	Month	115	1.20	0.11	Unlikely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waitahuna at Tweeds Bridge	Month	116	-1.06	0.81	Likely
Waiwera at Maws Farm	Month	114	0.25	0.42	As likely as not

Over the 20-year total phosphorus trend period one site, the Waitahuna at Tweeds Bridge, has a trend probability of *unlikely* to be improving or lower which indicates total phosphorus has increased at this site (Table 227). All other sites have probabilities of *as likely as not* to be improving, or higher, indicating total phosphorus levels are either stable or likely to be decreasing.

Over the 10-year trend period, the majority of sites have *likely* to be improving probabilities, or higher, indicating total phosphorus is decreasing across the Lower Clutha FMU (Table 228). The exception is the Wairuna at Millar Road monitoring site which is *unlikely* to be improving.

Table 227: Lower Clutha Rohe 20-year trends for total phosphorus for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	239	-1.14	0.96	Extremely likely
Crookston Burn at Kelso Road	Qtr	68	0.41	0.33	As likely as not
Heriot Burn at Park Hill Road	BiMonth	117	0.00	0.40	As likely as not
Pomahaka at Burkes Ford	BiMonth	115	0.00	0.46	As likely as not
Pomahaka at Glenken	BiMonth	115	0.00	0.39	As likely as not
Waipahi at Cairns Peak	BiMonth	109	-0.96	0.83	Likely
Waipahi at Waipahi	BiMonth	117	-0.26	0.68	Likely
Waitahuna at Tweeds Bridge	BiMonth	118	1.13	0.02	Extremely unlikely

Table 228: Lower Clutha Rohe 10-year trends for total phosphorus for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Clutha @ Balclutha	Month	119	-1.11	0.73	Likely
Crookston Burn at Kelso Road	Month	109	0.30	0.35	As likely as not
Heriot Burn at Park Hill Road	Month	115	-2.44	0.99	Virtually certain

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Lovells Creek at Station Road	Month	111	-3.13	1.00	Virtually certain
Pomahaka at Burkes Ford	Month	115	-0.86	0.76	Likely
Pomahaka at Glenken	Month	109	-2.38	0.92	Very likely
Waipahi at Cairns Peak	Month	109	-2.80	0.99	Virtually certain
Waipahi at Waipahi	Month	115	-0.89	0.78	Likely
Wairuna at Millar Road	Month	115	0.83	0.11	Unlikely
Waitahuna at Tweeds Bridge	Month	116	-1.37	0.85	Likely
Waiwera at Maws Farm	Month	114	-0.66	0.76	Likely

Network state

For total nitrogen in relation to the periphyton biomass 20% under-protection risk nutrient criteria, network modelling results indicate 100% (100-100) of mountain segments comply with the B-band criteria (Table 229). In the hill management class, 61% (35-90) of segments comply with the B-band criteria and 100% (99-100) comply with C-band criteria. For the lowland management class 0% (0-1) of segments comply with the B-band criteria and 29% (7-93) comply with the C-band. Few segments comply with the A-band criteria in any management class.

For total phosphorus, network modelling results indicate 96% (49-100) of mountain segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria (Table 229). In the hill management class, 39% (8-43) of segments comply with the B-band criteria and 88% (58-100) comply with C-band criteria. For the lowland management class 1% (0-2) of segments comply with the B-band criteria and 42% (7-96) comply with the C-band. Few segments comply with the A-band criteria in any management class.

Table 229: Percent of river segments in the Lower Clutha Rohe complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
M	A	4 (0 - 20)	0 (0 - 0)	91
M	B	100 (100 - 100)	96 (49 - 100)	91
M	C	100 (100 - 100)	100 (100 - 100)	91

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
H	A	1 (0 - 1)	0 (0 - 0)	612
H	B	61 (35 - 90)	39 (8 - 43)	612
H	C	100 (99 - 100)	88 (58 - 100)	612
L	A	0 (0 - 0)	0 (0 - 0)	979
L	B	0 (0 - 1)	1 (0 - 2)	979
L	C	29 (7 - 93)	42 (7 - 96)	979

Periphyton biomass state summary

The Lower Clutha Rohe has four periphyton biomass monitoring sites; three comply with the A-band and one fails to comply with the C-band. When compared to the 20% under-protection risk periphyton nutrient criteria, most sites fail to comply with both the total nitrogen and total phosphorus C-band criteria. Total nitrogen trends indicate increased total nitrogen levels over the 20-year period and generally improving trends over the 10-year trend period. Total phosphorus trends indicate decreasing, or neutral total phosphorus levels over the 20-year period and decreasing levels over the 10-year period. Network modelling confidence intervals fail to overlap 100% for the C-band in the lowland class indicating with 95% confidence that some level of reduction in total nitrogen and total phosphorus concentrations is required for all segments to comply with the C-band criteria.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

For MCI three sites, including the Waipahi at Waipahi, Wairuna at Millar Road, and Waiwera at Clutha Confluence u/s, fail to comply with the national bottom line (Table 230). The Heriot Burn at Park Hill Road complies with the C-band. The Waipahi at Cairns Peak and Waitahuna at Tweeds bridge range from complying with C to B-band in the rolling analysis.

For ASPM, over the 2012-2017 period no sites fail to comply with the national bottom line (Table 230). However, two sites, including the Waipahi at Waipahi and Waiwera at Clutha Confluence fail to comply with the national bottom line in the rolling analysis ranging from D to C-band. The Heriot Burn at Park Hill Road and Waitahuna at Tweeds Bridge comply with the B-band. The Waipahi at Cairns Peak complies with the B-band and ranges from C to B-band in the rolling analysis.

Table 230: Lower Clutha Rohe macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in

paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Clutha @ Balclutha	CWLk				
Crookston Burn at Kelso Road	CDL				
Heriot Burn at Park Hill Road	CDL	92.86 (92.86^{2017} - 104.23^{2021})	C (C - C)	0.52 (0.52^{2020} - 0.535^{2021})	B (B - B)
Lovells Creek at Station Road	CDL				
Pomahaka at Burkes Ford	CDL				
Pomahaka at Glenken	CDH				
Waipahi at Cairns Peak	CDL	108.33 (102.63^{2021} - 112.5^{2019})	C (C - B)	0.41 (0.35^{2022} - 0.41^{2017})	B (C - B)
Waipahi at Waipahi	CWL	90 (84.62^{2021} - 90^{2019})	D (D - D)	0.36 (0.3^{2021} - 0.36^{2019})	C (D - C)
Wairuna at Millar Road	CDL	88 (80.136^{2022} - 88^{2017})	D (D - D)		
Waitahuna at Tweeds Bridge	CDL	111.43 (100^{2019} - 111.43^{2017})	B (C - B)	0.49 (0.483^{2022} - 0.52^{2018})	B (B - B)
Waiwera at Clutha confluence u/s 1km	CDL	84.55 (81.647^{2021} - 85.965^{2022})	D (D - D)	0.35 (0.28^{2022} - 0.35^{2017})	C (D - C)
Waiwera at Maws Farm	CDL				

Site-based trends

Over both the 10 and 20-year MCI trend period, both monitored sites are *unlikely* to *very unlikely* to be improving which indicates the MCI score has decreased over this period (Table 231; Table 232).

Table 231: Lower Clutha Rohe 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipahi at Waipahi	Year	18	-0.30	0.92	Very unlikely
Waitahuna at Tweeds Bridge	Year	16	-0.88	0.94	Very unlikely

Table 232: Lower Clutha Rohe 10-year trends for the macroinvertebrate community index (MCI) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipahi at Waipahi	Year	10	-0.68	0.88	Unlikely
Waitahuna at Tweeds Bridge	Year	10	-2.16	0.94	Very unlikely

Over the 20-year ASPM trend period, the Waipahi at Waipahi is *as likely as not* to be improving which is an ambiguous result classed as neither increasing nor decreasing (Table 233). Over the 10-year trend period, both sites are *unlikely* to be improving indicating ASPM has decreased (

Table 234).

Table 233: Lower Clutha Rohe 20-year trends for the average score per metric (ASPM) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipahi at Waipahi	Year	16	0	0.43	As likely as not

Table 234: Lower Clutha Rohe 10-year trends for the average score per metric (ASPM) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Waipahi at Waipahi	Year	9	-2.62	0.85	Unlikely
Waitahuna at Tweeds Bridge	Year	9	-2.90	0.83	Unlikely

Network state

Network modelling results for MCI show 96% of mountain segments comply with the B-band and 98% comply with the C-band. In the hill management class, 64% comply with the B-band and 100% comply with the C-band. For the lowland class, 4% comply with the B-band and 73% comply with the C-band (Table 235).

Table 235 Percent of segments in the Lower Clutha Rohe complying with potential A,B and C macroinvertebrate community index (MCI) target attribute bands, split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
M	A	0	93
M	B	96	93
M	C	98	93
H	A	0	635
H	B	64	635
H	C	100	635
L	A	0	1,541
L	B	4	1,541
L	C	73	1,541

Macroinvertebrate state summary

Three out of six sites in the Lower Clutha Rohe fail to comply with the national bottom line for MCI or ASPM across the rolling analysis. Network results show approximately 27% of lowland segments fail to comply with the national bottom line. Over the 10-year and 20-year trend period, degrading trends are present. To comply with the national bottom line, improvements across the Rohe are required. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. While the causes of low macroinvertebrate metric scores are not known, management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Site-based baseline state

All sites in the Lower Clutha Rohe fail to comply with the fish IBI C-band in the rolling analysis (Table 236). In 2017, the Heriot Burn at Park Hill Road and Wairuna Millar Road comply with the B-band while the Waipahi at Cairns Peak and Waiwera Hillfoot Road comply with the C-band.

Table 236: Lower Clutha Rohe annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not

confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Heriot Burn at Parkhill Rd	32 (16[2012] - 32[2017])	B (D - B)	A (C - A)
Waipahi at Cairns Peak	20 (16[2015] - 20[2017])	C (D - C)	B (C - B)
Wairuna at Millar Rd	30 (16[2012] - 32[2013])	B (D - B)	A (C - A)
Waiwera at Hillfoot Road	20 (16[2012] - 20[2020])	C (D - C)	B (C - B)

Catlins

Ammonia Toxicity (NPSFM Table 5)

Site-based baseline state

All sites in the Catlins FMU comply with the ammoniacal nitrogen A-band (Table 237).

Table 237: Catlins FMU NH toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2017 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF (5-year period ending August 2017- 5-year period ending August 2022) is presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Catlins at Houipapa	CWL	0.006 (0.003[2022] - 0.006[2017])	A (A - A)	0.018 (0.008[2022] - 0.018[2017])	A (A - A)
Owaka at Katea Road	CWL	0.007 (0.004[2022] - 0.007[2017])	A (A - A)	0.024 (0.014[2022] - 0.024[2017])	A (A - A)

Site-based trends

Over both the 10 and 20-year trend periods, monitored sites in the Catlins FMU have *likely* to be improving, or higher, probabilities indicating ammoniacal nitrogen has decreased (Table 238;Table 239).

Table 238: Catlins FMU 20-year trends for ammoniacal nitrogen (NH) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	114	0	0.83	Likely

Table 239: Catlins FMU 10-year trends for ammoniacal nitrogen (NH) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	0	0.99	Virtually certain
Owaka at Katea Road	Month	99	0	0.95	Extremely likely

Ammoniacal nitrogen toxicity state summary

For ammoniacal nitrogen toxicity, all sites in the FMU comply with the national bottom line and have improving trends. Therefore, no reductions are required for this attribute to comply with the national bottom line.

Nitrate Toxicity (NPSFM Table 6)

Site-based baseline state

All sites in the Catlins FMU comply with the national bottom line for nitrate toxicity (Table 240). The Catlins at Houipapa complies with the A-band and the Owaka at Katea Road complies with the B-band.

Table 240: Catlins FMU NNN toxicity state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the B band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Catlins at Houipapa	CWL	0.43 (0.39^{2022} - 0.43^{2017})	A (A - A)	0.76 (0.7^{2019} - 0.76^{2017})	A (A - A)
Owaka at Katea Road	CWL	1.3 (1.01^{2022} - 1.3^{2017})	B (B - B)	2.325 (2.17^{2020} - 2.43^{2019})	B (B - B)

Site-based trends

Over the 20-year trend period, the Catlins at Houipapa is *exceptionally unlikely* to be improving indicating nitrate levels have increased (Table 241).

Over the 10-year trend period both sites have *likely,* or higher, probabilities of an improving trend which indicates nitrate levels have decreased at these sites (Table 242).

Table 241: Catlins FMU 20-year trends for nitrite/nitrate nitrogen (NNN) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	114	1.86	0	Exceptionally unlikely

Table 242: Catlins FMU 10-year trends for nitrite/nitrate nitrogen (NNN) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	-0.55	0.69	Likely
Owaka at Katea Road	Month	99	-3.33	0.98	Extremely likely

Network State

Network modelling for nitrate toxicity indicates 100% of hill segments comply with nitrate toxicity B and A bands (100%; 100-100) (Table 243). In the lowland class, 93% (76-100) comply with the A-band 100% (97-100) comply with the B band and 100% (99-100) comply with the C-band.

Table 243: Percent of river segments in the Catlins FMU complying with potential nitrate toxicity target attribute bands, split by management class, with 90 percent confidence intervals. The national bottom line is the B-band. Model results based on Snelder and Fraser (2023).

Management Class	Band	Current	Count
H	A	100 (100 - 100)	83
H	B	100 (100 - 100)	83
H	C	100 (100 - 100)	83

Management Class	Band	Current	Count
L	A	93 (76 - 100)	563
L	B	100 (97 - 100)	563
L	C	100 (99 - 100)	563

Nitrate toxicity state summary

All sites and segments in the Catlins FMU comply with the national bottom line for nitrate toxicity. Over the 20-year trend period degrading trends have occurred. However, over the 10-year period, trends have improved. To maintain baseline state, measures which limited any additional input are required. For all segments and sites to comply with the A-band, some reduction may be necessary as approximately 7% of segments and a monitoring site fail to comply with the A-band.

Suspended Fine Sediment (NPSFM Table 8)

Site-based baseline state

The Catlins at Houipapa complies with the B-band for suspended fine sediment and ranges from B to A in the rolling analysis (Table 244).

Table 244: Catlins FMU clarity state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band
Catlins at Houipapa	CWL	1.333 (1.333^{2021} - 1.451^{2020})	B (B - A)
Owaka at Katea Road	CWL		

Site-based trends

Over the 20-year trend period, turbidity is *very unlikely* to be improving at the Catlins at Houipapa monitoring site which indicates turbidity has increased (Table 245).

Over the 10-year monitoring period, the Catlins at Houipapa is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading. The Owaka at Katea Road is *extremely likely* to be improving which indicates turbidity has decreased at this site (Table 246).

Table 245: Catlins FMU 20-year trends for turbidity for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	109	1.13	0.07	Very unlikely

Table 246: Catlins FMU 10-year trends for turbidity for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	0.00	0.50	As likely as not
Owaka at Katea Road	Month	99	-3.69	0.96	Extremely likely

Network state

Network modelling for clarity indicates 94% of hill segments comply with the A-band and 100% comply with the B-band (Table 247). In the lowland class, 69% of segments comply with the A-band, 80% of segments comply with the B-band and 95% of segments comply with the C-band.

Table 247: Percent of segments in the Catlins FMU complying with potential A, B, and C suspended fine sediment target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
H	A	94	83
H	B	100	83
H	C	100	83
L	A	69	627
L	B	80	627
L	C	95	627

Suspended sediment state summary

Rivers in the Catlins FMU are affected by natural occurring process (such tannin staining) which naturally result in lower clarity. The Catlins River at Houipapa complies with the B/A band over the rolling analysis. Trends analysis indicates mixed patterns with an improving or ambiguous trends over the 10-year period and degrading trend over the 20-year period. Appropriate targets are difficult to

determine without a better understanding of natural state in these systems. In the interim, to ensure sites maintain their current state, measures which manage sediment inputs are required.

Escherichia coli (NPSFM Table 9)

Site-based baseline state

The Catlins at Houipapa complies with the *E. coli* B-band in the 2012-2017 period (Table 248). However, in the rolling analysis, this site ranges from D to B- band failing to comply with the national bottom line.

Table 248: Catlins FMU E. coli state based on state of environment monitoring with over 54 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line is the C band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017-5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band	g260	g260 Band	g540	g540 Band
Catlins at Houipapa	CWL	130 (120^{2019} - 150^{2022})	A (A - D)	589.5 (589.5^{2017} - 1600^{2022})	B (B - D)	0.263 (0.183^{2019} - 0.263^{2017})	B (A - B)	0.07 (0.07^{2017} - 0.164^{2022})	B (B - C)
Owaka at Katea Road	CWL								

Site-based trends

Over the 20-year trend period, the Catlins at Houipapa is *exceptionally unlikely* to be improving indicating *E. coli* levels have increased (Table 249).

Over the 10-year trend period the Catlins at Houipapa is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading. The Owaka at Katea Road site is *unlikely* to be improving which indicates *E. coli* has increased at this site (Table 250).

Table 249: Catlins FMU 20-year trends for E. coli for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	114	2.45	0.01	Exceptionally unlikely

Table 250: Catlins FMU 10-year trends for E. coli for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	-1.04	0.61	As likely as not
Owaka at Katea Road	Month	98	2.24	0.17	Unlikely

Network state

Network modelling results for *E. coli* show 25% (0-73) of hill class segments comply with the A-band, 58% (2-96) comply with the B-band and 78% (32-98) comply with the C-band (Table 251). In the lowland class, 6% (0-24) of segments comply with the A-band, 21% (4-47) comply with the B-band and 34% (12-73) comply with the C-band.

Table 251: Percent of river segments in the Catlins FMU complying with potential E. coli target attribute bands with 90 percent confidence intervals for current state. Modelling altered from Snelder and Fraser (2021).

Management Class	Band	Current	Count
H	A	25 (0 - 73)	83
H	B	58 (2 - 96)	83
H	C	78 (32 - 98)	83
L	A	6 (0 - 24)	629
L	B	21 (4 - 47)	629
L	C	34 (12 - 73)	629

Escherichia coli state summary

The monitoring site in the Catlins FMU fails to comply with the *E. coli* national bottom line across the rolling analysis. Trend results indicate degrading trends are present in both the 10 and 20-year periods. Network modelling results show hill and lowland class confidence intervals do not overlap 100%. This indicates there is 95% confidence that a reduction in *E. coli* concentrations is required for all segments to comply with the national bottom line. To improve state, measures which reduce *E. coli* inputs would be required.

Dissolved Reactive Phosphorus (NPSFM Table 20)

Site-based baseline state

Both sites in the Catlins FMU comply with DRP C-band (Table 252).

Table 252: Catlins FMU DRP state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. There is no national bottom line for this attribute. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	Median	Median Band	95th	95th Band
Catlins at Houipapa	CWL	0.014 (0.01^{2022} - 0.014^{2017})	C (C - C)	0.02 (0.014^{2022} - 0.02^{2017})	A (A - A)
Owaka at Katea Road	CWL	0.018 (0.015^{2022} - 0.018^{2017})	C (C - C)	0.028 (0.025^{2020} - 0.029^{2018})	B (B - B)

Site-based trends

Over both the 10 and 20-year trend period both sites in the Catlins FMU have *likely* to be improving probabilities, or higher, indicating DRP concentrations have decreased (Table 253;

Table 254).

Table 253: Catlins FMU 20-year trends for dissolved reactive phosphorus (DRP) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	113	-1.49	1	Virtually certain

Table 254: Catlins FMU 10-year trends for dissolved reactive phosphorus (DRP) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	-2.01	0.98	Extremely likely

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Owaka at Katea Road	Month	99	-0.40	0.69	Likely

Dissolved reactive phosphorus state summary

Both sites in the Catlins FMU comply with the DRP C-band and have improving trends over the 10- and 20-year trend period. Whether phosphorus reductions are required depends upon the target attribute state set for this table and the periphyton biomass target.

Periphyton (NPSFM Table 2)

Site-based baseline state

The Owaka at Katea Road monitoring site complies with the C-band for periphyton biomass and the Tahakopa at Tahakopa complies with the B-band (Table 255).

Table 255: Catlins FMU periphyton biomass state based on state of environment monitoring data from sites with >20 observations in the 1 July 2019 to 30 June 2022 period.

Site	92nd percentile	Band	# of Obs.
Owaka at Katea Road	178	C	28
Tahakopa at Tahakopa	111	B	28

For both total nitrogen and total phosphorus, in relation to the periphyton biomass 20% under-protection risk nutrient criteria, both sites comply with the C-band criteria (Table 256).

Table 256: Catlins FMU total nitrogen and total phosphorus compliance with the 20% UPR periphyton nutrient criteria (Snelder et al. 2023) baseline state based on state of environment monitoring with over 30 observations in the 1 September 2012 to 30 August 2017 period. The periphyton national bottom line is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	TN	TN Band	TP	TP Band
Catlins at Houipapa	CWL	0.64 (0.62^{2022} - 0.65^{2021})	C (C - C)	0.028 (0.025^{2021} - 0.029^{2019})	C (C - C)

Site	Class	TN	TN Band	TP	TP Band
Owaka at Katea Road	CWL	1.5 (1.31[2022] - 1.5[2018])	C (C - C)	0.031 (0.03[2018] - 0.032[2020])	C (C - C)

Site-based trends

Over the 20-year total nitrogen trend period, the Catlins at Houipapa is *exceptionally unlikely* to be improving indicating total nitrogen levels have increased (Table 257). Over the 10-year trend period, this site is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading (Table 258). The Owaka at Katea Road is *very likely* to be improving over the 10-year period indicating total nitrogen levels have decreased.

Table 257: Catlins FMU 20-year trends for total nitrogen for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	114	1.18	0	Exceptionally unlikely

Table 258: Catlins FMU 10-year trends for total nitrogen for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	0.10	0.42	As likely as not
Owaka at Katea Road	Month	99	-2.16	0.94	Very likely

Over the 20-year trend period, the Catlins at Houipapa is *as likely as not* to be improving which is an ambiguous result classed as neither improving nor degrading (Table 259). Over the 10-year trend period, both sites are *likely* to be improving which indicates total phosphorus levels have decreased (Table 260).

Table 259: Catlins FMU 20-year trends for total phosphorus for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	BiMonth	113	0	0.5	As likely as not

Table 260: Catlins FMU 10-year trends for total phosphorus for the 2012-2022.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Catlins at Houipapa	Month	113	-0.64	0.8	Likely
Owaka at Katea Road	Month	99	-1.01	0.8	Likely

Network state

For total nitrogen, in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results indicate 93% (79-100) of hill segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria (Table 261). For the lowland management class 14% (2-32) of segments comply with the B-band criteria and 85% (75-96) comply with the C-band. Few segments comply with the A-band criteria in any management class which indicates this band may not be achievable even in natural state (Appendix 2).

For total phosphorus, in relation to the 20% under-protection risk periphyton biomass nutrient criteria, network modelling results indicate 88% (33-100) of hill class segments comply with the B-band criteria and 100% (100-100) comply with the C-band criteria. For the lowland management class 23% (3-48) of segments comply with the B-band criteria and 91% (82-99) comply with the C-band. Few segments comply with the A-band criteria in any management class which indicates this band may not be achievable even in natural state (Appendix 2).

Table 261: Percent of river segments in the Catlins FMU complying with Snelder et al., 2023 20% under-protection risk periphyton nutrient criteria (see appendix 1), split by management class, with 90 percent confidence intervals. Segments which do not support periphyton growth (i.e., soft bottom streams) have been removed prior to analysis. Modelling was completed by Snelder and Fraser (2023).

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
H	A	6 (0 - 57)	0 (0 - 0)	83

Management Class	Band	Total Nitrogen	Total Phosphorus	Total segments
H	B	93 (79 - 100)	88 (33 - 100)	83
H	C	100 (100 - 100)	100 (100 - 100)	83
L	A	0 (0 - 2)	0 (0 - 0)	563
L	B	14 (2 - 32)	23 (3 - 48)	563
L	C	85 (75 - 96)	91 (82 - 99)	563

Periphyton biomass state summary

The Catlins FMU has two periphyton biomass monitoring sites; both sites comply with the C-band 20% under-protection risk for periphyton total phosphorus and total nitrogen nutrient criteria. Total nitrogen trends indicate increased total nitrogen levels over the 20-year period and generally improving trends over the 10-year trend period. Total phosphorus trends indicate decreasing, or stable total phosphorus levels over the 20-year period and decreasing levels over the 10-year period. Network modelling confidence intervals fail to overlap 100% for the C-band in all classes indicating with 95% confidence that nitrogen and phosphorus reductions are required for all segments to comply with the C-band criteria.

Macroinvertebrates (NPSFM Table 14-15)

Site-based baseline state

The Catlins at Houipapa monitoring site complies with the B- band over the 2012-2017 period for both MCI and ASPM (Table 262). The MCI ranges from C- to B-band in the rolling analysis, whereas APSM remains in the B-band.

Table 262: Catlins FMU macroinvertebrate state based on state of environment monitoring with over 5 observations in the 1 September 2012 to 30 August 2017 period. The national bottom line for this attribute is the C-band. The minimum and maximum rolling NOF statistics (5-year period ending August 2017- 5-year period ending August 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence

intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Class	MCI	MCI Band	ASPM	ASPM Band
Catlins at Houipapa	CWL	112 (103.845[2022] - 112[2017])	B (C - B)	0.57 (0.506[2022] - 0.58[2020])	B (B - B)
Owaka at Katea Road	CWL				

Site-based trends

Over the 20-year trend period, the Owaka at Katea Road site is *as likely as not* to be improving which is an ambiguous result not classed as improving or degrading(Table 263). Over the 10-year trend period this site is *likely* to be improving which indicates the health of the macro-invertebrate community has increased over this period(Table 264).

Table 263: Catlins FMU 20-year trends for the macroinvertebrate community index (MCI) for the 2002-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Owaka at Katea Road	Year	9	-0.02	0.5	As likely as not

Table 264: Catlins FMU 10-year trends for the average score per metric (APSM) for the 2012-2022 period.

Site	Freq	# of Obs	% Annual Change	Confidence decreasing	Improving likelihood
Owaka at Katea Road	Year	8	2.13	0.31	Likely

Network state

Network modelling results for MCI show 99% of hill class segments comply with the B-band and 100% comply with the C-band (Table 265). In the lowland management class, 44% comply with the B-band and 92% comply with the C-band.

Table 265: Percent of segments in the Catlins FMU complying with potential A,B and C macroinvertebrate community index (MCI) target attribute bands split by management class in 2017 based on Whitehead (2018).

Management Class	Band	Segment %	# of Segments
H	A	0	83
H	B	99	83
H	C	100	83
L	A	0	621
L	B	44	621
L	C	92	621

Macroinvertebrate state summary

The macroinvertebrate monitoring site in the Catlins FMU complies with the national bottom line for both MCI and ASPM. Over the 10-year and 20-year trend period this site shows stable or improving trends. Network results show approximately 8% of lowland segments may fail to comply with the national bottom line. To comply with the national bottom line, improvements across the FMU may be required. Macroinvertebrates are influenced by many factors including sediment, temperature, nutrients, and habitat. Management of sediment and nutrients may help maintain or improve invertebrate scores.

Fish IBI (NPSFM Table 13)

Site-based baseline state

One site (the Owaka at Purekireki) in the Catlins FMU has fish IBI monitoring data available in 2017 which fails to comply with the C-band (Table 266). The other two sites with more recent monitoring data comply with the A-band.

Table 266: Catlins FMU annual fish index of biotic integrity (IBI) score occurring in 2017 with rolling annual statistics (end date 2012- end date 2022) are presented in the paratheses with the year the min and max occurred in super script. The values in paratheses are not confidence intervals. Instead, they are provided as a measure of site variability (natural and anthropogenic) over the rolling period analysed.

Site	Fish IBI	Band	Regional Band
Owaka at Katea Road	NA (34^{2020} - 34^{2020})	NA (A - A)	NA (A - A)
Owaka at Purekireki	16 (12^{2012} - 16^{2020})	D (D - D)	C (C - C)

Site	Fish IBI	Band	Regional Band
Tautuku D/S McLean Falls	NA (36[2020] - 54[2022])	NA (A - A)	NA (A - A)

Setting target attribute states

Selecting target attribute state is a decision to be made by decision makers. This report has provided the baseline state. To provide an initial starting point to facilitate target attribute state conversations, we provide a potential framework to derive initial draft target attribute states for the river network and monitoring sites.

Derivation of draft target attribute states

To derive an initial set of target attribute states for further refinement, a pragmatic solution is for policy to determine, for each FMU, initial network-based targets that align with the FMU visions and outcomes. As rivers vary naturally from their source to mouth, selecting target attributes for the mountain, hill and lowland management class would provide a framework that accounts for this variation while remaining simple and understandable. For some attributes, natural or reference state estimates are available and can provide an upper value on what a river may achieve in an un-impacted setting (McDowell et al. 2013). A comparison of available reference conditions to attribute bands is provided in Appendix 2.

These network-based targets can then be applied to monitoring sites as a "regional bottom line". For instance, if the target for hill-fed segments in a FMU is the B-band, and the result for a hill-fed monitoring site is currently a C, the initial target for that site would be set at the B-band threshold. Had the site currently complied with the A-band, the target would remain an A to comply with clause 3.11.2 of the NPSFM[3]. This approach will provide draft target attributes for both the network and every monitoring site. Having derived draft targets for each site based on the network targets, the site targets can then be considered in their local context to determine if the network target is suitable in that location. For example, the draft lowland target may be "C" for a given attribute, if community values at a given lowland site are not provided for by the class target, it may be appropriate to set a higher site-based target as long as it is achievable (i.e. not set as more stringent than reference state).

Setting network-based target attribute states

To set network-based targets, two components are needed. First, the target band for the river class must be selected. Second, the spatial exceedance must be considered. Spatial exceedance is the proportion of segments in the class which are not required to comply with the target attribute state. For example, the target for hill river may be set in the B-band. Some proportion of hill-fed segments, say 30 percent, may already comply with this target whereas the remaining 70 percent do not. While there are many ways to represent spatial exceedance, the tables in this report have been presented as the percentage of segments complying with potential target bands. A form of spatial exceedance has already been selected for the periphyton attribute through selection of a 20% under-protection risk. This means that if the nutrient target was reached in all segments, 80% of segments would actually comply with the target biomass objective. As a draft spatial exceedance criteria, 80% may be a pragmatic choice given it has already been selected for periphyton. This percentage could then be increased or decreased for attribute-management class combinations. For some attributes, such as nitrate toxicity, a higher threshold may be appropriate

[3] To maintain or enhance water quality

due to the current network state and the ecological risk associated with exceedance of attribute states.

The spatial exceedance component is particularly important for evaluating whether the network target attribute state has been met. Without this component, there is no defined threshold at which the "target" would be met. In lieu of a threshold, an environmentally precautionary approach would be to evaluate using a threshold of 100% of segments complying with the target band. This may not be possible even in a natural setting and therefore may require reductions larger than can be achieved.

Setting site-based target attribute states

Under policy 3.11.2, Target attribute state must be set at or above baseline state. For target attribute states which are set above baseline state, the bottom threshold of the target NPSFM band can be used as a numeric target.

Setting a numeric target which reflects maintaining baseline state is more difficult due to the complexity of natural variation and sample error. To provide a target aligned with the baseline state, a confidence interval would ideally be used. As previously discussed, a confidence interval provides a range of numbers in which the "true" statistic would fall for a given probability (i.e., 90% confident the "true" value is between 1.5 and 2.8). However, as water quality is not stationary, a confidence interval would indicate solely the range for the experienced observation period. It would not indicate whether a future period would fall within this range; it may naturally fall outside of it due to differing climate cycles, or other factors (e.g. suspended sediment concentrations may be elevated for several years following a major slip). This complicates the interpretation of confidence intervals. As a result, confidence intervals do not necessarily provide a robust range that would fully represent the baseline state.

Similarly, the lowest and highest values from the rolling analysis could be used to provide a range. However, the rolling analysis demonstrates that the numeric results from a given attribute statistic (e.g., *E. coli* 95th percentile) regularly vary, even in unimpacted sites. In many cases, the attribute state at a site regularly changes NPSFM band. This is particularly true for statistics which are influenced by a small number of observations (i.e., 95th percentiles). This indicates sites may move both above, and below, the numeric statistics derived on the baseline date because of natural variability and sample error. This is a particular issue where the attribute state is calculated over a short time period (3-5 years) but is influenced by longer-term climate cycles (e.g. Interdecadal Pacific Oscillation). These longer-term climate cycles may lead to cyclic variation in attribute state that is not captured within the timeframe over which the attribute state is calculated.

Further, in many cases, the 10- and 20-year trend analysis results conflict with NOF score. Trend analyses for some site-attribute combinations have a probability of *about as likely as not* to be improving or better. This would suggest the state of a given attribute at the site is either maintaining or improving. However, when the rolling analysis is considered, the worst NOF score occurs near the end of the rolling period. An example is the *E. coli* attribute at the Shag at Craig Road monitoring site. At this site the median, 95th percentile, and g540 statistics for *E. coli* all have their highest value (worst state) in the 5-year period ending 2022. This occurs despite a *likely to be improving* trend in both the 10- and 20-year trend analysis periods. Conflicting trend and NOF score patterns are common. As trend analyses are an appropriate tool for determining whether a site is progressing towards its target attribute state, the conflict between NOF score and trend

results is problematic; a site may be considered as no longer achieving its target attribute state despite a maintaining or improving trend.

Currently, there is no statistically robust solution to account for natural variability and sample error in baseline and target attribute states. There is also no perfect solution which resolves the disconnect between NOF score and trend analysis results. Where seeking to maintain state, a pragmatic solution is to incorporate both concepts. First, the desired NOF band (or range of NOF bands) in which the site is to remain to achieve the desired environmental outcome needs to be identified. To meet clause 3.11.2, a trend component should also then be included with a probability category of *as likely as not to be improving* or better. This would provide an additional numeric assessment component to indicate the site is, at least, maintaining state. If the site falls below the NOF band range, or the trend analysis shows degradation, further steps or interventions may be necessary. Further steps or interventions may be investigation into cause, an action plan, or additional limits on resource use.

Incorporation of additional sites from 2017 monitoring programme review

As a way of increasing the number of sites within an FMU, sites added through the 2017 monitoring review could be added with an alternative baseline period (i.e., 2017-2022). The results for all added sites are available in Ozanne et al., (2023). While adding sites from this review, or adding alternative sites in response to community consultation, is possible, these sites would not be representative on an FMU scale. To assess plan effectiveness, a monitoring programme review will be required which will alter the monitoring programme to ensure it can assess performance against both network and site-based targets. Adding additional “named” monitoring sites in the plan “lock in” the sites requiring them to be monitored. This may constrain resource that would provide for more representative monitoring within an FMU if sites were allowed to be changed. Therefore, these trade-offs must be considered before adding additional “named” sites to the plan.

References

Fraser C. 2022. Dissolved oxygen in rivers of the Otago region. Christchurch, NZ: LWP.

Mcdowell R, Snelder T, Booker D, Cox N, Wilcock R. 2012. Establishment of reference or baseline conditions of chemical indicators in New Zealand streams and rivers relative to present condition. Mar Freshw Res. 64. https://doi.org/10.1071/MF12153

McDowell RW, Snelder TH, Cox N, Booker DJ, Wilcock RJ. 2013. Establishment of reference or baseline conditions of chemical indicators in New Zealand streams and rivers relative to present conditions. Mar Freshw Res. 64(5):387–400.

MFE. 2023. He tohutohu hei whakatinana i te rarangi 3.13 o Te Mana o Te wai: A guide to implementing clause 3.13 of the NPS-FM 2020. [Internet]. Wellington, NZ: Ministry for the environment. https://environment.govt.nz/assets/publications/Freshwater/A-guide-to-implementing-clause-3.13-of-the-NPS-FM-2020.pdf

Milne J, Norton N, Booker D, Franklin P, Wood D, Ausseil O, Young R, Patterson M, Fullard L. 2023. Attribute states and uncertainty: Preliminary expert commentary on implementation of clause 3.10(4) of the NPS-FM 2020. Wellington, NZ: NIWA.

Ministry for the Environment. 2020. National Policy Statement for Freshwater Management 2020 [Internet]. [place unknown]. https://www.water-reform.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwater-management-2020

Ozanne R. 2022. Biomonitoring Report Card 2017 to 2022. Dunedin, NZ: ORC.

Ozanne R, Levy A, Borges H. 2023. State and Trends of Rivers, Lakes, and Groundwater in Otago 2017 – 2022 [Internet]. Dunedin, NZ: ORC. https://www.orc.govt.nz/media/14523/orc-river-lake-groundwater-state-and-trends-2017-2022.pdf

Snelder T. 2023. Guidance on look-up tables for setting nutrient targets for periphyton: 2023 draft. Wellington: Ministry for the Environment.

Snelder T, Biggs B. 2007. Multi-Scale River Environment Classification for Water Resources Management. JAWRA J Am Water Resour Assoc. 38:1225–1239. https://doi.org/10.1111/j.1752-1688.2002.tb04344.x

Snelder T, Fraser C. 2021. Assessment of *Escherichia coli* Load Reductions to Achieve Freshwater Objectives in the Rivers of Otago. Christchurch, NZ: LWP.

Snelder T, Fraser C. 2023. Assessment of Nutrient Load Reductions to Achieve Freshwater Objectives in the Rivers, Lakes and Estuaries of Otago. [place unknown]: Land, Water, People.

Whitehead A. 2018. Spatial modelling of river water quality state: Incorporating monitoring data from 2013 to 2017 [Internet]. Christchurch, NZ: NIWA. https://environment.govt.nz/assets/Publications/Files/spatial-modelling-of-river-water-quality-state.pdf

Appendix 1: Interim results for lake attributes

Table 267: Interim results for mid-hypolimnetic dissolved oxygen (NPSFM Table 19) from 2018-2022

Site	Depth	Annual minimum	NOF
Lake Wanaka Open	150m	9.205798522	A
Lake Wakatipu Open	200m	9.271542512	A
Lake Hayes Mid Lake	27m	0	D
Lake Hawea South Open	150m	9.275392457	A

Table 268: Interim results for lake-bottom dissolved oxygen (NPSFM Table 18) from 2018-2022

Site	Annual minimum	NOF
Lake Wanaka Open	9.21	A
Lake Wakatipu Open	9.3	A
Lake Hayes Mid Lake	0	D
Lake Hawea South Open	9.3	A
Lake Waihola at Waihola Mid	6.9	B

Table 269: Interim results for cyanobacteria-planktonic (NPSFM Table 10) from 2018-2022

Site	Cyanobacteria biovolume (mm^3/L)	NOF
Lake Onslow	0.048	A
LakeWanakaOpen	0.001	A
LakeWanakaNorthOpen	0.000034	A
LakeWakatipuOpen	0.0003	A
LakeWakatipuNorthOpen	0.0002	A
LakeHayesMidLake	0.002	A
LakeHaweaSouthOpen	0.00062	A
LakeHaweaNorthOpen	0.000152	A
LakeDunstanatBoatClub	0.0012	A
LakeDunstanatClydeDam	0.001	A

Appendix 2: Comparison of TAS threshold values to reference conditions

Otago Regional Council

Document Id:

MEMORANDUM

To:	**Matthew McCallum-Clark**
From:	**Jason Augspurger**
Date:	**01/02/2024**
Re:	**Comparison of threshold values to reference condition from McDowell et al., 2012**

Purpose

The purpose of this memo is to compare reference state (natural) of rivers to potential target attribute state bands for ammoniacal nitrogen (Table 5), nitrate toxicity (Table 6), *E. coli* (Table 9) dissolved reactive phosphorus (Table 20) and, through total nitrogen and total phosphorus, periphyton biomass (Table 2).

Context

New Zealand's freshwater environments are under pressure from land use intensification resulting in deteriorating water quality and ecosystem health. To halt, and reverse, declines in freshwater ecosystem health, an amended National Policy Statement for Freshwater Management was released in 2020. This policy statement provides ecosystem health bottom lines for a suite of attributes and requires that ecosystem health be maintained, or improved, above these bottom lines. To do so, ORC must set freshwater visions, outcomes and target attribute states (Ministry for the Environment 2020).

To facilitate aligning freshwater outcomes with the target attribute state that achieves them, it is useful to understand what state occurs under reference conditions. This memo compares previously published estimates (McDowell et al. 2012) for reference conditions to potential target attribute states.

Methods

Previously published reference estimates for the median value are plotted and compared to attribute bands in the NPSFM 2020 for ammoniacal nitrogen (Table 5), nitrate toxicity (Table 6), *E. coli* (Table 9) dissolved reactive phosphorus (Table 20) and, through total nitrogen and total

phosphorus, periphyton biomass (Table 2). Total phosphorus and total nitrogen are compared to the 20% under protection risk non-shaded periphyton nutrient criteria (Snelder 2023) as previously selected by policy (Augspurger 2024; De Pelsemaeker 2024). For more information on under protection risk, see Augspurger (2024a,b).

To provide for natural heterogeneity that occurs within catchments, reference estimates are provided for different river classes based on the River Environment Classification (Snelder and Biggs 2007). Otago's river network is pre-dominantly comprised of cool-dry hill (CD/H), cool-dry low (CD/L), cool-wet mountain (CW/M) and cool-wet hill (CW/H) fed rivers.

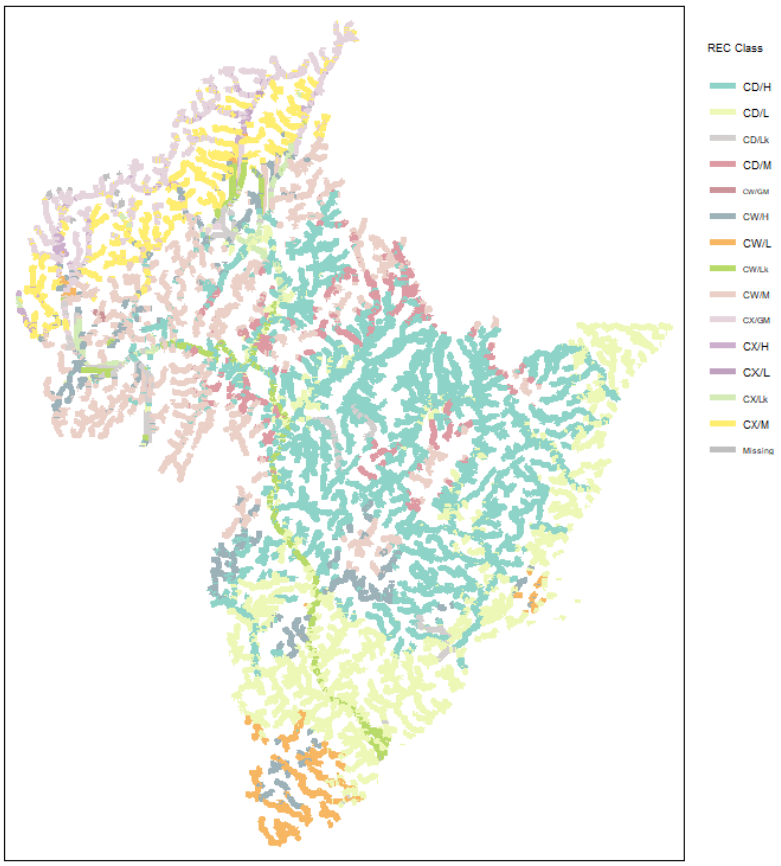

Figure 3: REC classes of Otago's river network

Table 270: Proportion of Otago's river network made up by reach REC, source of flow (SoF), class. A small proportion of the network does not have a source of flow class defined (1.1%).

SoF	Percent
CD/H	31.67
CD/L	23.69
CD/Lk	0.61
CD/M	3.06
CW/GM	0.01
CW/H	5.87
CW/L	3.11
CW/Lk	0.91
CW/M	15.58
CX/GM	3.93
CX/H	1.45
CX/L	0.03
CX/Lk	0.37
CX/M	8.61
	1.10

Results

Ammoniacal nitrogen (Table 5)

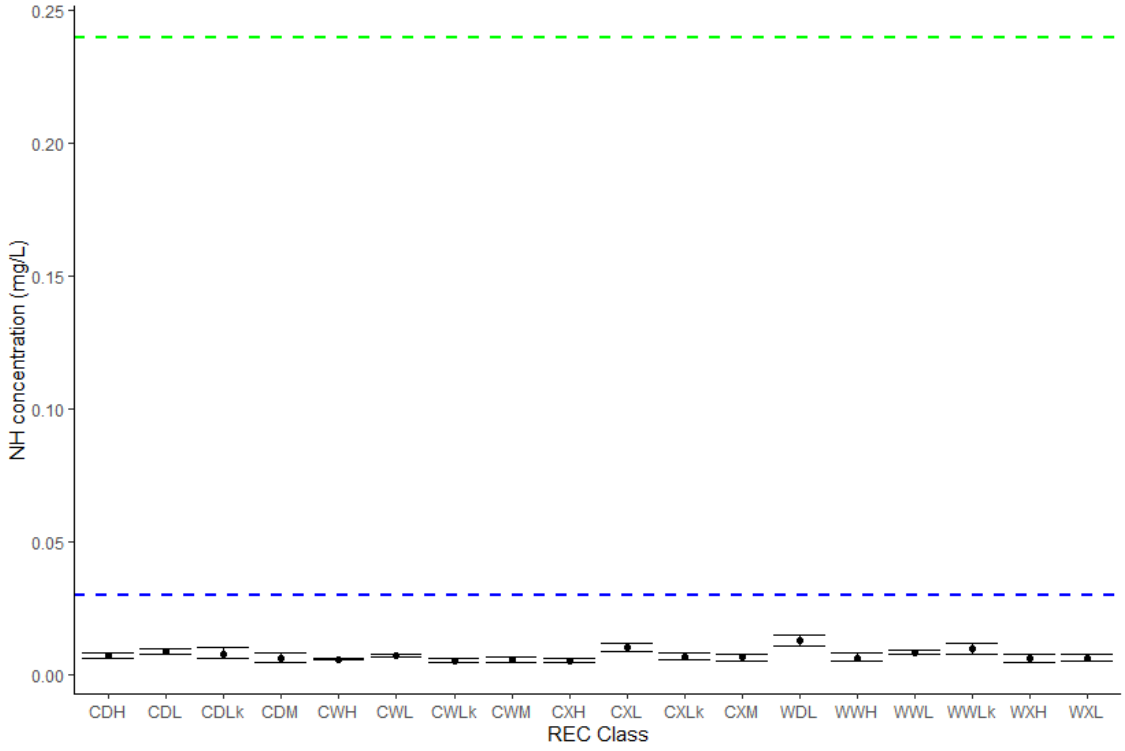

Figure 4: Predicted median ammoniacal nitrogen reference state with standard error. The median thresholds from NPSFM 2020 Table 5 are presented for the A (blue), and B (green) bands.

Comparisons with the median ammoniacal nitrogen reference state value show all classes would naturally comply with the A-band nutrient threshold.

Nitrate Toxicity (Table 6)

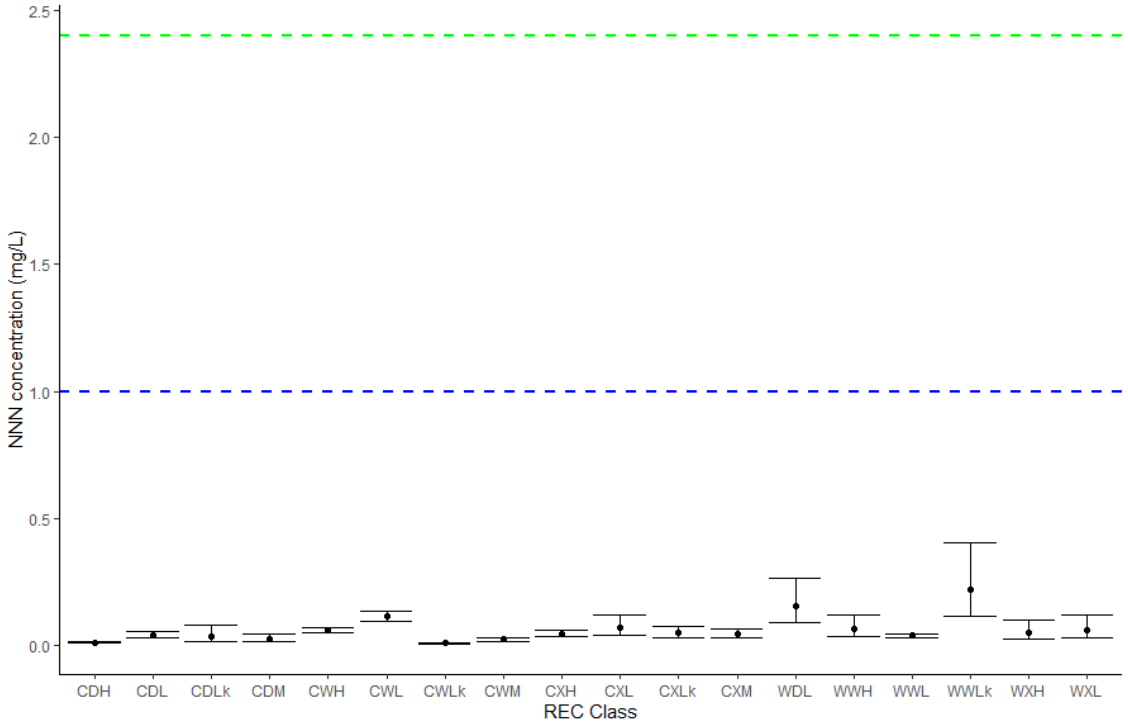

Figure 5: Predicted median nitrate-nitrogen reference state with standard error. The median thresholds from NPSFM 2020 Table 6 are presented for the A (blue), and B (green) bands.

Comparisons with the median nitrate nitrogen reference state value show all classes would naturally comply with the A-band nutrient threshold.

E. coli (Table 9)

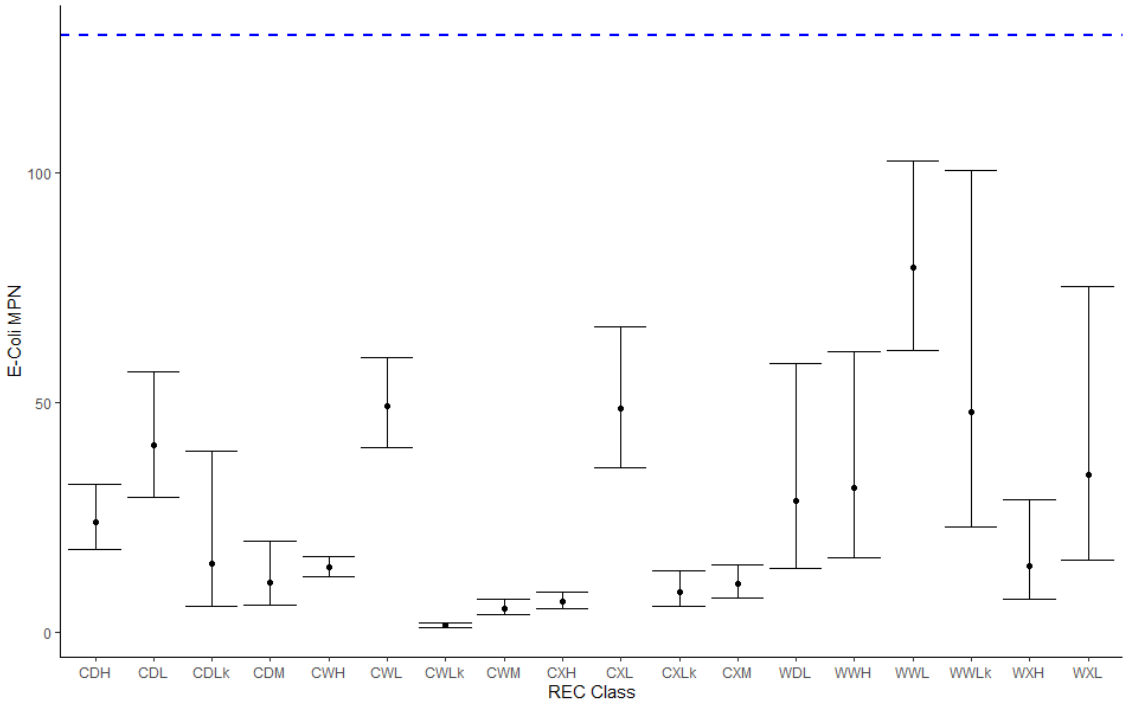

Figure 6: Predicted median E. coli reference state with standard error. The median threshold from the NPSFM 2020 Table 9 is presented as a blue line. The median comparison is binary representing the bottom of the A/B/C threshold.

Comparisons with the median *E. coli* reference state value show all classes would naturally comply with A/B/C-band nutrient threshold.

Dissolved Reactive Phosphorus

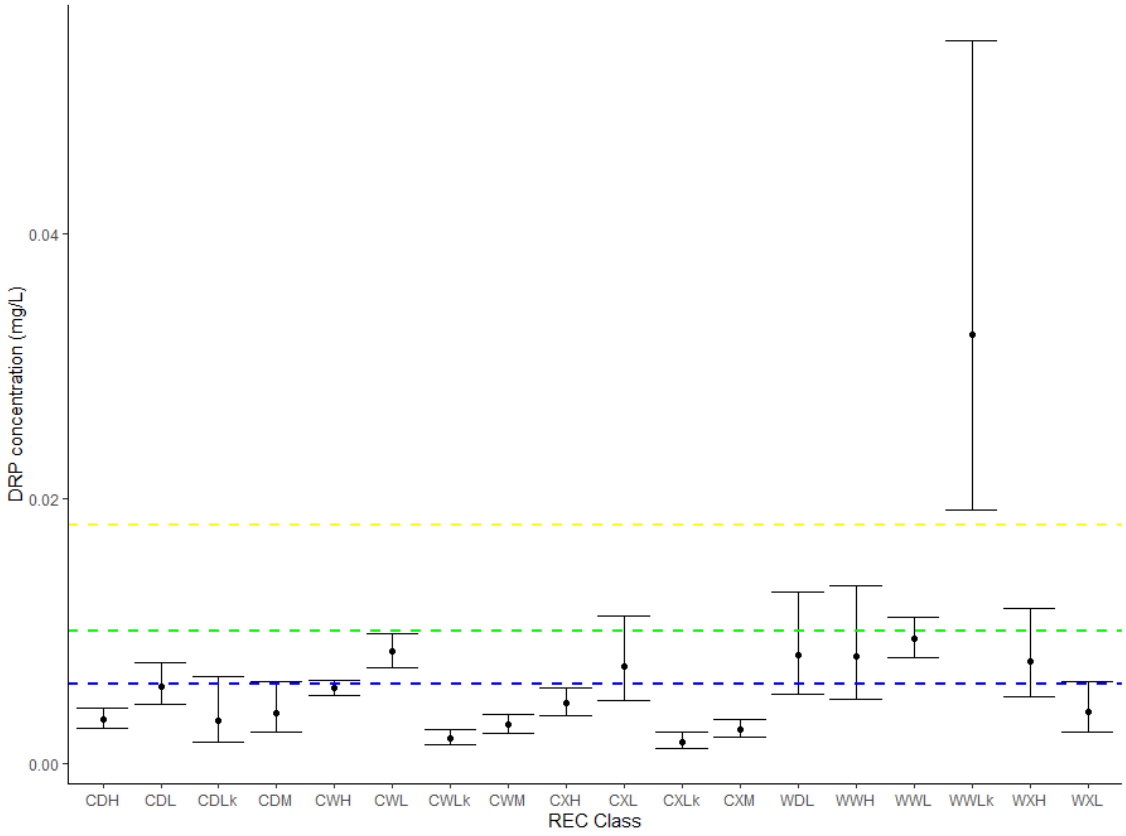

Figure 7: Predicted median dissolved reactive phosphorus (DRP) reference state with standard error. The median thresholds from NPSFM 2020 Table 20 are presented for the A (blue), B (green), and C (yellow) bands.

Comparisons with the median reference dissolved reactive phosphorus criteria result in about half of classes complying the A-band concentration (CDH, CDLk, CDM, CWH, CWLk, ,CWM, CXH, CXLk, CXM, WXL,). The CDL class complies with the A, or B-band, concentration and CWL complies with the B-band. C or B-band compliance occurs in the CXL, WDL, WWH, WWL, and WXH classes. The WWLk class naturally does not comply with the C-band.

Periphyton Nutrient Criteria

Total Nitrogen

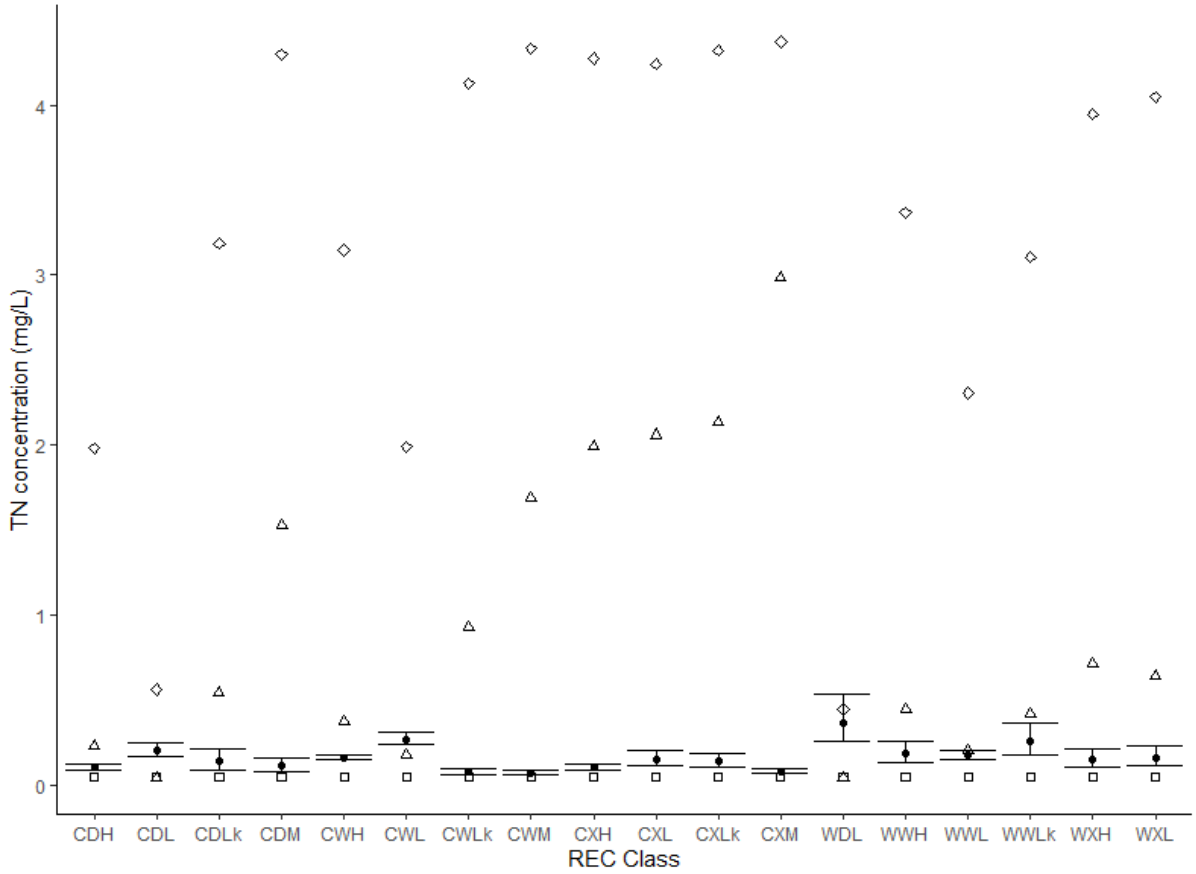

Figure 8: Predicted median total nitrogen (TN) reference state with standard error. The periphyton biomass criteria derived by Snelder et al., 2023 presented for a 20% under-protection risk for the A (square), B (triangle), and C (diamond) bands.

All classes comply with the C-band criteria apart from WDL which overlaps the criteria. The B-band criteria is also complied with by all classes except for CDL, CWL, and WDL. No class complies with the A-band criteria though some classes nearly overlap.

Total Phosphorus

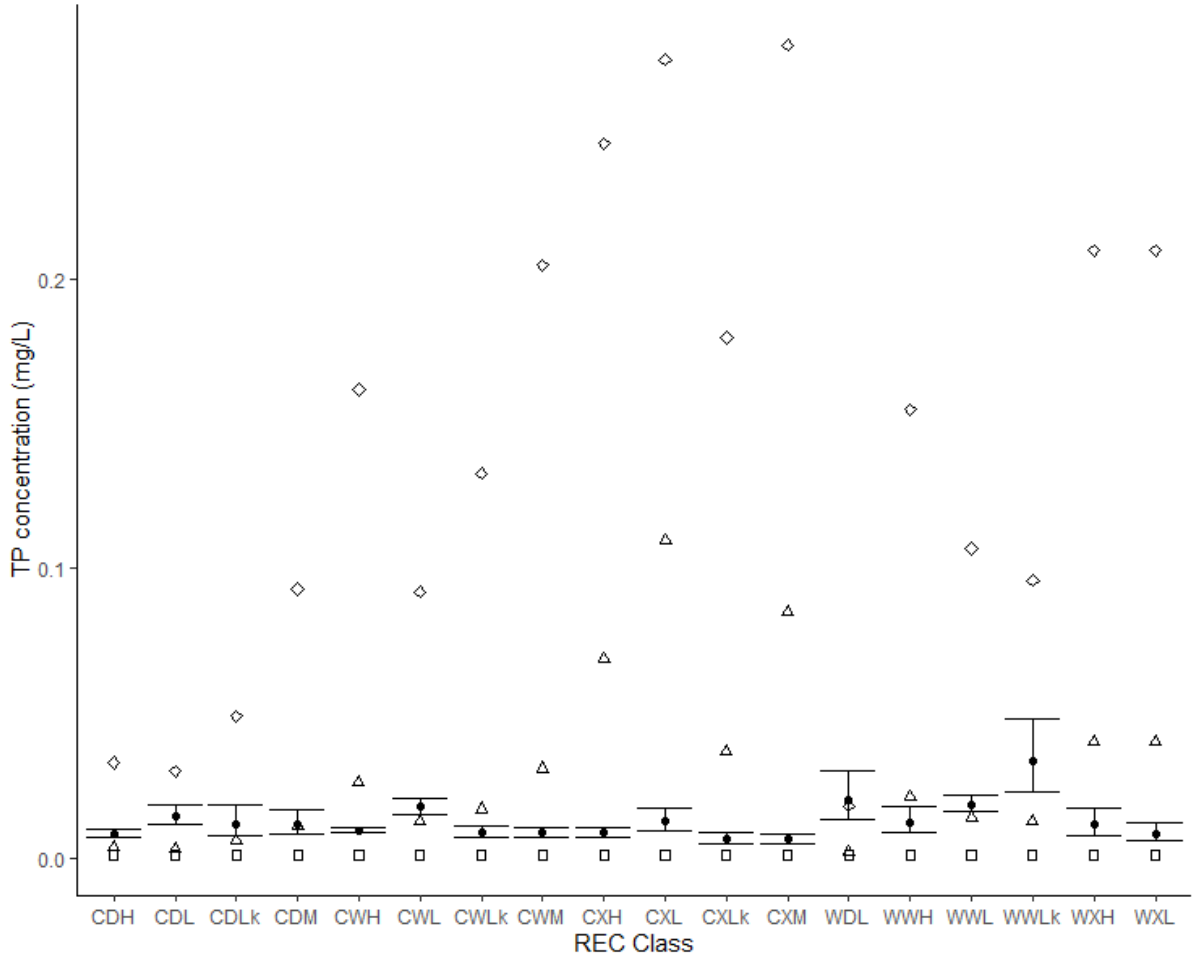

Figure 9: Predicted median total phosphorus (TP) reference state with standard error. The periphyton biomass criteria derived by Snelder et al., 2023 presented for a 20% under-protection risk for the A (square), B (triangle), and C (diamond) bands.

Except for WDL, all classes comply with the C-band criteria. The CWH, CWLk, CWM, CXH, CXL, CXM, WWH, WXH, WXL, and CXLk classes comply with the B-band criteria. No classes comply with the A-band criteria.

Discussion

Ammoniacal nitrogen, nitrate nitrogen and *E. coli*

The modelled reference median concentration for these attributes complies with the A-band across river classes. Given all classes comply with the A-band for median, all target attribute bands could be considered for the median statistics. These tables have other statistics, such as 95th percentiles, which were not modelled in the study used.

Dissolved reactive phosphorus

Compliance with NOF band of the modelled reference median concentration is more varied for DRP. However, in the classes which comprise the majority of Otago's river network (CDH, CDL, CWH, CWM, CXM), natural median would comply with the A or B band. The CDH, CWM and CXM classes all comply with the A-band. The CDL and CXH classes comply with the A or B band. Therefore, all target attribute bands could be considered for these classes.

Periphyton nutrient criteria

When compared to the modelled reference state, periphyton criteria compliance varied between river classes. However, no class complied with the A-band criteria for either total nitrogen or phosphorus. This suggests 80% of segments would not naturally comply with the A-band nutrient criteria in any management class. This does not mean 80% would not achieve A-band biomass as factors other than nutrients can limit periphyton biomass. However, the A-band nutrient criteria at a 20% UPR is not a realistic target as it would not be complied with naturally.

For total nitrogen, the modelled reference median in the common mountain and hill classes in Otago (CDH, CWH, CWM, CXM) complies with the B band criteria whereas common lowland classes comply with the C-band. For total phosphorus, the modelled reference median value in CDH and CDL comply with the C-band nutrient criteria. The CWH, CWM and CXM classes comply with the B-band nutrient criteria. As a result, B or C band targets could be complied with in many mountain and hill fed classes whereas the B-band would not naturally be complied with in lowland classes. This suggests 80% of segments would not naturally comply with the B-band nutrient criteria. Therefore, the C-band is the highest band lowland segments could be expected to comply with at this UPR.

Application to network vs. sites

The estimates derived in McDowell et al., 2012 provide median reference values for river classes based on a national dataset. As a result, comparisons with other nationally derived or river class-based models, such as the periphyton guidelines, would be consistent with this approach. Application of the reference values to a particular monitoring site is highly uncertain.

References

Augspurger J. 2024. Under-protection risk with updated periphyton criteria. Dunedin, New Zealand: Otago Regional Council.

Augspurger J. 2024a. Water Quality Baseline State. Dunedin, New Zealand: Otago Regional Council.

Augspurger J. 2024b. LWRP Nitrogen and Phosphorus Reduction Scenarios. Dunedin, New Zealand: Otago Regional Council.

De Pelsemaeker T. 2024. Selecting Under-protection risk. Dunedin, New Zealand: Otago Regional Council.

Mcdowell R, Snelder T, Booker D, Cox N, Wilcock R. 2012. Establishment of reference or baseline conditions of chemical indicators in New Zealand streams and rivers relative to present condition. Marine and Freshwater Research. 64. https://doi.org/10.1071/MF12153

Ministry for the Environment. 2020. National Policy Statement for Freshwater Management 2020 [Internet]. [place unknown]. https://www.water-reform.mfe.govt.nz/publications/fresh-water/national-policy-statement-freshwater-management-2020

Snelder T. 2023. Guidance on look-up tables for setting nutrient targets for periphyton: 2023 draft. Wellington: Ministry for the Environment.

Snelder T, Biggs B. 2007. Multi-Scale River Environment Classification for Water Resources Management. JAWRA Journal of the American Water Resources Association. 38:1225–1239. https://doi.org/10.1111/j.1752-1688.2002.tb04344.x

Periphyton Nutrient Criteria as at 1/2/2024

Table 271: 20% under-protection risk (UPR) periphyton nutrient criteria for total nitrogen from Snelder et al., 2023 with amended Otago/Southland specific A band criteria.

Class	A	B	C
CDH	0.047	0.231	1.981
CDL	0.047	0.047	0.562
CDLk	0.047	0.542	3.187
CDM	0.047	1.532	4.297
CWH	0.047	0.376	3.147
CWL	0.047	0.179	1.990
CWLk	0.047	0.934	4.127
CWM	0.047	1.693	4.333
CXH	0.047	1.994	4.272
CXL	0.047	2.061	4.241
CXLk	0.047	2.138	4.322
CXM	0.047	2.988	4.372
WDL	0.047	0.047	0.447
WWH	0.047	0.445	3.369
WWL	0.047	0.207	2.307
WWLk	0.047	0.419	3.105
WXH	0.047	0.715	3.947
WXL	0.047	0.644	4.046

Table 272: 20% under-protection risk (UPR) periphyton nutrient criteria for total phosphorus from Snelder et al., 2023 with amended Otago/Southland specific A band criteria.

Class	A	B	C
CDH	0.001	0.004	0.033
CDL	0.001	0.003	0.030
CDLk	0.001	0.006	0.049
CDM	0.001	0.011	0.093
CWH	0.001	0.026	0.162
CWL	0.001	0.013	0.092
CWLk	0.001	0.017	0.133
CWM	0.001	0.031	0.205
CXH	0.001	0.069	0.247
CXL	0.001	0.110	0.276
CXLk	0.001	0.037	0.180
CXM	0.001	0.085	0.281
WDL	0.001	0.002	0.018
WWH	0.001	0.021	0.155
WWL	0.001	0.014	0.107
WWLk	0.001	0.013	0.096
WXH	0.001	0.036	0.209
WXL	0.001	0.035	0.206