

Macraes Phase 4 Project

Recommended Surface Water Quality Compliance Framework

Prepared for: OceanaGold (New Zealand) Limited

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1 INTRODUCTION

OceanaGold (New Zealand) Limited (OGNZL) currently undertakes open pit and underground gold mining operations at the Macraes Operation located at Golden Point Road, Macraes Flat, East Otago ('the site'). As part of their ongoing operations, OGNZL continually review the remaining life of the Macraes Operation in light of updated knowledge of the gold resource and the economics of mining.

Reflecting recent exploration success and optimisation work, together with higher gold prices, the Macraes Phase Four Project (MP4 or 'the Project') seeks to extend the life of mining at the Macraes Operation until at least 2039. The Project, which will enable ongoing gold production at a rate of approximately 130,000 ounces per annum, is identified as a Listed Project in Schedule 2 of the Fast-track Approvals Act 2024 (FTAA) as a project providing significant national or regional benefits.

To support the development of the substantive application for the Project, OGNZL has engaged Viridis Limited (Viridis) to develop a compliance framework for assessing surface water quality at key receiving environments. While compliance limits already apply at various downstream surface water sites under existing consents, these have been developed over time through multiple consenting processes and reflect differing methodologies. As such, they do not constitute a single, consistent approach aligned with contemporary guidelines. The proposed MP4 development provides an opportunity to implement a more coherent and up-to-date framework for assessing and managing surface water quality effects across the site, consistent with guideline values.

The framework is intended to provide a more integrated and transparent approach to water quality compliance assessment, aligned with current best practice and guidance, tailored to site-specific conditions at the Macraes Operation. It will enable the identification of potential water quality issues and facilitate timely management responses to avoid adverse effects.

This report outlines the proposed framework, its application at the Macraes Operation, and the rationale for the development of trigger values and compliance criteria. The framework draws on relevant national and international guidance and, where appropriate, considers site-specific water chemistry, monitoring data, and ecological information, including factors relevant to both contaminant toxicity and nutrient enrichment.

2 BACKGROUND

2.1 Site Location and Description

OGNZL owns and operates the Macraes Operation at Macraes Flat, approximately 30 km northwest of Palmerston in the Otago Region. The Macraes Operation is the largest gold mine in New Zealand and, since commissioning in 1990, has produced more than 6 million ounces of gold.

Macraes Flat is situated on an elevated plateau at approximately 500 m above sea level. The plateau is flanked by the Taieri Ridge to the northwest, Shag Valley and Horse Range to the east, and the coastal hills and extinct volcanic cones of Palmerston and Waikouaiti to the southeast. Macraes Road provides access to Macraes Flat and the Macraes Operation, connecting to State Highway 85 to the east and State Highway 87 (SH87, the Middlemarch–Hyde Road) to the west.

The environment within and surrounding the Macraes Operation has been shaped by historical and current mining activities undertaken in accordance with existing resource consents. Figure 1 shows the arrangement of the major mine features at the Macraes Operation. In summary, the current components of the Macraes Operation include:

- Numerous open pits (both operational and non-operational).
- Two underground mines (Fraser's, now closed, and Golden Point, which is actively mined).
- Waste rock stacks at various stages of operation and rehabilitation.
- A network of haul roads and general mine service tracks.
- A processing plant.
- Five tailings storage facilities (three inactive, one active but nearing capacity, and one under construction and currently receiving tailings).
- An extensive network of water management infrastructure, including diversion drains, silt ponds, sumps, pit lakes, and freshwater storage reservoirs.
- Two consented but not yet constructed water storage reservoirs (Camp Creek and Coal Creek Dams).
- Associated infrastructure supporting ongoing operations, including district roads, powerlines, workshops, offices, and associated water and amenity facilities.

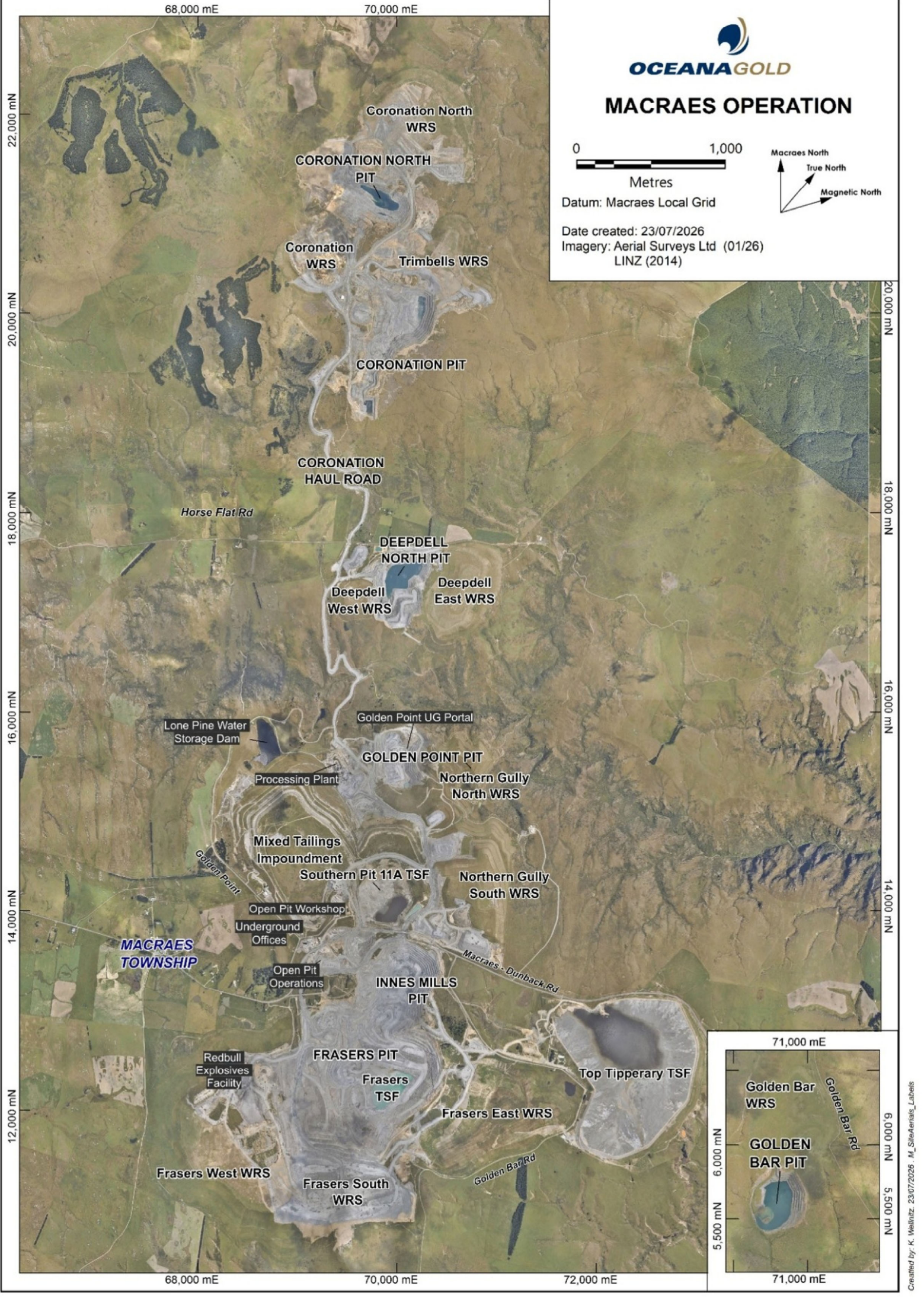
2.2 MP4 Project Overview

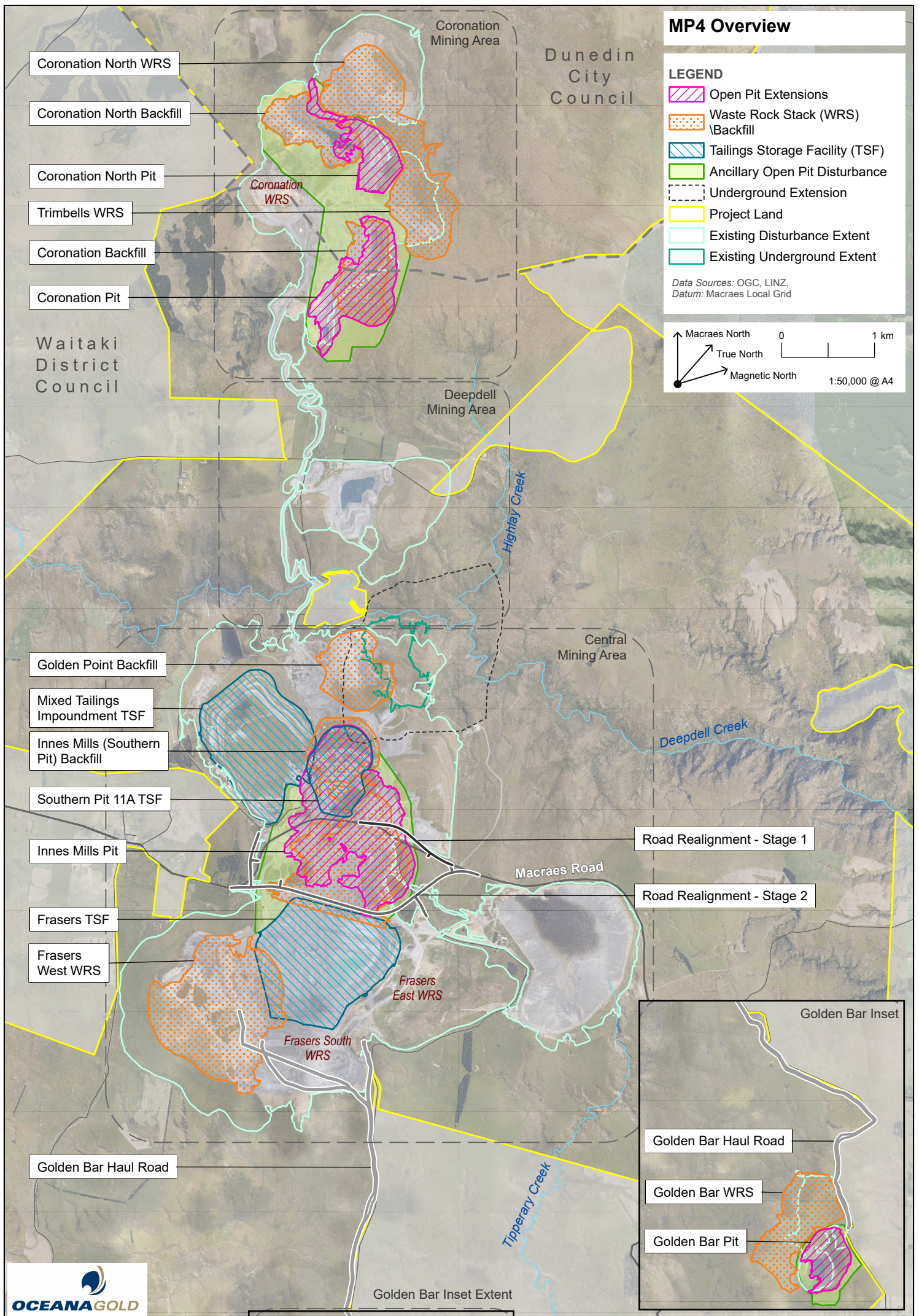
The MP4 Project comprises the following proposed key activities:

- Open pit extensions at Coronation, Coronation North, Innes Mills and Golden Bar.
- Underground mine expansion through further development of the Golden Point Underground mine ('GPUG').
- Tailings management, including:
 - Construction of the Fraser's Tailings Storage Facility ('FTSF') Stage 3 to accommodate a total tailings storage of up to 153 Mt.
 - Hydraulic mining and relocation of tailings from the Mixed Tailings Impoundment ('MTI'), Southern Pit Option 10 TSF ('SP10'), and Southern Pit Option 11A TSF ('SP11') to FTSF.

- Waste rock disposal, including increased storage capacity within open pits and at existing waste rock stacks at Coronation, Coronation North, Innes Mills, Golden Bar, Golden Point, and Frasers.
- Water management infrastructure and operations, including:
 - Construction of Camp Creek and Coal Creek dams for flow and water quality management.
 - Construction, operation and maintenance of a Water Treatment Plant.
 - Ongoing operation and maintenance of the Mine Water Management System ('MWMS').
- Infrastructure and roading works, including:
 - Realignment of Macraes Road in two stages; and
 - Relocation of the Open Pit Mining Workshop.
- Ecological enhancements, including establishment of:
 - Murphys Ecological Enhancement Area ('MEEA') near Murphys Creek, including predator-proof fencing, access tracks, and site facilities.
 - Mt Highlay restoration area.
 - Cranky Jims Link shrubland enhancement area.
 - Murphys Link tussock protection area.
 - Additional offset and compensation measures for residual ecological impacts.
- Mine closure and rehabilitation activities, including rehabilitation of mining landforms, creation of pit lakes, dry capping of tailings storage facilities, and revegetation in accordance with closure objectives.

An overview of the proposed activities which make up the Project is shown in Figure 2.





3 EXISTING COMPLIANCE FRAMEWORK

3.1 Overview

OGNZL currently holds resource consents¹ issued by Otago Regional Council (ORC) authorising discharges to surface water bodies within three key receiving catchments: Shag/Waihemo, Waikouaiti and Taieri. Compliance is assessed at prescribed monitoring sites in accordance with specified schedules, which define site locations, parameters, sampling frequency, consent limits, and how compliance is assessed. OGNZL also monitors supplementary sites to support interpretation of water quality within the wider receiving environment.

3.2 Monitoring Network

The monitoring network comprises sites located within key receiving environments downstream of mining activities, as well as at upstream control locations where available. These sites represent key locations for assessing the potential effects of discharges on receiving water quality.

Monitoring sites relevant to the Project are listed in Table 1 and shown in Figure 3. Table 1 lists compliance sites only, those carrying an applicable consent limit under Table 2. OGNZL voluntarily monitors control sites at DC00 in Deepdell Creek (Shag/Waihemo) and MB00 in Mare Burn (Taieri) to help distinguish potential project-related effects from background conditions. No upstream control sites exist in the Waikouaiti River catchment, as the Macraes Operation lies within its headwaters.

3.3 Consent Limits

A summary of existing consent limits in place at the Macraes Operation is provided in Table 2. These limits are applied at the compliance sites listed in Table 1, on a parameter-specific basis.

In general, the current consent limits have been informed by a range of national and international guideline values and standards available at the time of the relevant consenting, including:

- United States Environmental Protection Agency (USEPA) criteria for continuous concentration (CCC), representing concentrations protective of aquatic communities under chronic exposure.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality trigger values (ANZECC 2000), which have largely been superseded by ANZG default guideline values (DGVs).
- National Policy Statement for Freshwater Management (NPS-FM 2020) national bottom lines (NBL).
- Drinking-water Standards for New Zealand 2005 (revised 2008) (MoH 2008), which have been superseded by the Water Services (Drinking Water Standards for New Zealand) Regulations 2022 and the Taumata Arowai (2022) Aesthetic Values for Drinking Water Notice 2022.

As a result of national and international guidance evolving and changing over time, consent limits at the Macraes Operation often reflect outdated guidance and, in some cases, vary in purpose (e.g., protection of aquatic ecology, human health or livestock) between sites. This is particularly evident at HC02, where the more recently approved consents for Highlay Creek (i.e., RM20.024.09 and RM20.024.14) specify a distinct set of limits and compliance requirements compared with other sites. Accordingly, there is merit to moving to a consistent, site-wide framework that aligns with contemporary guideline approaches.

¹ 96808, 2002.491, 2002.759, 2002.763, 2003.640, 2004.359, 2005.341, 2006.303-308, RM10.351, RM12.378, RM16.138, RM19.085, RM20.024

Macraes MP4 footprint and key water quality monitoring sites.

-  Proposed footprint
-  Water quality sites
-  Clydesdale Creek
-  Trimbells Gully Creek
-  Tipperary Creek
-  Shag River
-  North Gully Creek
-  Murphys Creek
-  McCormicks Creek
-  Mare Burn
-  Maori Hen Creek
-  Highlay Creek
-  Golden Bar Creek
-  Deepdell Creek
-  Waikouaiti River NB
-  Crank Jims Creek
-  Camp Creek

SOURCES
Google Satellite 2023

DISCLAIMER: This map/plan is not an engineering draft. This map/plan is illustrative only and all information should be independently verified on site before taking any action.

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PROJECT NO. 10023
DRAWN BY: AJC
DATE: 12/08/2026

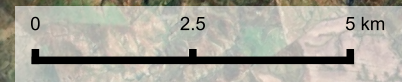
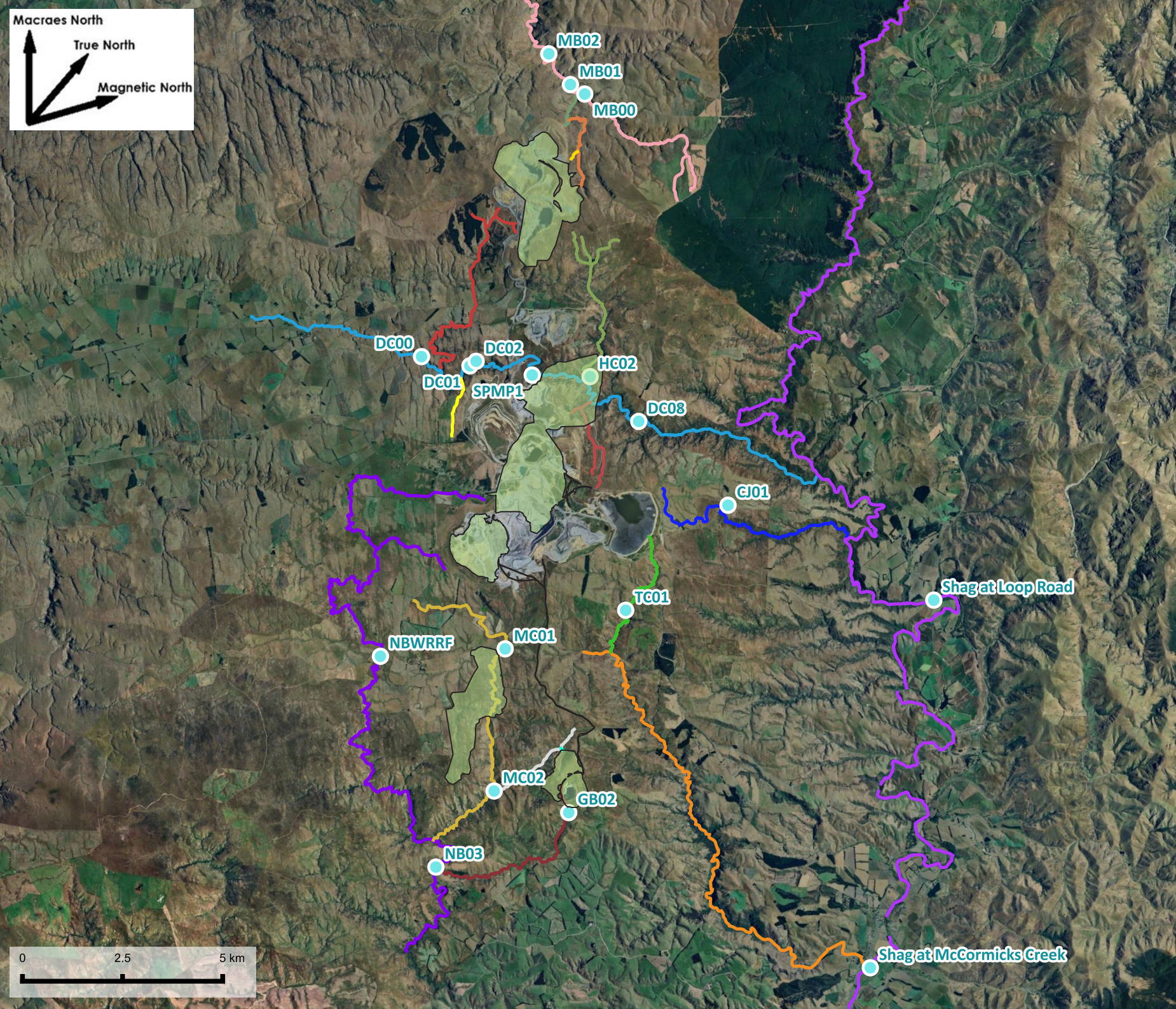


Table 1. Surface water quality compliance and control sites in existing Macraes Operation consents.

Site	Watercourse	Type
Shag/Waihemo River catchment		
DC00	Deepdell Creek	Control*
DC08	Deepdell Creek	Compliance
SPMP1	Battery Creek	Compliance
HC02**	Highlay Creek	Compliance
Shag at Loop Road	Shag/Waihemo River	Compliance
Shag at McCormicks	Shag/Waihemo River	Compliance
CJ01**	Cranky Jims Creek	Compliance
TC01**	Tipperary Creek	Compliance
Waikouaiti River catchment		
MC01	Murphys Creek	Compliance
MC02	Murphys Creek	Compliance
GB02***	Golden Bar Creek	Compliance
NBWRRF	North Branch of Waikouaiti River	Compliance
NB03	North Branch of Waikouaiti River	Compliance
Taieri River catchment		
MB00	Mare Burn	Control*
MB01	Mare Burn	Compliance
MB02	Mare Burn	Compliance

Notes: *Control sites are monitored by OGNZL on a voluntary basis; **these sites will not be affected by the Project and are therefore excluded from the new framework, as discussed in Section 4.3.1; ***GB02 is where the Golden Bar Pit lake standard (consent 2002.763) has been assessed since the pit lake began discharging in 2018.

3.4 Compliance Assessment

Under the existing framework, compliance is generally assessed through direct comparison of monthly monitoring results against applicable consent limits at each compliance site.

In most cases, exceedance of a consent limit on any sampling occasion constitutes non-compliance. However, consents RM20.024.09 and RM20.024.14 require that, at HC02, compliance with consent limits for nitrate nitrogen, arsenic, copper, lead, and zinc is assessed using rolling statistics². This contrasts with the single-sample exceedance approach applied at other sites and introduces a different basis for assessing compliance, incorporating longer-term exposure and site-specific considerations.

As a result, the existing framework applies a range of assessment approaches, including both instantaneous and rolling statistical measures, and does not provide a consistent, site-wide method for interpreting monitoring results or assessing ecological risk.

² Median or 95th percentiles, based on annual or 36 consecutive monthly samples, depending on parameter being assessed.

Table 2. Existing water quality compliance limits at Macraes Operation.

Parameter	Limit	Applicable sites	Source
pH (unitless)	7 - 8.5	Shag at Loop, Shag at McCormicks	MoH (2008) guideline value for aesthetic determinand
	6.5 - 9.5	MB02	
	6.0 - 9.5	CJ01, DC08, MB01, MC01, MC02, GB02*, HC02, NB03, NBWRRF, SPMP1, TC01	
Visibility (TSS / turbidity)	30-50% Δ	MB02	
Sulphate	1,000	CJ01, DC08, HC02, MB01, MC01, NBWRRF, TC01	ANZECC (2000) TV for livestock drinking water
	250	NB03, Shag at Loop Road, Shag at McCormicks	MoH (2008) guideline values for aesthetic determinands
Ammoniacal nitrogen (g N/m ³)	0.24	MB02	NPSFM (MfE 2025) NBL as annual median ^A
Nitrate nitrogen (g N/m ³)	2.4	DC08, HC02, MB02, Shag at Loop Road	NPSFM NBL (MfE 2025) as annual median ^{A,B}
	3.5	DC08, HC02, Shag at Loop Road	NPSFM NBL (MfE 2025) as annual 95th percentile ^{A,B}
Arsenic	0.15	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NBWRRF, SPMP1, TC01	USEPA (1995) CCC for As(III)
	0.013	HC02	ANZECC (2000) TV for As (V) at 95% protection level
	0.01	NB03, Shag at Loop Road, Shag at McCormicks	MoH (2008) maximum acceptable value
Copper	0.018**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	USEPA (1984) CCC
	0.0076**	HC02	ANZECC (2000) HMTV 95% protection level
Iron	1	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, SPMP1, TC01	USEPA (1986) CCC
	0.3	HC02	ANZECC (2000) interim level from CCREM (1987)
	0.2	NB03, Shag at Loop Road, Shag at McCormicks	ANZECC (2000) long-term TV in irrigation water
Lead	0.0059**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	USEPA (1985) CCC
	0.043**	HC02	ANZECC (2000) HMTV 95% protection level
Zinc	0.23**	CJ01, DC08, GB02, MB01, MB02, MC01, MC02, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, TC01	USEPA (1995) CCC
	0.044**	HC02	ANZECC (2000) HMTV 95% protection level
Cyanide	0.1	CJ01, DC08, MB01, MB02, MC01, NB03, NBWRRF, Shag at Loop Road, Shag at McCormicks, SPMP1, TC01	

Notes: Units are in g/m³ unless stated otherwise; all metals are tested in the dissolved fraction unless stated; HMTV = hardness modified trigger value; DGV = default guideline value; NBL = national bottom line; ^A applied as fixed limit; ^B Calculated at pH of 8; * GB02 is the site at which the pit lake standard for Golden Bar Pit (consent 2002.763) is assessed, as set out in Note *** to Table 1; and ** adjusted here for a standard Macraes Operation hardness of 220 g/m³ as CaCO₃, though typically presented in consent schedules at a hardness of 30 or 100 g/m³ as CaCO₃.

4 PROPOSED COMPLIANCE FRAMEWORK

4.1 Overview

To support the MP4 development, a new compliance framework is recommended. The framework will consist of trigger values that, when exceeded, initiate defined response actions. In practice, the framework will operate as a stepwise process:

- Surface water quality is monitored monthly at defined locations.
- Monitoring results at compliance sites are compared against trigger values, adjusted for site-specific chemistry where appropriate.
- Where a trigger value is exceeded, it will prompt further assessment and, where appropriate, investigation and / or management response.
- Where exceedances occur at a defined frequency or duration and are demonstrated to be attributable to mine operations, this results in non-compliance.
- Non-compliance will trigger management intervention and, if appropriate, longer-term mitigation measures.

This structure distinguishes between early warning indicators (trigger value exceedances) and elevated likelihood of adverse effects (non-compliance), enabling a proportionate, risk-based response.

4.2 Key Definitions

4.2.1 Compliance site

A compliance site is a defined monitoring location within the receiving environment where water quality is formally assessed against trigger values under this framework. Compliance sites represent locations where potential project-related effects are expected to be measurable and form the basis for compliance assessment.

4.2.2 Control site

A control site is not influenced by mine-related activities and is used to characterise background receiving environment conditions. Control sites provide a reference against which compliance site results can be compared to help distinguish natural variability or background quality from potential mine-related effects.

In the Waikouaiti River catchment, where upstream control sites are not available due to the headwater location of the Macraes Operation, background conditions are inferred from temporal trends and comparison with adjacent or downstream monitoring sites.

4.2.3 Trigger value

A trigger value is a concentration or condition used to indicate potential ecological risk, adjusted where appropriate for site-specific water chemistry. Trigger values are intended to replace the compliance limits previously defined under the existing Macraes Operation consents (refer Section 3.3).

Trigger values are defined for:

- Acute exposure - concentrations that may cause adverse effects from short-term exposure.
- Chronic exposure - concentrations that may cause adverse effects from sustained exposure.

- Eutrophication assessment - nutrient and ecological response indicators used to identify and assess excessive plant or algal growth and related ecological effects.

Drinking water values are also adopted as trigger values at several compliance sites (NB03, Shag at Loop Road and Shag at McCormicks) where protection of water quality for downstream drinking water uses is relevant (refer Section 4.3.4).

4.2.4 Exceedance

An exceedance occurs when a measured concentration or monitored condition at a compliance site is greater than the applicable trigger value. Exceedance of a trigger value does not in itself confirm an adverse effect or constitute non-compliance but indicates an increased likelihood of adverse effects and signals the need for further assessment and, where appropriate, management response.

4.2.5 Non-compliance

Non-compliance identifies mine-attributable conditions where there is an elevated likelihood of adverse ecological effects and where additional management intervention may be required.

A compliance site is considered non-compliant where exceedances of trigger values occur at defined frequencies or durations specified within this framework, and are demonstrated to be attributable to mine operations, subject to the compliance assessment approach described in Section 4.3.3.

4.3 Application at Macraes Operation

4.3.1 Monitoring network

Water quality monitoring sites relevant to the proposed framework are consistent with the sites listed in Table 1, except for HC02, CJ01, and TC01, which will not be affected by the proposed development as the associated watercourses are not subject to new or modified discharges. The compliance framework for these sites will be reviewed for consistency following the FTAA process.

Consistent with OGNZL's existing consents, surface water quality monitoring will be undertaken monthly, with sampling in the same catchment carried out on the same day to ensure comparability of results. Final monitoring locations and aquatic ecological monitoring requirements, including assessment of eutrophication response indicators, will be specified in the monitoring schedule proposed for MP4.

4.3.2 Proposed trigger values

Trigger values were derived using a weight-of-evidence approach considering regulatory requirements, ecological sensitivity, site-specific geochemical context, and historical monitoring data. Parameters were selected based on their environmental relevance, association with mining-related processes, and potential to influence ecological health. In general, the trigger values align with a guideline protection level for 95% of species. Further methodology and rationale for trigger value derivation are provided in Section 5.

Proposed trigger values are presented in Table 3. Where adjustment for site-specific conditions is required, values are expressed as equations or refer to lookup tables in Appendix A. In these cases, trigger values are also presented for standard Macraes Operation receiving water conditions (pH 7.8, chloride 9.1 g/m³, dissolved organic carbon (DOC) 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and temperature 20°C) to support consistent comparison and interpretation. Compliance assessment will use site-specific water chemistry measured at the time of sampling.

4.3.3 Compliance assessment

The basis for assessing exceedance frequency and duration for each trigger value is presented alongside the trigger values in Table 3. A compliance site is considered non-compliant when trigger values are exceeded at a defined frequency or duration and are demonstrated to be attributable to mine operations, assessed in accordance with the compliance criteria and attribution considerations set out in this section. Compliance criteria vary by parameter type and exposure condition and align with the intended level of ecological protection.

The compliance criteria are as follows:

- Acute trigger values - non-compliance occurs when a trigger value is exceeded on any sampling occasion.
- Chronic trigger values - non-compliance occurs when a trigger value is exceeded on more than two occasions within any rolling 12-month period, based on routine monthly compliance monitoring. This approach distinguishes repeated departures from trigger values from isolated exceedances arising from natural variability or analytical uncertainty.
- Eutrophication assessment criteria - non-compliance occurs when:
 - The nutrient trigger value is exceeded by the rolling annual median; and
 - The ecological response trigger value is exceeded on repeated monitoring occasions, such that a sustained nuisance plant or algal growth response is demonstrated.

The methodology used to determine a sustained ecological response will be refined through further technical review during the FTAA process.

For chronic and acute trigger values, a site returns to compliant status where monthly compliance monitoring demonstrates no further exceedances over a continuous six-month period.

For eutrophication trigger values, a site returns to compliant status where either:

- The rolling annual median nutrient trigger value no longer exceeds the applicable threshold; or
- Monitoring no longer demonstrates a sustained exceedance of the ecological response trigger value.

Exceedances at compliance sites are interpreted in the context of:

- Conditions observed at relevant upstream control sites during the same monitoring event, where available; and
- Whether the observed response reflects broader background catchment conditions rather than site discharges alone.

The rationale for the application of the compliance criteria is provided in Section 5.4.

Table 3. Proposed ecological trigger values, toxicity modifiers and exceedance frequency/duration criteria.

Parameter	Type	Toxicity modifiers	Proposed trigger value ^A	Source	Exceedance frequency/duration criteria ^B
pH (unitless)	Chronic	-	6.5-9.0	USEPA (1986) FW CCC	More than two exceedances within any rolling 12-month period
Turbidity (NTU)	Chronic	-	5	ORC (2026) Regional Plan	More than two exceedances within any rolling 12-month period
Sulphate	Chronic	Hardness	500 (when <100 g/m ³ hardness) 1,000 (when ≥100 g/m ³ hardness)	Adapted Iowa DNR (2009) guideline	More than two exceedances within any rolling 12-month period
Ammoniacal nitrogen ^C (g N/m ³)	Chronic	pH, temperature	Refer to lookup Table A1 in Appendix A for TV adjustment Equivalent to 0.52 when the pH is 7.8 and T is 20 °C.	ANZG (2026) DGV	More than two exceedances within any rolling 12-month period
Nitrate nitrogen ^C (g N/m ³)	Chronic	Hardness, chloride	1.1 (when <30 g/m ³ hardness) 2.6 (when 30-150 g/m ³ hardness or >150 g/m ³ with Cl <30 g/m ³) 29 (when >150 hardness with Cl ≥30 g/m ³)	ANZG (2025a) DGV	More than two exceedances within any rolling 12-month period
SIN (g N/m ³) ^D Ecological response indicator	Eutrophication	-	0.075 Periphyton-based trigger outlined in the water quality management plan	Biggs (2000) WGA (2026)	Rolling annual median exceeds the applicable nutrient trigger value; and Repeated exceedance of the ecological response trigger value, demonstrating sustained nuisance plant or algal growth
Arsenic ^E	Chronic	-	0.013 (0.042 at DC08 and SPMP1 for the reasons outlined in Section 5.3.3)	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period
Boron	Chronic	-	0.94	ANZG (2021) DGV	More than two exceedances within any rolling 12-month period
Copper	Chronic	DOC	$TV = 0.00047 \times \left(\frac{DOC}{0.5}\right)^{0.977}$ Equivalent to 0.004 when DOC is 4.5 g/m ³	ANZG (2023a) draft DGV	More than two exceedances within any rolling 12-month period
	Acute	Hardness, pH, DOC	$TV = \frac{\exp(-6.6 + 0.78 pH + 0.58 \times \ln(hard.) + 0.70 \times \ln(DOC))}{1,000}$ Equivalent to 0.039 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	Gadd <i>et al.</i> (2024) acute GV	Single exceedance
Iron ^F	Chronic	-	0.28	ANZG (2025b) DGV	More than two exceedances within any rolling 12-month period
Lead	Chronic	Hardness	$TV = 0.0034 \times \left(\frac{Hardness}{30}\right)^{1.27}$ Equivalent to 0.045 when hardness is 220 g/m ³	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period
Nickel	Chronic	Hardness, pH, DOC	Refer to lookup Table A2 in Appendix A for TV adjustment Equivalent to 0.008 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	ANZG (2024a) draft DGV	More than two exceedances within any rolling 12-month period
Zinc	Chronic	Hardness, pH, DOC	Refer to lookup Table A3 in Appendix A for TV adjustment Equivalent to 0.016 when DOC is 4.5 g/m ³ , pH is 7.8, and hardness is 220 g/m ³	ANZG (2024b) draft DGV	More than two exceedances within any rolling 12-month period
	Acute	Hardness, pH, DOC	$TV = \frac{\exp(2.5 - 0.12 pH + 0.6 \times \ln(hardness) + 0.13 \times \ln(DOC))}{1,000}$ Equivalent to 0.15 when DOC is 4.5, pH is 7.8 and hardness is 220 g/m ³	Gadd <i>et al.</i> (2024) acute GV	Single exceedance
Cyanide ^G	Chronic	pH, temperature	$TV = 0.007 \times (1 + 10^{(pH - (9.721 - 0.0194 \times T))})$ Equivalent to 0.0072 when the pH is 7.8 and T is 20 °C.	ANZECC (2000) TV	More than two exceedances within any rolling 12-month period

Notes: All units g/m³ unless stated; metals analysed in dissolved fraction unless stated; TV = trigger value; DGV = default guideline value; DOC = dissolved organic carbon; ^A applies to all compliance sites, unless stated; ^B compliance assessment is based on routine monthly compliance monitoring results; ^C Not considered protective of eutrophication effects; ^D SIN = soluble inorganic nitrogen, which is the sum of ammoniacal nitrogen, nitrate nitrogen and nitrite nitrogen; ^E proposed TV for arsenic applies to As(V) concentrations; in the absence of speciation testing, dissolved arsenic is used as a conservative surrogate for comparison; ^F proposed TV for iron is ideally applied to weak acid extractable concentrations; in the absence of an available analytical method, total iron is used as a conservative surrogate for comparison; ^G proposed TV applies to free cyanide, with pH and temperature adjustments accounting for proportion present as un-ionised HCN (bioavailable fraction). As free cyanide analysis is not readily available, weak acid dissociable (WAD) cyanide is used as a conservative surrogate for comparison.

4.3.4 Other applicable water guideline values

In addition to the proposed ecological trigger values, drinking water guideline values are also applied at NB03, Shag at Loop Road, and Shag at McCormicks, where protection of drinking water uses is relevant.

The applicable drinking water guideline values are summarised in Table 4. Table 4 includes parameters already subject to drinking water values under existing consents (refer Table 2) and additional parameters introduced to align with current guideline recommendations and the expanded parameter suite adopted under the proposed framework.

The drinking water values include both maximum acceptable values (MAVs), which are health-based limits that must not be exceeded at any time, and aesthetic or irrigation-based values relating to water acceptability and long-term use suitability. All parameters are assessed on the basis of a single exceedance, but a MAV exceedance constitutes non-compliance, whereas an aesthetic or irrigation-based value exceedance is treated as a trigger for further investigation.

Irrigation water quality guidelines were generally not adopted, as they are typically less stringent than the ecological trigger values and drinking water values. The exception is iron, where an irrigation guideline value of 0.2 g/m³, consistent with the existing consent limit at the relevant compliance sites, has been retained as an appropriate and conservative benchmark, as the applicable drinking water aesthetic value (0.3 g/m³) is less stringent. Whether the irrigation-based value remains appropriate at sites where irrigation use does not apply is noted for further discussion, with the drinking water aesthetic value potentially applied instead at such sites.

Table 4. Proposed drinking water values applicable to NB03 and Shag River sites.

Parameter	Value*	Source
Arsenic	0.01	New Zealand Government (2022) MAV
Boron	2.4	New Zealand Government (2022) MAV
Copper	2	New Zealand Government (2022) MAV
Iron	0.2	ANZECC (2000) irrigation guideline (long-term)
Lead	0.01	New Zealand Government (2022) MAV
Nickel	0.08	New Zealand Government (2022) MAV
Nitrate nitrogen	11.3	New Zealand Government (2022) MAV
pH (unitless)	7-8.5	Taumata Arowai (2022) aesthetic value
Sulphate	250	Taumata Arowai (2022) aesthetic value (taste)

Notes: Metals are in the dissolved fraction; *units are in g/m³ unless otherwise stated.

4.4 Performance Monitoring

The Project is expected to result in a managed change in receiving water quality, with implementation of the trigger values and compliance criteria detailed in Table 3 anticipated from 2033. Timing may vary by parameter and will be confirmed prior to Phase B based on Phase A monitoring data, including catchment scale investigation of natural attenuation. This reflects the time required to implement operational controls and mine water management measures, and for resulting improvements to be reflected in receiving water quality outcomes.

Performance monitoring will support this managed change through monitoring of water quality at source locations, including seeps, sump and pond discharges, as detailed in GHD (2026). The primary

objective of this approach is to identify changes in discharge quality at source, enabling issues to be detected and addressed before they propagate to the receiving environment.

Performance monitoring is intended to complement, but remain distinct from, instream compliance monitoring. Its purpose is to inform operational decision-making, support proactive management of discharge sources, and identify changes in water quality before they have the potential to affect the receiving environment.

4.5 Summary

Overall, the proposed framework provides a precautionary, risk-based approach to managing water quality, integrating established guideline values with site-specific modifiers and monitoring data. The use of trigger values and defined exceedance criteria enables early identification of potential ecological risks while maintaining a clear distinction between short-term variability and sustained adverse effects. The framework is fit-for-purpose for the Macraes Operation receiving environment and supports adaptive management in response to changing conditions.

5 SUPPORTING RATIONALE

5.1 Overview

This section provides the technical basis and supporting rationale for the compliance framework described in Section 4. It outlines the derivation of ecological trigger values, including justification for departures from guideline values, and their application within the compliance framework. The overall approach is technically robust, site-appropriate, and aligned with current best practice for protecting aquatic ecosystem health.

Drinking water values are not discussed in detail in this section, as they are adopted from established drinking water standards and aesthetic and irrigation-based guideline values, and will be applied within the framework as described in Section 4.3.4.

5.2 Methodology

5.2.1 Identification

Potential constituents of concern were identified in the light of regulatory requirements, known ecological sensitivities, site-specific geochemical context, and available monitoring data. Parameters selected for water quality trigger derivation met a combination of the following criteria:

- The parameter is currently regulated through existing consent limits for the Macraes Operation, or comparable mining operations (i.e., gold mining operations in similar geochemical environments).
- The parameter is well studied and widely recognised as an anthropogenic contributor to ecological deterioration in freshwater systems.
- The parameter is associated with local geochemical characteristics of the Macraes Operation or represents a process-related contaminant with an elevated likelihood of mobilisation, informed by process knowledge, leachate characterisation, and operational performance.
- Historical surface water monitoring data for Macraes Operation receiving water sites indicate elevated concentrations, temporal trends, or associations with observed ecological responses.

This structured screening process identified parameters of greatest environmental relevance and compliance risk for the proposed MP4 development.

5.2.2 Sources

For each identified parameter, relevant contemporary national and international guideline values and supporting ecotoxicological data were reviewed³. These included:

- Otago Regional Council Regional Plan for Water, Schedule 15 water quality targets (ORC 2026).
- ANZG DGVs for the protection of freshwater aquatic ecosystems, which superseded ANZECC (2000) trigger values.
- The Ministry for the Environment's (MfE) acute guideline values (GVs) developed to manage copper and zinc in freshwater environments (Gadd *et al.* 2024).
- USEPA national recommended aquatic life criteria.

³ Guidelines relating to human health and other water uses are discussed further in Section 4.3.4.

- The Iowa Department of Natural Resources criteria (Iowa DNR 2009).
- The New Zealand Periphyton Guidelines (Biggs 2000).

5.2.3 Application of guideline values

In developing the recommended trigger framework, priority was given to contemporary, ecologically derived guidance, with a primary focus on chronic protection values intended to manage longer-term exposure risks⁴. Where available and relevant, acute guideline values⁵ have also been recommended alongside chronic triggers to provide protection against short-duration, higher-concentration events. For eutrophication, a trigger value for soluble inorganic nitrogen (SIN⁶) has been identified, recognising that nutrient concentrations represent a pressure on the system. Assessment of ecological response is also required to determine whether nutrient enrichment is resulting in nuisance plant or algal growth. The assessment methodology is discussed in Section 5.3.2.

Where guideline frameworks incorporate toxicity-modifying factors, ancillary water quality parameters (e.g., pH, DOC, hardness, chloride and temperature) were incorporated into bioavailability-based assessments. Adjustment factors were derived from the relevant lookup tables or equations, to reflect site-specific water chemistry. For consistency in comparison and interpretation, standard index conditions were adopted for the Macraes Operation, corresponding to a pH of 7.8, chloride concentration of 9.1 g/m³, DOC of 4.5 g/m³, hardness of 220 g/m³ as CaCO₃, and a temperature of 20°C (refer Section 4.3.2).

An ecologically protective approach, appropriate to the condition and values of the receiving environment, was adopted in developing the proposed trigger framework. Many of the proposed inorganic toxicant trigger values are based on ANZG DGVs, which are available at four species protection levels (99%, 95%, 90% and 80%). ANZG recommends applying 95% species protection levels to slightly to moderately disturbed systems, which are defined as systems affected by human activity but retain ecological function.

The Macraes Operation receiving environment is considered to meet the definition of a slightly to moderately disturbed system. This reflects the historical and ongoing land uses within its catchments (i.e., mining and rural activities), while recognising that the watercourses continue to support functioning aquatic communities. The latter is demonstrated by the retention of diverse macroinvertebrate assemblages and at-risk galaxias species (Viridis 2026). On this basis, adoption of the 95% species protection level was considered suitable for the proposed framework.

Departure from the 95% protection approach is limited to physicochemical parameters, for which species protection levels are generally less clearly defined, and dissolved arsenic in Deepdell Creek and Battery Creek. In these watercourses, naturally elevated background levels and legacy mining influences cause arsenic concentrations to frequently exceed the ANZG 95% DGV. In this context, adoption of the 90% species protection level provides a more appropriate basis for distinguishing project-related effects from background conditions (refer Section 5.3.3).

⁴ Chronic guidelines are intended to protect organisms from adverse effects associated with long-term or continuous exposure to a contaminant, including sub-lethal impacts on growth, reproduction, and survival.

⁵ Acute guidelines are intended to protect aquatic organisms from adverse effects resulting from short-term exposure to a contaminant, typically addressing immediate or lethal toxicity effects.

⁶ SIN is the sum of ammoniacal nitrogen and total oxidised nitrogen, comprising nitrate nitrogen and nitrite nitrogen.

The compliance assessment criteria set out in Section 4.3.3 were developed to reflect the nature of the trigger values and associated exposure pathways. For chronic triggers, which are intended to manage longer-term exposure risks, a limited number of exceedances is permitted over defined assessment periods, consistent with approaches adopted in regional and international guideline frameworks. This allows for natural variability and analytical uncertainty while maintaining protection of ecological health. In contrast, acute trigger values are applied on the basis of a single exceedance, reflecting the potential for short-duration, high-concentration events to cause immediate biological effects. Supporting rationale for the compliance assessment framework is provided in Section 5.4.

5.2.4 Local context

The local relevance of trigger values was evaluated by comparison with historical surface water quality and aquatic biological data collected between 1990 and 2026 at the monitoring sites outlined in Table 1. Although HC02, CJ01, and TC01 are excluded from the MP4 application, data from these sites, along with other non-compliance monitoring locations, have been included for comparison.

Where background concentrations (i.e., pre Macraes Operation or at control sites) exceeded generic guideline values, ecological monitoring (e.g., macroinvertebrate community index (MCI) scores) was used to assess the alignment between water quality and ecological condition, and to evaluate whether the default guideline values were suitable for application at the site, particularly where concentrations are influenced by natural background conditions.

The intent of this framework is to provide a consistent and scientifically robust set of trigger values applicable across all Macraes Operation receiving water sites, superseding the existing suite of historically derived consent limits. It is designed to provide early warning of potential water quality changes, enabling identification of exceedances and timely management responses to avoid adverse effects. The same trigger value is generally proposed for all compliance sites to ensure consistency, with exceptions limited to specific sites and parameters where legacy influences necessitate alternative values.

5.3 Trigger Value Derivation

5.3.1 Physicochemical parameters

pH

Recommended trigger

A pH range of 6.5 to 9.0 is recommended.

Basis for trigger

The recommended pH range is based on the USEPA (1986) Quality Criteria for Water (“Gold Book”), which has been widely applied internationally for the protection of freshwater aquatic life. The range also aligns with New Zealand regional guidance, such as Waikato Regional Council’s (WRC) classifications, where pH values of 7–8 are considered excellent and ranges of 6.5–7 and 8–9 are considered satisfactory for ecological health in rivers (WRC 2026). Similarly, the range is consistent with NIWA’s proposed National Objectives Framework, where pH values outside the range of 6–9 correspond to B and D conditions, which are associated with significant and persistent stress to aquatic organisms (Davies-Colley *et al.* 2013).

The proposed range is comparable to existing Macraes Operation consent limits, which are typically 6.0 to 9.5 across most water quality compliance sites. A narrower range of 7.0 to 8.5 applies at NB03 and Shag River sites to protect drinking water uses.

The adoption of the broader 6.5 to 9.0 range is considered suitable for impact assessment as it is directly linked to ecotoxicological response thresholds and ensures consistency across the monitoring network while maintaining protection of aquatic ecosystem health.

Local context

Historical pH data for Macraes Operation monitoring sites were compared with the proposed trigger range, with time-series plots of this comparison provided in Appendix B (Figures B1 and B2).

A review of long-term pH monitoring data indicates that the proposed pH range of 6.5 to 9.0 is well aligned with prevailing conditions at both impact and control sites, which generally exhibit stable, circumneutral pH values. Departures from this range have been rare and generally limited to a few isolated historical results just outside this range. The main exception is one notably low measurement (3.5) at NBWRRF, with no comparable values observed within the past five years.

Overall, pH does not indicate an elevated risk to receiving water environments, and the proposed trigger range is appropriate for maintaining existing conditions and protecting freshwater aquatic life.

Turbidity (Water clarity)

Recommended trigger

A turbidity trigger of 5 NTU is recommended.

Basis for trigger

The recommended trigger value is based on Schedule 15 of the ORC Regional Plan for Water (ORC 2026), which specifies trigger values for receiving environments with limited flushing and moderate turbidity, consistent with Macraes Operation conditions.

While the ORC Regional Plan applies this trigger under baseflow conditions, this restriction is not considered appropriate for Macraes Operation sites. Sediment discharges are most likely during rainfall events, when sediment control infrastructure is actively operating and the potential for effects on receiving environments is greatest. Applying the trigger across all flow conditions, in conjunction with upstream control sites, allows natural flow-related increases in turbidity to be accounted for while maintaining sensitivity to mine-related inputs.

Turbidity is adopted as the primary compliance parameter due to its responsiveness to short-term changes in suspended sediment and its suitability for operational monitoring. Analysis of Macraes Operation monitoring data⁷ indicates a moderate positive relationship between turbidity and total suspended solids (TSS), supporting the use of turbidity as a surrogate indicator of suspended sediment (refer Figure C1 in Appendix C). While variability reflects differences in particle characteristics and site conditions, the relationship is sufficiently consistent for operational monitoring purposes. TSS will be retained as a supporting parameter to inform interpretation and refine site-specific relationships with turbidity over time.

⁷ Date-matched measurements of turbidity and TSS at key monitoring sites.

Local context

Available monitoring data indicate that turbidity values exceeding 5 NTU are infrequent but occasionally occur at both impact and upstream control sites (refer Appendix B, Figures B3 and B4). The recurrence of exceedances did not, however, meet the framework criteria for non-compliance (i.e., greater than two exceedances in any rolling 12-month period).

The use of upstream control sites enables differentiation between natural variability and site-related effects. The proposed trigger is therefore considered suitable for identifying departures from background conditions while accounting for inherent variability in turbidity.

Sulphate

Recommended trigger

A sulphate trigger value derived from site-specific hardness is recommended, with a value of 500 g/m³ applied where hardness is less than 100 g/m³ as CaCO₃, and 1,000 g/m³ when hardness is greater than or equal to 100 g/m³ as CaCO₃.

Basis for trigger

National sulphate guidance in New Zealand is limited. The ANZECC (2000) stock drinking water guideline value of 1,000 g/m³ has historically been used for livestock watering supplies, with more recent ANZG (2023b) draft guidance proposing a lower value of 500 g/m³.

The earlier ANZECC (2000) value of 1,000 g/m³ remains the basis for the existing sulphate consent limit at most sites across the Macraes Operation. However, a lower limit of 250 g/m³ applies at NB03 and the Shag/Waihemo River sites, reflecting their use as drinking water sources and will continue to apply (refer Section 4.3.4).

The proposed ecological trigger value is informed by the Iowa Department of Natural Resources sulphate criteria (Iowa DNR 2009), which relate sulphate toxicity to water hardness and chloride. For application to Macraes Operation receiving waters, the framework has been simplified to a hardness-based approach, with chloride-dependent adjustments not retained. This reflects a review of site data, which indicated that chloride concentrations had limited influence on the applicable sulphate criterion, and as such, hardness is the primary driver of sulphate toxicity under site conditions.

Locally relevant ecotoxicity data were used to refine a suitable level of protection. Laboratory studies using site-representative seepage water indicate that mortality effects on Taieri flathead galaxias (*Galaxias depressiceps*) - a species known to be present within Macraes Operation receiving waters (Viridis 2026) - did not occur until exposure to sulphate concentrations between 1,640 g/m³ and 1,920 g/m³ (OGNZL 2018). A NIWA study on single-gill mayflies (*Deleatidium* sp.), conducted under comparatively low hardness conditions, reported a no observable effects concentration (NOEC; a chronic endpoint) of 775 g/m³, with 15% and 50% effect concentrations of 963 and 1,597 g/m³, respectively (NIWA 2024).

On this basis, a chronic trigger value of 1,000 g/m³ for waters with hardness greater than or equal to 100 g/m³ as CaCO₃ is considered appropriate. This value lies above the reported NOEC (775 g/m³) for single-gill mayflies and, while close to the 15% effect concentration (963 g/m³), remains below the 50% effect concentration (1,597 g/m³), providing a balance between protection against chronic effects and avoidance of overly conservative limits.

As the NIWA toxicity endpoints were generated under relatively low hardness conditions, they are considered conservative relative to the moderate-to-high hardness typical of the Macraes Operation

receiving environment. The trigger framework has therefore been simplified to two hardness bands, reflecting hardness as the primary driver of sulphate toxicity within the receiving environment.

Local context

Historical data from control sites DC00 and MB00 indicate low background sulphate concentrations (typically less than 25 g/m³) (refer Figures B5 and B6, Appendix B). Assessment of historical data against the proposed sulphate trigger values, adjusted where possible for site-specific hardness⁸ indicates that exceedances meeting the framework criteria for non-compliance occurred at sites CJ01, SPMP1, MC01 and MC02, where exceedances were recurrent (Table B1, Appendix B).

To assess whether the maximum trigger value of 1,000 g/m³ for high-hardness waters is appropriate, long-term trends in *Deleatidium* species abundance were examined (Figures C2 and C3, Appendix C). As demonstrated in the NIWA (2024) study, single-gill mayflies are sensitive to sulphate and are therefore a useful indicator species for assessing potential impact. Declines in abundance were most pronounced at sites that frequently exceed 1,000 g/m³ of sulphate (e.g., at CJ01 and MC01). While reductions in abundance were also observed at lower sulphate concentrations, these patterns were less consistent and are likely influenced by multiple interacting environmental factors. At sites where sulphate concentrations remained low (e.g. DC00), no adverse relationship with *Deleatidium* abundance was evident.

While sulphate is not the sole driver of ecological condition, the co-occurrence of elevated sulphate concentrations and reduced abundance of a sensitive indicator species at key sites supports the application of 1,000 g/m³ as a biologically relevant upper bound for chronic exposure in high-hardness Macraes Operation receiving waters. Above this concentration, adverse ecological effects become more likely.

5.3.2 Nutrients

Ammoniacal nitrogen

Recommended trigger

A pH- and temperature-dependent ammoniacal nitrogen trigger value is recommended, derived using the ANZG (2026) lookup table in Appendix A. Under the standard Macraes Operation index conditions (pH 7.8 and 20°C; see Section 5.2.3), this corresponds to a trigger value of 0.52 g N/m³.

Basis for trigger

The only applicable ammoniacal nitrogen compliance limit for Macraes Operation surface water sites is based on the NPS-FM annual median NBL of 0.24 g N/m³ (MfE 2025), which applies to MB02 and has been implemented as a fixed concentration. However, this approach does not incorporate the pH-dependent adjustment described in Appendix 2 of the NPS-FM and therefore does not fully reflect site-specific toxicity conditions. The previous ANZECC (2000) trigger values for ammoniacal nitrogen (which included a 95% species protection level of 0.9 g N/m³ at a pH 8) similarly required adjustment to account for site-specific pH. These values have, however, been recently superseded by the ANZG (2026) updated guidance for ammoniacal nitrogen.

The ANZG (2026) DGV for ammoniacal nitrogen incorporates recent toxicity data and joint toxicity models developed by USEPA (1999, 2013), to account for the influence of both pH and temperature on

⁸ In absence of a site-specific measurement, a site or global mean was applied for assessment.

ammonia toxicity. This approach recognises that pH and temperature alter the balance between ionised and unionised forms of ammonia, with the unionised fraction being the primary driver of ecotoxicity.

The recommended trigger value is based on the latest ANZG guidance, which provides a site-responsive framework for ecological protection. Tabulated DGVs for a range of pH and temperature conditions are reproduced in Appendix A of this report. This trigger addresses direct toxicity but does not, on its own, manage eutrophication. Nutrient-related effects are addressed separately through a SIN trigger and assessment of ecological response (refer eutrophication section below).

Local context

In the absence of temperature data for the Macraes Operation compliance sites, the standard index condition of 20°C was applied in conjunction with site-specific pH measurements to assess compliance with the trigger. This temperature was adopted as a representative assessment condition for retrospective evaluation of historical monitoring data. Exceedances of the adjusted trigger value were rare, with only single exceedances recorded at CJ01 (1.5 g N/m³ on 16/11/2020), MB01 (0.75 g N/m³ on 17/03/2020) and (MB02 1.3 g N/m³ on 16/03/2020) (refer Figures B7 and B8, Appendix B).

Accordingly, given the isolated nature of historical elevated results, the proposed ammoniacal nitrogen trigger value is considered achievable under site conditions while maintaining a high level of ecological protection.

Nitrate nitrogen

Recommended trigger

A nitrate nitrogen toxicity trigger value (i.e. as NO₃-N, reported in g N/m³) derived from site-specific hardness and, where applicable, chloride conditions is recommended:

- 1.1 g N/m³, when hardness is less than 30 g/m³ as CaCO₃.
- 2.6 g N/m³, when hardness is between 30-150 g/m³ as CaCO₃, or greater than 150 g/m³ as CaCO₃ but chloride concentrations are less than 30 g/m³.
- 29 g N/m³, when hardness is greater than 150 g/m³ as CaCO₃ and chloride concentration is greater than or equal to 30 g/m³ as CaCO₃.

Basis for trigger

National DGVs for nitrate nitrogen toxicity have evolved over time, with earlier ANZECC (2000) values subsequently revised following identification of methodological issues (Hickey 2002, 2013). More recent guidance is provided in ANZG (2025a), which incorporates updated chronic toxicity data and defines nitrate nitrogen DGVs across three hardness categories: soft (<30 g/m³ as CaCO₃), moderately hard (30-150 g/m³ as CaCO₃), and hard (>150 g/m³ as CaCO₃) waters. The recommended trigger values are based on the ANZG DGVs at the 95% species protection level, consistent with application to moderately disturbed freshwater systems, as is the case for the Macraes Operation receiving environment.

The ANZG (2025a) dataset includes chronic growth toxicity data for koura, confirming representation of locally relevant taxa within the species sensitivity distribution underpinning the DGVs.

Supporting information in ANZG (2025a) indicates that nitrate toxicity in hard waters may be moderated by chloride concentrations. Chloride effects are therefore incorporated only for high-hardness waters, where interactions between chloride and nitrate toxicity are most pronounced. In softer waters, hardness remains the dominant modifying factor. Consistent with this approach, the high-hardness trigger value (29 g N/m³) is applied only when chloride concentrations are ≥30 g/m³, with the

intermediate trigger value (2.6 g N/m^3) adopted where hardness exceeds 150 g/m^3 as CaCO_3 but chloride is $<30 \text{ g/m}^3$.

Existing consent limits for Macraes Operation sites are based on the NPS-FM (2020) nitrate NBL, expressed as fixed annual median (2.4 g N/m^3) and an annual 95th percentile (3.5 g N/m^3) concentrations. However, these limits do not account for the influence of hardness on nitrate toxicity, which is now well established.

Nitrate sources within the Macraes Operation catchments may include both anthropogenic inputs (e.g. explosives residues) and natural geological contributions; however, the proposed trigger values are based on toxicity and are independent of source.

The proposed nitrate nitrogen trigger values address direct toxicity but do not, on their own, manage eutrophication. Like ammonia, elevated nitrate concentrations can stimulate algal growth and associated secondary stressors; therefore, nutrient-related effects are addressed separately through a SIN trigger and assessment of ecological response (refer eutrophication section below).

Local context

Nitrate nitrogen concentrations within the Shag/Waihemo catchment compliance sites are generally low (refer Figure B9 of Appendix B). Nitrate concentrations at MB01 and MB02 on Mare Burn in the Taieri River catchment, and at MC01 and MC02 in Murphys Creek in the Waikouaiti River catchment (refer Figure B10 of Appendix B) periodically exceed the proposed hardness-adjusted trigger values, with exceedances persisting at some locations through to 2025 (Table B2 of Appendix B). MB01 and MB02 are located downstream in the Mare Burn system, which receives flows from the Trimble Gully tributary, where nitrate was previously noted as a potential contributor to toxicity effects on kōura alongside ammonia (Ryder 2016).

Sites exhibiting elevated nitrate concentrations generally correspond with lower QMCI and MCI scores, where monitored (refer Appendix C, Figures C4 through C7). While it is not possible to attribute observed ecological condition solely to nitrate, given the potential influence of other constituents and habitat factors, the coincidence of elevated nitrate with reduced macroinvertebrate indices indicates that ecological communities may be constrained or impacted at these locations.

In contrast, sites that do not demonstrate consistent elevation of nitrate concentrations (e.g., DC00) exhibit higher invertebrate indices (refer Appendix C). Given the established chronic toxicity of nitrate at elevated concentrations, the proposed hardness-adjusted trigger values are considered appropriate for identifying exceedances that may adversely affect aquatic communities and for informing management actions to reduce these effects within the Macraes Operation receiving environment.

Eutrophication

Recommended trigger

A SIN trigger value of 0.075 g N/m^3 is recommended as an indicator of nutrient enrichment and eutrophication risk. Assessment of ecological response is also required to determine whether nutrient enrichment is resulting in nuisance plant or algal growth. This is assessed in parallel against a periphyton-based trigger, with non-compliance determined where both the nutrient and ecological response trigger values are exceeded. The ecological response metric is outlined in the site's water quality management plan (WGA 2026), with the optimal method to be determined on an adaptive basis.

Basis for trigger

The ammoniacal nitrogen and nitrate nitrogen trigger values discussed above address direct toxic effects and do not, in isolation, protect against eutrophication effects associated with elevated nutrients.

Eutrophication in streams typically manifests as increased periphyton growth and associated effects such as reduced habitat quality and oxygen availability. These responses are influenced by nutrient supply as well as flow regime, light availability and invertebrate grazing pressure.

The New Zealand Periphyton Guidelines (Biggs 2000) remain a key reference for understanding relationships between nutrient enrichment, periphyton growth and stream ecosystem response. Biggs (2000) identifies that periphyton biomass is influenced by both nutrient supply and the duration of accrual between disturbance events (i.e., higher-flow events, such as flushing flows or floods, that have sufficient energy to remove accumulated periphyton biomass from the stream bed). Corresponding SIN concentrations are provided for different accrual periods and disturbance regimes.

In this context, a SIN trigger value of 0.075 g N/m³ has been adopted as an indicator of nutrient enrichment and eutrophication risk, consistent with the 30-day accrual threshold identified by Biggs (2000). Hydrological analysis indicates that accrual periods of approximately 30 days or greater occur within the Macraes Operation catchments, providing conditions under which nuisance plant and algal growth may occur (refer Figures C8, Appendix C).

Biggs (2000) also provides nationally recognised approaches for assessing ecological responses to nutrient enrichment. Periphyton cover-based methods are currently applied at several Macraes Operation monitoring sites and provide an existing dataset for comparison; however, Biggs (2000) also identifies more quantitative biomass measures, including ash-free dry weight (AFDW) and chlorophyll-*a*, as alternative metrics, and these are increasingly favoured as a basis for ecological response assessment. Chlorophyll-*a* is also the metric adopted for the periphyton attribute under the NPS-FM (2020) (MFE 2025), providing a nationally consistent basis against which any site-specific approach could be benchmarked. The ecological response metric is outlined in the site's water quality management plan (WGA 2026).

Dissolved reactive phosphorus (DRP) thresholds are also identified in Biggs (2000); however, historical monitoring data indicate that DRP concentrations at Macraes Operation are generally low and mine-related contributions are minimal (refer Appendix D).

Local context

Analysis of historical Macraes Operation monitoring data indicates no clear relationship between nutrient concentrations and periphyton cover, with high variability in cover observed even at low nutrient concentrations (refer Figure C9 in Appendix C). This indicates that nutrient availability acts as a pressure on the system rather than a direct predictor of ecological response and suggests that ecological responses at Macraes Operation are strongly influenced by non-nutrient factors such as flow regime, light availability, and grazing pressure.

A SIN concentration of 0.075 g N/m³ is considered appropriate for the Macraes Operation monitoring framework as it reflects historical nutrient conditions observed within the Macraes Operation catchments, while still providing sensitivity to incremental increases in nutrient concentrations.

The observed variability in ecological response supports the use of a combined nutrient and ecological response assessment approach, while highlighting the need for the ecological response methodology to be tailored to site-specific conditions.

Supporting rationale for the proposed eutrophication assessment framework is discussed further in Section 5.4.3, with retrospective application of the SIN trigger value to historical monitoring data presented in Figures B11 and B12 of Appendix B. Comparison of historical nutrient conditions and ecological response data supports the conclusion that nutrient concentrations act as a pressure on the system, while ecological outcomes are influenced by a range of site-specific factors and therefore require separate assessment.

5.3.3 Inorganic toxicants

Arsenic

Recommended trigger

A trigger value of 0.013 g/m³ for dissolved arsenic is recommended for most compliance sites, with a higher trigger value of 0.042 g/m³ applied at DC08 and SPMP1 to reflect natural background and legacy mining influences.

Basis for trigger

Under oxic surface water conditions, arsenic is predominantly present in the pentavalent form, As(V). Accordingly, the recommended arsenic triggers are based on the ANZECC (2000) trigger values for As(V) at the 95% species protection level (0.013 g/m³) and the 90% species protection level (0.042 g/m³).

Arsenic speciation analysis is not routinely undertaken for Macraes Operation samples, as it requires specialised analytical methods that are costly and typically outsourced internationally. Routine monitoring is therefore limited to total or dissolved arsenic concentrations. The As(V) DGVs are considered a conservative proxy for assessing dissolved arsenic.

Existing consent limits for dissolved arsenic across the Macraes Operation range from 0.01 g/m³ to 0.15 g/m³ (the latter reflecting the USEPA (1995) chronic criterion concentration (CCC) for As(III)), depending on the applicable schedule, with the most stringent limits at NB03 and the Shag/Waihemo River sites reflecting drinking water standards. A standardised trigger framework, aligned with national ecotoxicological guidance, is therefore considered suitable for application across Macraes Operation compliance sites.

Local context

Historical monitoring data for dissolved arsenic indicate that elevated concentrations are primarily observed in Deepdell Creek (particularly DC08) and GB02.

Review of pre-mining data shows that dissolved arsenic concentrations increased downstream along Deepdell Creek (from upstream site DC02 to the then most downstream site DC07), with downstream concentrations at or above the 95% species protection trigger value (0.013 g/m³) prior to mining (refer to relevant sections of BHP (1988), reproduced in Appendix C⁹). This pattern is consistent with inputs from mineralised geology and legacy mining features (including the historical Golden Point adit and Battery Creek), rather than site operations.

Post-mining monitoring indicates that dissolved arsenic concentrations at DC07 and DC08 remain within the historical range, with no clear long-term increase (refer Figure C10 of Appendix C). DC08 is located slightly downstream of the historical DC07 site and is therefore considered representative of the same lower catchment conditions. SPMP1 is located on Battery Creek, which discharges to Deepdell Creek just

⁹ BHP (1988) apply different names to the compliance sites referred to in this document. DC02, SPMP1 and DC07 are referred to as C, F and L, respectively, in Figure 4.1.4.

upstream of DC05. Pre-mining data indicate that arsenic concentrations in Battery Creek were already elevated (mean 40.7 g/m³; range 27-51 g/m³; Table 4.1.8 of BHP (1988), reproduced in Appendix C). This is consistent with the mineralised setting of the lower catchment.

In contrast, other parameters (e.g. sulphate) show clearer patterns associated with current mine operations, which are not evident for arsenic at DC08 or SPMP1, where concentrations reflect natural and legacy sources.

Elevated arsenic concentrations were also observed at GB02, with the highest values recorded during active mining prior to 2007 (refer Figure B14 of Appendix B). Concentrations reduced following cessation of mining and subsequent filling of the pit with water, but a later period of elevated concentrations is evident from around 2017, consistent with discharge from the pit to Golden Bar Creek. Exceedances of the 95% species protection trigger at this site, in accordance with the non-compliance criteria, are summarised in Table B3 (Appendix B). Additional episodic non-compliances were also observed at MC01, NBWRRF and SPMP1 (refer Figures B13 and B14 of Appendix B).

Macroinvertebrate metrics (MCI and QMCI) show an early decline at sites downstream of DC00; however, no ongoing decline is evident over time (refer Figures C4 and C6 of Appendix C). This, together with the absence of a clear relationship with arsenic concentrations, suggests that ecological condition is influenced by multiple factors rather than arsenic alone.

On this basis, the 95% species protection trigger value (0.013 g/m³) is below natural background concentrations within the lower Deepdell Creek and Battery Creek catchments. Adoption of a site-specific trigger value based on 90% species protection (0.042 g/m³) at DC08 and SPMP1 is therefore considered appropriate and consistent with pre-mining conditions.

Boron

Recommended trigger

A dissolved boron trigger value of 0.94 g/m³ is recommended.

Basis for trigger

There are currently no consent limits in place for boron at the Macraes Operation. However, boron is emerging as a constituent of potential concern following recent column leachate testing, which identified elevated boron concentrations in leachate from two waste rock domains (MWM 2026)¹⁰.

National guidance is provided by ANZG (2021) for dissolved boron, which specifies a DGV of 0.94 g/m³ at the 95% species protection level. The DGV is formally applicable only within a defined hardness range of 9.2 g/m³ to 250 g/m³ as CaCO₃ and pH range of 6.8–10. These bounds reflect the conditions under which the underlying toxicity datasets were generated. As several Macraes Operation compliance sites exhibit hardness values higher than the defined range, applying the DGV as a trigger requires extending its use beyond the water chemistry range on which it was originally derived.

The ANZG (2021) boron technical brief indicates that water hardness only begins to materially reduce acute boron toxicity at levels greater than 500 g/m³ as CaCO₃, based on studies of several crustacean species (*Daphnia magna*, *Ceriodaphnia dubia* and *Hyalella azteca*). Therefore, application of the ANZG DGV to harder waters is expected to be conservative, rather than under-protective. In addition, any shift

¹⁰ Leachate concentrations were elevated above the ANZG (2021) DGV of 0.94 g/m³.

towards lower pH conditions would be addressed through the site's proposed pH trigger (refer Section 5.3), which would initiate a management response at pH values below 6.5.

In the absence of site-specific toxicity data or updated national guidance extending the validated chemistry range, adoption of the ANZG (2021) DGV as a trigger value provides a precautionary, nationally consistent, and technically defensible basis for assessment.

Local context

Boron has not historically formed part of the Macraes Operation routine surface water monitoring programme and has only recently been incorporated into the suite of analytes. Results from a targeted one-off sampling round undertaken in January 2026 indicate that concentrations were below the laboratory detection limits (0.05 g/m³) at all monitored sites, with the exception of CJ01, where two low-level detections (0.06 and 0.08 g/m³) were recorded (refer Appendix D). These values are well below the proposed trigger value. While the dataset is limited, the results do not indicate any current elevation of boron in receiving waters.

Copper

Recommended trigger

A DOC dependent dissolved copper trigger value is recommended for chronic exposure, defined by the following equation:

$$\text{Chronic TV} = 0.00047 \times \left(\frac{\text{DOC}}{0.5} \right)^{0.977}$$

At a representative DOC concentration of 4.5 g/m³, this corresponds to a trigger value of 0.004 g/m³.

An acute trigger value is also recommended, defined as a function of DOC, hardness and pH using the following equation:

$$\text{Acute TV} = \frac{\exp(-6.6 + 0.78 \text{ pH} + 0.58 \times \ln(\text{hard.}) + 0.70 \times \ln(\text{DOC}))}{1,000}$$

At representative Macraes Operation conditions, (pH of 7.8, hardness of 220 g/m³ as CaCO₃ and DOC of 4.5 g/m³), this corresponds to a trigger value of 0.039 g/m³.

Basis for trigger

National chronic guidelines for copper in freshwater include trigger values published in ANZECC (2000), for which hardness-based algorithms were originally provided for site-specific adjustments. However, subsequent research demonstrated that water hardness exerts limited influence on copper toxicity relative to other water chemistry parameters. Accordingly, the copper guidance was revised in 2018 (Warne *et al.* 2018) to no longer recommend hardness adjustment.

Existing consent limits across the Macraes Operation network reflect earlier regulatory approaches. These include the now superseded USEPA chronic criterion concentration (CCC), expressed as a hardness dependent value (e.g., 0.018 g/m³ at a hardness of 220 g/m³ as CaCO₃) and the hardness modified ANZECC (2000) DGV at the 95% protection level (e.g., 0.0076 g/m³ at a hardness of 220 g/m³ as CaCO₃), which is applied at HC02. These limits are applied inconsistently and are based on hardness-modification frameworks that do not reflect current understanding of copper bioavailability.

The draft ANZG (2023a) DGV for copper, which is expected to replace the ANZECC (2000) trigger value, represents further advancement by incorporating updated toxicity datasets and explicitly accounting for DOC as a primary toxicity-modifying factor. The guideline includes a DOC-based adjustment algorithm,

recognising the strong influence of DOC on copper complexation¹¹ and reduced bioavailability in freshwater systems at higher concentrations. Recent national acute guidance released by MfE similarly adopts a bioavailability-based methodology but also incorporates pH and hardness in an adjustment expression (Gadd *et al.* 2024).

Adoption of the draft ANZG (2023a) and recent MfE (Gadd *et al.* 2024) guidelines, as chronic and acute trigger values at the 95% species protection level, is recommended. Inclusion of both chronic and acute triggers ensures protection against long-term exposure effects as well as short-duration, higher-concentration events that may cause immediate toxicity. While the ANZG guideline remains in draft form, it represents the most current and scientifically robust national guidance available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2023), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The proposed trigger values may be subject to minor refinement following finalisation of the ANZG guideline. The final guideline can be incorporated through updates to this framework and, where necessary, via consent conditions requiring its review and update. As discussed below, dissolved copper concentrations in MGP-impacted water have generally been low, so minor refinements to the draft ANZG guideline are unlikely to have material implications for compliance.

Local context

Historically, dissolved copper concentrations within the key receiving environments of the Macraes Operation have been consistently low, frequently at or below laboratory detection limits (refer Figures B15 and B16, Appendix B). Assessment of the monitoring data against the proposed chronic trigger value¹² indicates that exceedances were limited to a few occasions at compliance sites (i.e. DC08, MC01 and MC02). Non-compliance criteria were only met at SPMP1, for a short window in 2002-2003 (refer Table B4 of Appendix B).

Exceedance of the proposed acute trigger was limited to a single elevated result at GB02 in February of 2009 (Table B4, Appendix B), which likely reflects a short-term operational influence during the period when Golden Bar Pit remained active. No ongoing or recurrent acute exceedances are evident in the dataset¹³.

Overall, the monitoring data demonstrate that copper concentrations have remained generally low, with exceedances limited to isolated events, and that the proposed chronic and acute trigger framework is appropriate to maintain current water quality conditions, while providing a robust, effects-based trigger should conditions change.

Iron

Recommended trigger

A trigger value of 0.28 g/m³ for total iron is recommended.

¹¹ Copper complexation refers to the binding of dissolved copper to other constituents in water, which reduces the proportion present as free copper ions and therefore lowers its bioavailability and toxicity to aquatic organisms.

¹² In the absence of a DOC measurement for an individual sample, the site-specific historical mean DOC concentration was applied. Where no site-specific DOC data were available, the overall mean DOC derived from all Macraes sites was used.

¹³ Similar to the adjustment method for the chronic trigger value, adjustment of the acute trigger was based on sample DOC, pH and hardness measurements, or in their absence, specific-site or Macraes Operation global means.

Basis for trigger

Existing consent limits for iron across the Macraes Operation surface water sites are based on either the USEPA (1986) CCC of 1 g/m³ or the ANZECC (2000) long-term trigger value in irrigation water of 0.2 g/m³.

The proposed trigger is based on the recently published ANZG (2025b) DGV for iron of 0.28 g/m³ at the 95% species protection level. This DGV supersedes the interim indicative working level of 0.3 g/m³ presented in ANZECC (2000) in the absence of sufficient data to derive a reliable trigger value. This was consistent with the Canadian water quality guideline for iron in freshwater (CCREM 1987).

The ANZG (2025b) DGV is expressed for total iron, with weak-acid extractable iron identified as the preferred analytical fraction where available. As weak-acid extractable iron testing is not routinely available through commercial laboratories (Hills Laboratories, pers. comm., February 2026), total iron is retained as the applicable trigger parameter. While dissolved iron can provide additional insight into bioavailable fractions, total iron is retained to align with the ANZG (2025b) guideline derivation and to avoid underestimation of exposure associated with colloidal and particulate forms. This is conservative, as total iron may include mineralised sediment-bound forms that are unlikely to be bioavailable.

Local context

Total iron data are limited across the monitoring network, with several sites represented by a single sampling event in April 2024. The concentrations at these sites are generally below the proposed trigger (refer Appendix D), with a single exceedance at MB02 (0.31 g/m³).

More comprehensive total iron datasets are available for NB03, MC02 and NBWRRF (refer Figure B17, Appendix B). At MC02, concentrations were generally below the proposed trigger, with only occasional exceedances (up to a maximum of 0.37 g/m³). At NB03, concentrations are generally below the proposed ecological trigger value, although the more stringent drinking water value of 0.2 g/m³ applies separately for protection of drinking water uses. Isolated elevated results of 1 g/m³ and 4 g/m³ were recorded in July 2022, but these were not sustained in subsequent monitoring. At NBWRRF, concentrations were more variable and frequently exceed the proposed trigger, with values up to 0.65 g/m³. Some of these exceedances meet the defined recurrence criteria for non-compliance (Table B5, Appendix B).

Available dissolved iron data, reviewed as a proxy for total, indicate that exceedances likely occurred at several sites across the monitoring network, including at control sites such as DC00 and MB00 (refer Figures B18 and B19, Appendix B).

The available data indicate that elevated iron concentrations are spatially variable and influenced by broader catchment and geological conditions rather than a consistent mine-related signal. Elevated concentrations at control sites support the interpretation that naturally elevated iron concentrations occur within the Macraes catchment.

To account for this, exceedances should be interpreted in the context of available control site data collected during the same monitoring event, broader catchment conditions, temporal trends, and comparison with adjacent or downstream monitoring sites, consistent with the compliance assessment framework described in Section 4.3.3. This assessment approach considers whether observed concentrations are consistent with background variability or indicate an additional contribution from site-related sources.

Overall, elevated iron concentrations are variable across the monitoring network, with no consistent downstream increase evident. Elevated concentrations, including within the dissolved fraction, also occur at control sites and support the interpretation that broader catchment and geological conditions contribute to observed exceedances. The proposed ecological trigger therefore remains appropriate as a conservative benchmark for identifying and assessing potential site-related effects.

Lead

Recommended trigger

A dissolved lead trigger value is recommended, defined as a function of hardness by the following equation:

$$TV = 0.0034 \times \left(\frac{\text{Hardness}}{30} \right)^{1.27}$$

At the standard Macraes Operation hardness of 220 g/m³ as CaCO₃, this corresponds to a trigger value of 0.043 g/m³.

Basis for trigger

Most sites across the Macraes Operation apply a hardness dependent limit derived from the USEPA CCC for lead (e.g., 0.0059 g/m³ at a hardness of 220 g/m³ as CaCO₃). A higher hardness adjusted limit (e.g., 0.043 g/m³ at a hardness of 220 g/m³ as CaCO₃) applies at HC02 under the Deepdell East Waste Rock Stack schedule, reflecting use of the ANZECC (2000) hardness modified trigger value (HMTV) for lead rather than the USEPA CCC.

The ANZECC (2000) HMTV provides a nationally recognised, effects-based approach that incorporates hardness as a toxicity-modifying factor. Although the current ANZECC HMTV for lead carries a moderate reliability rating, adoption of the 95% species protection level, with site-specific hardness adjustment, provides a consistent and technically defensible trigger for application across all compliance sites.

Local context

Historical monitoring indicates that dissolved lead concentrations are consistently low across the Macraes Operation monitoring network, with most results at or near analytical detection limits (refer Figures B20 and B21 of Appendix B). All recorded detections are below the proposed hardness-adjusted trigger value. No spatial or temporal pattern of elevated concentrations is evident.

On this basis, dissolved lead does not indicate any elevation relative to the proposed trigger across the monitoring network. The trigger value is therefore considered appropriate for identifying potential site related ecological effects.

The proposed trigger value is intended for ecological protection. The more stringent drinking water value for lead (0.01 g/m³) applies separately at sites where protection of potable water supply is required, and observed concentrations are also below this value.

Nickel

Recommended trigger

A dissolved nickel trigger value is recommended, defined as a function of DOC, hardness and pH using the ANZG (2024a) lookup table in Appendix A.

At representative Macraes Operation conditions (DOC 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and pH 7.8), this corresponds to a trigger value of 0.008 g/m³.

Basis for trigger

Nickel is a trace metal that may be present in a range of geological materials and can be mobilised through weathering or mine-related disturbance, making it a relevant parameter within the Macraes Operation even where historical concentrations have been low. There are no existing consent limits for nickel across the Macraes Operation network. Development of a trigger therefore addresses a gap in the existing consent framework.

The ANZECC (2000) HMTV for nickel at the 95% species protection level (e.g., 0.002 g/m³ at a hardness of 220 g/m³ as CaCO₃) has a low reliability rating, reflecting limitations in the underlying toxicity dataset (Warne *et al.* 2018). The draft ANZG (2024a) update represents a significant improvement, incorporating expanded chronic toxicity data and a bioavailability-based framework that adjusts for DOC, hardness and pH. This approach aligns with recent revisions for other metals and better reflects site-specific exposure conditions. Adoption of the draft ANZG (2024a) DGV at a 95% species protection level is recommended as the most technically robust and nationally consistent framework currently available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2024a), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The draft DGV is formally applicable only within defined water chemistry ranges of 0.5-20 g/m³ DOC, hardness between 12-397 g/m³ as CaCO₃, and pH 6-8.5, based on the ecotoxicity studies that informed the guideline development. However, as some compliance sites record hardness values outside this range, a pragmatic adaptation is required. In these instances, the nearest boundary value within the validated range is applied. Consistent with the approach adopted for boron, this results in a precautionary (i.e., potentially over-protective) trigger, rather than one that risks under-protection.

Local context

Nickel has not historically been included in routine Macraes Operation surface water monitoring, with available data limited to a superseded compliance site (DC07) from the 1990s. Historical concentrations at DC07 were consistently low (≤ 0.0026 g/m³), indicating no evidence of elevated nickel under baseline conditions.

More recent data are limited to retrospective laboratory analyses for samples collected between July and December 2025, supplemented by results from the January 2026 sampling round (Appendix D). Across the wider Macraes Operation monitoring network, nickel concentrations are generally low and below site-specific trigger values, with exceedances confined to the Mare Burn catchment (MB01 and, to a lesser extent, MB02).

Within the Mare Burn catchment, concentrations at the upstream control site (MB00) are consistently low (≤ 0.0009 g/m³) and well below site-specific trigger values, confirming that background nickel concentrations within the Mare Burn catchment are minimal. In contrast, elevated nickel concentrations are observed at MB01, with multiple exceedances of site-specific trigger values. At MB02, nickel concentrations are generally lower than those observed at MB01 and are typically at or below site-specific trigger values.

Several exceedances occur where hardness exceeds the validated range of the draft ANZG (2024a) guideline (> 397 g/m³ as CaCO₃). In these instances, application of the upper hardness boundary is conservative, resulting in trigger values that are likely over-protective and may overstate exceedance frequency.

The absence of exceedances at the upstream control site (MB00), combined with elevated concentrations at MB01, indicates that nickel is being introduced within the catchment downstream of the control site. Lower concentrations at MB02 are consistent with downstream dilution. This pattern indicates a localised source within the Mare Burn catchment. The proposed trigger framework, applied with control site comparison, is considered appropriate for identifying site-related effects.

Zinc

Recommended trigger

A dissolved zinc trigger value is recommended for chronic exposure, defined as a function of DOC, hardness and pH using the ANZG (2024b) lookup table in Appendix A.

At representative Macraes Operation conditions (DOC 4.5 g/m³, hardness 220 g/m³ as CaCO₃ and pH 7.8), this corresponds to a chronic trigger value of 0.016 g/m³.

An acute trigger value is also recommended, defined as a function of DOC, hardness and pH by the following equation:

$$Acute\ TV = \frac{\exp(2.5 - 0.12\ pH + 0.6 \times \ln(hard.) + 0.13 \times \ln(DOC))}{1,000}$$

At representative Macraes Operation conditions, this corresponds to an acute trigger value of 0.148 g/m³.

Basis for trigger

National chronic guidance for zinc in freshwater is provided in ANZECC (2000). The trigger values for zinc incorporate hardness-based adjustment to account for reduced bioavailability under higher calcium carbonate concentrations. Unlike copper, the 2018 review (Warne *et al.* 2018) retained hardness as an appropriate toxicity-modifying factor for zinc.

Existing consent limits across Macraes Operation reflect earlier regulatory approaches, including hardness-adjusted values derived from the USEPA CCC (e.g., 0.23 g/m³ at hardness of 220 g/m³ as CaCO₃) and the ANZECC (2000) HMTV (e.g., 0.044 g/m³ at a hardness of 220 g/m³ as CaCO₃ at HC02). These approaches do not account for DOC or pH, which are now recognised as key controls on zinc bioavailability.

The draft ANZG (2024b) update represents a substantive refinement, incorporating expanded chronic toxicity datasets and a bioavailability-based framework that accounts for DOC, hardness and pH. This reflects contemporary understanding of zinc speciation in freshwater systems, where abiotic factors substantially influence the bioavailable fraction (Zn²⁺). Recent national acute guidance released by MfE (Gadd *et al.* 2024) similarly applies a bioavailability-based methodology.

Adoption of the draft ANZG (2024b) chronic framework, alongside the MfE (Gadd *et al.* 2024) acute guidance, is therefore recommended. Inclusion of chronic and acute triggers provides protection against long-term exposure effects as well as short-duration peak concentrations. While the ANZG guideline remains in draft form, it represents the most current and scientifically robust national guidance available. Viridis has previously reviewed and provided commentary on the guideline for OGNZL (Viridis 2024b), including consideration of its scientific basis, derivation methodology, and applicability to New Zealand conditions. This prior assessment provides confidence in the application of the draft values.

The proposed trigger values may be subject to minor refinement following finalisation of the ANZG guideline. The final guideline can be incorporated through updates to this framework and, where necessary, via consent conditions requiring its review and update.

Local context

Dissolved zinc concentrations within the Macraes Operation receiving environment are generally low, with many results at or near laboratory detection limits (refer Figures B22 and B23 of Appendix B). Concentrations occasionally exceeded the chronic trigger at several sites, including control site DC00. Within the Mare Burn catchment, concentrations at the upstream control site (MB00) remained consistently low, while repeated exceedances were observed downstream at MB01, particularly over the past year, meeting the framework criteria for non-compliance (Table B6, Appendix B).

This pattern indicates a localised increase in zinc concentrations between MB00 and MB01. At MB01, concentrations frequently exceed the chronic trigger, although this has not resulted in a consistent decline in macroinvertebrate community metrics (MCI/QMCI), which have fluctuated without a clear long-term trend (refer Appendix C).

A single exceedance of the proposed acute trigger was recorded at DC00 in June 2024 (Table B6, Appendix B), corresponding to the highest recorded dissolved zinc concentration at this site (0.13 g/m^3). This likely reflects an isolated upstream event or anomalous result, rather than a persistent condition.

On this basis, while elevated zinc concentrations are observed at some locations, these are not uniformly associated with mine-related activities across the monitoring network. However, the persistent exceedances observed at MB01 represent a localised issue downstream of the Mare Burn control site. The proposed trigger framework, applied with control site comparison as defined in this framework, is considered appropriate for identifying site-related effects.

Cyanide

Recommended trigger

A free cyanide ($\text{HCN} + \text{CN}^-$) trigger value is recommended, defined as a function of pH and temperature by the following equation:

$$TV = 0.007 \times (1 + 10^{(pH - (9.721 - 0.0194 \times Temp))})$$

Note: For conditions outside 10-30°C and 6-9 pH, the nearest boundary condition within the validated range should be applied.

At representative Macraes Operation conditions (pH 7.8 and temperature 20°C), this corresponds to a value of 0.0072 g/m^3 .

Basis for trigger

The ANZECC (2000) trigger value for cyanide is 0.007 g/m^3 , expressed as unionised hydrogen cyanide (HCN) at the 95% species protection level. HCN is the toxicologically active fraction, and its proportion within free cyanide is strongly influenced by pH and temperature.

To enable practical application, the ANZECC (2000) HCN-based guideline is used to derive a pH and temperature dependent trigger value for free cyanide. This approach defines the concentration of free cyanide ($\text{HCN} + \text{CN}^-$) that would correspond to the ANZECC HCN limit under site-specific conditions. In this way, the toxicity-based HCN guideline is retained, while expressing the trigger in a form that can be readily applied in monitoring and compliance assessment.

Routine monitoring at Macraes Operation has historically focused on weak acid dissociable (WAD) cyanide, which includes free cyanide and weak metal-cyanide complexes, but excludes strongly bound

iron-cyanide complexes. As unionised HCN represents only a fraction of free cyanide, and free cyanide is itself a subset of WAD cyanide, direct comparison of WAD cyanide results to an HCN-based trigger is inherently conservative and may overestimate ecological risk. This is particularly relevant under the circumneutral to mildly alkaline conditions typical of Macraes Operation receiving waters, where the proportion of unionised HCN is expected to be comparatively low.

Measurement of free cyanide is recommended to allow direct comparison with the proposed trigger value. However, given current analytical limitations in New Zealand (Hills Laboratories, pers. comm., February 2026), WAD cyanide may be used as a conservative interim surrogate.

Local context

Historical WAD cyanide results for key Macraes Operation compliance sites were reviewed as a surrogate for free cyanide and compared against a pH adjusted free cyanide trigger value. In the absence of measured temperature data, a standard assessment temperature of 20°C was adopted for retrospective evaluation of historical monitoring data.

Use of WAD cyanide as a surrogate for free cyanide is likely to overestimate ecological risk, particularly under the mildly alkaline conditions typical of Macraes Operation waters, where the proportion of unionised HCN is expected to be low. As a result, most detected cyanide concentrations were interpreted as exceedances, including isolated detections at control sites MB00 and DC00 (refer Figures B24 and B25 of Appendix B). Compliance sites most frequently exceeding the trigger value under this assumption, and thus qualifying as non-compliant, were CJ01 and TC01 (Table B7, Appendix B).

On this basis, the apparent frequency of exceedances reflects limitations in the use of WAD cyanide as a surrogate rather than a clear indication of ecological risk. The proposed trigger framework, supported by measurement of free cyanide where practicable, is considered appropriate for identifying site-related ecological effects.

5.3.4 Excluded constituents

Overview

A broad suite of constituents was reviewed as part of the screening assessment; however, only those considered relevant to the MP4 receiving environment have been selected for development of trigger values. The parameters discussed below were identified as potentially relevant but have not been progressed further, based on their risk profile and site-specific context.

Aluminium

Aluminium is a naturally abundant element that commonly enters aquatic systems via weathering processes. Its toxicity is strongly pH-dependent, with the most bioavailable and toxic forms occurring under acidic conditions. At the circumneutral to mildly alkaline pH typical of Macraes Operation receiving waters, aluminium is expected to predominate as hydroxide complexes, which are substantially less bioavailable.

The ANZECC (2000) 95% species protection level trigger value for aluminium of 0.055 g/m³ (applicable at pH >6.5) is assigned low reliability and is recommended only as an interim value under updated ANZG guidance (Warne *et al.* 2018). At the Macraes Operation, aluminium has not historically formed part of routine surface water monitoring. However, a six-month retrospective dataset (July to December 2025) obtained for some Macraes Operation sites indicates concentrations within key catchments are consistently below the interim DGV, ranging from below the laboratory detection limit (0.003 g/m³) to a

maximum of 0.043 g/m³ (Appendix D). No clear differences between control and compliance sites were observed. Additionally, mine seepage monitoring undertaken in 2023 and 2024 indicates relatively low dissolved aluminium concentrations (all below 0.03 g/m³) are being generated from the site's waste rock stacks (Appendix D).

Given the pH conditions of the receiving waters and the absence of elevated aluminium concentrations in available monitoring data, aluminium does not indicate an elevated risk to receiving water environments at Macraes Operation, and development of a trigger value is not warranted at this stage.

Antimony

Antimony has been excluded as a constituent of concern. Column leach testing undertaken by MWM (2026) identified low-level antimony release from two waste rock domains; however, concentrations remained well below the adopted water quality reference value of 0.074 g/m³ (i.e., Canadian chronic value; BC 2023). Available surface water monitoring data similarly indicate that antimony concentrations across the Macraes Operation remain consistently low and do not indicate a material risk to surface water quality.

Across the Macraes Operation monitoring network (Appendix D), total antimony concentrations are typically below laboratory detection limits (0.00021 g/m³), including at sites with longer-term records (NB03, MC02 and NBWRRF). Where detected, concentrations are very low; the maximum recorded value (0.006 g/m³ at DC08) is well below the adopted water quality reference value. Dissolved antimony data show a consistent pattern of non-detects or negligible concentrations, at upstream and control sites, further confirming that antimony has not been elevated in the receiving environment as a result of mining operations.

Cadmium

Cadmium has been monitored intermittently at Macraes Operation surface water sites, including limited historical data from the 1990s, recent monitoring in 2024, and retrospective data for 2025. Available results were at or below the detection limit (0.00005 g/m³) (Appendix D).

Guidance for cadmium includes the ANZECC (2000) HMTV of 0.012 g/m³ (at the 95% species protection level, adjusted for a representative Macraes Operation hardness of 220 g/m³ as CaCO₃). On this basis, cadmium concentrations in Macraes Operation receiving waters are well below guideline levels and do not indicate an elevated ecological risk. Development of a trigger value for cadmium is therefore not warranted at this stage.

Chloride

Chloride is relevant to irrigation water quality due to its potential effects on crop productivity and soil salinity. This is of particular relevance to the Shag River and NB03 receiving water sites, which may be subject to downstream irrigation uses.

The ANZECC (2000) irrigation guidelines include chloride criteria for the prevention of foliar injury to crops and for managing the risk of increased cadmium uptake in soils. Based on historical monitoring data for these sites (refer Appendix D), chloride concentrations fall within the most stringent category for protection of sensitive crops (<175 g/m³), and the 'low' risk category for increased cadmium uptake in soils (0-350 g/m³).

Given the low concentrations observed historically and their compliance with the most stringent irrigation guideline category, chloride does not currently indicate an elevated risk to irrigation uses at

the relevant receiving water quality sites. Accordingly, development of a chloride trigger value is not considered necessary for the proposed framework at this stage. This position should be revisited if future project design or treatment approaches indicate the potential for materially increased chloride concentrations in receiving waters.

Chromium

The environmental behaviour and toxicity of chromium are strongly dependent on oxidation state, with hexavalent chromium (Cr(VI)) recognised as the more bioavailable and toxic species in surface waters, compared with trivalent chromium (Cr(III)). In this context, the ANZECC (2000) trigger value for Cr(VI) of 0.001 g/m³ (at a 95% species protection level) provides an appropriate and conservative benchmark for assessing potential ecotoxicological risk.

Chromium has not been routinely monitored in Macraes Operation surface waters; however, recent back-trace data (July to December 2025) for dissolved chromium show that concentrations were consistently at or below the detection limit (0.0005 g/m³) at all sites assessed (Appendix D). These results represent dissolved chromium and do not distinguish between oxidation states; accordingly, comparison with the Cr(VI) trigger value is conservative. Notwithstanding this conservatism, concentrations remained well below the Cr(VI) guideline.

Given that results are at or near detection limits and that the limited detections are not associated with site-derived influences, chromium does not indicate an elevated risk to receiving water environments at Macraes Operation and development of a trigger value for chromium is not warranted at this stage.

Cobalt

Cobalt has not been routinely monitored in surface waters or mine waters at Macraes Operation. Guidance remains limited, with criteria available in the Canadian Federal Water Quality Guidelines (Environment Canada 2017) and ANZECC (2000).

The ANZECC (2000) freshwater trigger value of 0.0014 g/m³ is of uncertain reliability and does not specify a defined species protection level. The Canadian FWQG is hardness-dependent and corresponds to 0.0014 g/m³ at a hardness of 220 g/m³ as CaCO₃.

Retrospective data for July to December 2025 indicate that cobalt concentrations were generally low, with most sites below the detection limit (0.0002 g/m³). Relative to the hardness-adjusted Canadian guideline, exceedances were limited to a single event at MB00 (control site) and MB02. The absence of a consistent downstream signal (refer Appendix D) indicates that these exceedances are unlikely to be associated with mine-related sources.

On this basis, cobalt does not indicate an elevated risk to receiving water environments at Macraes Operation, and development of a trigger value is not warranted at this stage.

Fluoride

Fluoride was included in the January 2026 monitoring round at several compliance sites to inform an initial risk assessment. Concentrations across the relevant surface water sites ranged from 0.08 g/m³ at MB00 to 0.22 g/m³ at CJ01 (Appendix D). These values are well below the ANZG (2024c) DGV at the 95% species protection level of 1.7 g/m³ (expressed as fluoride ion). On this basis, development of a trigger value is not warranted at this stage.

Mercury

Dissolved mercury has been measured intermittently over time, with recent surface water results reported below detection limits (0.00008 g/m^3 - refer Appendix D). This detection limit is well below the ANZECC (2000) trigger value for inorganic mercury at the 95% level of protection of 0.0006 g/m^3 .

The 2018 guideline review (Warne *et al.* 2018) recommends accounting for mercury bioaccumulation by applying a higher level of protection than would ordinarily be selected (i.e., the 99% species protection level, which is 0.00006 g/m^3). As the current laboratory detection limit exceeds this DGV, comparison against the more conservative benchmark is not practicable.

Notwithstanding this limitation, available monitoring data indicate that dissolved mercury concentrations are consistently low and below the 95% level of protection. On this basis, and given the absence of evidence for elevated concentrations in receiving waters, inclusion of a specific trigger value is not warranted at this stage.

Molybdenum

To date, molybdenum has not been included in routine surface water or mine water monitoring at Macraes Operation, and no site-specific data are currently available to inform an assessment of risk. National guidance is limited to the ANZECC (2000) trigger value of 0.034 g/m^3 ; however, this value is assigned an uncertain reliability and does not specify a protection level.

In the absence of monitoring data and any indication of a mobilisation pathway associated with MP4 activities, development of a trigger value for molybdenum is not warranted at this stage.

Sodium

Like chloride, sodium is relevant to irrigation water quality due to its potential effects on crop productivity. This is of particular relevance to the Shag River and NB03 receiving water sites, which may be subject to downstream irrigation uses.

Based on historical monitoring data (refer Appendix D), sodium concentrations at the Shag River and NB03 sites consistently fall within the most stringent ANZECC (2000) category for protection of sensitive crops ($<115 \text{ g/m}^3$). Accordingly, sodium does not indicate an elevated risk to irrigation uses¹⁴.

Given the low sodium concentrations observed historically and their compliance with the most stringent irrigation guideline category, sodium does not currently indicate an elevated risk to irrigation uses at the relevant receiving water sites. Accordingly, development of a sodium trigger value is not considered necessary for the proposed framework at this stage.

Tungsten

Tungsten has not been monitored in Macraes Operation surface waters, and no site-specific data are currently available to inform risk. Although historically considered relatively immobile, more recent investigations have shown that tungsten can dissolve and migrate under certain environmental conditions. The USEPA classifies tungsten as an emerging contaminant, with limited and evolving information regarding its environmental fate and ecological toxicity (USEPA 2017).

¹⁴ The ANZECC (2000) irrigation guidelines also assess sodium-related soil impacts using the sodium adsorption ratio (SAR) in combination with salinity. Given the low sodium concentrations observed and their placement within the most stringent crop sensitivity category, SAR was not evaluated as part of this screening-level assessment.

In the absence of monitoring data and any indication of a mobilisation pathway associated with MP4 activities, development of a trigger value for tungsten is not warranted at this stage.

5.4 Compliance Assessment Rationale

5.4.1 Chronic trigger value assessment

Many of the proposed chronic trigger values are based on ANZG default guideline values (DGVs). ANZG recommends assessment against the 95th percentile of monitoring data to evaluate chronic ecological risk (ANZG 2023c). For monthly monitoring programmes, this percentile is typically evaluated over a five-year period to provide a statistically robust estimate¹⁵.

While this approach provides a high degree of statistical confidence, it is not always well suited to compliance frameworks where timely identification of emerging impacts and management responses is required. Accordingly, the MP4 framework adopts compliance assessment based on exceedance frequency and duration over shorter rolling timeframes, rather than formal percentile calculations. This provides a more practical and responsive method, while still capturing sustained exposure conditions and seasonal influences relevant to chronic ecological risk.

The adopted exceedance frequency (i.e., more than two exceedances in any rolling 12-month period) distinguishes repeated departures from trigger values from isolated exceedances that may arise from natural variability, episodic events or analytical uncertainty. The approach reflects a low tolerance for repeated exceedance of trigger values while providing confidence that non-compliance represents a persistent condition rather than a short-term fluctuation.

5.4.2 Acute trigger value assessment

Acute trigger values are assessed on the basis of any single exceedance, reflecting the potential for short-term exposures to cause immediate ecological effects. This approach aligns with the application of acute guideline values in ANZG and other international frameworks, where a single exceedance represents an elevated likelihood of adverse ecological effects.

5.4.3 Eutrophication trigger assessment

The eutrophication assessment framework adopts a SIN trigger value as an indicator of nutrient enrichment and eutrophication risk and recognises the need for ecological response assessment to determine whether nutrient enrichment is resulting in nuisance plant or algal growth.

The SIN trigger value is derived from the New Zealand Periphyton Guidelines (Biggs 2000), which identify nutrient thresholds associated with periphyton growth under different accrual periods and flow disturbance regimes. Consistent with the underlying intent of the guideline, the MP4 framework assesses the SIN trigger using a rolling annual median concentration to reflect the importance of sustained nutrient conditions in influencing plant and algal growth over time.

Historical monitoring within the Macraes Operation catchments demonstrates substantial variability in plant and algal growth at similar nutrient concentrations, indicating that ecological responses are strongly influenced by site-specific factors, including flow regime, riparian shading, light availability and grazing pressure. Accordingly, ecological response assessment is also required alongside the SIN trigger

¹⁵ At a 95% confidence interval. For example, to estimate a 90th percentile to this degree of accuracy, a minimum sample size of 36 is required. For a monthly sampling programme, five years of monitoring provides a sufficient number of samples to calculate a 95th percentile to this degree of accuracy.

assessment and should be interpreted in the context of broader site conditions and relevant control site data where available.

5.4.4 Return to compliance

For chronic and acute trigger values, return to compliant status requires a sustained period without further exceedance, reflecting the need to demonstrate that elevated concentrations were not persistent and that water quality conditions have stabilised.

For eutrophication, return to compliance will be assessed in accordance with the nutrient and ecological response assessment framework adopted through the consenting process. In general, return to compliance is expected to occur where either nutrient concentrations no longer exceed the applicable trigger value, or monitoring demonstrates that the ecological response assessment criteria are no longer exceeded.

The adopted return-to-compliance periods provide an appropriate balance between demonstrating sustained improvement and avoiding unnecessary delay in recognising recovery. For chronic and acute trigger values, a six-month lag period was selected to provide sufficient time to demonstrate that elevated concentrations are not persistent, while still allowing the framework to remain responsive to changing receiving environment conditions.

6 CONCLUSION

This report presents a recommended framework of surface water quality trigger values to support assessment and management of potential effects associated with the proposed MP4 development under the FTAA. The framework establishes a consistent, site-wide approach to water quality management at the Macraes Operation, replacing historically derived limits with a unified system aligned with contemporary national and international guidance.

The proposed trigger values have been developed using a weight-of-evidence approach that integrates site-specific water chemistry, historical monitoring data, and available ecological information. Where appropriate, bioavailability-based methods have been applied to ensure that trigger values reflect both current scientific understanding and local receiving environment conditions.

Historical monitoring indicates that surface water quality across the Macraes Operation is generally consistent with the trigger values. Exceedances are typically localised and parameter-specific, reflecting a combination of natural background influences, legacy mining effects, and, in some cases, inputs associated with the current Macraes Operation. For several constituents assessed but not included in the proposed trigger framework (Section 5.3.4), available data show concentrations are consistently low relative to guideline values, with no evidence of ecological effects; accordingly, additional trigger values are not proposed at this stage.

The framework distinguishes between early warning trigger exceedances and defined non-compliance conditions, enabling a proportionate and risk-based response to changes in water quality. This approach supports timely investigation and, where required, management intervention, while avoiding over-interpretation of short-term variability.

Overall, the proposed framework provides a scientifically robust, site-specific, and effects-based basis for assessing surface water quality, supporting consistent compliance assessment and adaptive management of the Macraes Operation receiving environment. The framework also provides flexibility to further refine aspects of the assessment methodology, including ecological response assessment for eutrophication, through the consenting process.

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Appendix A

Toxicity Modifier Lookup Tables

Table A1. ANZG (2026) freshwater 95% species-protection guideline values for ammoniacal nitrogen (g N/m³) at different pH and temperature values.

Temp. (°C)	pH																														
	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	8.4	8.5	8.6	8.7	8.8	8.9	9.0
10	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7	1.7	1.6	1.6	1.5	1.4	1.3	1.2	1.2	1.0	0.94	0.84	0.74	0.64	0.55	0.47	0.40	0.34	0.29	0.24	0.21	0.17	0.15	0.13
11	1.8	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.90	0.80	0.71	0.61	0.53	0.45	0.38	0.33	0.27	0.23	0.20	0.17	0.14	0.12
12	1.7	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.3	1.2	1.1	1.0	0.95	0.85	0.76	0.67	0.58	0.50	0.43	0.36	0.31	0.26	0.22	0.19	0.16	0.13	0.12
13	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.1	1.1	0.99	0.90	0.81	0.72	0.63	0.55	0.47	0.41	0.34	0.29	0.25	0.21	0.18	0.15	0.13	0.11
14	1.5	1.5	1.5	1.5	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.0	0.94	0.85	0.77	0.68	0.60	0.52	0.45	0.39	0.33	0.28	0.23	0.20	0.17	0.14	0.12	0.10
15	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.3	1.3	1.3	1.2	1.2	1.1	1.0	0.98	0.90	0.82	0.74	0.66	0.58	0.50	0.43	0.37	0.31	0.27	0.22	0.19	0.16	0.14	0.12	0.10
16	1.4	1.4	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.1	1.1	1.0	0.93	0.86	0.78	0.70	0.63	0.55	0.48	0.41	0.35	0.30	0.25	0.21	0.18	0.15	0.13	0.11	0.096
17	1.3	1.3	1.3	1.3	1.3	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.0	0.95	0.89	0.82	0.75	0.67	0.60	0.52	0.46	0.39	0.34	0.29	0.24	0.20	0.17	0.15	0.12	0.11	0.091
18	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.13	1.10	1.1	1.0	0.97	0.91	0.85	0.78	0.72	0.64	0.57	0.50	0.44	0.38	0.32	0.27	0.23	0.20	0.17	0.14	0.12	0.10	0.087
19	1.2	1.2	1.2	1.2	1.2	1.15	1.13	1.11	1.09	1.06	1.0	0.98	0.93	0.88	0.82	0.75	0.69	0.62	0.55	0.48	0.42	0.36	0.31	0.26	0.22	0.19	0.16	0.13	0.11	0.098	0.084
20	1.1	1.1	1.1	1.1	1.1	1.09	1.08	1.06	1.03	1.00	0.97	0.93	0.88	0.83	0.78	0.72	0.65	0.59	0.52	0.46	0.40	0.34	0.29	0.25	0.21	0.18	0.15	0.13	0.11	0.093	0.080
21	1.1	1.1	1.1	1.0	1.0	1.03	1.01	0.99	0.97	0.94	0.91	0.87	0.83	0.78	0.73	0.67	0.61	0.55	0.49	0.43	0.37	0.32	0.28	0.23	0.20	0.17	0.14	0.12	0.10	0.087	0.075
22	1.0	1.0	1.0	1.0	1.0	0.99	0.98	0.96	0.94	0.91	0.88	0.84	0.80	0.76	0.71	0.65	0.59	0.53	0.47	0.42	0.36	0.31	0.27	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.072
23	0.98	0.98	0.97	0.96	0.95	0.94	0.93	0.91	0.89	0.87	0.84	0.80	0.76	0.72	0.67	0.62	0.56	0.51	0.45	0.40	0.34	0.30	0.25	0.22	0.18	0.15	0.13	0.11	0.093	0.080	0.069
24	0.93	0.92	0.92	0.91	0.90	0.89	0.88	0.86	0.84	0.82	0.79	0.76	0.72	0.68	0.63	0.58	0.53	0.48	0.42	0.37	0.32	0.28	0.24	0.20	0.17	0.15	0.12	0.10	0.088	0.075	0.065
25	0.88	0.88	0.87	0.87	0.86	0.85	0.83	0.82	0.80	0.78	0.75	0.72	0.68	0.65	0.60	0.55	0.51	0.45	0.40	0.36	0.31	0.27	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.072	0.062
26	0.84	0.83	0.83	0.82	0.81	0.80	0.79	0.78	0.76	0.74	0.71	0.68	0.65	0.61	0.57	0.53	0.48	0.43	0.38	0.34	0.29	0.25	0.22	0.18	0.16	0.13	0.11	0.094	0.080	0.068	0.058
27	0.79	0.79	0.78	0.78	0.77	0.76	0.75	0.74	0.72	0.70	0.68	0.65	0.62	0.58	0.54	0.50	0.45	0.41	0.36	0.32	0.28	0.24	0.20	0.17	0.15	0.12	0.11	0.089	0.075	0.064	0.056
28	0.75	0.75	0.74	0.74	0.73	0.72	0.71	0.70	0.68	0.66	0.64	0.61	0.58	0.55	0.51	0.47	0.43	0.39	0.34	0.30	0.26	0.23	0.19	0.16	0.14	0.12	0.099	0.084	0.071	0.061	0.052
29	0.71	0.71	0.70	0.70	0.69	0.68	0.67	0.66	0.64	0.62	0.60	0.58	0.55	0.52	0.48	0.45	0.41	0.37	0.32	0.29	0.25	0.21	0.18	0.16	0.13	0.11	0.094	0.079	0.067	0.058	0.050
30	0.66	0.66	0.66	0.65	0.65	0.64	0.63	0.62	0.60	0.58	0.57	0.54	0.52	0.49	0.45	0.42	0.38	0.34	0.30	0.27	0.23	0.20	0.17	0.15	0.12	0.10	0.088	0.074	0.063	0.054	0.046

Notes: For conditions outside the ranges of 10-30°C and 6-9 pH, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Table A2. ANZG (2024a) freshwater 95% species-protection guideline values for dissolved nickel (g/m³) at different pH, hardness and DOC values.

Parameter		DGV (g/m ³)							
pH		6.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0027	0.0041	0.0048	0.0055	0.0079	0.011	0.012	0.016
	1	0.0039	0.0061	0.0073	0.0084	0.012	0.017	0.02	0.025
	3	0.0065	0.01	0.013	0.015	0.023	0.033	0.039	0.051
	5	0.0081	0.013	0.016	0.019	0.03	0.044	0.051	0.068
	10	0.011	0.017	0.02	0.024	0.04	0.061	0.072	0.106
	15	0.013	0.02	0.023	0.028	0.046	0.071	0.086	0.118
	20	0.015	0.022	0.026	0.03	0.05	0.079	0.096	0.134
pH		6.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0024	0.0034	0.0039	0.0044	0.0061	0.0079	0.0089	0.011
	1	0.0034	0.005	0.0058	0.0066	0.0094	0.012	0.014	0.018
	3	0.0053	0.0082	0.0099	0.012	0.017	0.024	0.028	0.035
	5	0.0065	0.01	0.012	0.014	0.022	0.032	0.037	0.047
	10	0.0084	0.013	0.016	0.019	0.03	0.044	0.052	0.069
	15	0.0099	0.015	0.018	0.022	0.035	0.053	0.062	0.084
	20	0.011	0.017	0.02	0.024	0.038	0.059	0.07	0.096
pH		7.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0019	0.0026	0.0029	0.0033	0.0043	0.0056	0.0062	0.0077
	1	0.0027	0.0038	0.0043	0.0048	0.0065	0.0085	0.0095	0.012
	3	0.0043	0.0063	0.0074	0.0084	0.012	0.016	0.018	0.023
	5	0.0051	0.0077	0.0091	0.01	0.015	0.021	0.024	0.03
	10	0.0065	0.0098	0.012	0.014	0.021	0.03	0.034	0.044
	15	0.0074	0.011	0.013	0.016	0.024	0.035	0.041	0.055
	20	0.0082	0.012	0.015	0.017	0.027	0.04	0.047	0.062

Parameter		DGV (g/m ³)							
pH		7.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0014	0.0018	0.002	0.0022	0.0028	0.0034	0.0038	0.0046
	1	0.002	0.0027	0.003	0.0033	0.0042	0.0052	0.0057	0.0068
	3	0.0032	0.0045	0.0052	0.0057	0.0077	0.0098	0.011	0.013
	5	0.0038	0.0055	0.0064	0.0072	0.01	0.013	0.014	0.017
	10	0.0047	0.0069	0.0082	0.0093	0.014	0.019	0.021	0.026
	15	0.0052	0.0078	0.0093	0.011	0.016	0.022	0.025	0.032
	20	0.0057	0.0085	0.01	0.012	0.018	0.025	0.029	0.037
pH		8.0							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.001	0.0012	0.0013	0.0014	0.0016	0.002	0.0023	0.003
	1	0.0014	0.0018	0.002	0.0021	0.0024	0.0029	0.0031	0.0039
	3	0.0023	0.003	0.0034	0.0037	0.0047	0.0055	0.0059	0.0067
	5	0.0026	0.0037	0.0042	0.0047	0.0062	0.0075	0.008	0.009
	10	0.0031	0.0045	0.0053	0.006	0.0084	0.011	0.012	0.014
	15	0.0033	0.005	0.0059	0.0067	0.0097	0.013	0.015	0.018
	20	0.0035	0.0053	0.0063	0.0072	0.011	0.015	0.017	0.02
pH		8.5							
Hardness (g/m ³ CaCO ₃)		12	23	31	39	83	166	223	397
DOC (g/m ³)	0.5	0.0007	0.0008	0.0008	0.0008	0.0011	0.0015	0.0017	0.0021
	1	0.001	0.0012	0.0012	0.0013	0.0014	0.0019	0.0022	0.0028
	3	0.0015	0.002	0.0022	0.0023	0.0028	0.003	0.0032	0.004
	5	0.0017	0.0023	0.0026	0.0029	0.0037	0.0042	0.0043	0.0049
	10	0.0019	0.0027	0.0032	0.0036	0.0049	0.0062	0.0067	0.0073
	15	0.002	0.0029	0.0034	0.0039	0.0056	0.0074	0.0082	0.0094
	20	0.002	0.003	0.0036	0.0041	0.006	0.0082	0.0092	0.011

Notes: For conditions outside pH 6-8.5, hardness 12-397 g/m³ and DOC 0.5-20 g/m³, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Table A3. ANZG (2024b) freshwater 95% species-protection guideline values for dissolved zinc (g/m³) at different pH, hardness and DOC values.

Parameter		DGV (g/m ³)							
pH		6.2							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0079	0.0092	0.012	0.013	0.015	0.017	0.019	0.021
	1	0.0087	0.01	0.013	0.015	0.016	0.019	0.021	0.023
	2	0.0096	0.011	0.014	0.016	0.018	0.021	0.024	0.026
	5	0.011	0.013	0.016	0.019	0.021	0.025	0.028	0.03
	10	0.012	0.014	0.018	0.021	0.024	0.028	0.031	0.033
	15	0.013	0.015	0.019	0.023	0.026	0.029	0.032	0.035
pH		6.5							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0065	0.0076	0.0097	0.011	0.012	0.014	0.016	0.017
	1	0.0075	0.0087	0.011	0.013	0.014	0.017	0.018	0.02
	2	0.0086	0.01	0.013	0.015	0.017	0.019	0.021	0.023
	5	0.01	0.012	0.015	0.018	0.02	0.023	0.026	0.028
	10	0.012	0.014	0.018	0.021	0.023	0.027	0.03	0.033
	15	0.013	0.015	0.019	0.023	0.025	0.03	0.033	0.035
pH		7.0							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0048	0.0056	0.0072	0.0083	0.0092	0.011	0.012	0.013
	1	0.0059	0.0068	0.0087	0.01	0.011	0.013	0.015	0.016
	2	0.0072	0.0083	0.011	0.012	0.014	0.016	0.018	0.019
	5	0.0094	0.011	0.014	0.016	0.018	0.021	0.023	0.025
	10	0.011	0.013	0.017	0.02	0.022	0.026	0.029	0.031
	15	0.013	0.015	0.019	0.022	0.025	0.029	0.032	0.035

Parameter		DGV (g/m ³)							
pH		7.5							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0035	0.0041	0.0053	0.0061	0.0068	0.0079	0.0088	0.0096
	1	0.0045	0.0053	0.0068	0.0079	0.0088	0.01	0.011	0.012
	2	0.0059	0.0069	0.0088	0.01	0.011	0.013	0.015	0.016
	5	0.0083	0.0097	0.012	0.014	0.016	0.018	0.02	0.022
	10	0.011	0.013	0.016	0.018	0.02	0.024	0.026	0.028
	15	0.013	0.015	0.019	0.021	0.024	0.027	0.03	0.033
pH		8.0							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0025	0.003	0.0039	0.0045	0.0051	0.0059	0.0066	0.0072
	1	0.0035	0.0041	0.0053	0.0062	0.0069	0.008	0.0089	0.0097
	2	0.0048	0.0056	0.0073	0.0084	0.0093	0.011	0.012	0.013
	5	0.0072	0.0085	0.011	0.013	0.014	0.016	0.018	0.019
	10	0.0097	0.011	0.015	0.017	0.019	0.021	0.023	0.025
	15	0.012	0.014	0.018	0.02	0.022	0.025	0.028	0.03
pH		8.3							
Hardness (g/m ³ CaCO ₃)		20	30	60	90	120	180	300	440
DOC (g/m ³)	0.5	0.0021	0.0025	0.0033	0.0038	0.0042	0.005	0.0055	0.006
	1	0.003	0.0035	0.0046	0.0053	0.0059	0.0069	0.0077	0.0084
	2	0.0042	0.005	0.0065	0.0075	0.0083	0.0095	0.011	0.011
	5	0.0065	0.0077	0.01	0.012	0.013	0.015	0.016	0.017
	10	0.0089	0.011	0.014	0.016	0.018	0.02	0.022	0.023
	15	0.011	0.013	0.017	0.019	0.021	0.024	0.026	0.028

Notes: For conditions outside 6 pH, 2-8.3, hardness 20-440 g/m³ and 0.5-15 g/m³ DOC, the trigger value corresponding to the nearest boundary condition within the validated range should be applied.

Appendix B

Evaluation of Trigger Values against Historical Data

pH

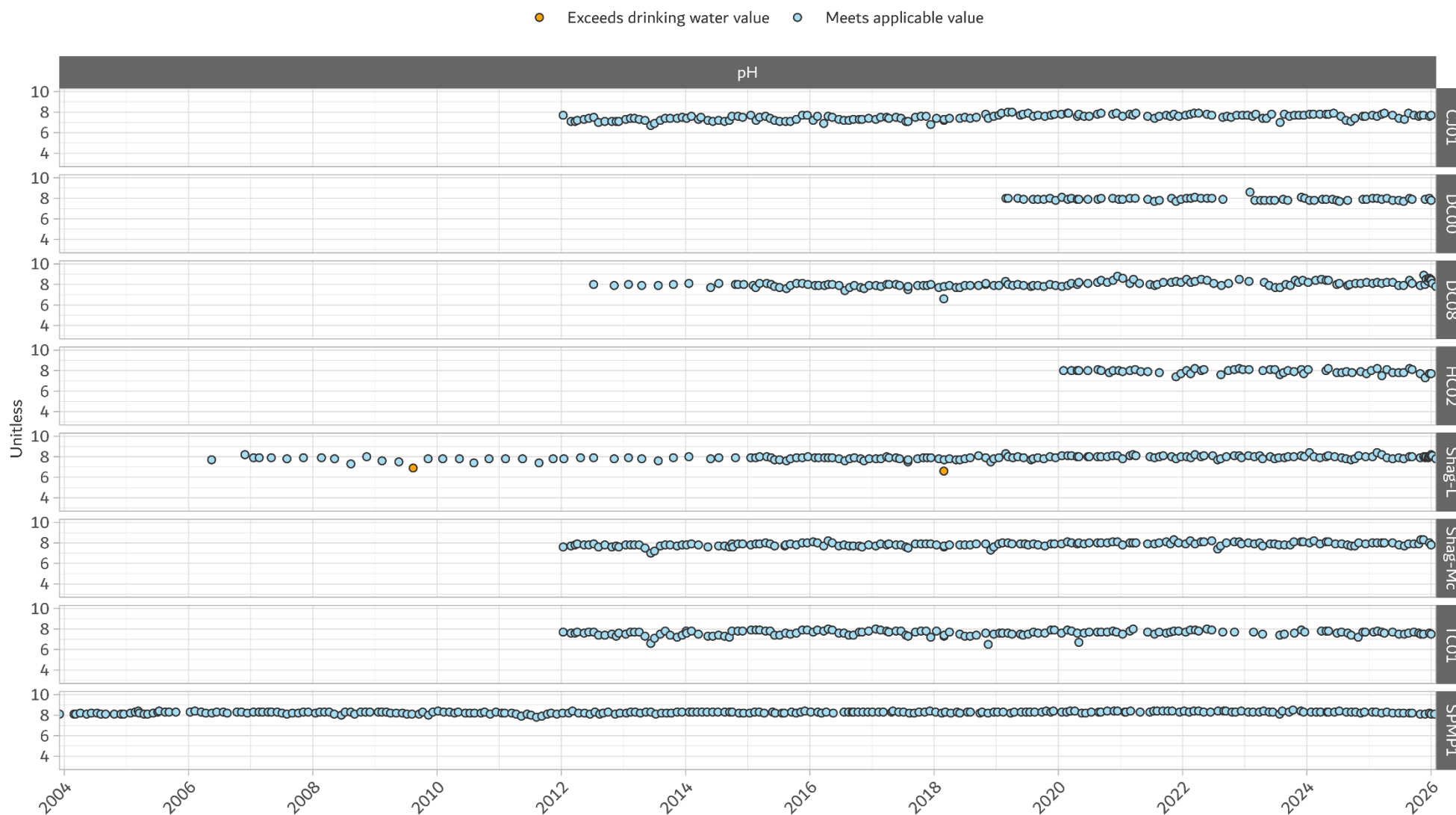


Figure B1. Historical pH measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed pH trigger range.

Note: scale excludes earlier measurements at SPMP1 between 2001 and 2004, all of which were within the proposed trigger range (refer Appendix D).

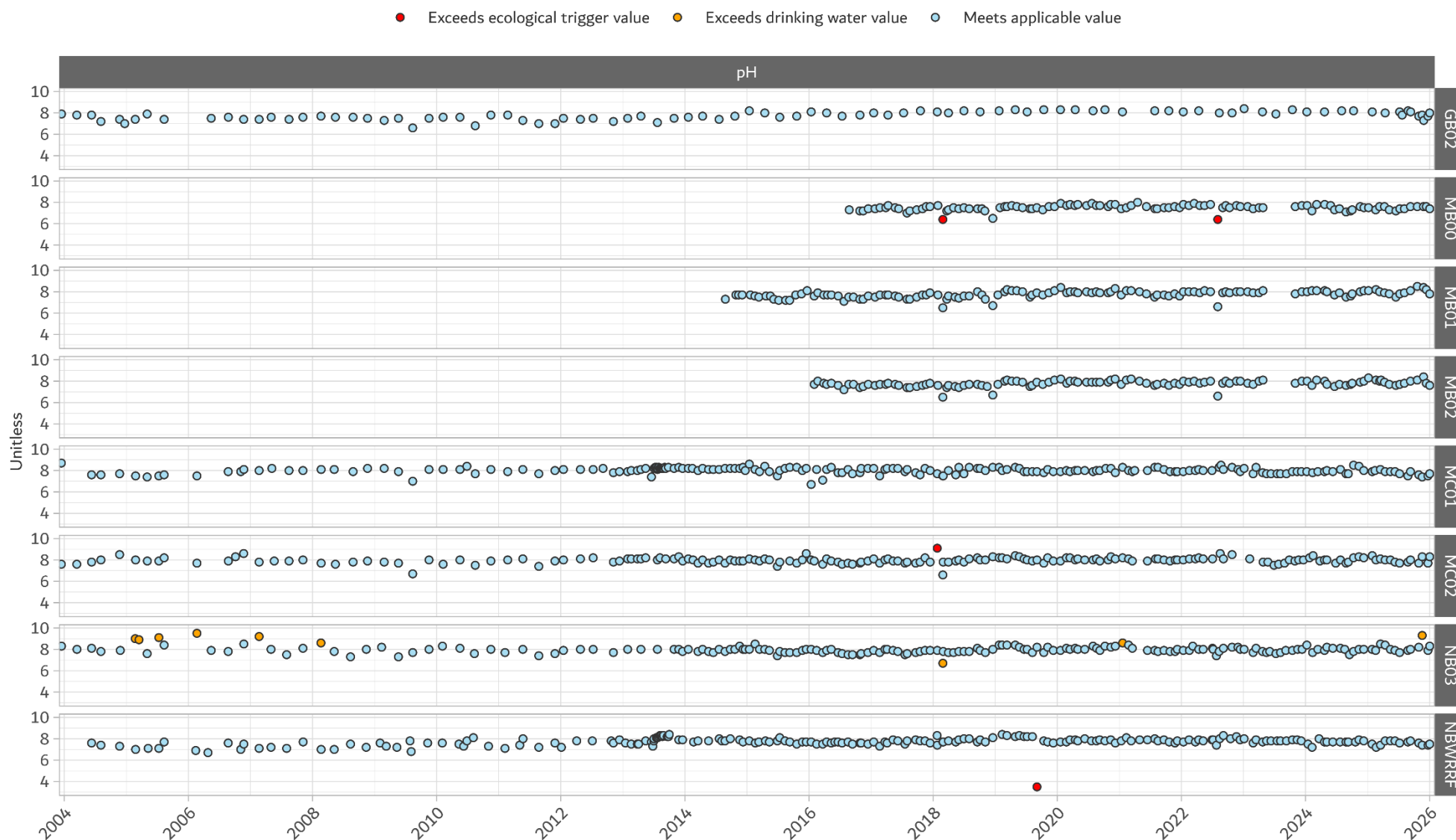


Figure B2. Historical pH measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed pH trigger range.

Turbidity

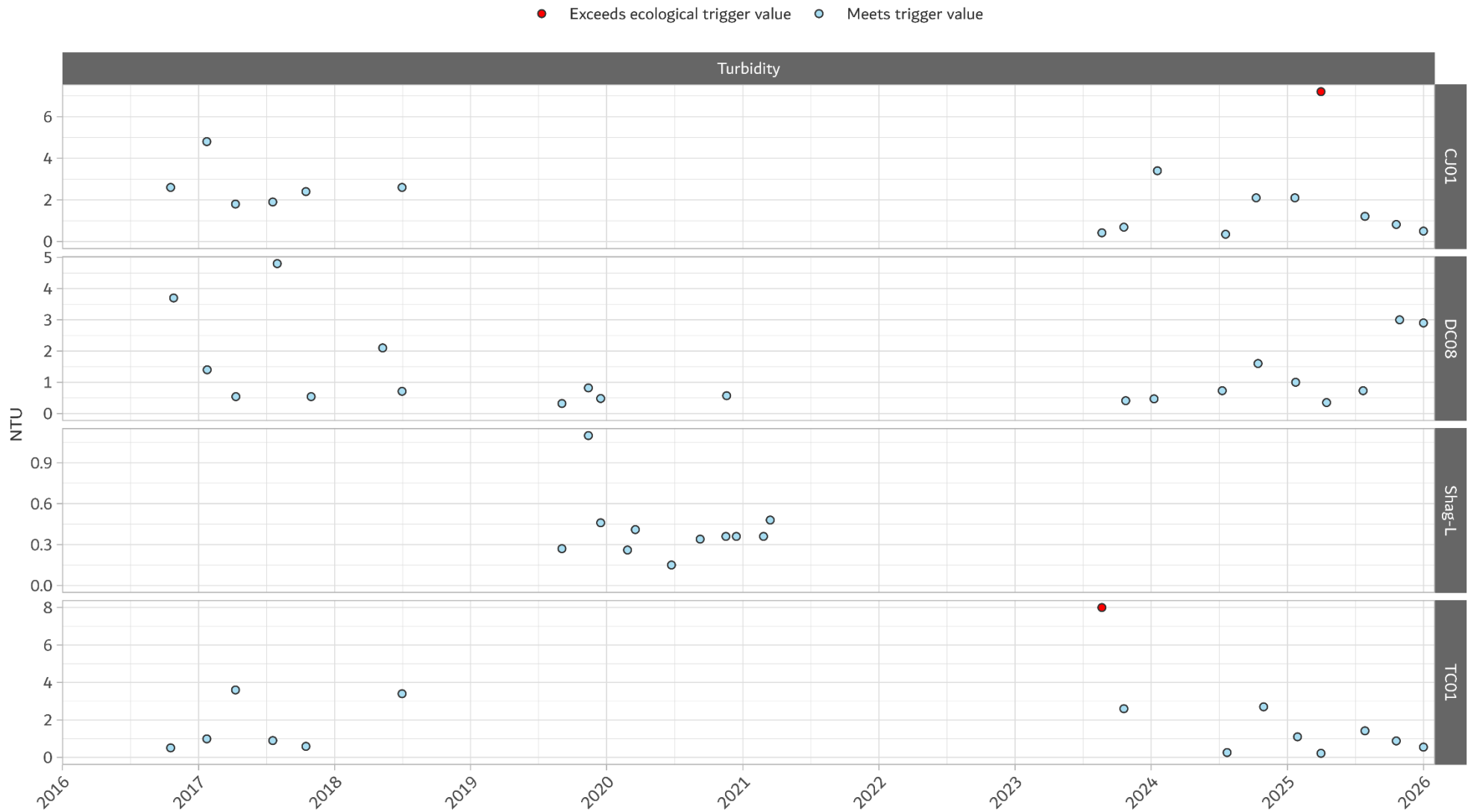


Figure B3. Historical turbidity measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed turbidity trigger.

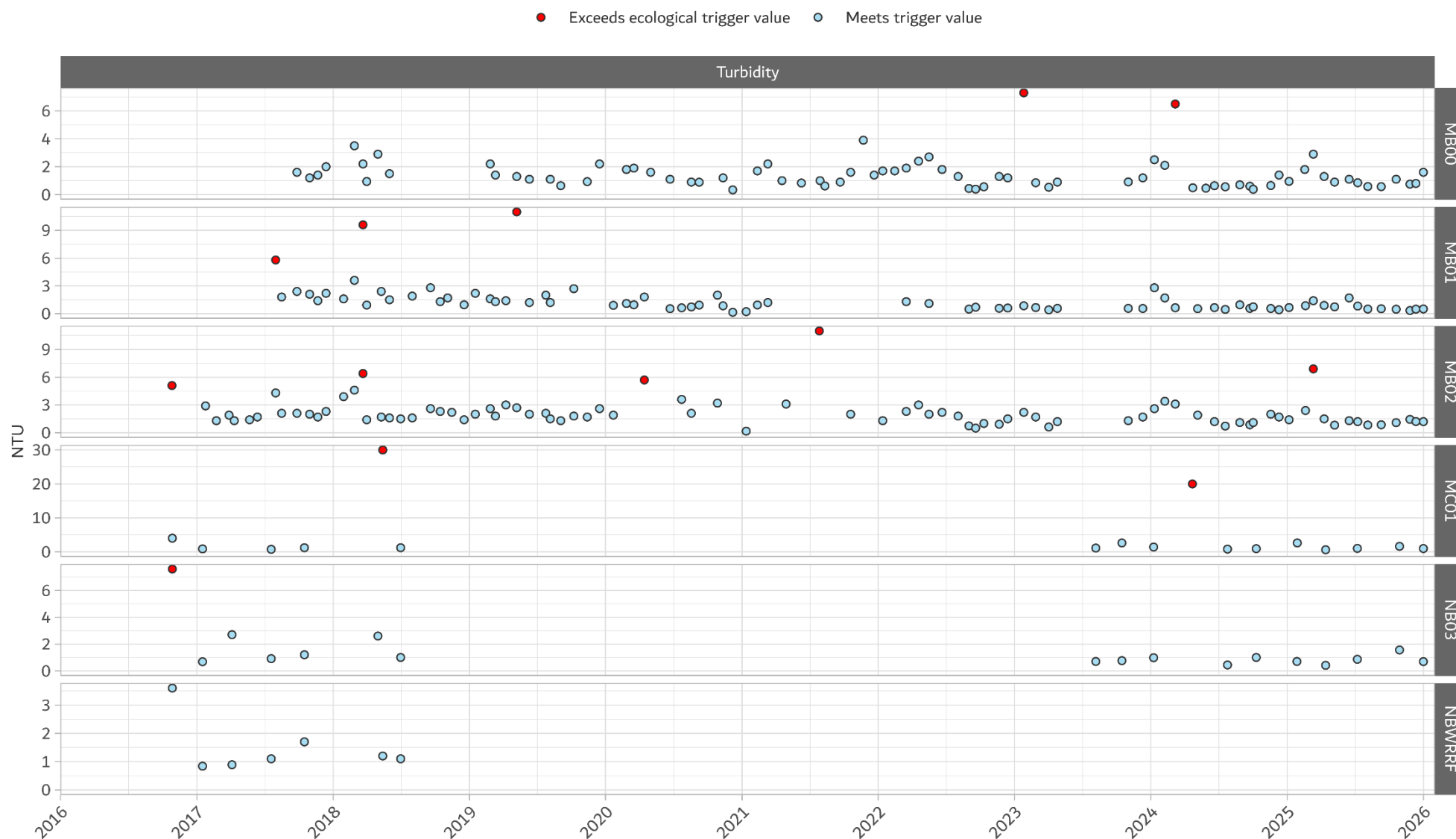


Figure B4. Historical turbidity measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed turbidity trigger. Note: scale excludes isolated exceedance of 40 NTU at NBWRRF on 26 April 2006.

Sulphate

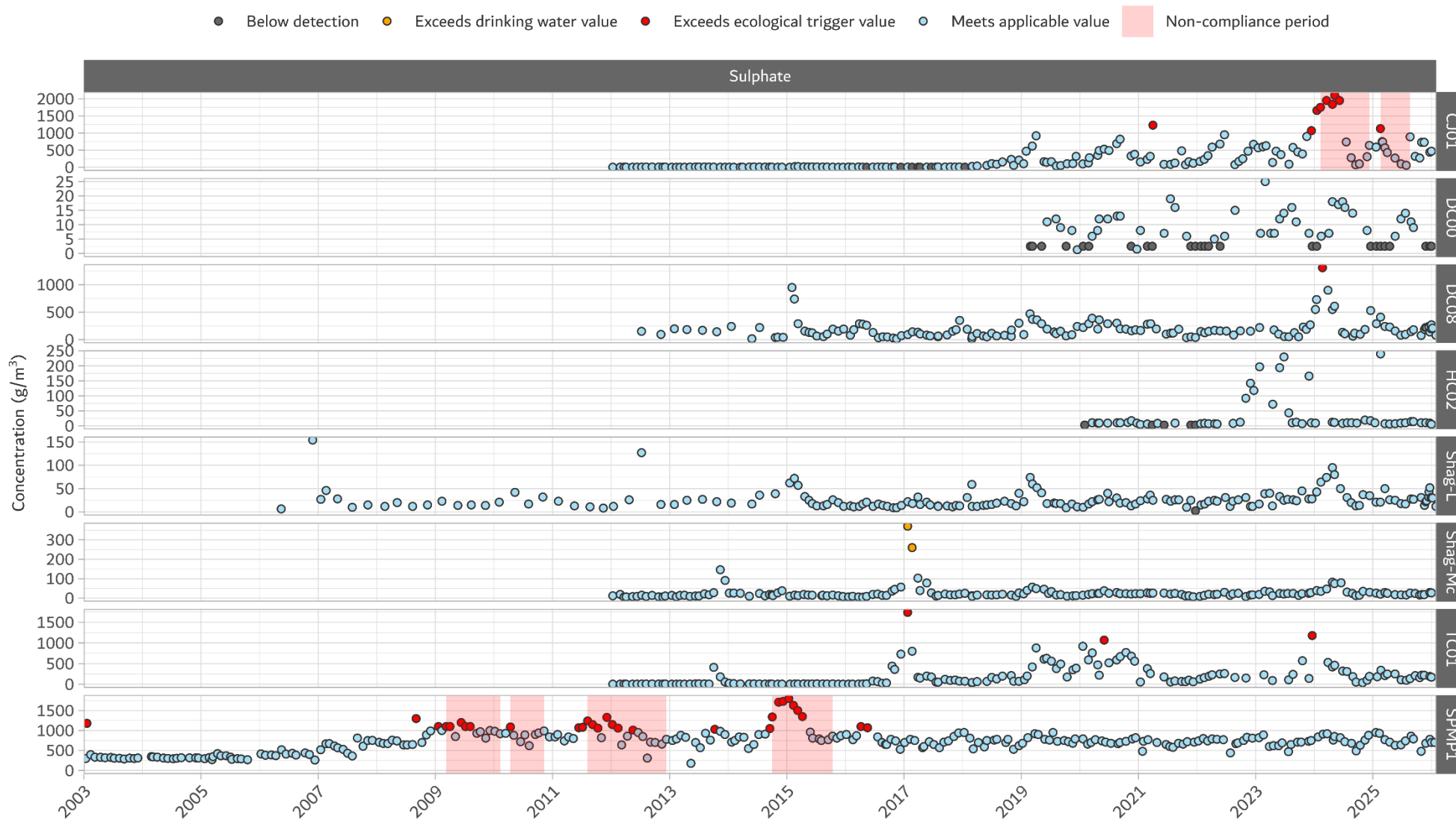


Figure B5. Historical sulphate measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed sulphate trigger.
Note: scale excludes earlier measurements at SPMP1 between 2001 and 2003, all of which were below the applicable trigger value (refer Appendix D).

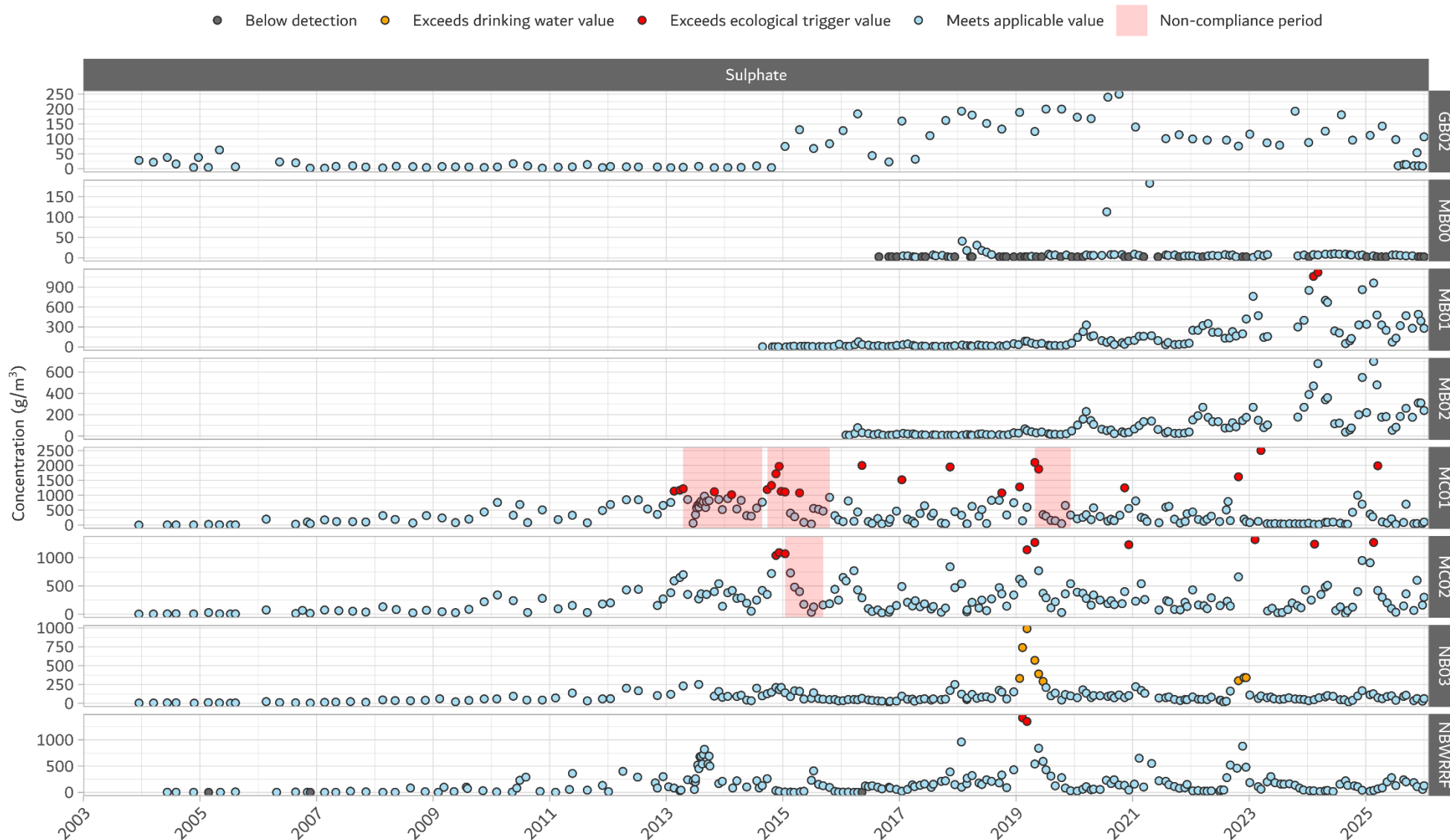


Figure B6. Historical sulphate measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed sulphate trigger.

Table B1. Non-compliance periods for sulphate, defined as >2 exceedances of the ecological trigger value, within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
CJ01	9/02/2024	10/12/2024	11	5
CJ01	17/02/2025	21/08/2025	9	1
MC01	17/04/2013	25/08/2014	27	3
MC01	25/09/2014	21/10/2015	15	7
MC01	29/04/2019	9/12/2019	9	2
MC02	15/01/2015	10/09/2015	8	1
SPMP1	9/03/2009	9/02/2010	12	5
SPMP1	14/04/2010	9/11/2010	8	1
SPMP1	8/08/2011	11/12/2012	17	7
SPMP1	2/10/2014	13/10/2015	13	7

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Ammoniacal nitrogen

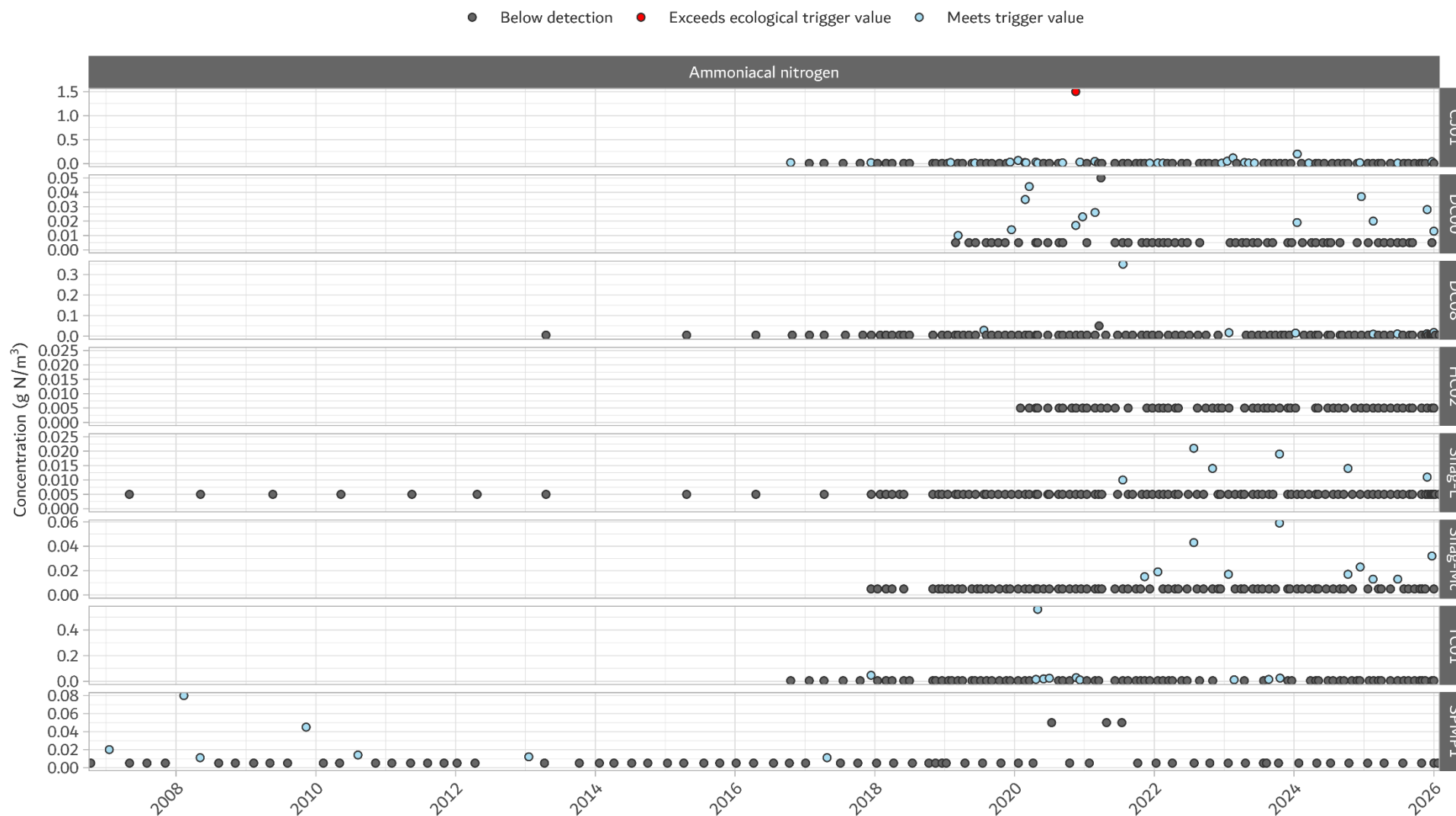


Figure B7. Historical ammoniacal nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger. Note: scale excludes earlier measurements at SPMP1 between 2001 and 2007, all of which were below the applicable trigger value (refer Appendix D).



Figure B8. Historical ammoniacal nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Nitrate nitrogen

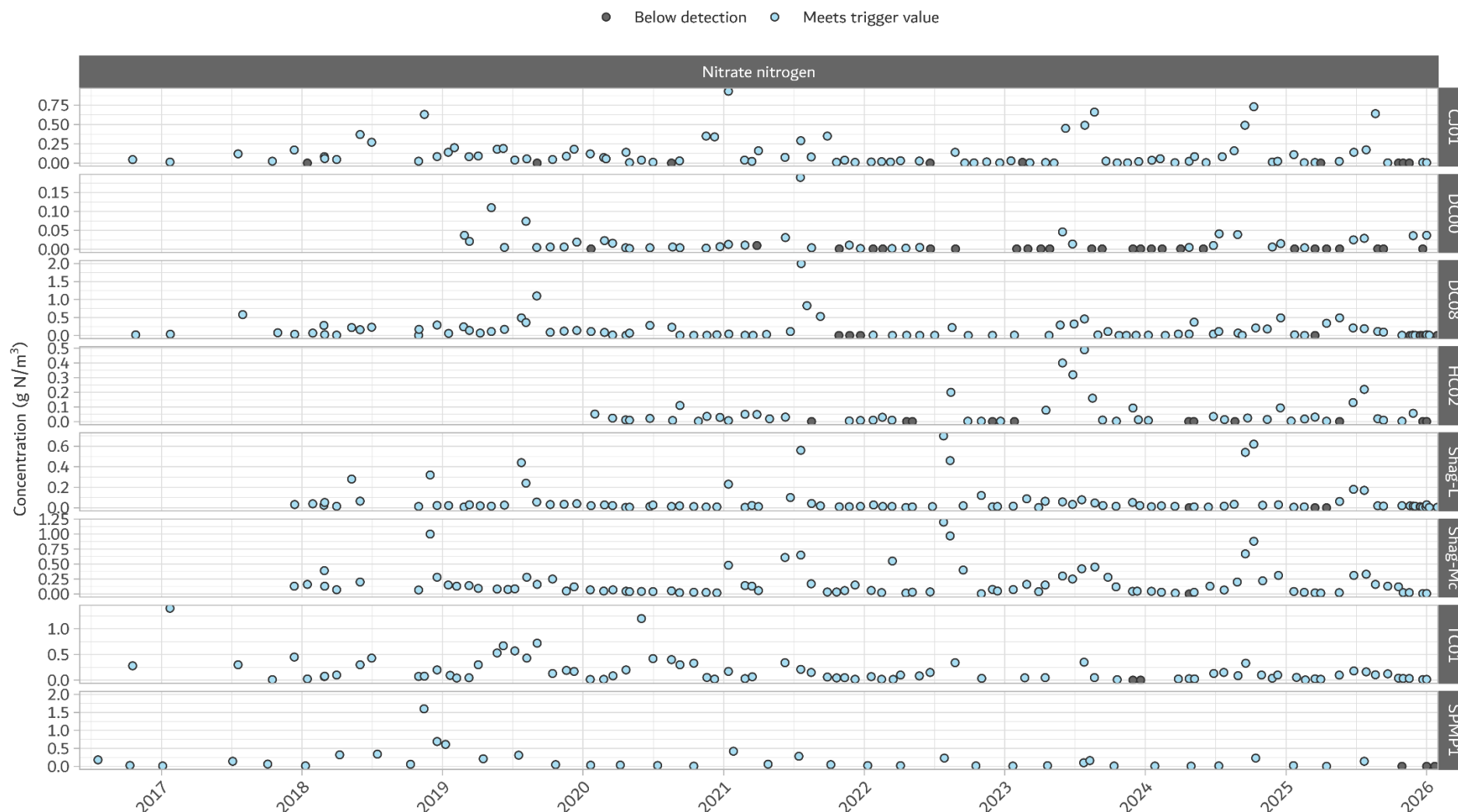


Figure B9. Historical nitrate nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: scale excludes earlier measurements at some sites between 2001 and 2016, which were below the proposed trigger, except for SPMP1 in January 2003 and TC01 in May 2020 (refer Appendix D).

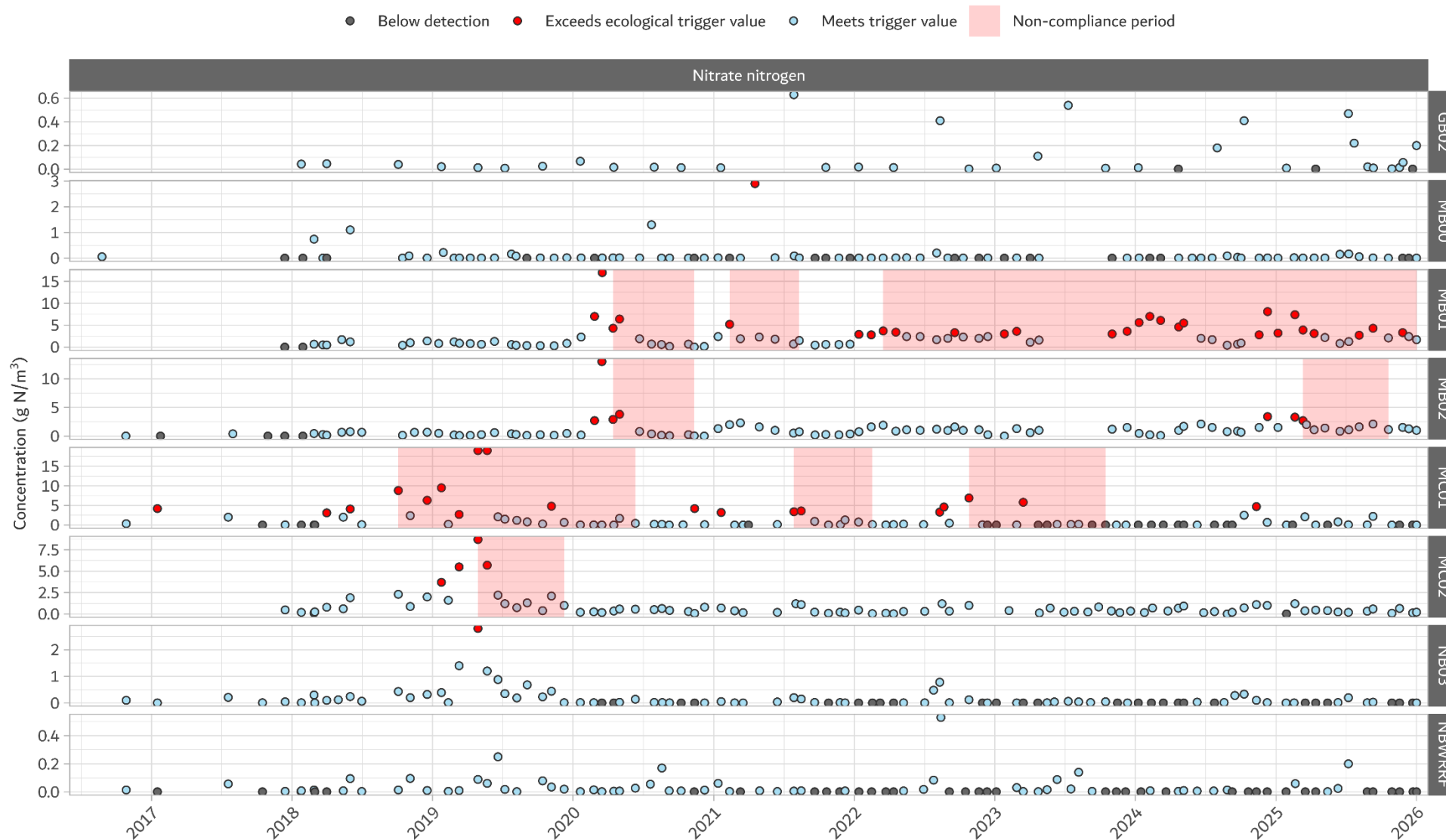


Figure B10. Historical nitrate nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger. Note: scale excludes sporadic measurements between 2003 and 2010 at a few sites, all of which were below with the proposed trigger, and single exceedance at NBWRRF in September 2019 (refer Appendix D).

Table B2. Non-compliance periods for nitrate nitrogen, defined as >2 exceedances of the ecological trigger value, within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
MB01	14/04/2020	11/11/2020	8	2
MB01	11/02/2021	11/08/2021	6	1
MB01	17/03/2022	1/01/2026	41	21
MB02	14/04/2020	11/11/2020	8	2
MB02	12/03/2025	20/10/2025	9	1
MC01	4/10/2018	11/06/2020	21	7
MC01	28/07/2021	17/02/2022	8	2
MC01	26/10/2022	16/10/2023	13	2
MC02	29/04/2019	9/12/2019	9	2

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Eutrophication (soluble inorganic nitrogen)

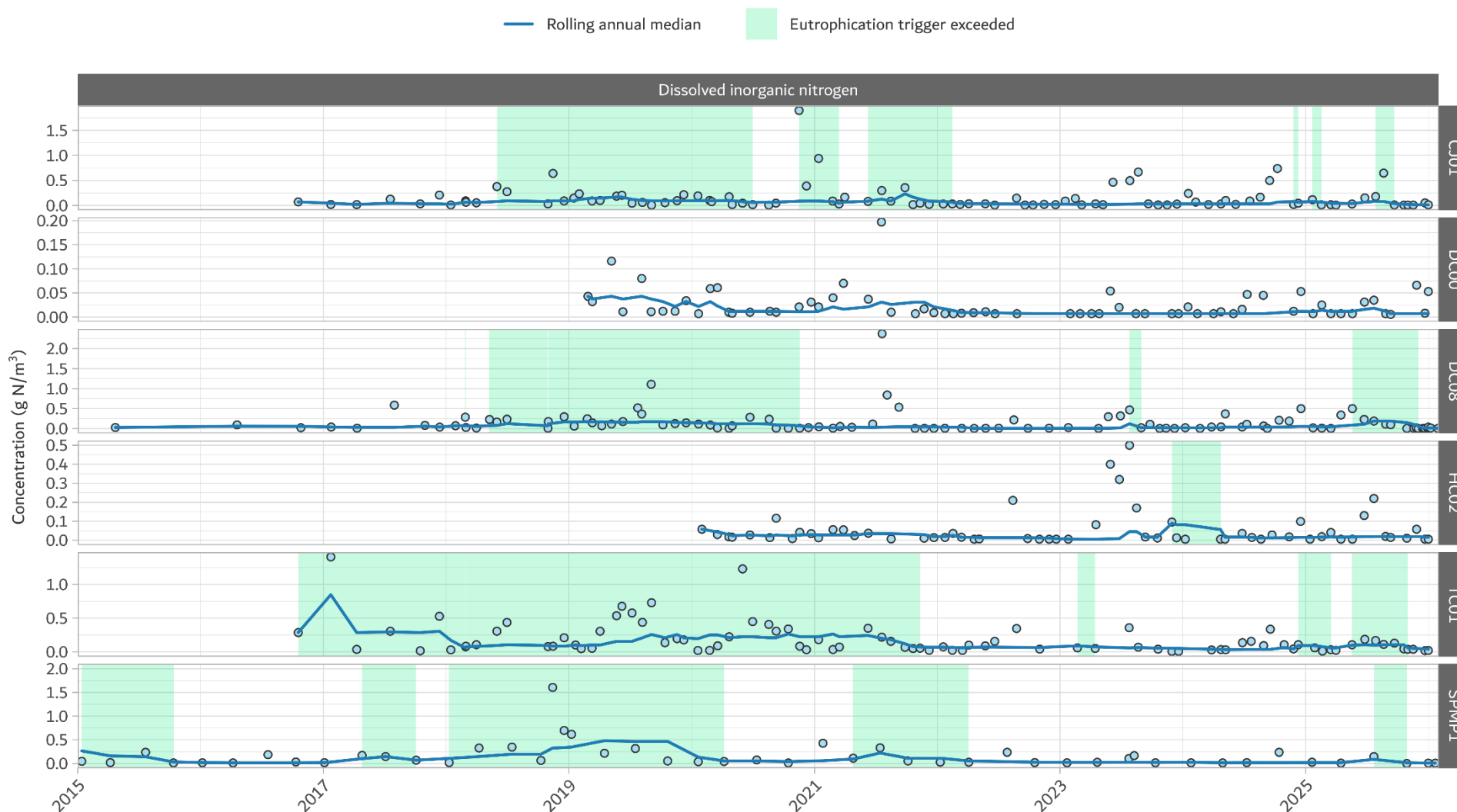


Figure B11. Historical soluble inorganic nitrogen measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger for SIN. Note: exceedances assessed against rolling annual median. Non-compliance criteria still to be determined. Scale excludes earlier (2007-2015) measurements at SPMP1 and a one-off elevated SIN measurement at TC01 in May 2020.

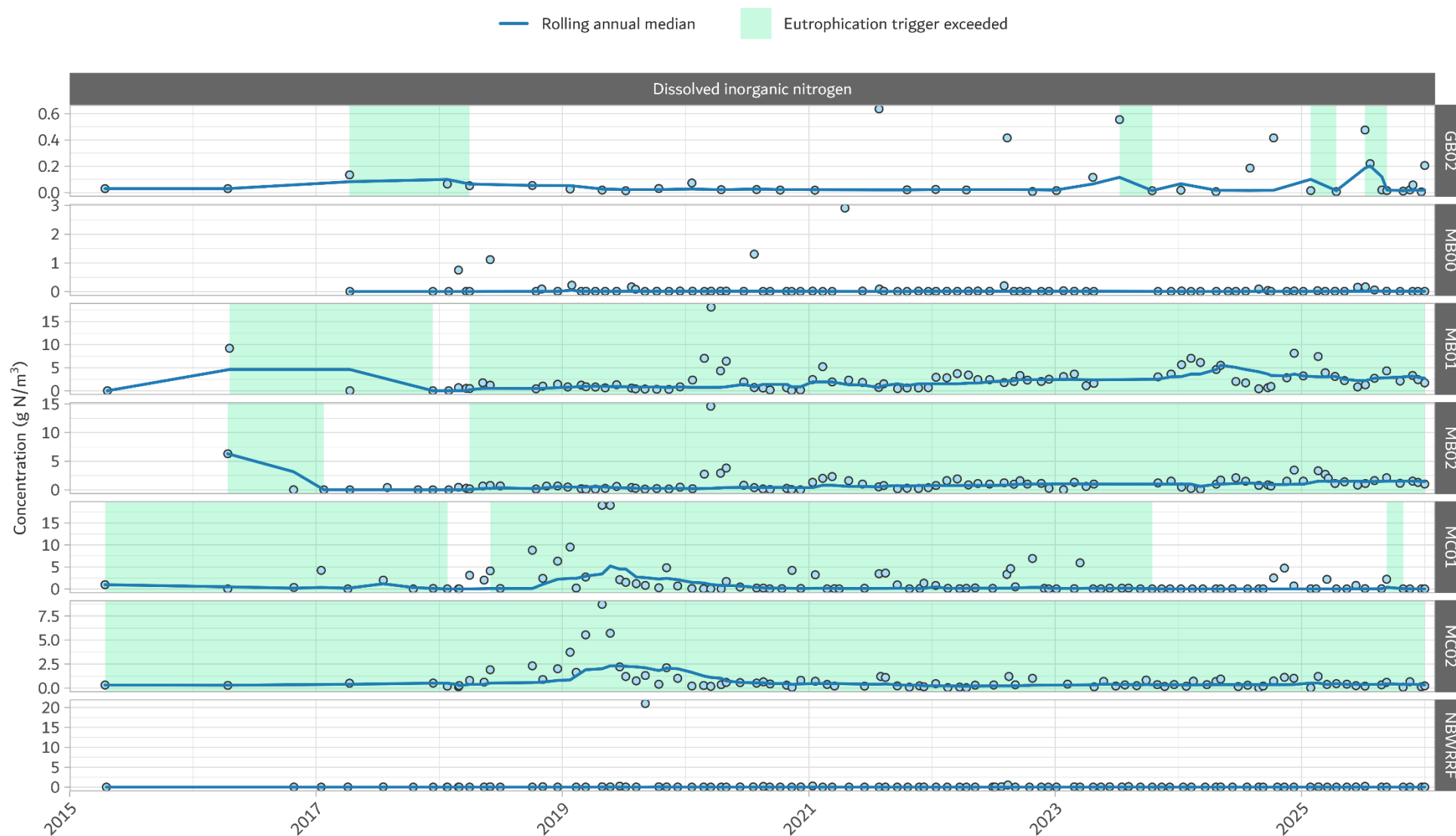


Figure B12. Historical soluble inorganic nitrogen measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger for SIN. Note: exceedances assessed against rolling annual median. Non-compliance criteria still to be determined. Scale excludes earlier measurements at few sites (GB02, MC01, MC02, NBWRRF).

Arsenic

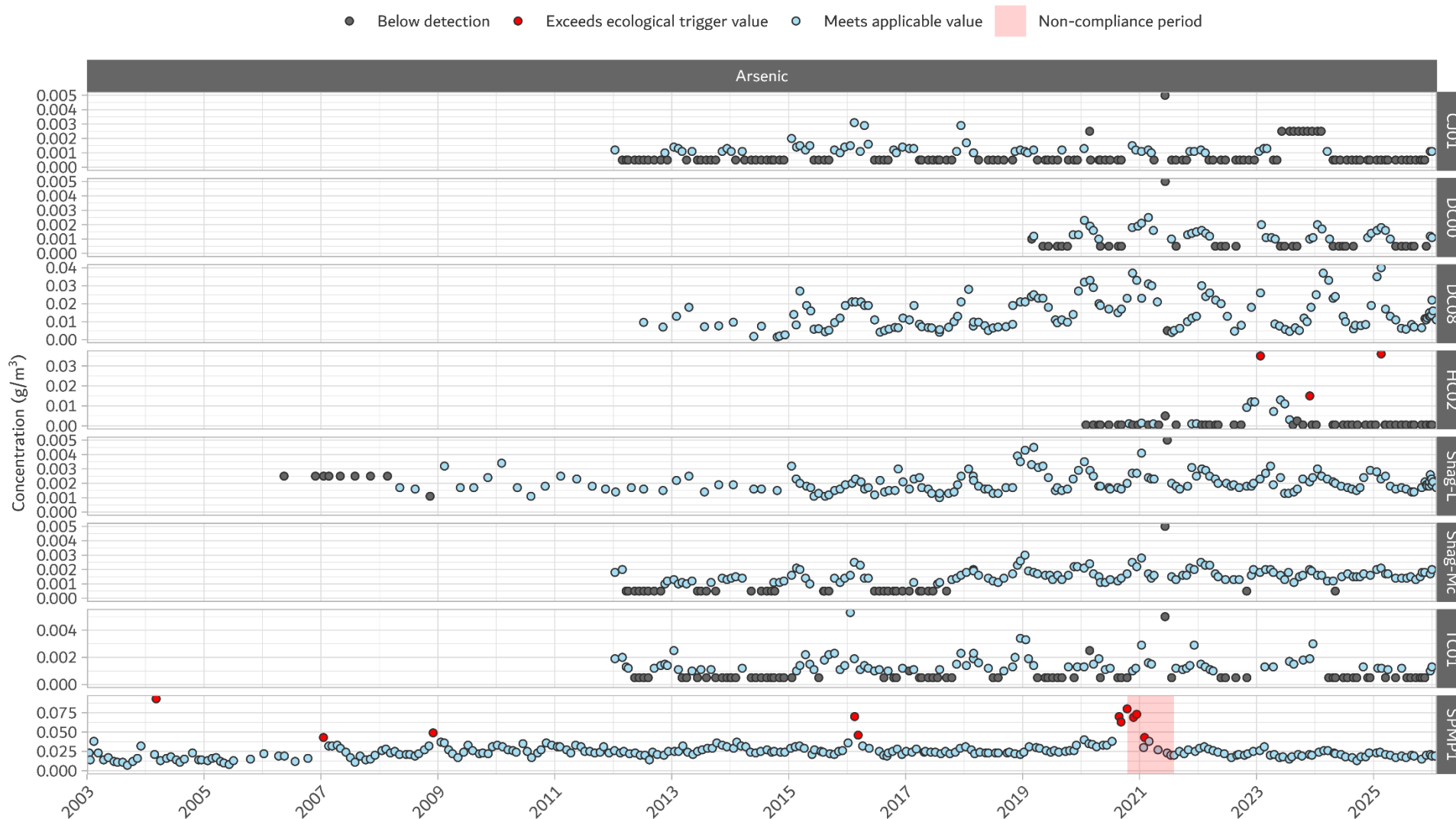


Figure B13. Historical dissolved arsenic measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: a less stringent trigger value applies at DC08 and SPMP1 due to elevated background concentrations of arsenic in the catchment, as a result of legacy mine influences. Scale excludes earlier measurements at SPMP1 that follow a similar compliance pattern (see Table B4 below) and likely erroneous elevation at Shag McCormicks in July 2020 (refer Appendix D).

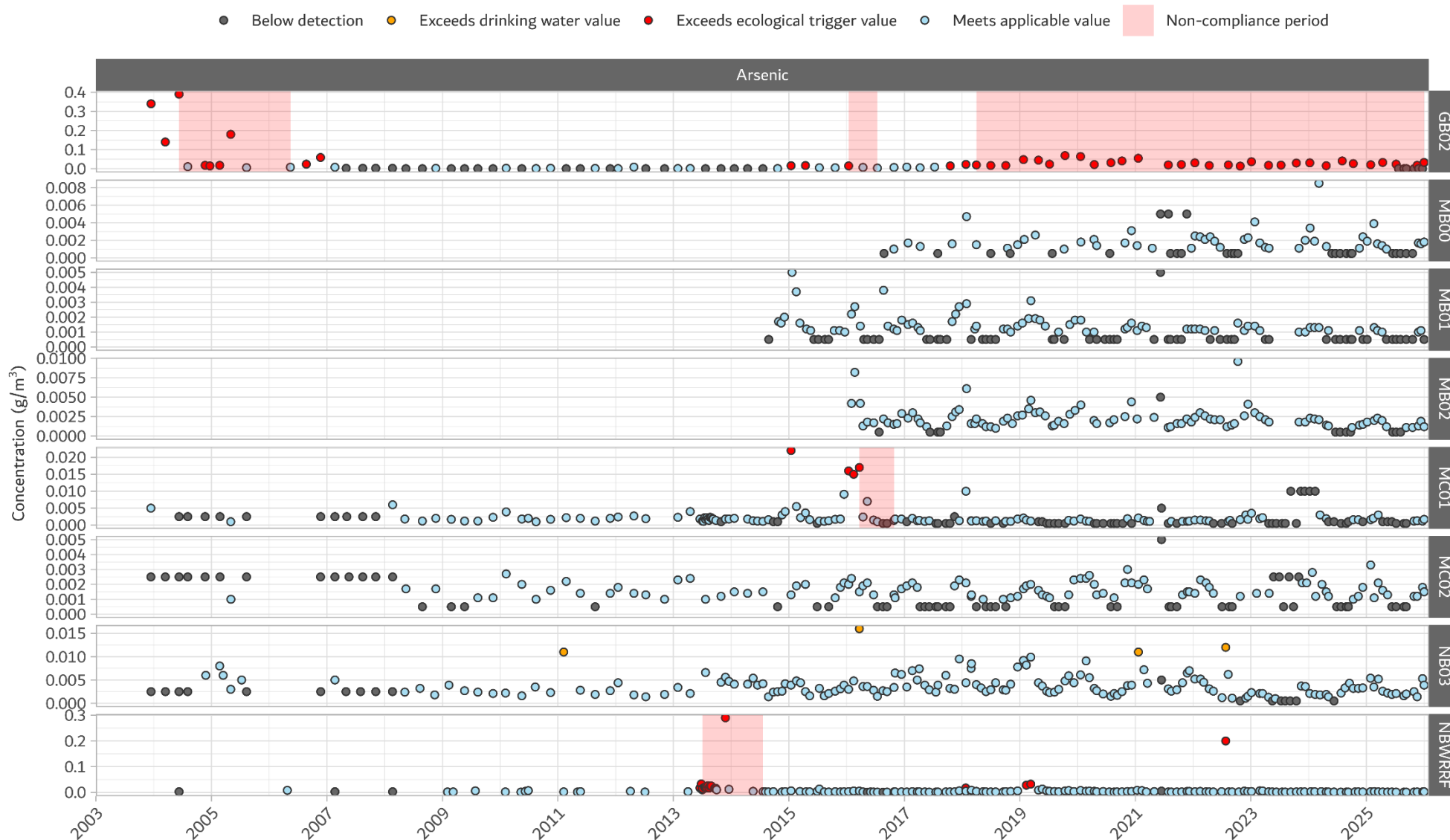


Figure B14. Historical dissolved arsenic measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Table B3. Non-compliance periods for arsenic, defined as >2 exceedances of the ecological trigger value within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
GB02	10/06/2004	15/05/2006	8	5
GB02	14/01/2016	14/07/2016	3	1
GB02	1/04/2018	1/01/2026	37	31
MC01	22/03/2016	27/10/2016	8	1
NBWRRF	3/07/2013	22/07/2014	15	11
SPMP1	15/10/2020	4/08/2021	10	4

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Copper

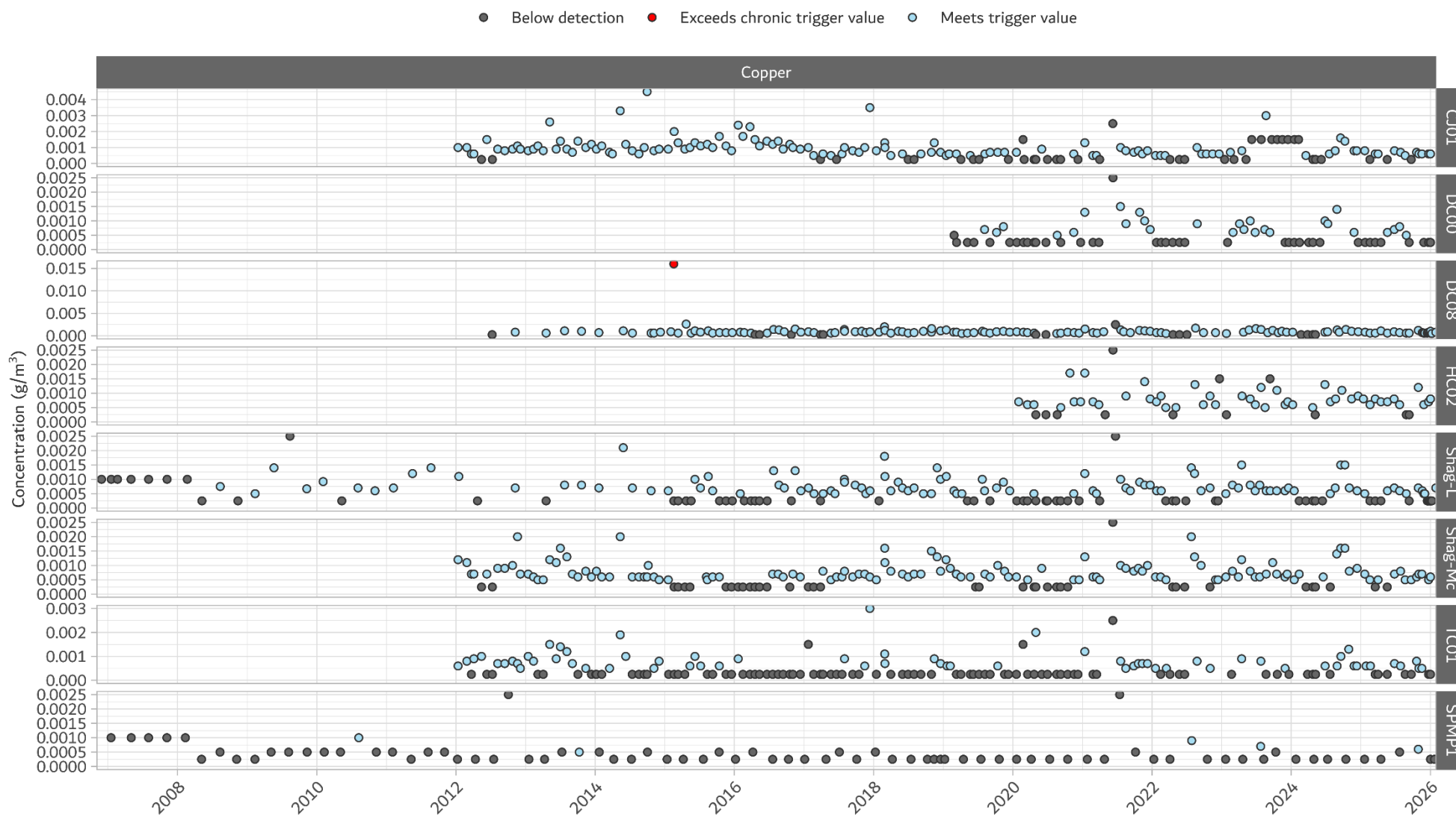


Figure B15. Historical dissolved copper measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed chronic and acute trigger values. Scale excludes earlier measurements at SPMP1 that resulted in non-compliance (see Table B5 below).



Figure B16. Historical dissolved copper measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed chronic and acute triggers. Note: scale excludes isolated below detect measurements in 2003 and 2004 at sites GB02, MC01, MC02, and NB03.

Table B4. Non-compliance periods for copper, defined as a single acute trigger exceedance, or >2 chronic trigger exceedances within any rolling 12-month period.

Site	Non-compliance window		Type	Number of measurements	Number of exceedances*
	Start	End			
SPMP1	15/01/2002	21/01/2003	Chronic	8	1
GB02	26/02/2009	8/02/2010	Acute	2	1

Notes: *The number of exceedances recorded during the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Iron

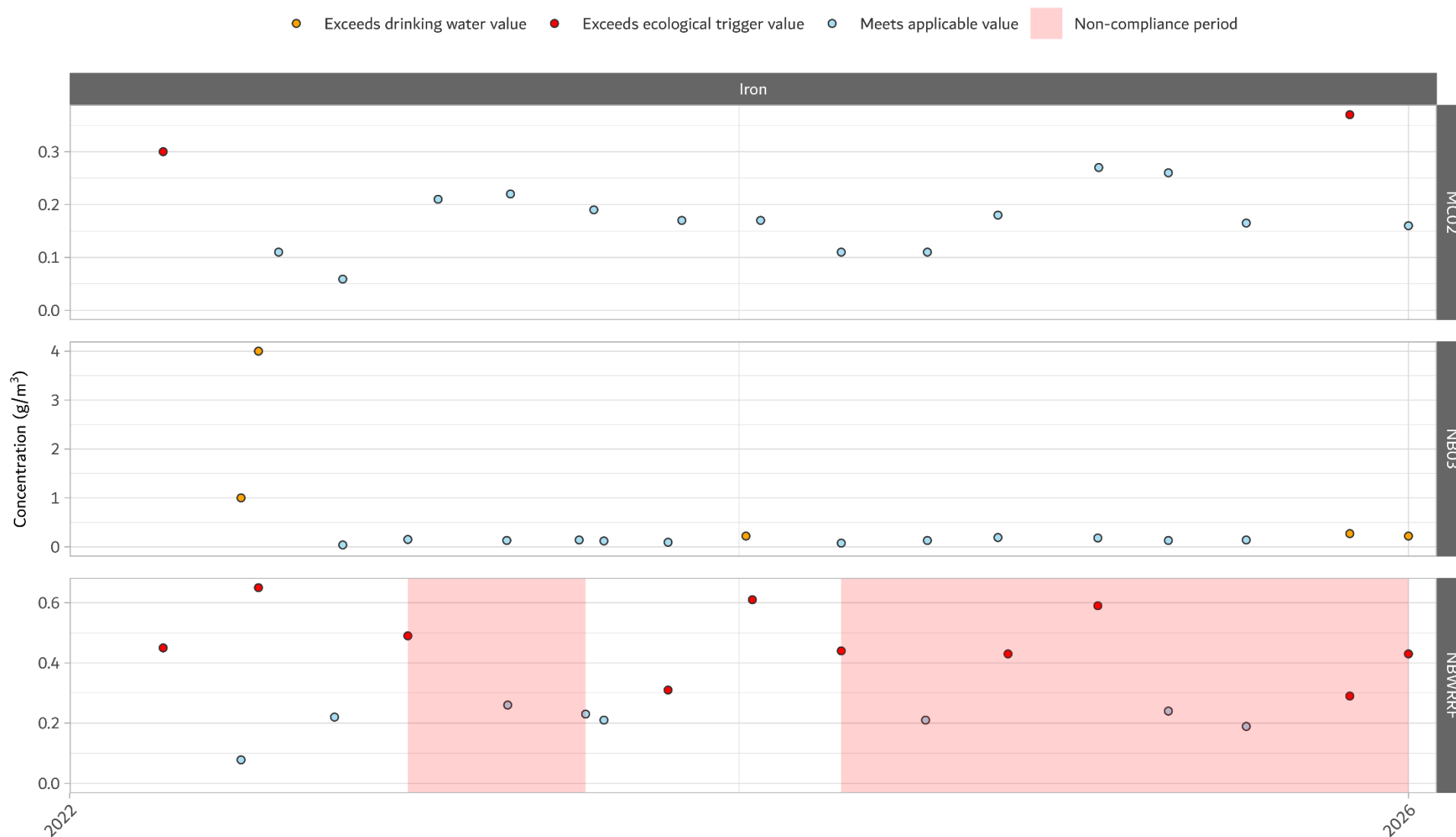


Figure B17. Historical total iron measurements at compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Table B5. Non-compliance periods for total iron, defined as >2 exceedances of the ecological trigger value within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
NBWRRF	26/07/2022	18/07/2023	5	2
	16/10/2023	1/01/2026	10	7

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

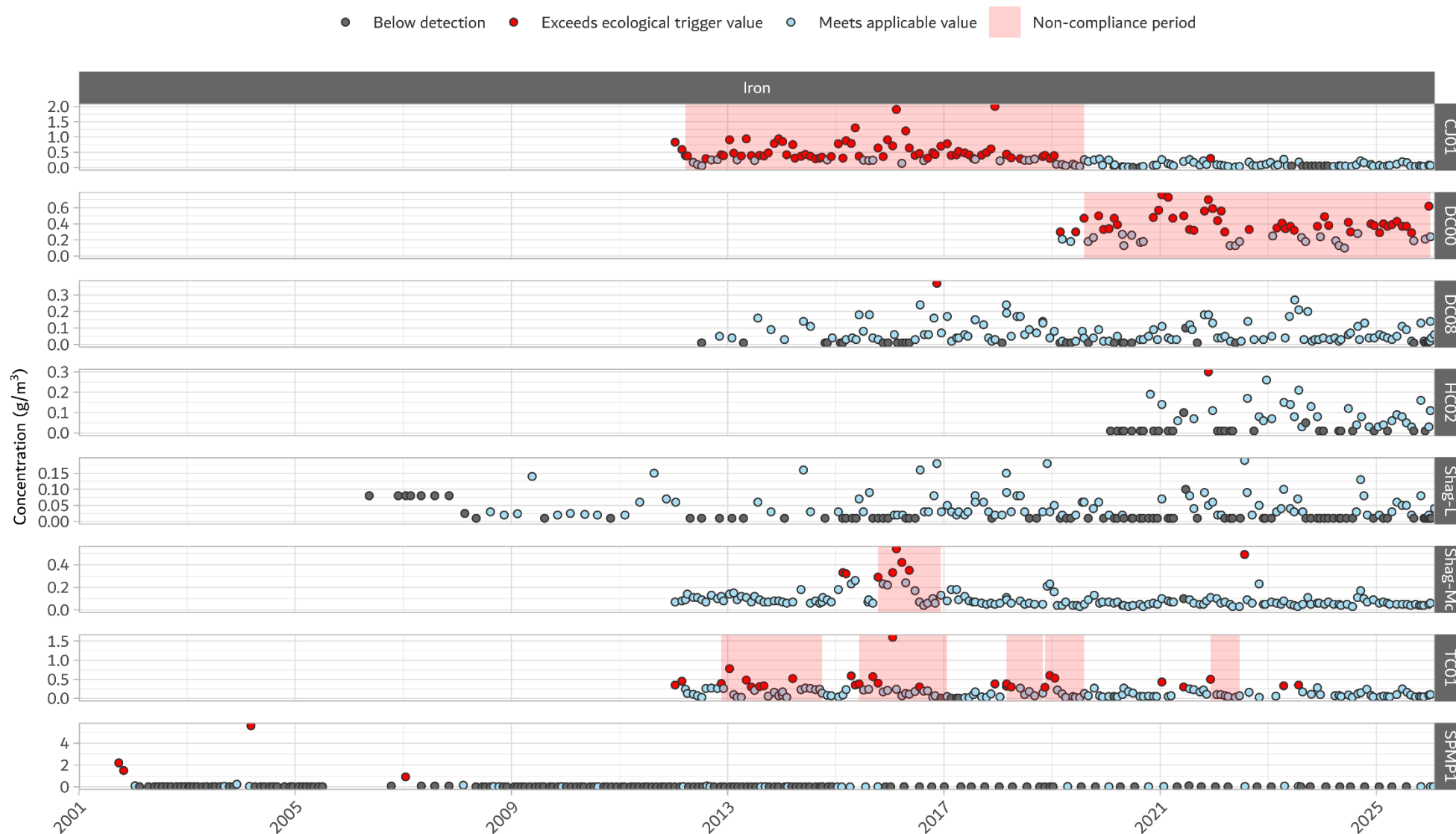


Figure B18. Historical dissolved iron measurements (as a proxy for total iron) at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

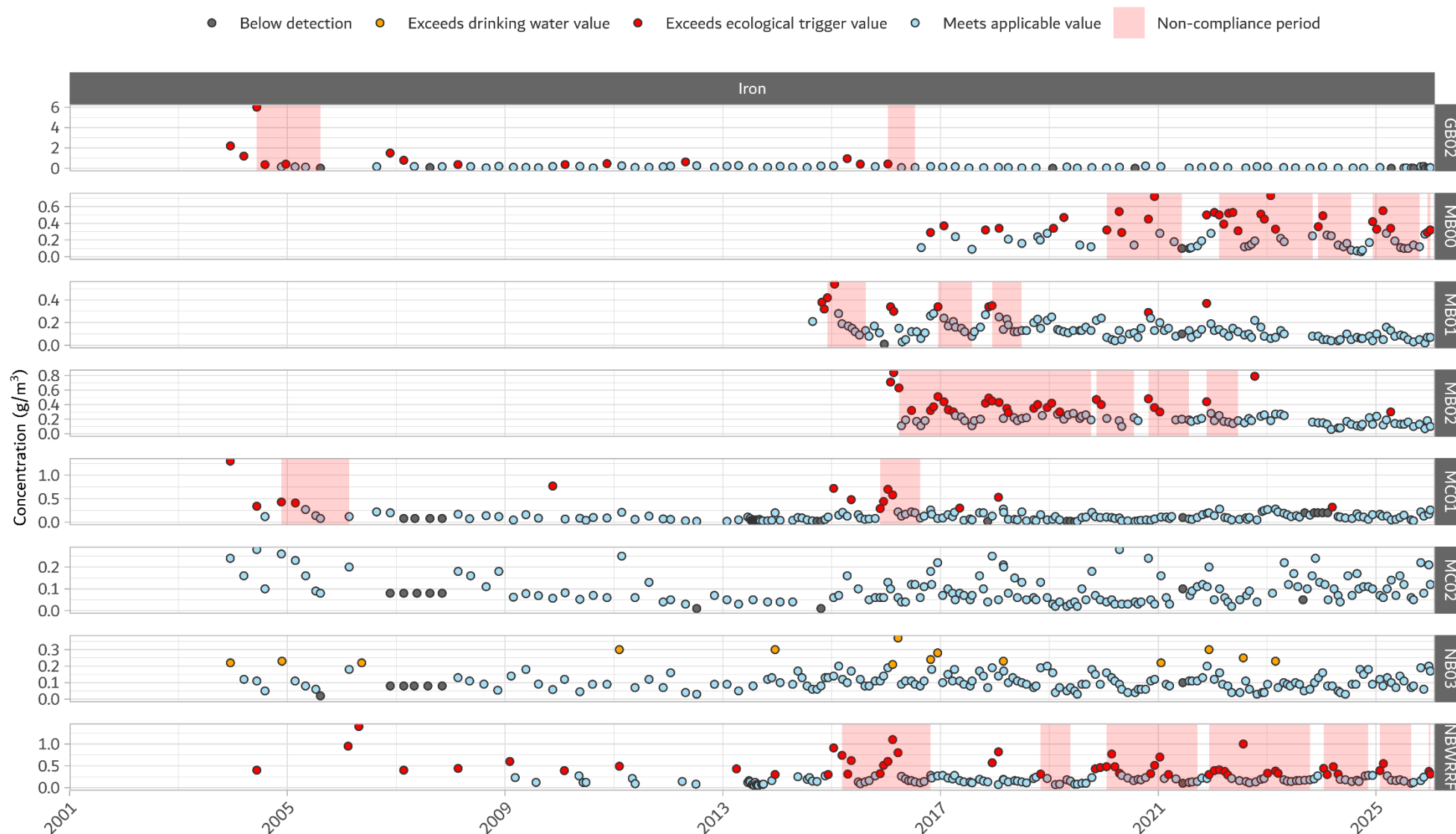


Figure B19. Historical dissolved iron measurements (as a proxy for total iron) at key compliance sites within the Waikouaiti and Taieri River catchment, assessed against the proposed trigger.

Lead

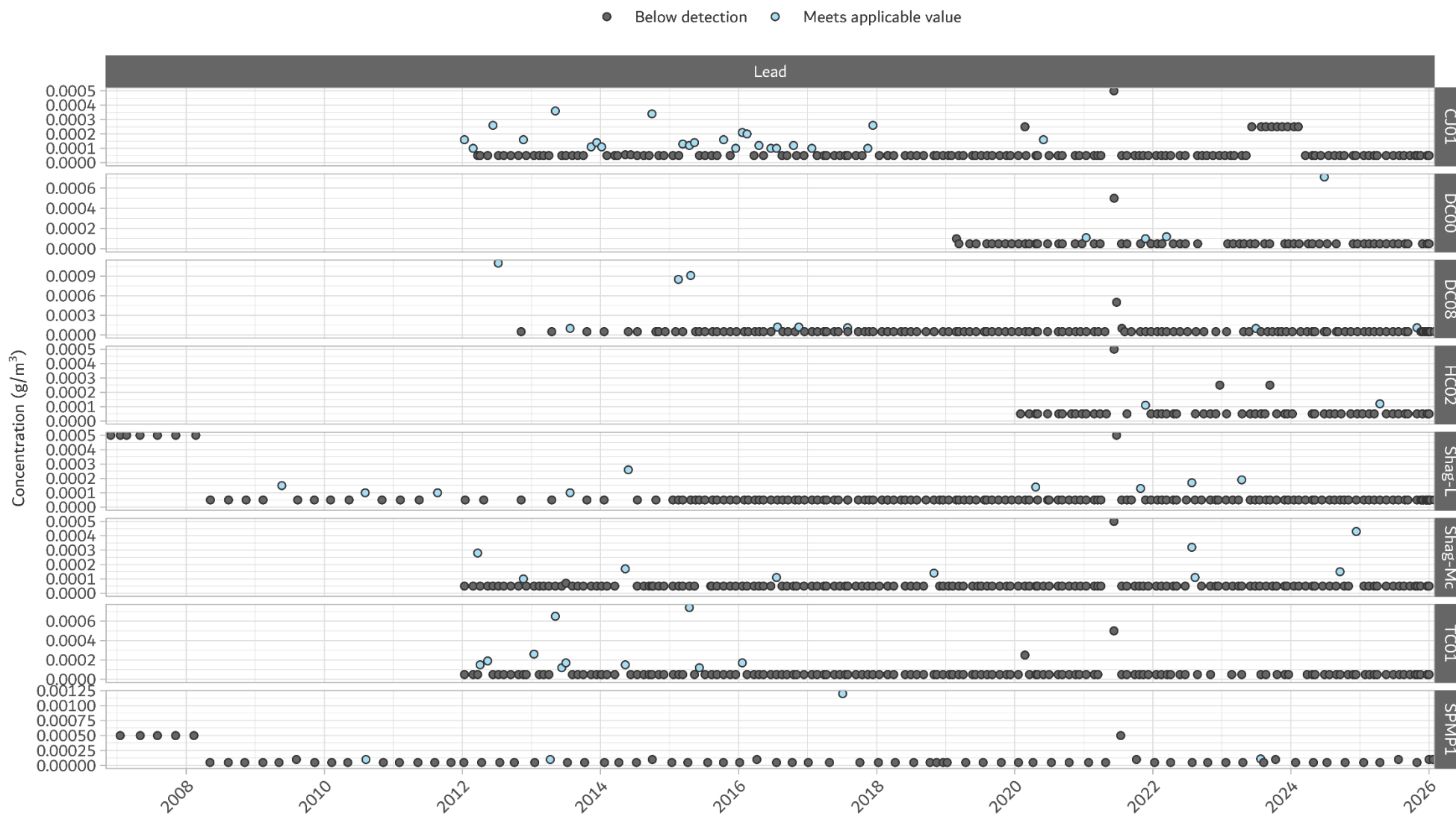


Figure B20. Historical dissolved lead measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger.

Note: scale excludes earlier measurements at SPMP1, all of which were below the proposed trigger (refer Appendix D).

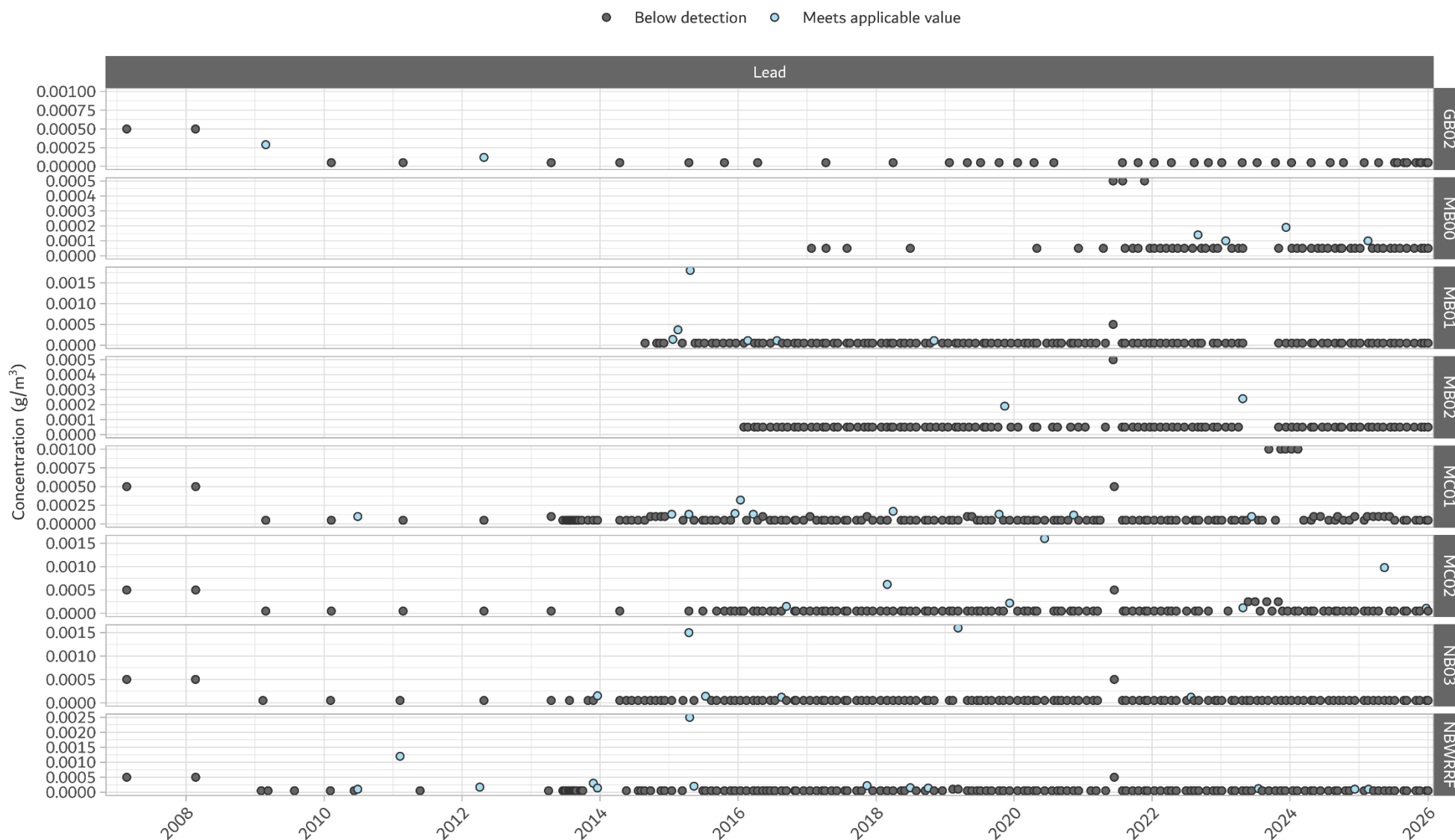


Figure B21. Historical dissolved lead measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger.

Zinc

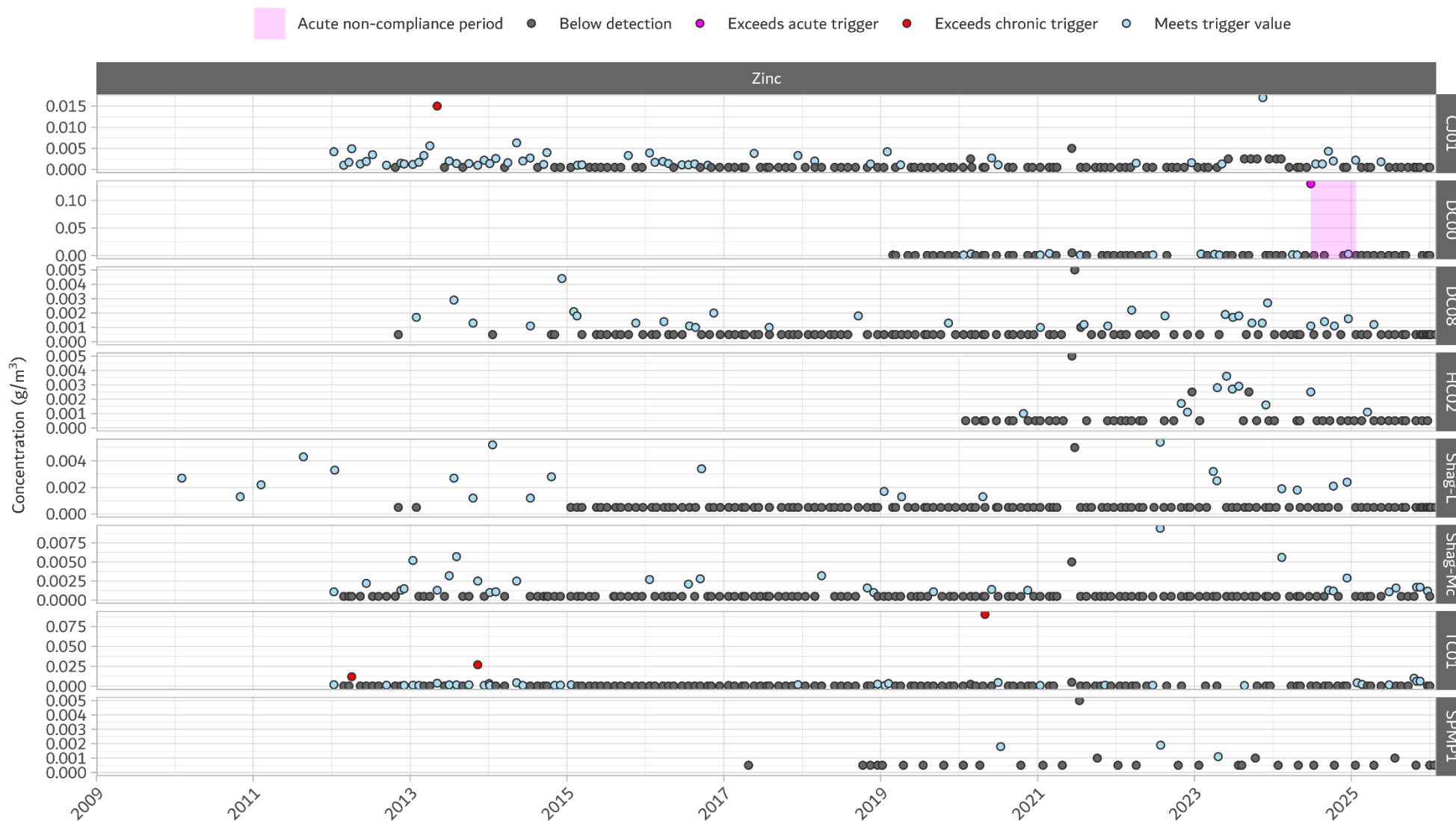


Figure B22. Historical dissolved zinc measurements at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed triggers.



Figure B23. Historical dissolved zinc measurements at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed triggers.

Table B6. Non-compliance periods for zinc, defined as a single acute trigger exceedance, or >2 chronic trigger exceedances within any rolling two-year period.

Site	Non-compliance window		Type	Number of measurements	Number of exceedances*
	Start	End			
DC00	26/06/2024	23/01/2025	Acute	6	1
MB01	23/09/2024	1/01/2026	Chronic	17	5

Notes: *For chronic exceedances, this is the number of exceedances recorded during the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Cyanide

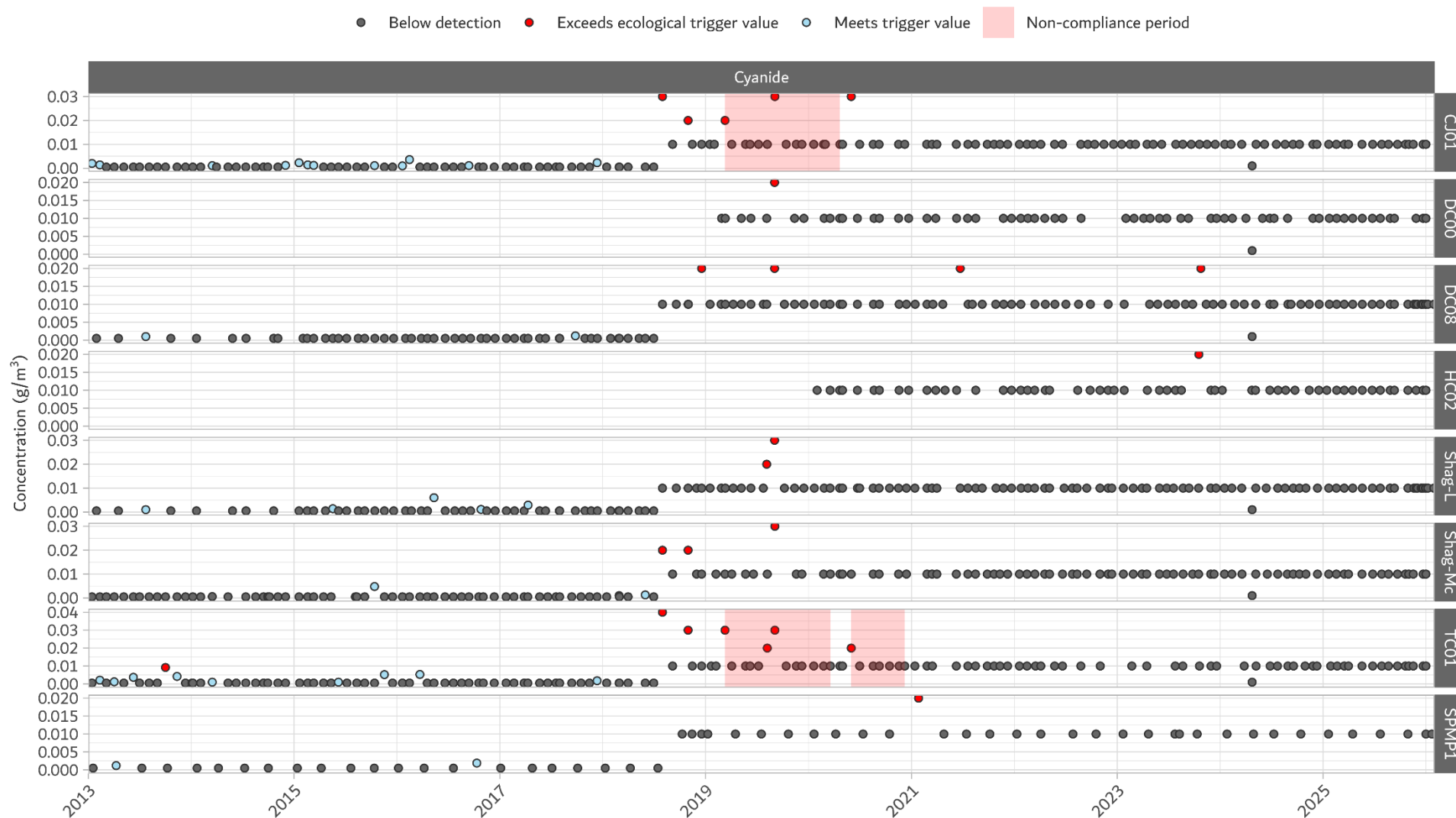


Figure B24. Historical WAD cyanide measurements (as a proxy for free cyanide, adjusted for HCN proportions) at key compliance sites within the Shag/Waihemo River catchment, assessed against the proposed trigger. Note: scale excludes earlier measurements at few sites between 2001 and 20013, all of which were below the applicable trigger value (refer Appendix D).

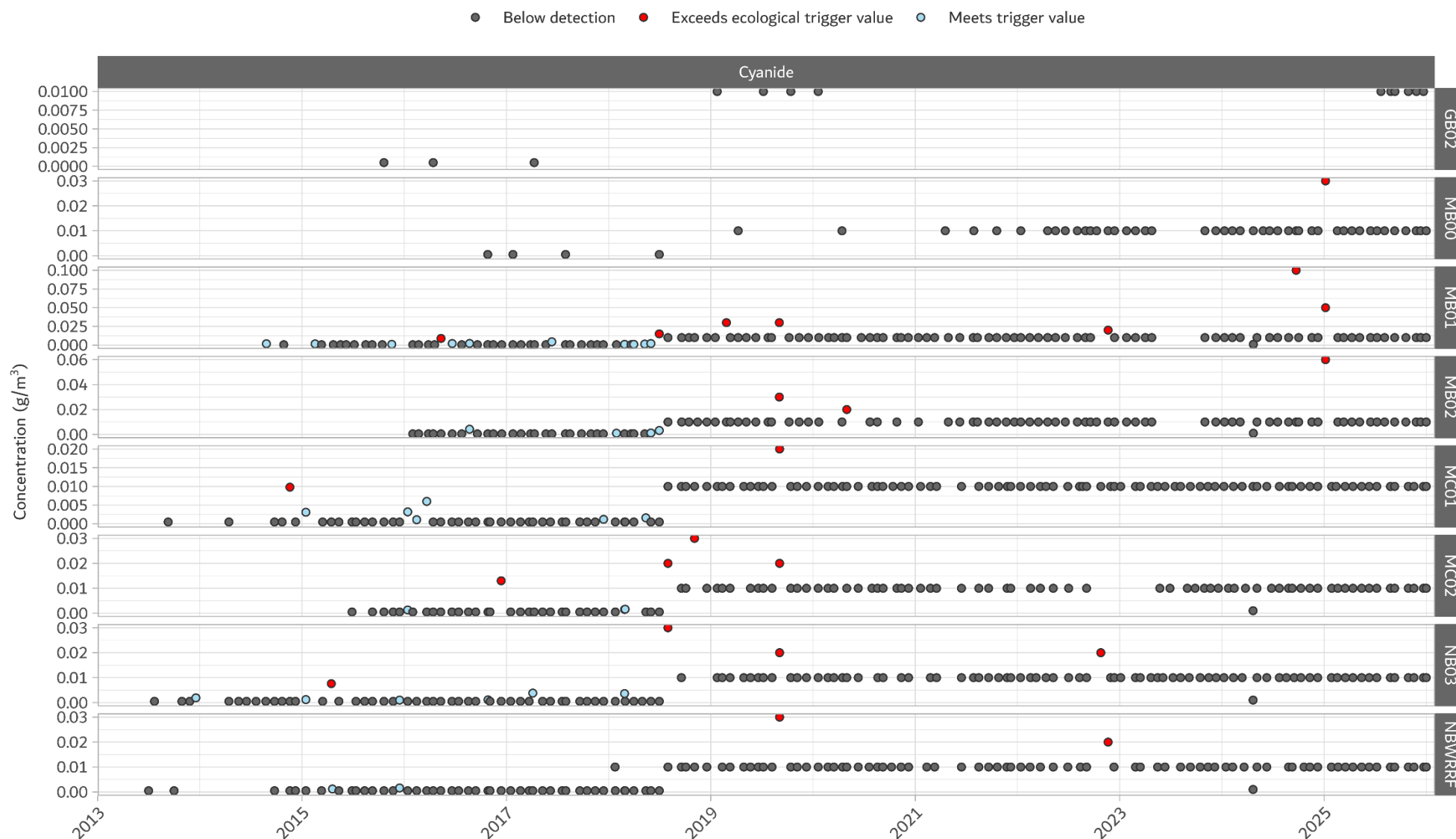


Figure B25. Historical WAD cyanide measurements (as a proxy for free cyanide, adjusted for HCN proportions) at key compliance sites within the Waikouaiti and Taieri River catchments, assessed against the proposed trigger. Note: scale excludes isolated below detect measurement at NBWRRF on 10 June 2004.

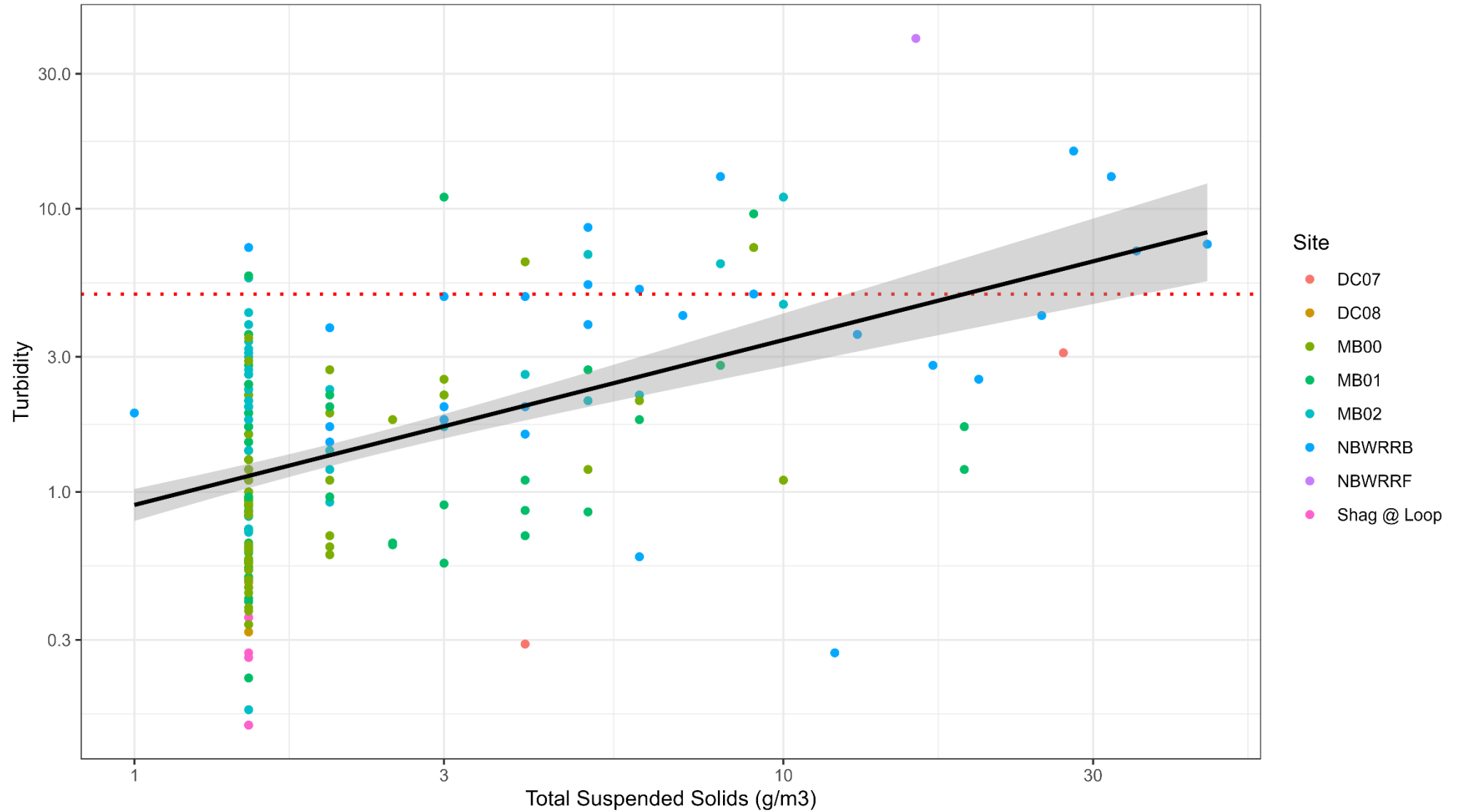
Table B7. Non-compliance periods for cyanide, defined as >2 exceedances within any rolling 12-month period.

Site	Non-compliance window		Number of measurements	Number of exceedances*
	Start	End		
CJ01	11/03/2019	22/04/2020	14	2
TC01	11/03/2019	19/03/2020	13	3
TC01	1/06/2020	8/12/2020	7	1

Notes: *During the non-compliance window; inclusive of the first measurement that triggers non-compliance.

Appendix C

Supporting Data Analyses



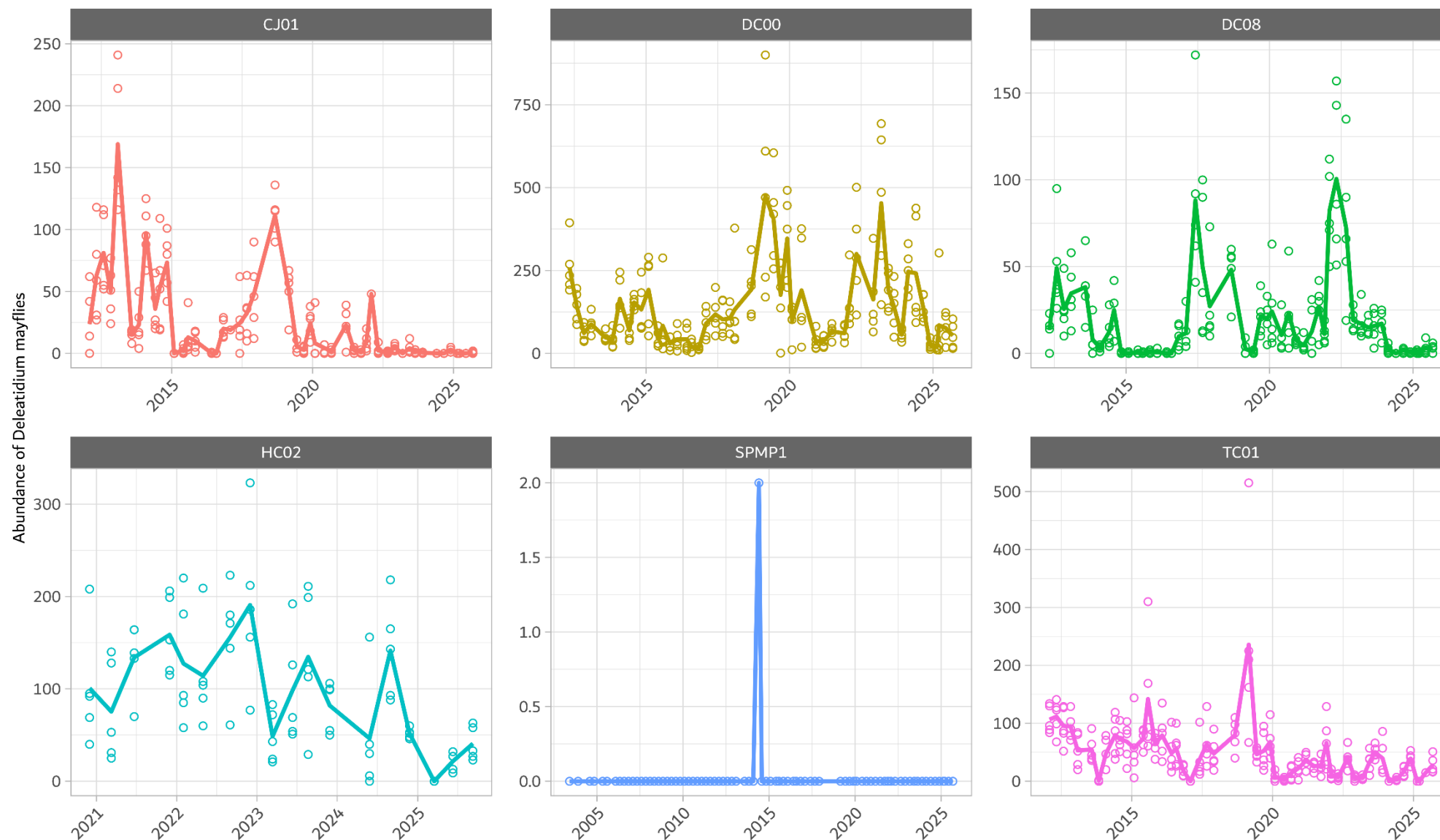


Figure C2. Abundance of *Deleatidium* mayflies in replicate samples collected at key compliance sites within the Shag/Waihemo River catchment, presented over time. Mean abundance is presented as a trend line.

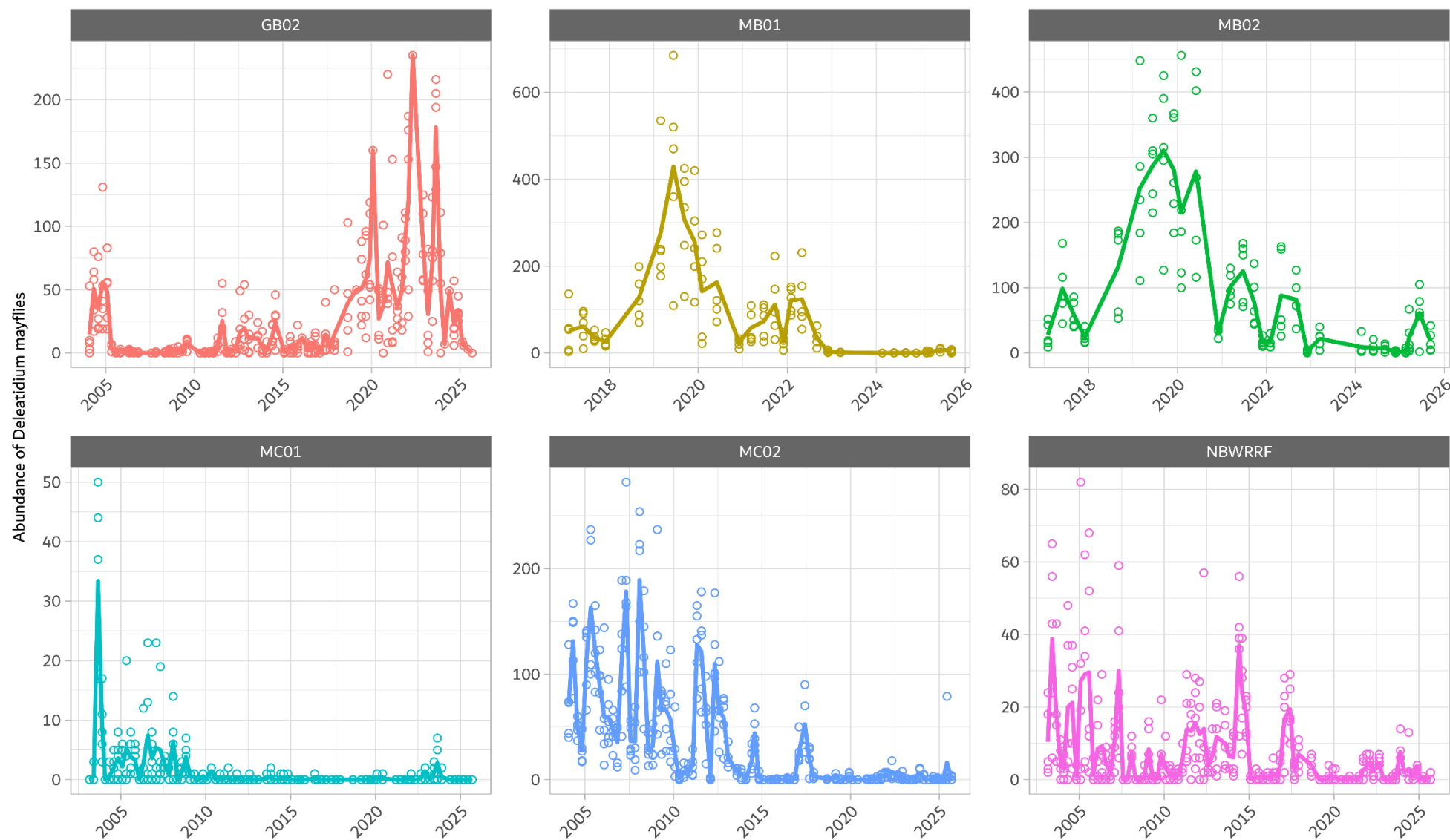


Figure C3. Abundance of *Deleatidium* mayflies in replicate samples collected at key compliance sites within the Waikouaiti and Taieri River catchments, presented over time. Mean abundance is presented as a trend line.

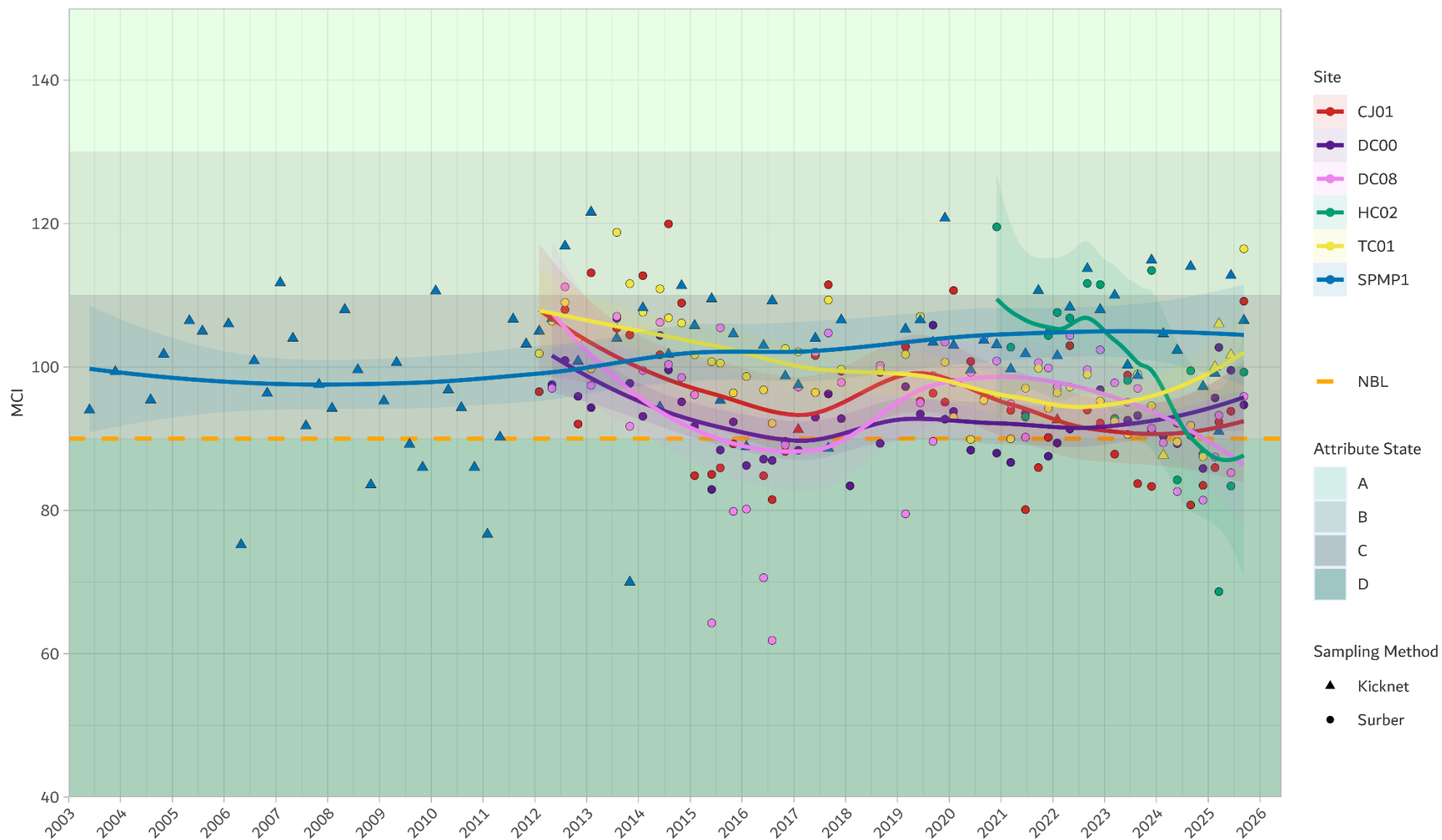


Figure C4. Long-term MCI trends in key Shag/Waihemo catchment sites between 2003 and 2026.

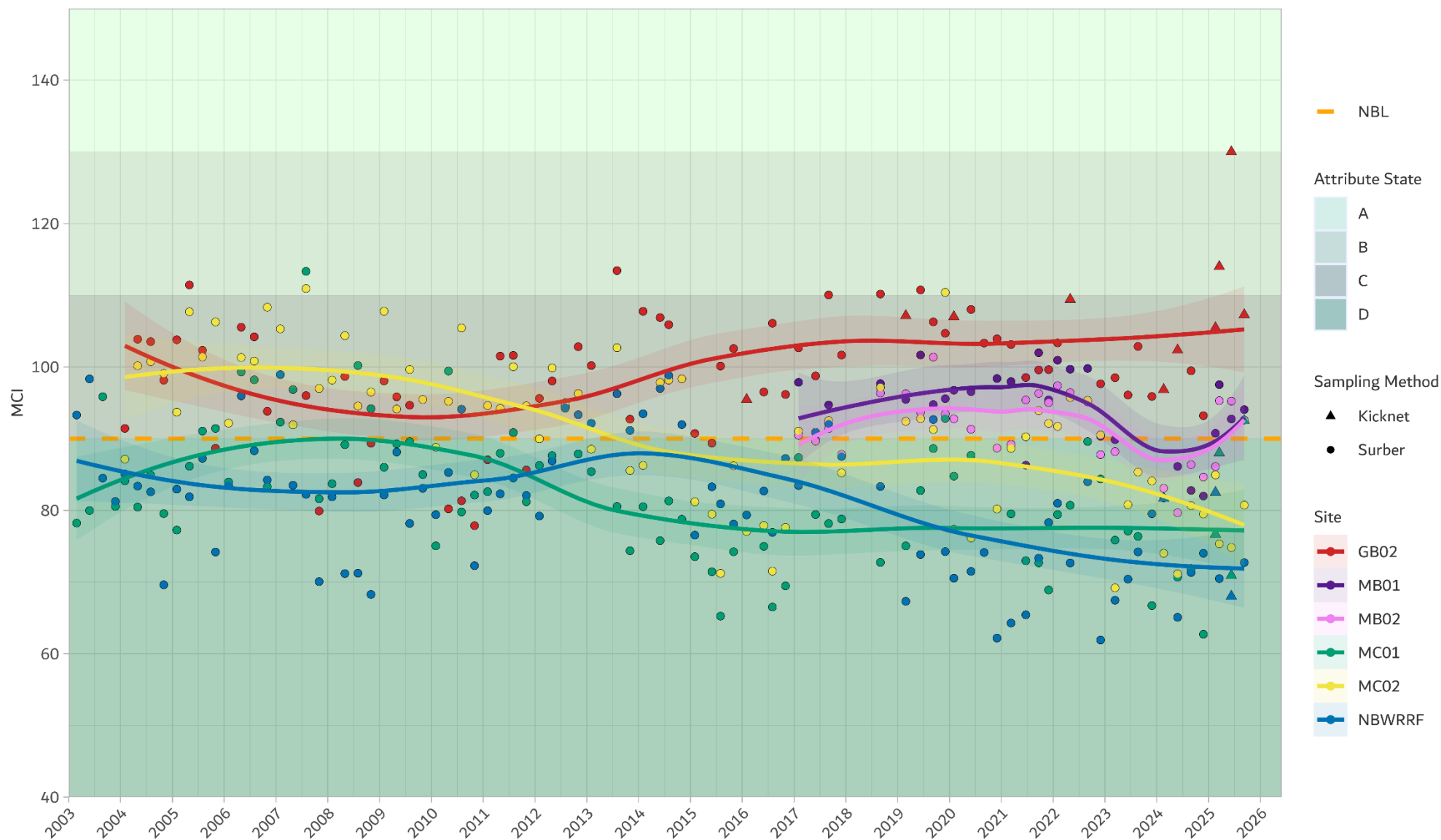


Figure C5. Long-term MCI trends in key Waikouaiti and Taieri River catchment sites between 2003 and 2026.

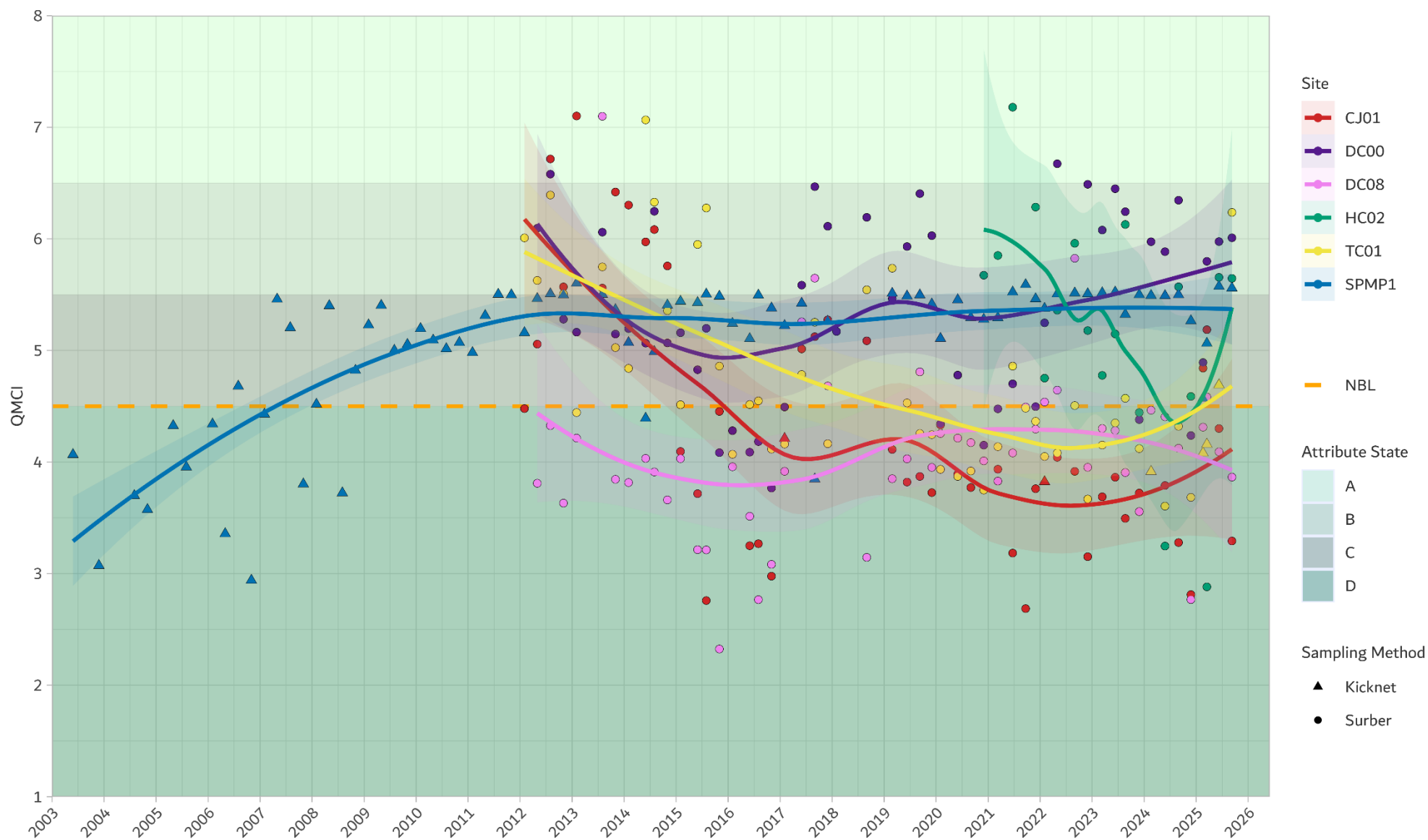


Figure C6. Long-term QMCI trends in key Shag/Waihemo catchment sites between 2003 and 2026.

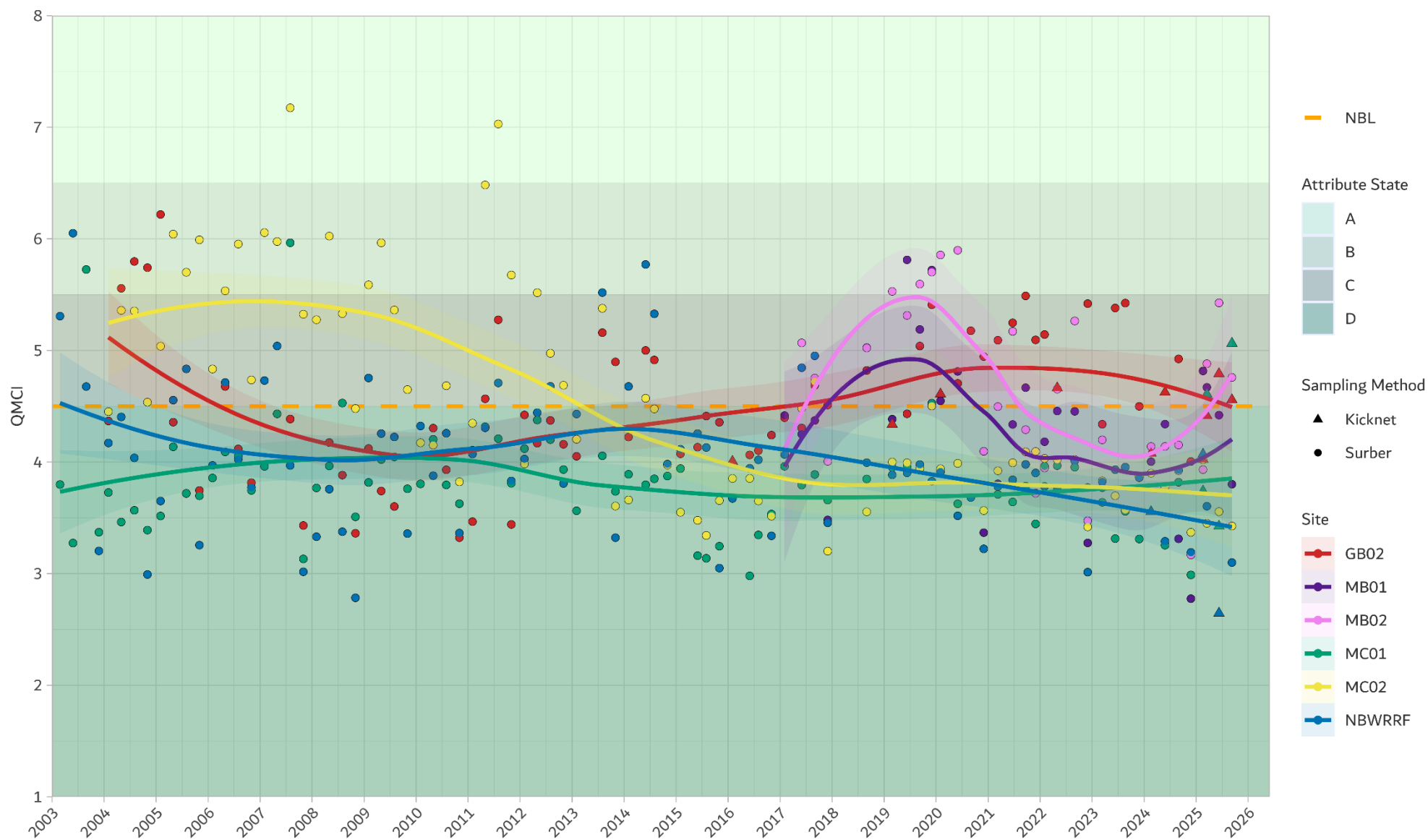


Figure C7. Long-term QMCI trends in key Waikouaiti and Taieri River catchment sites between 2003 and 2026.

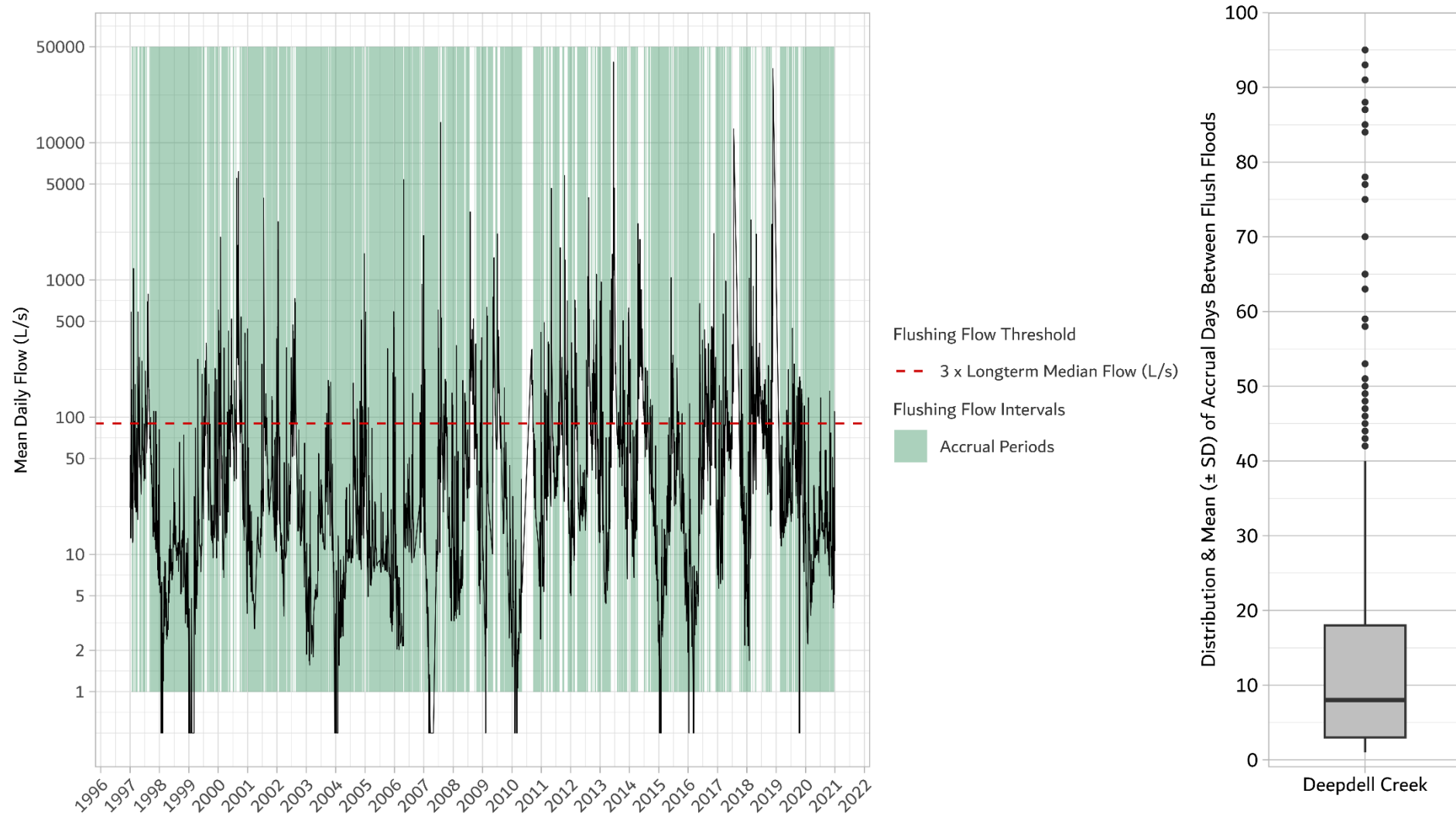


Figure C8. Mean daily flow in Deepdell Creek at Golden Point weir from 1997 to 2022, showing flushing flow threshold and accrual periods. Right: boxplot of accrual duration between flushing events, where box spans the interquartile range, the central line is median, whiskers extend to $1.5 \times$ IQR, and points beyond are outliers.

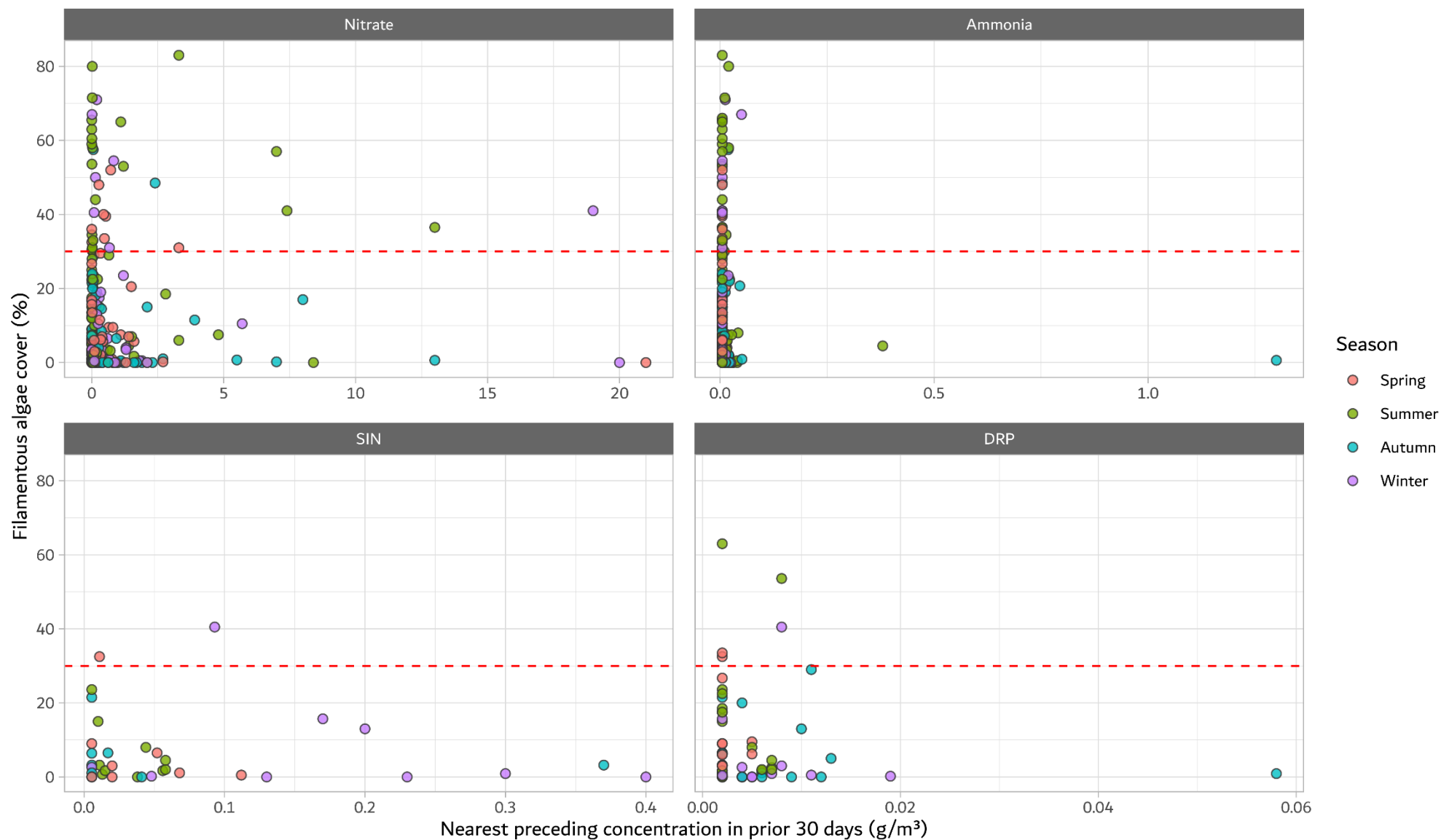


Figure C9. Relationship between filamentous algae cover and nearest preceding 30-day nutrient concentrations (nitrate, ammonia, SIN, and DRP) at MGP sites.

● Below detection ○ Measured value

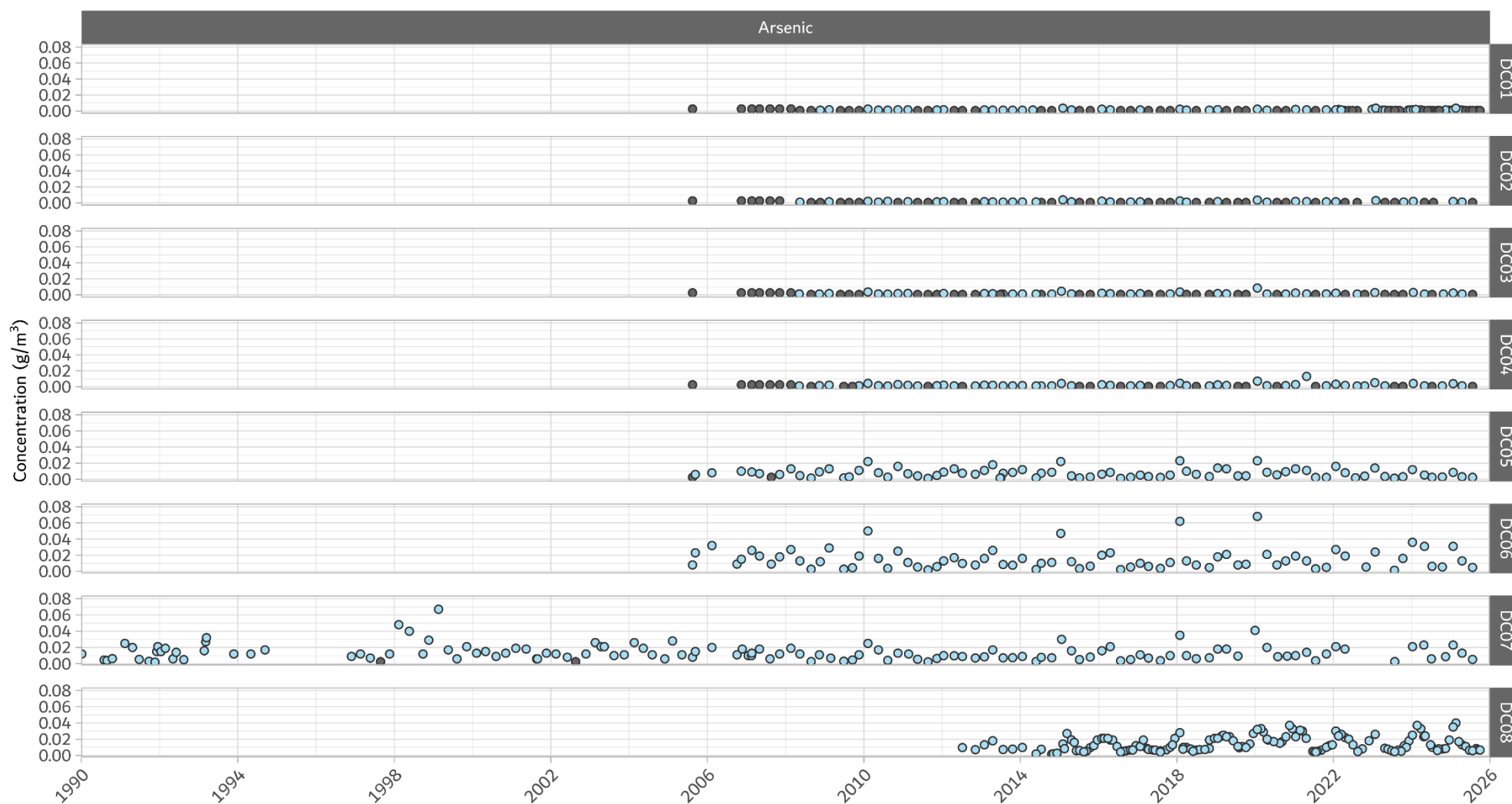
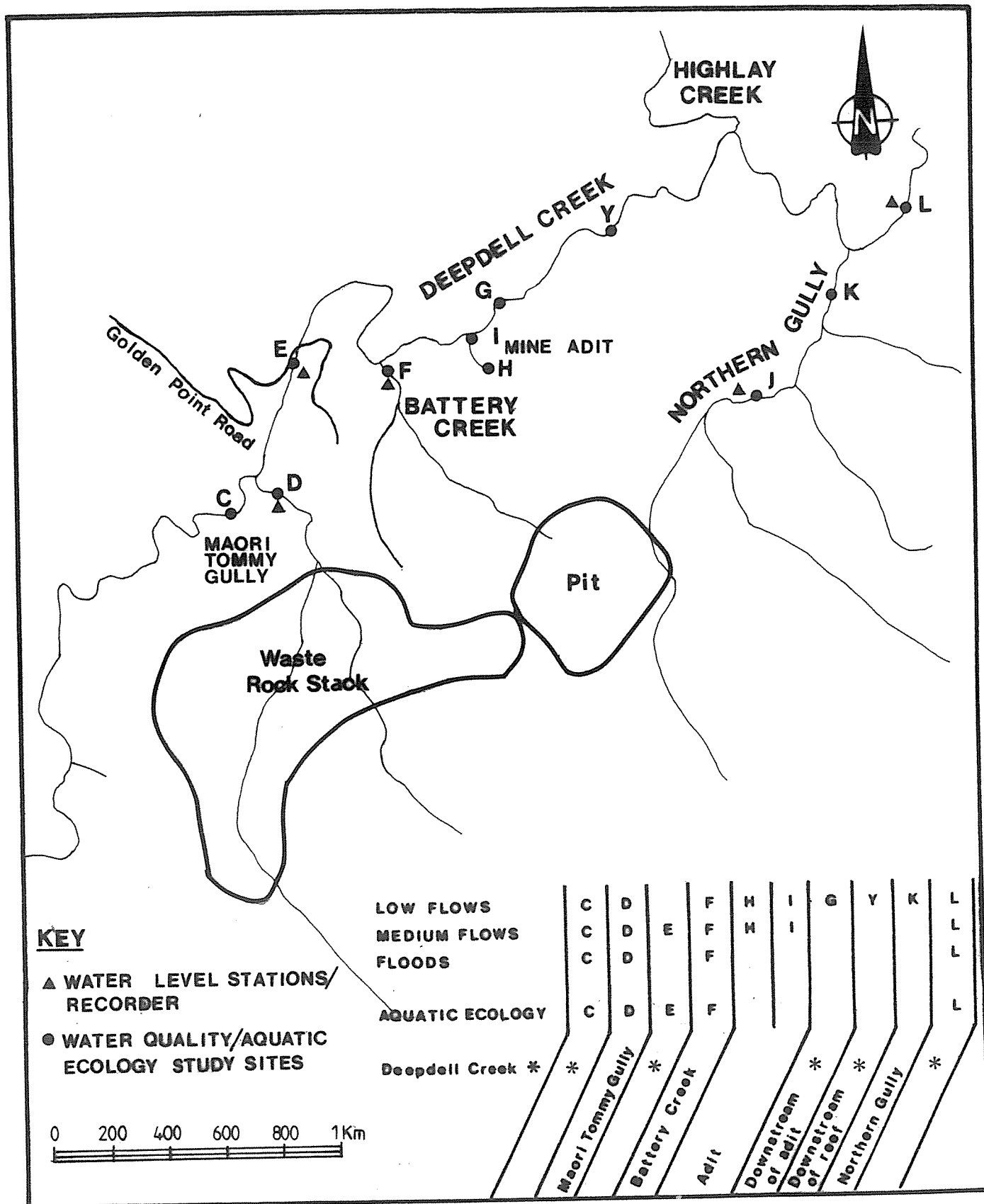


Figure C10. Historical concentrations of dissolved arsenic in Deepdell Creek, dating from the commencement of MGP (mid 1990) to 2026.



HYDROLOGICAL NETWORK WATER QUALITY/AQUATIC ECOLOGY STUDY SITES

Macraes Joint Venture
Gold Mine Project Otago

Figure 4-1-4

TABLE 4.1.7 VARIATION IN WATER QUALITY FOR A RANGE OF FLOW REGIMES

PARAMETER		----- LOW FLOW (8 - 11 l/s) -----			----- MEDIUM FLOW (41 - 161 l/s) -----			----- HIGH FLOW (672 - 6900 l/s) -----		
		Deepdell C.	Maori Tommy	Deepdell C.	Deepdell C.	Maori Tommy	Deepdell C.	Deepdell C.	Maori Tommy	Deepdell C.
		(Upper Site)	Gully	(D/S N.Gully)	(Upper Site)	Gully	(D/S N.Gully)	(Upper Site)	Gully	(D/S N.Gully)
		C	D	L	C	D	L	C	D	L
		(n=3)	(n=3)	(n=3)	(n=3)	(n=1)	(n=3)	(n=1)	(n=1)	(n=2)
pH	Mean	8.1	7.8	7.8	7.5	7.7	7.8	6.0	6.1	6.9
	Range	7.6 - 8.9	7.6 - 7.9	7.5 - 8.2	7.4 - 7.6	-	7.5 - 8.4	-	-	6.2 - 7.5
CONDUCTIVITY at 20 deg C (mS/cm)	Mean	13.7	25.3	18.3	10.6	21.0	12.5	4.7	5.0	8.4
	Range	12 - 15	24 - 27	17 - 20	8.8 - 13.0	-	9.5 - 16.0	-	-	8.0 - 8.7
ALKALINITY - TOTAL (as HCO ₃) (g/m ³)	Mean	60.3	156.7	95.0	45.0	12.0	56.0	15.0	17.0	21.2
	Range	66 - 75	150 - 160	91 - 98	35 - 57	-	41 - 73	-	-	33 - 42
HARDNESS - TOTAL (as CaCO ₃) (g/m ³)	Mean	51.0	117.7	78.0	33.0	81.0	43.0	16.0	19.0	26.5
	Range	44 - 59	106 - 130	68 - 83	26 - 43	-	32 - 54	-	-	24 - 29
SOLIDS - SUSPENDED (g/m ³)	Mean	LT 6	LT 6	LT 6	2.5	-	3.0	280.0	17.0	148.5
	Range	-	-	-	2.0 - 3.0	-	1.0 - 5.0	-	-	17 - 280
TURBIDITY (NTU)	Mean	0.7	2.7	0.2	1.7	2.0	1.2	40.0	20.0	35.0
	Range	0.7 - 0.8	2.5 - 3.0	0.2 - 0.3	1.2 - 2.5	-	0.4 - 2.2	-	-	7 - 63
SULPHATE (g/m ³)	Mean	2.9	4.8	7.4	3.6	3.6	5.3	1.5	0.77	2.4
	Range	2.2 - 3.8	3.4 - 5.8	6.1 - 8.7	3.3 - 4.1	-	4.0 - 6.8	-	-	2.2 - 2.5
CALCIUM (g/m ³)	Mean	13.4	33.0	21.0	8.3	23.0	11.0	3.9	5.4	6.8
	Range	11 - 16	30 - 36	18 - 23	6 - 11	-	8 - 14	-	-	6.1 - 7.5
MAGNESIUM (g/m ³)	Mean	4.4	8.6	6.1	3.1	5.8	3.7	1.5	1.3	2.4
	Range	3.9 - 4.9	7.6 - 9.7	5.5 - 6.6	2.6 - 3.9	-	2.9 - 4.5	-	-	2.1 - 2.6
POTASSIUM (g/m ³)	Mean	1.3	0.6	1.3	1.0	0.7	1.1	2.1	2.3	1.5
	Range	1.0 - 1.5	0.4 - 0.8	1.1 - 1.5	0.9 - 1.2	-	0.9 - 1.3	-	-	0.9 - 2.0
SODIUM (g/m ³)	Mean	11.6	14.3	12.7	9.8	13.0	10.1	3.8	4.6	7.0
	Range	11 - 12	14 - 15	12 - 13	9 - 11	-	9 - 12	-	-	5.8 - 8.2
ALUMINIUM (µg/m ³)	Mean	68.0	59.0	15.0	27.3	10.0	32.3	2300	670	1440
	Range	-	-	-	10 - 47	-	34 - 58	-	-	280 - 2600
ARSENIC (µg/m ³)	Mean	1.6	8.9	18.7	1.8	14.1	15.6	9.2	13.0	30.5
	Range	1.3 - 2.1	4.6 - 11.0	17.0 - 21.0	1.3 - 2.1	-	7.1 - 29.3	-	-	8.9 - 52.0
CADMIUM (µg/m ³)	Mean	LT 0.010	0.020	LT 0.010	0.010	0.006	0.009	-	-	LT 0.010
	Range	-	LT 0.01-0.02	-	0.009-LT 0.01	-	0.007-LT 0.01	-	-	-
COBALT (µg/m ³)	Mean	0.56	0.28	0.07	0.13	LT 0.05	0.09	2.60	0.66	1.40
	Range	-	-	-	0.06 - 0.19	-	LT 0.05-0.11	-	-	0.39 - 2.40
COPPER (µg/m ³)	Mean	0.62	0.19	0.66	0.64	0.27	0.65	5.1	1.5	3.8
	Range	0.47 - 0.75	0.14 - 0.24	0.56 - 0.76	0.53 - 0.75	-	0.60 - 1.00	-	-	2.2 - 6.3
IRON (µg/m ³)	Mean	200	483	33	320	600	153	6600	2000	3680
	Range	180 - 240	350 - 580	28 - 36	250 - 370	-	50 - 230	-	-	960 - 6400
LEAD (µg/m ³)	Mean	LT 0.10	LT 0.10	LT 0.10	0.09	0.14	0.10	6.20	0.90	2.85
	Range	-	-	-	0.08 - LT 0.1	-	LT 0.1-0.1	-	-	0.39 - 5.30
MANGANESE (µg/m ³)	Mean	20.0	46.0	4.6	15.2	40.0	5.9	580	150	352
	Range	-	-	-	7.4 - 30.0	-	3.5 - 10.0	-	-	64 - 640
MERCURY (µg/m ³)	Mean	LT 0.01	0.03	0.01	0.03	0.01	0.04	0.017	0.010	0.095
	Range	-	LT 0.01-0.056	LT 0.01-0.01	LT 0.01-0.04	-	LT 0.01-0.07	-	-	0.03 - 0.16
NICKEL (µg/m ³)	Mean	0.42	0.39	0.52	0.53	0.40	0.47	5.50	0.84	2.76
	Range	-	-	-	0.52 - 0.54	-	0.56 - 0.58	-	-	0.52 - 5.00
ZINC (µg/m ³)	Mean	0.31	0.22	0.16	0.41	1.29	0.38	34.0	2.9	13.60
	Range	0.16 - 0.54	0.08 - 0.41	0.11 - 0.20	0.24 - 0.63	-	0.32 - 0.57	-	-	2.1 - 25.0

- Where values are less than (LT) the lower detection limits, the mean is calculated using lower detection limit value.

- * indicates n = 1 for all sites at Low Flow.

- ** indicates n = 2 for all sites at Low Flow.

- Metals indicate total recoverable concentrations (see Volume 3, Appendix 8 for acid soluble concentrations).

TABLE 4.1.8 DOWNSTREAM VARIATION IN WATER QUALITY IN DEEPELL CREEK (Low Flows : 8 - 11 l/s)

PARAMETER		Deepdell C. Maori Tommy (Upper Site)	Deepdell C. Maori Tommy Gully	Battery C. F	Mine Adit (U/S Wetland)	Mine Adit (D/S Wetland)	Deepdell C. (D/S Adit)	Deepdell C. (D/S Reef)	Northern Gully	Deepdell C. (D/S N. Gully)
		C (n=3)	D (n=3)	F (n=3)	H (n=1)	I (n=3)	G (n=2)	Y (n=2)	K (n=3)	L (n=3)
pH	Mean	8.07	7.77	7.83	6.90	7.63	7.60	8.10	6.77	7.80
	Range	7.6 - 8.9	7.6 - 7.9	7.8 - 7.9	-	7.5 - 7.7	7.5 - 7.7	7.8 - 8.4	6.7 - 6.8	7.5 - 8.2
CONDUCTIVITY at 20 deg C (mS/cm)	Mean	13.67	25.33	41.00	88.00	79.67	18.00	18.00	16.00	18.33
	Range	12 - 15	24 - 27	40 - 42	-	78 - 81	17 - 19	17 - 19	13 - 18	17 - 20
ALKALINITY - TOTAL (as HCO ₃) (g/m ³)	Mean	70.3	156.7	253.3	410.0	330.0	95.5	96.5	86.3	95.0
	Range	66 - 75	150 - 160	240 - 270	-	320 - 340	93 - 98	94 - 99	71 - 97	91 - 98
HARDNESS - TOTAL (as CaCO ₃) (g/m ³)	Mean	51.00	117.67	206.67	510.00	466.67	73.50	76.50	60.67	78.00
	Range	44 - 59	106 - 130	200 - 210	-	440 - 480	68 - 79	72 - 81	46 - 68	68 - 83
SOLIDS - SUSPENDED (g/m ³)	Mean	LT 6	LT 6	15	13	LT 6	LT 6	LT 6	LT 6	LT 6
	Range	-	-	12 - 16	-	-	-	-	-	-
TURBIDITY (NTU)	Mean	0.72	2.67	2.53	27.0	0.35	0.45	0.42	0.77	0.24
	Range	0.65 - 0.80	2.5 - 3.0	2.2 - 2.8	-	0.20 - 0.52	0.35 - 0.55	0.40 - 0.44	0.45 - 1.10	0.16 - 0.32
SULPHATE (g/m ³)	Mean	2.93	4.80	17.67	200.00	203.33	6.75	7.05	4.63	7.40
	Range	2.2 - 3.8	3.4 - 5.8	11.0 - 23.0	-	200 - 210	6.2 - 7.3	6.5 - 7.6	2.6 - 5.7	6.1 - 8.7
CALCIUM (g/m ³)	Mean	13.43	33.00	61.67	150.00	125.67	20.00	21.00	15.00	21.00
	Range	11.3 - 16.0	30.0 - 36.0	60.0 - 64.0	-	117 - 130	18.0 - 22.0	20.0 - 22.0	11.0 - 17.0	18.0 - 23.0
MAGNESIUM (g/m ³)	Mean	4.43	8.60	12.67	35.00	36.00	5.75	5.85	5.63	6.07
	Range	3.9 - 4.9	7.6 - 9.7	12.0 - 13.0	-	35 - 37	5.4 - 6.1	5.5 - 6.2	4.5 - 6.3	5.5 - 6.6
POTASSIUM (g/m ³)	Mean	1.27	0.63	0.33	2.2	2.13	1.20	1.20	1.07	1.30
	Range	1.0 - 1.5	0.4 - 0.8	0.1 - 0.7	-	2.0 - 2.3	1.0 - 1.4	1.0 - 1.4	1.0 - 1.1	1.1 - 1.5
SODIUM (g/m ³)	Mean	11.60	14.33	16.67	18.00	16.67	13.50	13.50	13.67	12.67
	Range	11 - 12	14 - 15	16 - 18	-	16 - 18	13 - 14	13 - 14	13 - 14	12 - 13
ALUMINIUM (mg/m ³)	Mean	68	59	120	11	36	29	14	67	15
	Range	-	-	-	-	-	-	-	-	-
ARSENIC (mg/m ³)	Mean	1.63	8.87	40.67	4000.00	836.67	23.50	33.00	0.55	18.67
	Range	1.3 - 2.1	4.6 - 11.0	27 - 51	-	780 - 890	21 - 26	27 - 39	0.33 - 0.72	17 - 21
CADMIUM (mg/m ³)	Mean	LT 0.01	0.02	LT 0.01	-	0.01	LT 0.01	LT 0.01	0.01	LT 0.01
	Range	-	LT 0.01-0.02	-	-	LT 0.01-0.01	-	-	LT 0.01-0.01	-
COBALT (mg/m ³)	Mean	0.56	0.28	0.75	7.7	0.76	0.36	0.26	0.30	0.07
	Range	-	-	-	-	-	-	-	-	-
COPPER (mg/m ³)	Mean	0.62	0.19	0.53	LT 0.10	0.19	0.69	0.66	0.73	0.66
	Range	0.47 - 0.75	0.14 - 0.24	0.45 - 0.59	-	0.15 - 0.21	0.65 - 0.72	0.64 - 0.68	0.61 - 0.84	0.56 - 0.76
IRON (mg/m ³)	Mean	200	483	457	7300	74	160	195	65	33
	Range	180 - 240	350 - 580	420 - 490	-	12 - 140	140 - 180	150 - 240	26 - 99	28 - 36
LEAD (mg/m ³)	Mean	LT 0.10	LT 0.10	0.49	LT 0.10	LT 0.10	LT 0.10	LT 0.10	LT 0.10	LT 0.10
	Range	-	-	0.44 - 0.56	-	-	-	-	-	-
MANGANESE (mg/m ³)	Mean	20	46	60	1500	32	14	15	3.3	4.6
	Range	-	-	-	-	-	-	-	-	-
MERCURY (mg/m ³)	Mean	LT 0.01	0.03	0.03	0.03	0.02	0.01	0.03	0.01	0.01
	Range	-	LT 0.01-0.06	0.02 - 0.05	-	LT 0.01-0.03	LT 0.01-0.01	LT 0.01-0.05	LT 0.01-0.01	LT 0.01-0.01
NICKEL (mg/m ³)	Mean	0.42	0.39	0.25	2.20	0.58	0.47	0.57	1.00	0.52
	Range	-	-	-	-	-	-	-	-	-
ZINC (mg/m ³)	Mean	0.31	0.22	2.53	1.20	0.56	0.48	0.38	0.45	0.16
	Range	0.16 - 0.54	0.08 - 0.41	1.70 - 3.70	-	0.35 - 0.80	0.30 - 0.65	0.26 - 0.50	0.22 - 0.79	0.11 - 0.20

- Where values are less than (LT) the lower detection limits, the mean is calculated using lower detection limit value.

- * indicates Run 1 only : Flow = 8 l/s (All flows measured in Deepdell Creek at Ford Gauging Site).

- *** indicates Run 2 and 3 : Flows = 9 l/s and 11 l/s respectively.

- Metals indicate total recoverable concentrations (see Volume 3, Appendix 8 for acid soluble concentrations).

Appendix D

Raw Data

The following supporting data files are provided separately in electronic format. These files contain detailed datasets and analyses referenced in this report and its appendices.

Files provided:

- OGNZL_Macraes_MP4_Data_Surface_Water_Quality.xlsx

Raw grab sample data for surface water quality monitoring sites collected between 1990 and 2026, including back-trace analyses referenced in this report. Values below the laboratory detection limit and have been presented as '<' but were halved for data analyses, consistent with standard practice.

- OGNZL_Macraes_MP4_Data_Invertebrates.xlsx

Macroinvertebrate sampling results for key ecological monitoring sites between 2003 and 2026, presented as abundance counts from replicate samples. Zeros indicate absence of a given taxon; null values are shaded in grey and indicate no measurement.

- OGNZL_Macraes_MP4_Data_Flora.xlsx

Periphyton and macrophyte coverage data for key ecological monitoring sites between 2002 and 2026, including percent cover estimates for long filamentous algae. Data are derived from field assessments using standard quantitative methods. Transect-level resolution of coverage is not available for all surveys, as data have been transcribed and compiled from previous reports. Zeros indicate absence of observable coverage; null values are shaded in grey and indicate no measurement.

- OGNZL_Macraes_MP4_Data_Mine_Seepage.xlsx

A small subset of mine seepage water quality data for dissolved aluminium between 2023 and 2024.

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