

Stockton Plateau Aquatic Ecology: history, thresholds and long-term management

July 2026

Prepared for:

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (Bathurst)



Instream Consulting Limited



Document Control

Citation: Instream 2026. Stockton Plateau aquatic ecology: history, thresholds and long-term management. Client report prepared by D. P. Gray for BT Mining. 146p.

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Glossary of Terms, Acronyms and Abbreviations

Term	Definition
Acid Mine Drainage / Acid and Metalliferous (AMD)	The initialism AMD can variously mean Acid Mine Drainage or Acid and Metalliferous Drainage. This report uses the term Acid Mine Drainage, that is considered to be interchangeable and synonymous with Acid and Metalliferous drainage.
Adaptive Management	A learning-oriented approach to managing environmental uncertainty associated with AMD. Monitoring and compliance reporting any change over time to reflect new information as it becomes available.
Adit	A horizontal or near-horizontal passage driven into a hillside to access underground mine workings, provide drainage, ventilation, or allow haulage. Millerton area at Stockton contains multiple adits into historic underground workings.
Bathurst	Bathurst Resources Limited, including its subsidiary companies Bathurst Coal Ltd and Buller Coal Ltd, and joint venture company BT Mining Ltd.
Betterment	The definition of 'Betterment' in the context of the BPCP as outlined in Bathurst (2026c) is described below: <i>The term Betterment has been applied to rivers in New Zealand (i.e. Waikato River) that have experienced long term anthropogenic contamination. It is recognised that managed improvement will take 3 generations (80-100 years) and require a collective, sustained, and sustainable effort between stakeholders.</i> <i>Betterment is the process of active and progressive improvement of river health over the long-term.</i> <i>The Betterment pathway for a given waterbody is marked by a combination of discrete events and long-term decay in AMD sources. Performance monitoring is used to track short- to medium-term water quality improvements along the Betterment pathway. These improvements are site / project specific, but contribute to overall long-term recovery.</i>
Betterment Reference Values	Time-dependent 'Betterment reference (water quality) values' for acidity loads and acidity / dissolved aluminium concentrations modelled for the period 2010 – 2106 as presented in the Millerton AMD Water Management Report (Bathurst 2026a) to guide the long-term AMD management of Millerton Block waterways – Granity Stream, Miller Stream,

Term	Definition
	Mine Creek and Twins Stream. The Betterment reference values assume that: – Millerton Block opencast mining cease in 2010. – Millerton Block underground workings remain at the 2010 extent and untreated. – The load / concentration change from 2010 – 2106 is solely due to acidity decaying at a rate of 0.62% per year.
Buller Plateaux	A collective reference to the Stockton Plateau and Denniston Plateau.
Cleanwater	Runoff from undisturbed ground or rehabilitated areas where water quality is suitable for direct discharge into natural streams without treatment and is comparable to natural background water quality.
Compliance monitoring	Water quality or aquatic ecology monitoring with associated pass/fail limits. Non-compliance typically associated with reporting and response requirements.
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit (Cavanagh et al., 2018).
Future State	Post 'Point of Exit' when responsibility of the site is with the Crown.
Legacy AMD / historic AMD	Acid Mine Drainage generated from past mining disturbance, workings or waste rock rather than current mining activities. In this report, legacy or historic AMD refers particularly to ongoing contamination arising from pre-existing mine features and materials.
Mahinga kai	The customary gathering, use and protection of freshwater and other natural resources for food, materials and cultural purposes. In this report, mahinga kai refers to stream conditions that are suitable to support the presence, harvest and safe use of valued aquatic species.
Macroinvertebrates	Report discusses aquatic macroinvertebrates. Macroinvertebrates are organisms without backbones (e.g., worms, snails, insects and crustaceans) which are visible to the naked eye.
Millerton Block	AMD impacted waterways draining various catchments within the Millerton and northern Rockies mining areas at Stockton.

Term	Definition
Mining	The act of extracting a mineral existing in its natural state in land or a chemical substance from a mineral existing in its natural state in land.
Minewater	Runoff from disturbed, mining and historic areas where the water requires AMD correction and/or sediment capture prior to discharge into natural streams. Minewater is largely contaminated by coal fines (i.e. runoff from stripped coal and coal stockpiles). Can also be referred to as 'Mine Impacted Water'.
Mine Closure	The point at which mining operations at Stockton cease and terrestrial rehabilitation of the site is complete.
Mitigation hierarchy	A structured approach to managing adverse effects that prioritises avoiding effects where practicable, then minimising, remedying, offsetting or compensating for any residual effects that remain.
Opencast mining	This is the main mining method used at Stockton to extract coal. At Stockton, this involves the removal of topsoil and vegetation which are placed in specific terrestrial rehabilitation areas. The overlying rock is then broken up by drilling and blasting, removed and placed in nearby already mined areas ready for rehabilitation. An excavator then extracts the coal for processing.
Performance monitoring	Water quality or aquatic ecology monitoring undertaken with no associated consent compliance limits. Used to inform progress against water quality predictions and assess the efficacy of treatment or rehabilitation.
Point of Exit	The point, when the mining company is released from its obligations to manage AMD at Stockton and can formally hand the site back to the Crown under LINZ administration.
Recovery trajectory	The predicted pathway and rate of ecological or water quality improvement over time following remediation, treatment or natural recovery processes. A recovery trajectory may be expressed qualitatively or through modelled milestones and monitoring results.
Reference site	Site unaffected by current or historic activities that impact upon water quality or aquatic ecology. Used to provide context for the monitoring of impact sites.

Term	Definition
Remote site	Water quality and ecology monitoring site not readily accessible by foot or road. Sampled at a lower frequency than a routine site.
Residual effects	The adverse effects that remain after avoidance, mitigation, remediation and any other management measures have been applied.
Routine site	Water quality and ecology monitoring site readily accessible by foot or road. Sampled at a higher frequency than a remote site.
Sludge	Comprised of physical sediments eroded from upstream mining activities and mineral precipitates formed during AMD treatment.
Stockton	Term used for Stockton Mine.
Stockton Mine	Mining Licence and Permit areas     
Stormwater	Runoff from disturbed areas where the water requires sediment capture prior to discharge into natural streams.
Turbidity	A measure of the amount of light scattered by suspended particles in a sample, typically reported in nephelometric turbidity units (NTU).
Water Infrastructure	Water management structures e.g. sumps, pumps, drains, dams, ponds, pipelines and monitoring equipment.
Waterway	Receiving environment surface water body. Generally, a stream or river. Distinct from the cleanwater, minewater and stormwater run-off into the waterways.
West Coast Regional Council (WCRC)	The local government authority for the West Coast region of New Zealand responsible for environmental management, including flood control, air and water quality, and pest control.
Water quality impacted site	Site predicted to have a severely impacted ecological communities on based on pH and dissolved aluminium concentrations.
Water quality recovering site	Site predicted to be beginning ecological recovery based on pH and dissolved aluminium concentrations.
Water quality recovered site	Site predicted to be suitable to support a recovered ecological community based on pH and dissolved aluminium concentrations.

Acronyms and abbreviations	Definition
AMD	Acid Mine Drainage / Acid and Metalliferous Drainage
AMDI	Acid Mine Drainage Index
ANZG	Australian and New Zealand water quality guidelines
BCM	Brunner Coal Measures
BPCP	Buller Plateaux Continuation Project
BRL	Bathurst Resources Limited
CEWQG	Canadian Environmental Water Quality Guidelines
CCME	Canadian Council of Ministers of the Environment
CFSF	Coal Fines Storage Facility
CHPP	Coal Handling and Processing Plant
~	Approximately
cm	centimetre
CML	Coal Mining Licence (for Stockton)
DCA	Millerton Drainage Control Adit
DOC	Dissolved Organic Carbon
DoC	Department of Conservation
EC	Electrical Conductivity
EclA	Ecological Impact Assessment
ELF / ELF _s	Engineered Landform(s)
EOML	Stockton End of Mine Life
EPT	Ephemeroptera (Mayflies), Plecoptera (Stoneflies) and Trichoptera (Caddisflies)
ESE	Escarpment Extended (BPCP sub-area)
ESNZ	Earth Science New Zealand (ESNZ) previously National Institute of Water and Atmospheric Research
FTA	Fast-track Approvals Act 2024
ha	Hectare(s)

Acronyms and abbreviations	Definition
km	Kilometres
LOM	Stockton Life of Mine to 2033
LoP	Limit of Protection
L/s	Litres per second
LDP 1 & 2	Lime Dosing Plant (1 & 2)
LDS	Low Density Sludge
LINZ	Land Information New Zealand
m	metres
m ³ /s	Cubic metres per second
MALF	7-Day Mean Annual Low Flow
MFS	Mount Fredrick South (BPCP sub-area)
mg/L	milligrams per litre
MSR	Mussel Shell Reactor
NTU	Nephelometric Turbidity Units
PAF	Potentially Acid Forming
PCE	Parliamentary Commissioner for the Environment
pH	Potential Hydrogen
RMA	Resource Management Act 1991
TSS	Total Suspended Solids

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Executive Summary

Introduction

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (Bathurst) are seeking Fast-track approval to continue mining operations at the Stockton and Denniston Plateaux through the Buller Plateaux Continuation Project (BPCP). Concurrently, Bathurst is planning for the closure and long-term rehabilitation of the Stockton Mine as coal resources become exhausted, along with mining of new project areas to replace those resources. A key environmental concern associated with these operations is the impact of Acid Mine Drainage (AMD) on adjacent waterbodies. This report reviews the effects of AMD on stream ecology and derives water quality thresholds for recovery of impacted streams. The report also explores current and future trajectories for water quality and ecology and describes a monitoring and compliance programme for the Stockton Mine.

A focus for Bathurst mine planning is an 80 to 100-year (three generations) water quality improvement programme that will be carried out in partnership with the Crown and Iwi. The Crown (LINZ) has liability for treating AMD from acid forming mine waste rock disturbed at Stockton prior to 2017. Responsibility for AMD generated subsequently lies with Bathurst as the incumbent mining licence holder. The three-generation improvement programme aims to restore mahinga kai values in the streams flowing from the Stockton Mine and surrounding areas.

Mining history, water management and ecological values

Mining of the Stockton Plateau commenced in the 1880's and targeted Brunner Coal Measures (BCM). Early underground mining left a legacy of historic workings that discharge AMD to streams and rivers. Latterly mining has been open-cast and more extensive, peaking at 2,000,000 tonnes of coal per annum in the 2000's. Contemporary AMD is derived from waste rock deposits and the exposure of rock strata to the atmosphere. AMD draining BCM is, without treatment, typically high in acidity, metals and sulphur.

In addition to the legacy aspect, AMD management associated with the BCM is complex and challenging due to the terrain and climate. Bathurst currently employs a range of methods to manage and treat AMD from both historic and contemporary sources. Passive and active treatments include lime dosing, sediment settling facilities and mussel shell reactors (MSR). These methods raise the pH of the discharge, causing dissolved metals to precipitate, flocculate and be retained, while treated water is discharged to the environment. Excavation

of underground workings, diversion and treatment of contaminated water, weathered granite capping of waste rock, engineered landforms (ELFs) and revegetation are employed by the mine to reduce AMD. A natural decay rate for AMD within BCM has been estimated at 0.62 % per annum. The ecological characteristics of BCM streams are diverse. Streams range in size from small seeps to large rivers, and the surroundings vary between low growing vegetation on the plateau, to dense native podocarp-broadleaf-beech forest at lower elevations. Biota are adapted to the high annual rainfall and distinctive water chemistry. Natural pH in BCM catchments can be as low as 3.4 due to weathering of pyrite and organic acids along with the lack of calcium and magnesium in the silica dominated BCM rocks. Fish are typically present in the lower altitude streams but may be prevented from accessing the headwaters of steeper systems by physical obstacles, such as waterfalls, or poor water quality. [REDACTED]

[REDACTED]

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Ecological effects of AMD and thresholds for recovery

AMD effects on aquatic ecosystems are well documented. Biota are affected by the low pH and elevated dissolved metals contained within the discharge. Dissolved aluminium is the primary metal toxicant of concern in BCM streams and has been used throughout this report as a proxy for all metals. However, other metals are present in elevated concentrations and will also have ecotoxicological effects that collectively can impact aquatic ecology. Increasing AMD results in a reduction in the diversity and abundance of fish and macroinvertebrates present, and the sequential loss of sensitive taxa. Natural pH and dissolved metal concentrations in BCM streams generally fall beyond standard guideline criteria, resulting in some tolerance of AMD among fish and particularly aquatic macroinvertebrates.

This context of naturally low pH and high metal concentrations presents challenges when undertaking an assessment of effects and developing criteria for consent conditions and necessitates the development of locally specific thresholds for monitoring and mine planning. The focus for many BCM streams is on recovery from an impacted state rather than protection of an otherwise healthy biota. Mine planning requires water quality thresholds that represent the beginning of the water quality recovery zone to guide remediation, rather than a protection focused threshold that will become a consideration in the future as recovery progresses.

The ecological literature provides suitable thresholds for fish in BCM streams, however an analogous assessment had not previously been undertaken for aquatic macroinvertebrates. This report combines aquatic macroinvertebrate and water quality data from 217 site-occasion

combinations in BCM streams to derive water quality thresholds for macroinvertebrate recovery. Thresholds of pH > 4.1, and dissolved aluminium of < 1.3 mg/L are associated with the recovery of macroinvertebrate communities. However, this report uses the more conservative fish thresholds of pH > 4.5, and dissolved aluminium of < 1 mg/L to include fish and represent ecological recovery more generally.

Comparison of these thresholds to water quality information allows streams and sites to be classified in terms of AMD effect according to Exec. Summary Table 1. For stream classification in this report, the fish-based thresholds (pH > 4.5 and dissolved aluminium < 1 mg/L) are adopted as the general benchmark for ecological recovery, while macroinvertebrate recovery is expected to begin at lower thresholds and inform the status of recovering streams. The transition between water quality impacted and water quality recovering uses the thresholds derived from the relationship between macroinvertebrates and water quality. There is no analogous threshold for fish.

Exec. Summary Table 1. Stream classification based on derived and literature thresholds of pH and dissolved aluminium.

Site / stream classification	pH (Annual median)	Aluminium (annual 75 th percentile)
Water quality impacted	<4	>2.8 mg/L
Water quality recovering	>4 - <4.5	>1-<2.8 mg/L
Water quality recovered	>4.5 unless due to natural processes	<1 mg/L

In naturally acidic BCM streams, pH alone is not sufficient to determine ecological condition. Accordingly, the pH threshold adopted in this report is intended as a management indicator for AMD-affected systems and must be interpreted in the context of reference conditions and evidence of natural acidity.

The pH and dissolved aluminium thresholds used in this report are practical management surrogates for ecological condition in AMD-affected BCM streams, not complete descriptors of ecological health or contaminant risk.

Current water quality and aquatic ecology

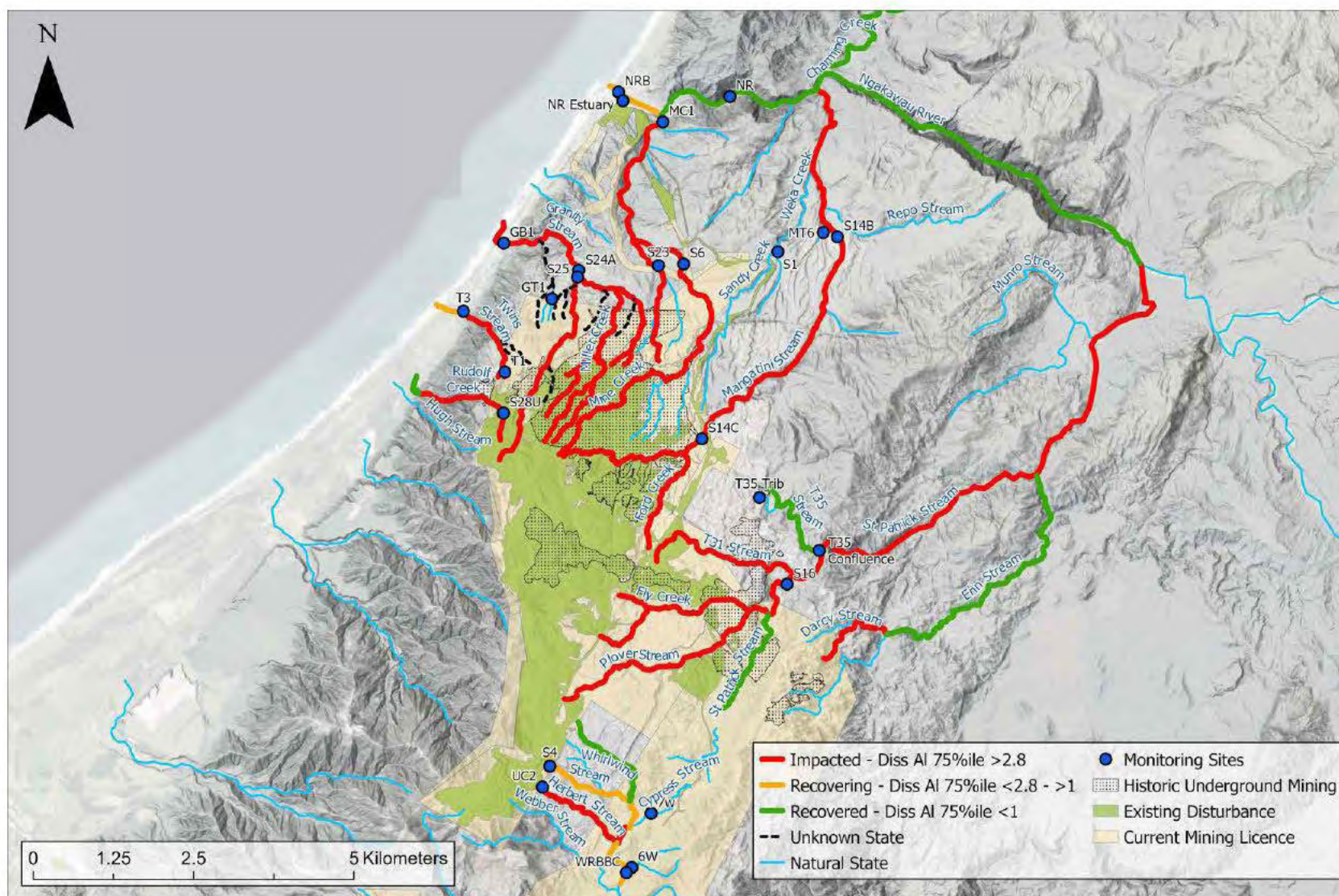
Many BCM streams are impacted by AMD. The highest impact sites typically drain both historic and contemporary mine workings, and in some cases, the impacts include the effects of fire suppression activities to manage underground burning coal seams.

This report describes the key affected streams in terms of change in water quality over time and the resulting condition of ecological communities. Case studies are provided to demonstrate successful active treatment of Mangatini and St. Patrick streams to restore the Ngākawau River migratory fish populations, the passive treatment of the Whirlwind Stream and the ecological effects of natural acidity decay in Rapid Stream, among others.

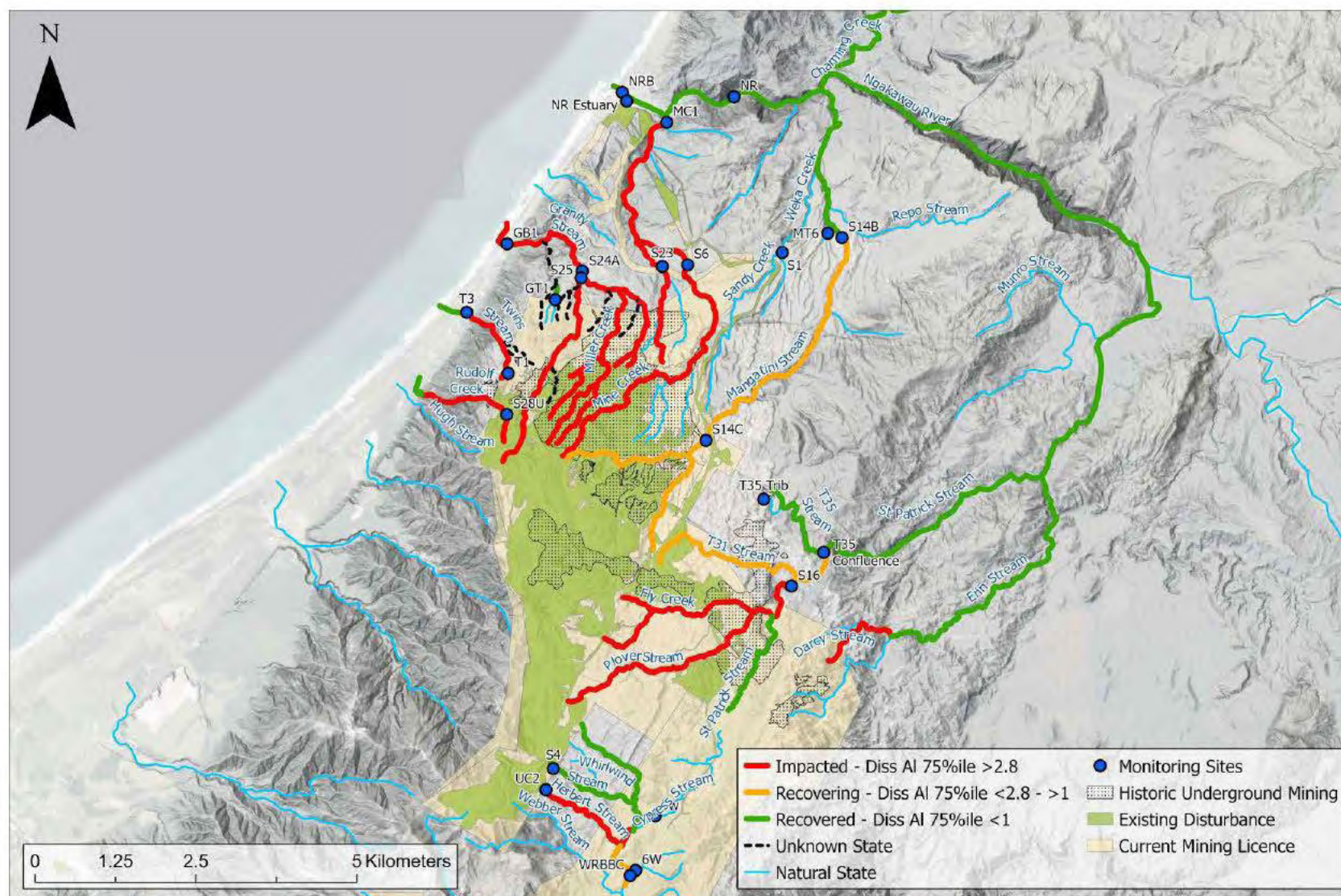
The current state of AMD affected streams draining the Stockton Plateau are displayed in Exec. Summary Figure 1 according to the classification in Exec. Summary Table 1.

Future water quality and aquatic ecology

This report reviews examples of proposed water quality remediation. These case studies use information on the efficacy of capping and rehabilitation, active and passive treatment, water diversion, dilution and natural decay to inform a timeline for the water quality and ecological recovery of streams. While full recovery at some sites is predicted to require at least 80 years and ongoing intervention, there are streams that are likely to become suitable for biota soon after mine closure and land rehabilitation. In particular, the lower St. Patrick Stream is predicted to attain ecological recovery and contribute to the ongoing rehabilitation of the Ngākawau catchment within 80 years. Exec. Summary Figure 2 shows the predicted classification of streams as of 2107, after 80 years, under the BPCP.



Exec. Summary Figure 1. Current state of ecology on Stockton Streams based on available water quality and ecology information.



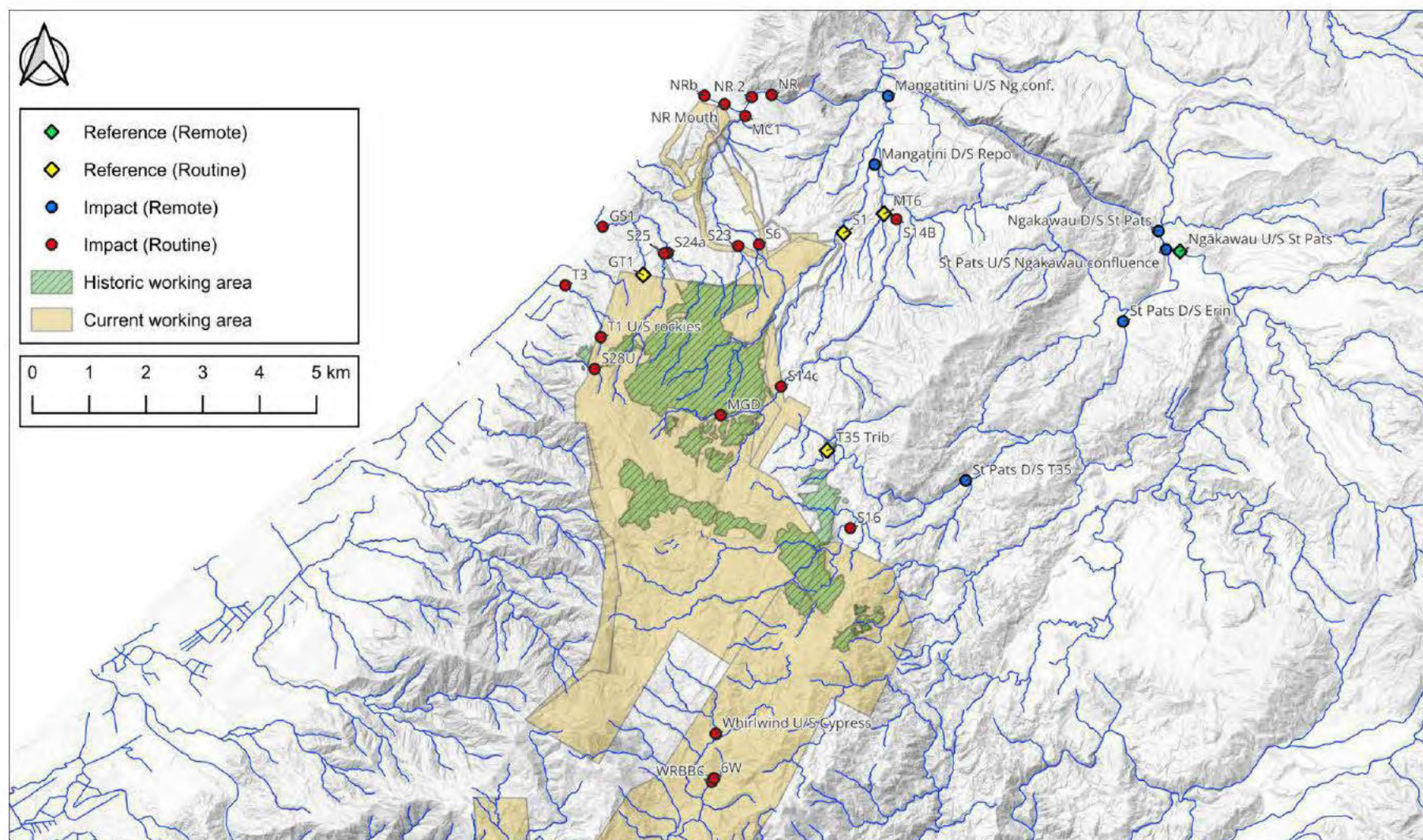
Exec. Summary Figure 2. Future state of ecology on Stockton Streams based on available water quality and ecology information.

The assessment of water quality and AMD used to summarise effects in Exec. Summary Figures 1 and 2 can be translated to an Ecological Impact Assessment (EclA). A comparison of ecological values and the effects of the proposal after the application of the mitigation hierarchy are used to determine any residual effects and their significance. The effects of the BPCP are positive over the 80-year time period, relative to a situation where the project does not proceed. However, some streams do not achieve ecological recovery in the allotted time period due primarily to historic untreated AMD. Residual effects of mining on some streams, particularly those associated with legacy AMD outside of the BPCP footprint, will require additional treatment and investment to remediate.

Proposed monitoring

Water quality and ecological monitoring is proposed that reflects the condition of rivers (i.e. stream classification) over time and their predicted trajectory over the ensuing 80-100 years. The concept of 'betterment' is built into water management and monitoring to ensure continual improvement. The betterment reference is the trajectory of improving water quality that would have occurred over time in the absence of opencast mining activities since 2010. Monitoring is variably used for 'performance' reporting, to track recovery over time, without associated limits, but also for compliance reporting linked to limits stipulated in consent conditions.

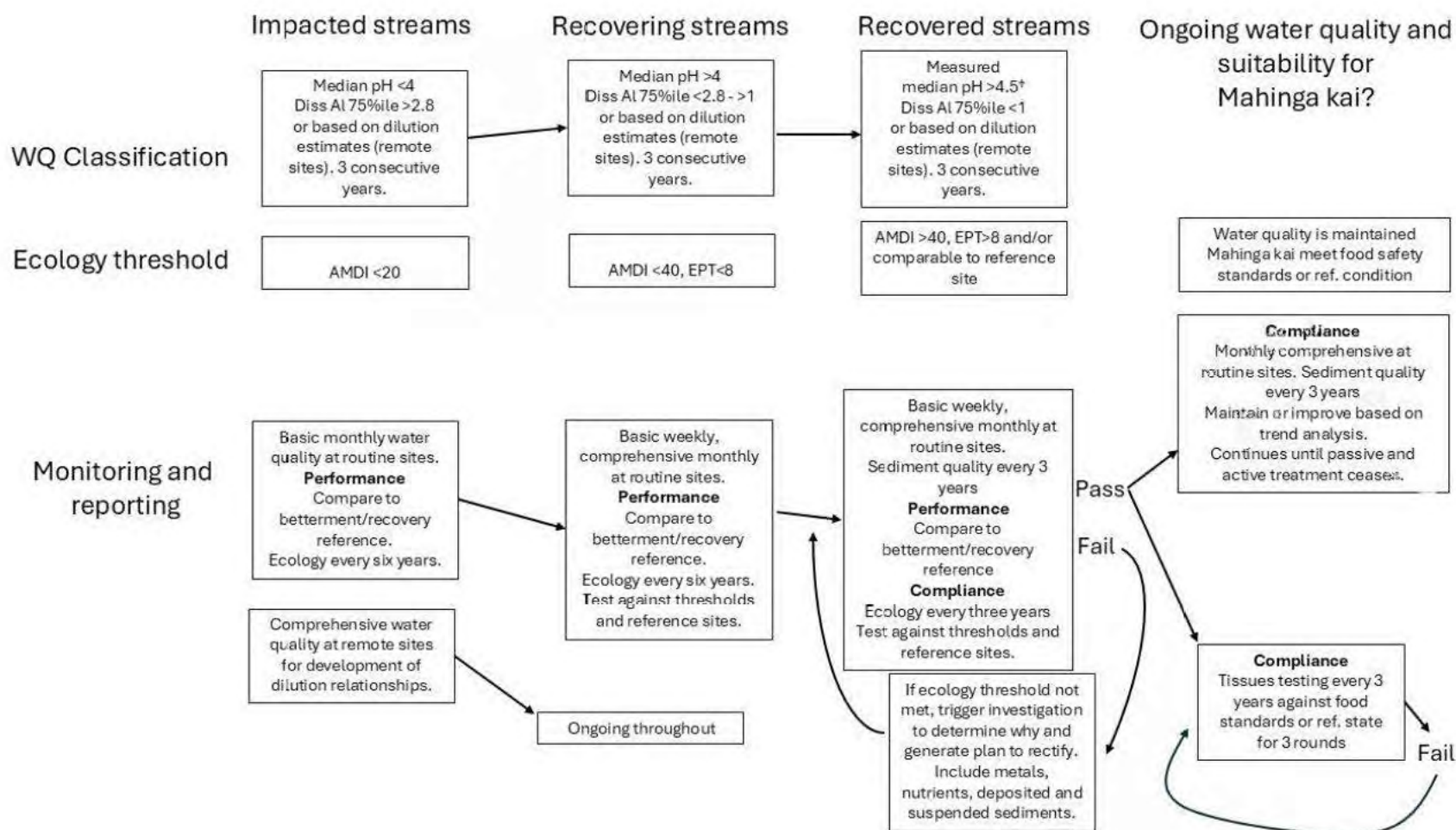
A six yearly review and reporting periodicity is proposed. Ecology sites are positioned longitudinally along streams to gauge the effects of dilution with increasing distance from the AMD source and the addition of clean tributary water (Exec. Summary Figure 3). Water quality is monitored regularly at accessible 'routine' sites, but less frequently at 'remote' locations.



Exec. Summary Figure 3. Proposed sites for water quality and ecological monitoring. Note additional sites associated with the ESE and MFS mines are proposed by ESNZ and RMA Science.

Monitoring follows an adaptive design that increases the level of scrutiny and introduces compliance testing as streams reach thresholds of ecological recovery (Exec. Summary Figure 4).

In 'water quality impacted' streams, monitoring is for the purpose of tracking the degree of impairment over a long period of time and so involves the assessment of a 'basic' suite of AMD indicators on a monthly basis (at road accessible 'routine' sites) and less frequently at 'remote' sites. Ecology assessments will occur on a six yearly basis.



Exec. Summary Figure 4. Schematic of adaptive monitoring design across a gradient of stream recovery. [†] Unless caused by natural processes. Note the inclusion of reference sites in threshold testing in Recovered streams. Monitoring suites and periodicity described here are considered a minimum standard. Performance and compliance monitoring may require additional sampling.

As streams/monitoring sites become 'water quality recovering', sampling will increase in periodicity and use the 'comprehensive' suite of analytes to inform relationships between chemistry and ecology.

Once streams reach 'water quality recovered' status formal testing to determine compliance with 'ecological recovery' will occur based on ecological sampling every three years in the context of reference sites. In the event streams do not achieve 'ecological recovery', adaptive management and the development of site-specific remediation, water quality targets and revised timelines will be agreed between the regulator and the operator.

After streams become 'ecologically recovered,' selected biota will be analysed for the bioaccumulation of contaminants in tissues (as a proxy measure), to inform suitability for mahinga kai through a comparison to reference levels and food safety standards.

Water quality compliance monitoring limits

Compliance, performance and reference water quality and ecology monitoring and reporting is required for the term of the consent. The design of that reporting variously reflects ecological criteria as well as proposed mine scheduling and water treatment over time. To allow flexibility, the proposed monitoring format for performance and compliance monitoring and reporting is subject to a six-year periodicity adaptive review. Exec Summary tables 2 – 6 present the sites and format of proposed monitoring to track stream recovery over time.

Exec Summary Table 2. Water quality monitoring regime and compliance statistics for sites draining the Stockton Plateau. These statistics are variously intended for the maintenance of water quality or the recovery and protection of fish and macroinvertebrates. Percentile and median values inform annual reporting, while rolling medians trigger a more immediate response. See Exec. Summary Figure 3 for site locations.

Site details (code)	Sampling regime	Analyte (units)	Annual 5 TH percentile	Rolling Annual median (unless specified)	Annual upper percentile	Rolling median
Ngākawau River NR2 ^a	Daily weekday	Turbidity ^a (NTU)		< 10.0 ‡	<48.0 (95 th) ‡	<25 (15 samples)*
		Dissolved aluminium (mg/L)			<1 (75 th) §	<1 mg/L (15 samples) §
		pH	>4.5§		<7.5 (95 th)*	>4.5 & < 7.5 (15 samples) §*
	Weekly	Nitrate N (mg/l)		<2.40	<3.5 (95 th)	
	Weekly	Ammoniacal N (mg/l) ¥		<0.69 assuming a pH of 6	<1.1 (95 th) assuming a pH of 6	

Site details (code)	Sampling regime	Analyte (units)	Annual 5 TH percentile	Rolling Annual median (unless specified)	Annual upper percentile	Rolling median
NR2 ^a – During LDS discharge	Continuous	Turbidity (NTU)	a) Adhere to the operating regime and monitoring procedures set out in the Mangatini Sump Management Plan; and b) Comply with the turbidity limits as set out in Table 1.			
			Table 1: Flow conditions at S14B and turbidity at NR2 during LDS discharge			
			Flow Percentile band (%)	Flow rates S14B (m ³ /s)	LDS discharge to stream	Turbidity averaged over 8 hours NR Two (NTU)
			95+	7.349+	Yes	n/a
			90–95	3.373 to 7.349	Yes	100
			80–90	1.672 to 3.373	Yes	50
			70–80	1.139 to 1.672	Yes	25
			0–70	0 to 1.139	No	25
Mangatini Stream S14B	Daily weekday	pH	>4.0‡		<7 (95 th)*	>4 & < 7 (15 samples)*‡
Mine Creek MC1	Daily weekday	Turbidity (NTU)				<25.0 (15 samples)*
St. Patrick S16	Daily weekday	Dissolved aluminium (mg/L)		<5‡	<8 (95 th) ‡	<8 (15-samples) ‡
		pH	>3.4‡		<7 (95 th)*‡	>3.4 & < 7 (15 samples) *‡
		Turbidity (NTU)		<6.9‡	<44 (95 th) ‡	<24 (15-samples) ‡
Twins Stream T1	Weekly	Dissolved aluminium (mg/l)		<28‡		
		Turbidity (NTU)				<25 (15 samples)*
Rudolph Stream S28U	Weekly	Turbidity (NTU)				<25 (15 samples)
		Dissolved aluminium (mg/L)		30‡		
Granity Stream S25	Daily weekday	Turbidity (NTU)				<25 (15 sample)*
Miller Stream S24a	Daily weekday	Turbidity (NTU)				<25 (15 sample)*

Note: ^a >1 in 10 year flood events should be excluded for annual statistics for turbidity (i)*Indicates an ecologically based limit for the protection of biota or indicative of the natural state of the waterway; (ii) ‡ site-specific value based on monitoring data. Limits are based on expected performance of treatment and water management systems within the constraints of the benchmarking period; (iii) § Ecological recovery water quality target (Exec. Summary Table 1). (iv) ¥Ammoniacal N should be corrected for pH and be less than the national bottom line listed in National Policy Statement – Freshwater Management (MfE 2020). Annual median compliance assessment and pH

correction as detailed by MfE (2018). (v) Site NR2 is subject to seawater intrusion and backing up of Mine Creek water at tide heights > 2500mm based on the NIWA tide forecasting model (<https://tides.niwa.co.nz/>). Data collected during tidal cycle periods exceeding 2500mm should be excluded.

Exec. Summary table 3. Water quality monitoring regime and performance analytes (and the associated basic or comprehensive suites) for sites draining the Stockton Mine. This table is subject to revision at each six yearly review at the discretion of the regulatory authority. Sites that achieve water quality recovered status to begin comparison against 80% toxicity guidelines values of Hickey (2026a) and develop water quality and ecology compliance thresholds. See Exec. Summary Figure 3 for site locations. Sampling will be either the full basic or comprehensive suite of analytes plus any additional analytes listed below.

Site details	Sampling regime	Suitable reference site	Reporting Analytes
Ngākawau River NRB	Daily weekday		Dissolved aluminium, pH, EC, turbidity
	Weekly (Comprehensive suite)		*¥ Ammoniacal-N, Nitrate-N, turbidity Dissolved aluminium (Al), EC, pH, Dissolved zinc (Zn), Dissolved iron (Fe), Dissolved nickel (Ni), Dissolved copper (Cu), Dissolved cobalt (Co), Dissolved cadmium (Cd), Dissolved chromium (Cr), Dissolved manganese (Mn), Calcium (Ca), Magnesium (Mg), Dissolved Organic Carbon (DNPOC) for comparison to bioavailability guidelines developed by Hickey (2026a).
Ngākawau River NR2 ^Ω	Weekly (comprehensive suite)	Ngākawau River US of St. Patricks Stream	*Dissolved aluminium (Al), EC, pH, Dissolved zinc (Zn), Dissolved iron (Fe), Dissolved nickel (Ni), Dissolved copper (Cu), Dissolved cobalt (Co), Dissolved cadmium (Cd), Dissolved chromium (Cr), Dissolved manganese (Mn), Calcium (Ca), Magnesium (Mg), Dissolved Organic Carbon (DNPOC) for comparison of metal concentrations to bioavailability guidelines developed by Hickey (2026a)
Mangatini Stream S14B	Daily weekday	S1, MT6 and T35 Trib	Dissolved aluminium, turbidity, pH
	Weekly (basic suite plus)		EC, Dissolved Iron Ammoniacal-N, Nitrate-N
	Continuous - during LDS discharge event		pH, EC, turbidity
Mangatini Stream MGD ^ê	Weekly (basic suite plus)	NA	Dissolved aluminium
Mine Creek MC1	Weekly	GT1	Dissolved aluminium and iron, pH, EC
	Monthly (basic suite plus)	GT1	Ammoniacal N, Nitrate-N
St. Patrick S16	Weekly (basic suite plus)	S1, MT6 and T35 Trib	EC, Dissolved Iron, Ammoniacal N, Nitrate N
Twins Stream T1	Weekly (basic suite plus)	GT1	EC, pH, Dissolved Iron, Ammoniacal-N, Nitrate-N
Rudolph Stream S28U	Weekly (basic suite plus)	GT1	EC, pH, Dissolved iron, Ammoniacal-N, Nitrate-N

Granity Stream S25	Monthly (basic suite plus)	GT1	Dissolved aluminium, Dissolved Iron pH, EC, Ammoniacal-N, Nitrate-N
Miller Stream S24a	Monthly (basic suite plus)	GT1	Dissolved aluminium, Dissolved Iron, pH, EC, Ammoniacal-N, Nitrate-N
Whirlwind Stream S4	Monthly (basic suite plus)	T35 Trib or Denniston site	Dissolved aluminium, Dissolved Iron pH, EC, Ammoniacal-N, Nitrate-N, turbidity
Herbert Stream UC2	Monthly (basic suite plus)	T35 Trib or Denniston site	Dissolved aluminium, Dissolved Iron, pH, EC, Ammoniacal-N, Nitrate-N, turbidity
MT6 (Mangatini Trib., GT1 (Granity Stream), T35 Trib (T35 Stream), S1 (S1 Stream)– reference sites	Monthly (comprehensive suite)		Dissolved aluminium and iron, pH, EC, Ammoniacal-N, Nitrate-N, turbidity

Notes: (i) Ω Site NR2 is subject to seawater intrusion and backing up of Mine Creek water at tide heights > 2500mm based on the NIWA tide forecasting model. Data collected during tidal cycle periods exceeding 2500mm should be excluded (<https://tides.niwa.co.nz/>). *Comprehensive water quality suite at trace detection limits (Table 20). ¥ Assessment of water quality against freshwater guidelines is only suitable when salinity <0.5 ppt. è Site MGD is a discharge to the Mangatini Stream rather than the stream itself.

Bathurst have extracted 6-yearly forecast AI concentration values (commencing 2027) from the AMD models developed for Millerton Block (BRL 2026a) and Mangatini / St Patrick Catchment (BRL 2026b) (Exec. Summary Table 4). A subset of the water quality performance monitoring dataset should be compared against recovery trajectory / betterment reference values (BRL 2026a) to track long term progress. Quantitative betterment targets are not applied to performance reporting for any other sites or parameters.

Exec. Summary Table 4. Modelled ecological recovery trajectory / betterment reference value AI concentration forecasts for comparison with performance monitoring data. Note that these predictions are subject to change over time as further data is amassed and models refined. Comparison to future predictions over the course of the consent should be made to the most recent iteration of modelling. See Exec. Summary Figure 3 for site locations. Grey shading indicates recovering stream status.

Project Year	Calendar year (year)	Forecast annual median or 75 th percentile AI concentration (mg/L)			
		St Patrick / Mangatini Catchment – Recovery Trajectory			
		S16 Annual Median	S16 Annual 75 th ile	S14B Annual Median	S14B Annual 75 th ile
Commenced	2027	3.0	3.6	3.5	5.4
6	2032	2.8	3.4	3.5	5.4
12	2038	1.9	2.4	2.9	4.5
18	2044	1.7	2.1	2.2	3.4
24	2050	1.5	1.9	1.2	1.8
30	2056	1.3	1.6	1.0	1.5
36	2062	1.3	1.6	0.9	1.4
42	2068	1.2	1.5	0.9	1.4
48	2074	1.2	1.5	0.8	1.3
54	2080	1.2	1.4	0.8	1.2
60	2086	1.1	1.4	0.8	1.2
66	2092	1.1	1.3	0.7	1.1
72	2098	1.0	1.3	0.7	1.1
78	2104	1.0	1.2	0.7	1.0
		Millerton Block – Betterment reference values			
		T1 annual median	S25 annual median	S24A annual median	MC1 annual median
Commenced	2027*	20.0	6.5	33.6	14.2
6	2032*	19.3	6.3	32.6	13.8
12	2038	18.6	6.1	31.4	13.2
18	2044	18.0	5.9	30.2	12.8
24	2050	17.3	5.6	29.1	12.3
30	2056	16.7	5.4	28.1	11.8
36	2062	16.1	5.2	27.0	11.4
42	2068	15.5	5.0	26.0	11.0
48	2074	14.9	4.9	25.1	10.6
54	2080	14.4	4.7	24.2	10.2
60	2086	13.8	4.5	23.3	9.8
66	2092	13.3	4.3	22.4	9.5
72	2098	12.8	4.2	21.6	9.1
78	2104	12.4	4.0	20.8	8.8

* Note: Millerton Block water and AMD management strategies are not expected to meet betterment reference values during the Operational Phase – Achieving Betterment only applies from EOML (2033) onwards. It should be noted that betterment targets are subject to revision as a greater volume of data is amassed to refine predictive models.

Sediment quality sampling every 3 years is proposed within the Ngākawau River (or any other water quality recovered site) to inform ecological recovery. Monitoring format and details are provided in Exec. Summary Table 5.

Sediment metal source attribution monitoring for the Ngākawau River to determine the relative influence of the LDS sediment discharge is proposed in the event that sediment volume or quality is considered to be limiting ecological recovery. The findings of the investigation are to be reported in the Mangatini Sump Management Plan Update. All sediment metal monitoring is for performance purposes, however data will be used to inform ecological compliance at water quality recovered sites.

Exec. Summary Table 5. Sediment quality sampling regime for the Ngākawau River for performance monitoring of effects of the Low Density Sludge (LDS) high flow discharge to Mangatini River. See Exec. Summary Figure 3 for site locations.

Site details	Water quality status ^a	Reporting type	Sampling regime	Focus ^b	Assessment thresholds
Ngākawau River U/S St. Patrick Conf.	Reference	Reference	Every 3 years – 2 samples true right bank (TRB) and true left bank (TLB)	Sediment Quality - Total recoverable Co, Cu, Fe, Mn, Zn, Al, Sb, Cr, Ni, Ag, Sn, As, Cd, Pb, Hg, TI from <2mm and <63µm size fractions. Grain size distribution.	Comparison to ANZG (2018) DGV and GV-high in the context of reference state ^c and ecological data Performance reporting only
Ngākawau River NR	Recovered	Performance	Every 3 years - 2 samples TRB and TLB		

Notes: ^a See Exec. Summary Table 1 for waterway status classifications and Exec. Summary Table 6 for current status. ^bTrace level chemical analysis. ^c As per <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants>. DGV -default guideline value below which there is a low likelihood of ecological effects. GV-high (guideline value high) indicates a threshold above which there is a high likelihood of ecological effects.

Exec Summary Table 6. Ecological monitoring sites, current site status, accessibility, sampling regime, focus and reporting thresholds. Note fish monitoring occurs at water quality recovering sites that are physically accessible to fish. Macroinvertebrates to include specific methods to assess the abundance of kōura (freshwater crayfish) where present. Reference sites to be monitored at the periodicity of the impact sites for they provide context, e.g. Ngākawau River U/S St. Patrick conf. is monitored every 3 years for comparison to NR2. Sampling may occur more regularly than prescribed to suit the rates of change in water quality at each site. See Exec. Summary Figure 3 for site locations.

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
Ngākawau River U/S St. Patrick Conf.	Reference site for NR2 and St. Patrick Stream	Remote	Reference	Every three years		Macroinvertebrates, fish, periphyton, bryophytes and habitat	NA
Ngākawau River Mouth	Recovering	Routine	Performance	Every three years ^c		Macroinvertebrates, fish and habitat	Compliance reporting, no ecologically significant degradation from baseline after attribution
Ngākawau River NR	Recovered	Routine	Compliance	Every three years	Ngākawau River U/S St. Patrick	Macroinvertebrates	Compliance reporting AMD1>40, EPT >8 and comparable to reference sites or regional species pool.
						Fish	Compliance reporting Diversity and abundance comparable to reference sites or regional species pool.
						Habitat (biophysical) including sediment deposition, sediment quality.	Context
Mangatini Stream U/S Ngākawau conf.	Recovering	Remote	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat ^b	Performance reporting only
Mangatini Stream D/S/ Repo Stream	Recovering	Remote	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mangatini Stream S14B	Impacted	Routine	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mangatini Stream S14C	Impacted	Routine	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
St. Patrick Stream U/S Ngākawau conf.	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick Stream D/S Erin	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick Stream D/S T35	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick S16	Impacted	Routine	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek MC1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek S6	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek S23	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream GS1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream S25	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream S24A	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
Twins Stream T1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Twins Stream T3	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Whirlwind U/S Cypress	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
WRBBC	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
6W	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
MT6, GT1, T35 Trib, S1	Reference sites for Mangatini and Millerton	Routine	Reference	Every six years	NA	Macroinvertebrates, periphyton, bryophytes and habitat	NA
Upper Ngākawau River fish survey	Reference	Remote	Compliance	Every three years ^c	NA	Fish	Maintenance of fish passage to the headwaters. Compliance reporting for site NRB in lieu of water quality compliance at that site.
St Patrick tributaries fish survey	Reference	Remote	Performance	Every six years	Upper Ngākawau River fish survey	Fish	Establishment of fish passage to the unimpacted tributaries

Notes: ^aWater way status defined in Exec. Summary Table 1

^bFish monitoring to commence once waterway reaches recovered status at sites fish can physically access.

^c Upper Ngākawau fish survey is recommended to occur annually for the first six years of the permit due to various changes planned to water quality management in the Mine Creek and Ngākawau River catchments during that period. Thereafter, there is an option on review to shift to every three years. Ngākawau mouth ecology survey to occur annually in lieu of water quality compliance at site NRB.

Conclusions

AMD from contemporary and historic mining has affected water quality and ecology in streams draining the Stockton Mine. However, water management and treatment have demonstrably resulted in improvements in receiving waterways currently affected. Proposed water and mine management is predicted to result in ongoing improvements.

The BPCP is envisaged to not only treat AMD created by Bathurst's operations but also remove/treat a portion of historic AMD. The BPCP has been developed in alignment with the concept of subsequent Crown investment in treating remaining historic sources through the provision of substantial infrastructure and knowledge.

The BPCP is also an integral part of the Crown led (LINZ) long term Stockton Plateau AMD Management project, details released in December 2025: <https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>

The net result of granting the BPCP consents will be the enabling of improvements to water quality and ecology on the Stockton Plateau.

1. INTRODUCTION

1.1. Scope of this report

Bathurst Resources Limited (including its subsidiary companies BT Mining Ltd, Bathurst Coal Ltd, and Buller Coal Ltd) (**Bathurst**) are engaged in processes to gain permissions for the continuation of mining at the Stockton and Denniston Plateaux, collectively termed the Buller Plateaux. Concurrently Bathurst is planning for the closure and long-term rehabilitation of areas of the Stockton Mine as coal resources are exhausted. A key environmental concern associated with these operations is Acid Mine Drainage (AMD^[1]) that impacts on rivers and streams flowing from the Stockton Plateau (GHD, 2026).

A focus for Bathurst mine planning at Stockton is an 80-plus year (three generations) water quality improvement programme that is being developed and which is referenced in the recently released December 2025 Treasury AMD business case <https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>.

The 80-year period is envisaged to begin in April 2027 to align with expiry of the Stockton Coal Mining Licence. The improvement programme aims to restore mahinga kai in the streams flowing from the Stockton Plateau through the progressive remediation of water quality.

This report reviews the implications of mining and mine water rehabilitation on the aquatic ecology of the streams and rivers flowing from the Stockton Plateau. To address the topic this report consists of six components:

- Review of the history and effects of mining on Brunner Coal Measures (BCM) waterways and the aquatic ecological values of the area.
- Criteria and design considerations for the long-term monitoring of ecological recovery.
- An assessment of the current state of aquatic ecology in the context of existing water quality remediation.
- An assessment of trajectories for ecological recovery based on proposed water quality remediation and patterns in water quality improvement.
- A proposed programme of water quality and ecological monitoring designed to track the rehabilitation of rivers and streams back to suitability for mahinga kai.
- A proposed suite of water quality monitoring for compliance and performance management over the course of the proposed consent.

1.2. Mining history

A review of the history of mining at the Stockton Plateau is provided by GHD (2026) and summarised here for context. Mining began in the late 1880's, primarily conducted underground and was largely manual. Pillars were left to support the mine roof and tunnels sloped to allow drainage. There are extensive underground workings on the Stockton Plateau that continue to contribute contaminated drainage to waterways and hazards such as voids, underground fires, hot rock, heated coal and gases.

The transition to open cast mining began in 1944 under the ownership of the State Coal Mines and greatly expanded the rate of coal extraction. The aerial ropeway and coal handling facilities at Ngākawau township were subsequently constructed and underground mining ceased. Solid Energy New Zealand Ltd (then called Coal Corporation of New Zealand Ltd) took over mine tenure at Stockton in the late 1980's and again expanded operations, reaching a peak of 2,000,000 tonnes of coal per annum. In 2015, Solid Energy entered voluntary administration, and Bathurst purchased the Stockton Mine in 2017.

Coal resources at some areas of Stockton are being depleted (cease mining ~2033) and the area requires a closure and rehabilitation plan. Meanwhile, Bathurst is seeking permission to expand operations in un-exhausted areas, particularly on the Denniston Plateau and in the portions of Stockton draining to the Waimangaroa River.

1.3. Current and future environmental management

The Buller Plateaux Continuation Project (BPCP or Project) maps out the various components of Bathurst's mining interests in terms of remaining mine life, rehabilitation and closure as well as prospects for expansion (Appendix 1). The aim of the Project is to maintain a viable mining operation into the future that includes managing historic and contemporary environmental effects such as AMD in waterways, vegetation and faunal recovery.

As each area of the mine is exhausted of coal, surface capping of waste rock using weathered granite occurs to prevent water and oxygen from accessing contaminant rich material and allow subsequent re-vegetation (O'Kane, 2015). Techniques for capping of waste-rock at Stockton have evolved over time to minimise the generation of AMD. A review by O'Kane (2015) indicated a 50 % reduction in AMD production due to capping is a reasonable working assumption. Following capping the land surface is contoured to approximate the original appearance and drainage networks are re-established. Land surface rehabilitation is envisaged to continue at least 10 years after mining ceases (with final rehabilitation in 2046) and will continue to contribute to the reduction in AMD over ensuing decades.

Around both active and rehabilitated mine sites, water management aims to separate AMD contaminated from clean water. Clean water is typically directed into streams, whereas contaminated water, either from contemporary opencast or historic mines, is diverted to treatment systems prior to discharge to streams. Due to the topography and heavy rainfall, water management on the Stockton and Denniston Plateaux is complex and challenging (Davies et al., 2011; Pope et al., 2010).

Available treatment systems may be either passive or active. Passive treatment typically involves the construction of reactor beds that promote the precipitation of metals by raising the pH as waters from small, constant, seeps pass through. Passive treatments often use

waste materials rich in acid buffering capacity such as crushed mussel shells. While the systems are gravity fed and passive, once established, they require maintenance to prevent clogging and eventual replacement of substrates once exhausted.

Active treatments typically involve the installation of dosing plants that supply the required rate of acidity buffering reagent (e.g., calcium oxide (CaO) slurry) to a treatment channel, sump or stream. Provision of a settling and precipitation location, or sump, along with ongoing power, reagent and maintenance costs mean active treatment systems are a more considerable long-term investment. However, they are the only viable option for treating larger discharges with variable flows.

The current management of AMD discharging to Mangatini Stream provides an example of active treatment and water management required on the Buller Plateaux. Lime-dosing is used to raise the pH and neutralise acidity of all AMD contaminated water. All lime dosed water, other than at high flows, is diverted through sediment containment and settling ponds to allow the precipitation of metals, and finally a flocculation process is used to settle out any residual precipitates and lime before it discharges to the waterway (Lindsay et al., 2007; PCE, 2006).

Each contemporary mining area requires a bespoke solution to manage/treat AMD dependent on the status of the mine (active or closure), flow magnitude and variability, contamination characteristics and the space available. Similarly, historic underground mines and burning coal seams that contribute AMD have, or will, be addressed by remediation projects.

This report discusses case studies of various AMD affected streams, either due to contemporary or historical mining, and the efforts underway or planned to remediate those streams. Process flow diagrams for the current, end of mine life and closure phases illustrate the complexity of water management at the Stockton Mine (Appendix 1).

1.3.1. AMD longevity and decay rates

AMD is a legacy issue that requires long term management (O'Kane, 2015). On the Stockton Plateau there are twenty-four¹ AMD affected waterways requiring treatment, the majority of which are shown in Figure 1. Treatment is required until capping, rehabilitation or natural decay results in AMD contaminant levels that do not affect the health of receiving stream environments. The generation and consequent effects of AMD have been shown to decrease over time, with the trajectory typically being exponential rather than linear (O'Kane, 2015). Mack & Skousen (2008) reviewed published AMD decay rates for mines above the water table and found decay rates varying between 3.3 and 2 % per annum. Stockton specific decay estimates of 0.62 % per annum were derived by Gandy & Younger (2007), and were adopted by the then operator Solid Energy New Zealand for mine closure planning. The decay rate of 0.62 % per annum has been assumed in this assessment for prediction of water quality and ecological outcomes over time.

¹ As at 2015.

1.4. Ecological context

The Stockton Plateau has a diverse array of streams and rivers that provide habitat to fish, macroinvertebrates and aquatic plants. Streams range from small seeps to 5th order rivers and flow along bedrock, sand or boulder/cobble dominated channels. Rainfall over 4 m per annum is common at the Millerton township, rising to 5-6 m in the headwaters of the Mangatini and St. Patrick streams. Due to the distinct topography and climate, stream ecological communities are adapted to regular elevated flows. On the plateau summit, woody vegetation is sparse, and is restricted to larger gullies, however on the flanks of the plateau, dense podocarp, broadleaf and beech forest occurs down to sea level.

Aquatic communities of plants, macroinvertebrates and fish are adapted to the characteristics of the various streams and the species' ability to colonise and persist within them. In particular, the occurrence of migratory fish in BCM streams is largely driven by the gradient (steepness) of the streams, and the physical obstacles to migration created by the terrain (Gray, 2024; Harding et al., 2006; McDowall, 1998).

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

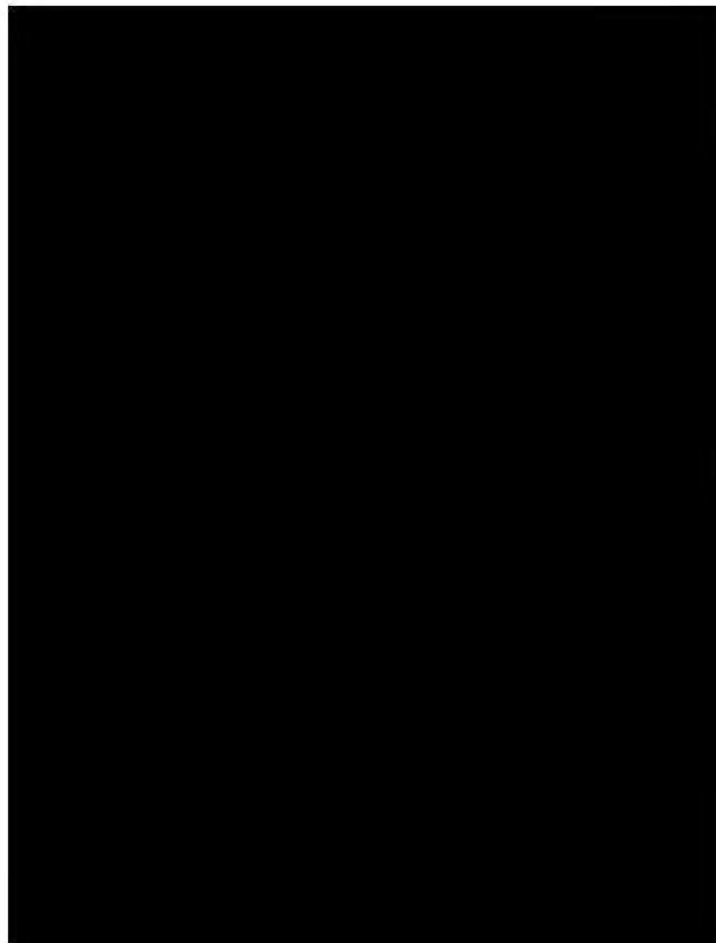


Figure 2. [REDACTED]
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Notably absent from the majority of BCM streams, other than in the lower reaches at low elevation, are introduced salmonids. These predatory species, particularly the brown trout, (*Salmo trutta*), have fundamental effects on native aquatic ecosystems and suppress a number of native species (McIntosh, 2000; McIntosh et al., 2010; Townsend & Cowl, 1991). Brown trout have been observed to be excluded from West Coast streams that have a pH <6, suggesting that to some degree naturally acidic streams may form a refuge for native fish and macroinvertebrates from trout (Olsson et al., 2006). There are two historic records of trout in the headwaters of Waimangaroa River, at, or about, Cedar Creek, from 1986 and 1995. It is uncertain if this population persists and fish are generally considered to be absent from the Denniston plateau due to the steepness of rivers and streams (Watson, Rose, et al., 2024).

1.5. Summary

A long history of underground and subsequent opencast mining at the Buller Plateaux has left a legacy of AMD impacted waterways. These waterways are currently fed by a patchwork of active mining, mine rehabilitation, clean water diversions, treatment systems and underground mine discharges. Irrespective of specific decay rates, O'Kane (2015) suggests that while natural decay, capping and rehabilitation will reduce AMD, acidity loads to waterways may remain elevated for many years in the absence of treatment. This context informs ongoing mine expansion, rehabilitation and closure planning. The ecological values of unimpacted BCM and adjacent streams are high and have characteristics unique to the area.

2. ECOLOGICAL EFFECTS OF ACID MINE DRAINAGE

2.1. Introduction

The impacts of AMD on aquatic ecology have been occurring since the onset of mining on the Buller Plateaux and have expanded to affect more streams as the area of exposed rock increases. The primary effect of coal mining is the acidification of water and subsequent mobilisation of metals (Harding & Boothroyd, 2004). Coal deposits on the Buller Plateaux occur within a formation known as 'Brunner Coal Measures' (BCM). These coal seams and surrounding rocks are relatively high in sulphur and metals (e.g. iron, aluminium). Exposure to oxygen and water results in oxidation of pyritic materials and acidic conditions. Sulphuric acid in the water subsequently dissolves any metals present which may become bioavailable in downstream environments (Greig et al., 2010; Harding & Boothroyd, 2004). The resultant AMD typically consists of elevated dissolved metals and low pH which have implications for the water quality and ecology of receiving environments (Gray & Harding, 2012; Greig et al., 2010; Harding & Boothroyd, 2004; Hogsden & Harding, 2012). On the Buller plateaux AMD affected pH has been recorded as low as 2.6, although pH as low as 3.4 has been recorded in unimpacted waterways due to natural organic and non-organic acids (pristine reference site MT6 between 2010-2025 – Median 4.4, Min 3.4, max 5.3). Dissolved aluminium and iron may reach in excess of 150 mg/L in impacted streams, compared with a maximum of 0.3 mg/L in pristine streams.

Elevated turbidity in streams draining active mines may occur due to accidental discharges of coal fines, road and excavation works or treatment systems (Harding & Boothroyd, 2004; Hore, 2024) or soil erosion from disturbed areas.

As waters move further away from the source of AMD, they become less acidic due to dilution from tributaries and buffering processes within the stream. As pH increases, metals fall out of solution and form precipitates in the water column or on the stream bed, e.g., iron at pH >3.5; aluminium at pH 4.2–4.8 (Barnden, 2005; Harding & Boothroyd, 2004; Hogsden & Harding, 2012). These precipitates may reduce water clarity or form obvious coloured layers over stream substrate and affect the quality of habitat for stream flora and fauna despite being an indication of improved water quality.

2.2. Ecological effects

2.2.1. Introduction

The aquatic ecological effects of AMD and associated turbidity and precipitates have been well studied both overseas and in New Zealand. There is a substantial body of literature on AMD impacts generally, as well as Brunner Coal Measures AMD specifically. Early surveys of the water quality and ecology of coal mining impacted streams were undertaken by Winterbourn (1998) and Collier et al. (1990) who observed a degree of tolerance to low pH amongst macroinvertebrate fauna derived from an adaptation to naturally acidic water. This context meant that conventional approaches to assessing stream health were not suitable for AMD affected streams and spurred a concerted effort to understand New Zealand specific responses of stream ecosystems to AMD (Greig et al., 2010; Hogsden & Harding, 2012).

Stream foodwebs have three interdependent levels typically considered by ecologists; the base level which consists of biofilms (primary producers e.g., bacteria, fungi and algae), the primary and secondary consumers (macroinvertebrates) and the tertiary consumers (e.g., fish). Each component of the stream ecosystem can be affected by AMD. A thorough review of those effects is provided by Hogsden & Harding (2012) and summarised here for context.

2.2.2. Macroinvertebrates

Macroinvertebrate species richness, diversity and abundance are frequently reduced in AMD streams relative to their unimpacted counterparts. Affected communities tend to be dominated by tolerant taxa or in extreme cases may be devoid of all but the occasional individual (Gray & Harding, 2012; Winterbourn, 1998). Stress and mortality can result from compromised regulation of ions and metabolically active metals in addition to the indirect effects of altered resource and habitat availability (Hogsden & Harding, 2012). Precipitates may directly impact macroinvertebrates due to clogging of the gills, however experimental studies suggest that water chemistry and toxicity have a greater impact than precipitates or habitat and resource availability (DeNicola & Stapleton, 2001).

However, macroinvertebrate community responses to AMD are often complex and can vary considerably between sites. Variation in species and locality-specific tolerance to acidity and metals means that communities dominated by different taxa, or from different regions of the country, may respond differently to AMD contamination. Gray & Harding (2012) analysed water quality and macroinvertebrate data from 91 sites on the West Coast of the South Island and found a stronger relationship between macroinvertebrates and metals than pH. The authors considered that this may be due to an adaptation by the macroinvertebrate taxa to naturally acidic streams and low pH.

Macroinvertebrate communities on the West Coast of the South Island are naturally adapted to low pH which appears to convey some resilience to AMD or at least low pH (Collier et al., 1990). AMD streams draining the Brunner Coal Measures (BCM) are dominated by taxa conventionally considered to be tolerant of pollution, such as Chironomidae larvae, other Diptera and worms. However, these streams also contain other taxa that are often used as indicators of unimpacted streams including a number of mayflies, stoneflies and caddisflies (Collier et al., 1990; Gray & Harding, 2012; Hickey & Clements, 1998). This situation creates uncertainty over the applicability of more generic broad scale approaches to setting thresholds for water quality and ecology for the management of AMD streams.

2.2.3. Biofilms and algae

Biofilms and algae tend to show strong responses to AMD gradients, with the typically diverse communities of acid- and metal-sensitive species replaced by fewer, more tolerant taxa. Precipitates of metal hydroxides, an indirect effect of changes in pH, have also been observed to result in a lower species richness as they tend to occupy colonisation sites and smother algae reducing light availability (Figure 4). Algal biomass of tolerant taxa, freed from competition with other algae and grazing by macroinvertebrates, may be very high given the conducive conditions of ample light and stable flow (Hogsden & Harding, 2012). However, precipitates have also been observed to result in low algal biomass. Microbial communities of fungi and bacteria are typically lower in the number of species and their biomass in AMD streams, although unique assemblages of extremophiles (species that thrive in extremes conditions) have been recorded in some AMD streams. While pH and metal concentrations

are likely to have a strong influence on microbial communities, precipitates have been recorded as the key driver. Shifts in microbial activity can influence the rate at which organic matter (leaves and wood) is broken down. Since both decaying organic matter and algae form the base food resource for macroinvertebrates, AMD impacts at this level are transferred upward through the food web.



Figure 4. Dilution of water with low pH and elevated dissolved aluminium results in an increase in pH and rapid precipitation of aluminium onto stream substrates (Image by Liv Hore).

2.2.4. Fish

Fish richness and abundance is generally low in streams affected by AMD. Fish are typically absent from streams with pH values of <5, although on the West Coast of the South Island they may persist down to a pH of 4.5 (Greig et al., 2010; Jellyman & Harding, 2014). Overseas studies have found that pH overwhelmingly accounted for variation in species richness and abundance in fish assemblages, however, in the naturally acidic streams of the West Coast of the South Island Greig (2010) found that dissolved metals had the strongest impact on fish, and that pH tended to be a poor predictor. Nonetheless, as pH declines and dissolved metals increase, associated impacts can intensify, eventually exceeding the tolerance of organisms. Similar to macroinvertebrates, fish taxa can be affected by direct toxicity of pH and metals, accumulation of precipitates on gills, stream bed degradation, reduced egg viability, decreased food resources and metal contaminated diet (Hogsden & Harding, 2012). Of particular relevance to downstream reaches of recovering BCM streams is the precipitation of aluminium hydroxides which occurs between pH 4.2-4.8. While fish are potentially able to tolerate pH at that level, the resultant aluminium precipitation on their gills is likely to be highly detrimental. This extends the effect of AMD further downstream than the direct toxicity due to dissolved metals.

An additional effect on fish relates to the migratory lifestyle of a significant proportion of the New Zealand fish fauna (Hore, 2024; McDowall, 1998). Diadromous species make the journey between freshwater and the ocean to complete their lifecycle. Aside from direct toxicity or indirect resource and habitat effects within an affected stream, fish may be discouraged from entering a stream or river due to the chemical cues in the water (Atland 1998). Gray et al. (2016) found that an AMD discharge into the Ngākawau River had historically created a chemical barrier to migration, [REDACTED]

2.3. Summary

AMD fundamentally alters the water quality of receiving streams. Low pH and elevated dissolved metals are sometimes also accompanied by elevated suspended fine sediments. These conditions may result in direct toxicity to flora and fauna, but also degradation of habitat and food resources and interruption of behavioural patterns. Under high levels of AMD contamination, streams are typically devoid of life other than extremophile bacteria and algae. However, ecological communities in waterways with lesser degrees of contamination show complex responses. Those responses, particularly among fish and macroinvertebrates, are tempered by locally specific background, natural conditions, that among BCM streams, equate to a tolerance to low pH and the occurrence of toxicity modifying factors. Accordingly, there is uncertainty around the use of more generic, broadly applicable approaches to assessing impacts or recovery of BCM streams from the effects of AMD. Rehabilitation of streams affected by AMD requires a consideration of all levels of the ecosystem in particular the base level that provides food resources to high levels. However, aquatic macroinvertebrates are a useful measure of overall ecosystem condition.

2.4. Measures of effect

2.4.1. Introduction

A substantial body of work exists to support the assessment of AMD effects and the setting of thresholds for remediation and consenting. These assessments may be approached from either of two perspectives, setting targets or limits for water quality of AMD streams, or using biological monitoring.

This section of the report discusses both options. In terms of water quality, we focus on pH and dissolved aluminium as these are considered to be useful proxies for the ecological effects of AMD in BCM streams. It is important to note that other metals in water will also be present and have ecological effects.

2.4.2. Water quality thresholds

Waters & Webster-Brown (2013) investigated the composition and speciation of dissolved aluminium in BCM streams, as dissolved aluminium (Al) varies in composition depending on

pH. The most toxic aluminium form is Al^{3+} and at Stockton, Al^{3+} varied between 0.2 and 85 % of dissolved Al. Al^{3+} tended to be more dominant in waters where pH was between 3.8 – 4.8. At lower pH, Al^{3+} was bound into aluminium-sulphate complexes, while at pH >4.8 -organic and -hydroxide complexes dominated. By calculating the proportion of dissolved Al^{3+} in water the authors identified an upper threshold of 0.42 mg/L Al^{3+} above which macroinvertebrate taxa declined rapidly based on field surveys (Waters & Webster-Brown, 2013).

Dissolved aluminium (as reported / measured by analytical laboratories) may also contain non-toxic colloidal clays in the size range 0.1-0.45 μm that pass through 0.45 μm filter, and organic bound aluminium. Neither of these species contribute to the bioavailable toxic fraction.

The toxicity of aluminium is also subject to various modifying factors. Toxicity increases with acidity (lower pH) and is greatest in the range pH 4.4 to 5.5 (ANZG, 2018), but much reduced at neutral solutions (pH~7). Bioavailability and toxicity of aluminium is reduced by binding to dissolved organic carbon compounds such as humic or fulvic acids. Elevated dissolved organic carbon will act to reduce the toxic effects of aluminium. Higher temperature and increasing water hardness may increase toxicity of aluminium (ANZG, 2018). In BCM streams, dissolved aluminium, pH, dissolved organic carbon, temperature and hardness are likely to vary significantly with flow, meaning that over time the concentration, bioavailability and toxic effects of aluminium will be variable and complex (Hickey, 2026a).

Aluminium speciation, binding and toxicity within solution in AMD is complex, however of note is that comparisons of dissolved aluminium to national and international guidelines will typically be a conservative assessment as only a proportion of dissolved aluminium is in the most toxic Al^{3+} form.

In New Zealand and Australia, initial considerations of suitable levels of water quality involve comparisons to the ANZG (2018) or similar toxicity guidelines. The ANZG (2018) default, and the Canadian Environmental Water Quality Guidelines (CEWQG) values for toxicants are used as management tools to inform the likely risks to aquatic ecosystems from chemical contamination. A number of contaminants also feature toxicity modification factors (TMF's) based on water characteristics such as pH, hardness or dissolved organic carbon. The guidelines are intended as screening tools in environmental risk assessments and help guide water quality management decisions. While not regulatory limits, unless incorporated into or referred to by a statutory document, they inform actions to reduce the likelihood of ecological harm.

ANZG (2018) provides a guideline for aluminium, among other contaminants, which is a key metal in BCM streams (Table 1). The ANZG (2018) guideline for streams with a pH >6.5 is considered to have moderate reliability, whereas reliability of the <6.5 pH guideline is low. The Canadian water quality guideline (CCME 2021) value for pH <6.5 shown in Table 1 is highly conservative, but has been updated with a spreadsheet that allows for pH, hardness and dissolved organic carbon modifying factors to be accounted for. Unfortunately, the lower limit for pH is 6, meaning the approach is not suitable for naturally acidic BCM streams.

Of note in Table 1 is the discrepancy between (non TMF adjusted) ANZG (2018) and CEWQG values for aluminium toxicity when compared to background conditions in the BCM reference site MT6 (a tributary of Mangatini Stream, Figure 1). When compared to the non-adjusted guidelines, the levels found at the reference site would suggest low levels of protection to aquatic biota, despite BCM streams with suitable habitat supporting highly diverse ecological communities. Similarly, TMF adjusted 95th % thresholds (CCME 2021) at the limit of the pH range are below the median value for the reference site MT6 although the strong influence of elevated DOC on bioavailability is apparent. This provides additional rationale for the need for local, site-specific guidance for these systems.

Table 1: Currently available contaminant toxicity guidelines with and without toxicity modificatory factor adjustment.

Contaminant	Aluminium mg/L (ANZG) <6.5 pH ¹	Aluminium mg/L (ANZG) >6.5 pH	Aluminium mg/L (CEWQG) ² <6.5 pH	TMF adjusted Aluminium mg/L (CCME 2021) ³
Level of protection				95% Protection
99 %		0.027		pH 6, hardness 10, DOC 0.5 = 0.018 Al mg/L
95 %		0.055		pH 6.5, hardness 10, DOC 3.5 = 0.12 mg/L
90 %		0.08		
80 %		0.15		
Unknown	0.0008		0.005	
BCM reference (MT6)	Dissolved aluminium 0.24 ⁴ (0.0002-0.452, n= 26) pH 4.4 (3.4-5.3, n= 26)			
Notes: 1. https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/aluminium-2000 2. Canadian Environmental Water Quality Guidelines 3. CCREM (Canadian Council of Resource and Environment Ministers). 1987. Canadian Water Quality Guidelines. Ottawa, Ontario. 4. Median (range, n=) derived from the full data set at reference site MT6 (2002-2025)				

An additional source of uncertainty in the ANZG (2018) or other guidelines is that they are derived from global toxicity data sets from a range of natural background water chemistry. As such, the applicability of results to naturally acidic streams and adapted biota is uncertain.

In acknowledgement of the general uncertainty around dissolved aluminium guidelines, the ANZG (2018) allows site specific information to be incorporated into the development of thresholds. Local species toxicity data may be used to inform effects and toxicity testing of kōura (freshwater crayfish) and the mayfly *Deleatidium* sp. has been undertaken to inform the BPCP. A complementary method is the use of field studies across a gradient of contamination to determine relationships between fauna, flora and water quality.

Another important consideration when applying ANZG (2018) or CEWQG toxicity thresholds on the Buller Plateaux is historical context. While ANZG (2018) provides guidance for setting values to protect 99 to 80 % of stream biota, many BCM streams are currently severely impacted or devoid of biota, requiring an approach to managing ecological recovery as opposed to an approach for protection.

2.4.3. Biological monitoring

Biomonitoring approaches use characteristics of flora or fauna, typically fish, macroinvertebrates or aquatic plants to determine stream health and assess the effects of

altered conditions such as water quality. The approach requires an initial understanding of the relationships between the stressor, e.g. water quality, and the biota, but thereafter may rely on biota alone. Biomonitoring is appealing because occupants of the stream integrate water quality effects over time, whereas multiple years of water quality samples may be required to adequately characterise conditions. Monitoring relies upon patterns in the biota rather than water quality to infer effects.

In the case of the BCM streams, both standard ecological and water quality approaches are difficult due to the differences in observed tolerance of taxa to pH and metals. National water quality and ecological assessment criteria frameworks do not appear to provide a suitable fit for BCM streams. However, several studies have addressed the topic of BCM (or West Coast) stream biota tolerance to AMD and provide information that can be used to inform thresholds and levels of effect (Gray & Harding, 2012; Greig et al., 2010; Jellyman & Harding, 2014; Waters & Webster-Brown, 2013).

Fish are often used as indicator species in streams and rivers, although the generally low diversity of species and overriding influence of diadromy in New Zealand complicates their use as a measure of ecosystem health (Joy & Death, 2004; McDowall, 1998). Greig et al. (2010) analysed fish communities, water quality and habitat from 42 streams on the West Coast of the South Island, including BCM streams. Sites spanned both natural and anthropogenically influenced acidic streams across a gradient of metal concentrations. Marked differences in pH and metal tolerance was observed across 15 species of fish.

The strongest predictor of fish communities however, appeared to be the concentrations of metals rather than pH. Fish were absent from streams with a combined dissolved metal concentration of >2.75 mg/L, with nine of the 15 taxa being limited by concentrations greater than 1 mg/L. Greig et al. (2010) suggested that suitable water quality targets for fish would be pH >4.5 and dissolved Al and Fe of <1.0 mg/L each.

Gray & Harding (2012) analysed macroinvertebrate and water quality data from 91 sites on the West Coast (60 from BCM streams) to determine taxa specific tolerance to AMD for the calculation of an Acid Mine Drainage Index (AMD_I). This index is specific to AMD impacted streams on the West Coast of the South Island. A drawback to the index is its use of a richness multiplier. The number of species, or richness, is strong predictor of AMD impacts and was used to control for the effect of occasional, 'stray' sensitive taxa biasing the index. However, richness may be low in streams for reasons other than AMD, such as homogenous, low-quality habitat or disturbance by flooding, and streams therefore may be mis-assigned as AMD impacted. Nonetheless, the index and relationships derived during its development provide useful insight into species specific tolerance to AMD. The AMD_I provides threshold scores for degrees of impact; <20 severely impacted, 20-40 impacted, >40 unimpacted (Gray & Harding 2012).

2.5. Macroinvertebrate thresholds for BCM streams

In a stream, a zone of water quality exists between the point where recovery or recolonisation of biota begins, and the onset of effects on an otherwise healthy community (Figure 5). From the perspective of an already impaired BCM stream, the 'recovery/stress zone' is assumed to be a range of contaminant concentrations between the point where a particular taxon (*a* or *b*) cannot persist, or the species exclusion line (*z*), and that taxa's optimal conditions (left of the

species optimum line, y). ANZG (2018) guidelines for 95 or 99 % species protection or local reference conditions likely represent optimal or near optimal conditions, which may be distant from the current conditions for many BCM streams. Using a point inside the recovery zone, left of the species exclusion line provides a more realistic target for water quality management in highly impacted BCM streams. As streams progress towards recovery, a more nuanced assessment of suitable criteria, involving a wider suite of metals to achieve outcomes, can be considered.

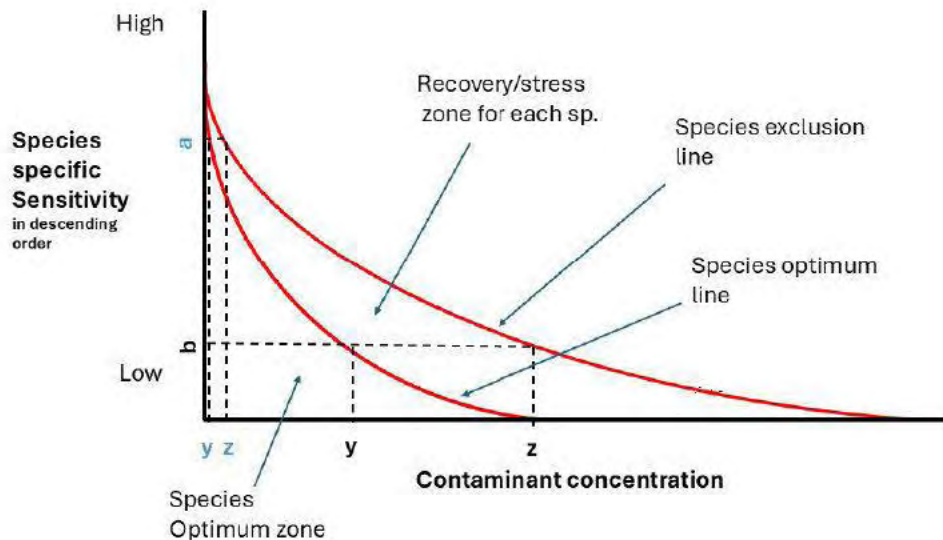


Figure 5. Conceptual diagram illustrating the recovery/stress zone for taxa of varying sensitivity.

Greig et al. (2010a) provided suitable thresholds for the recovery zone of fish communities in AMD affected BCM streams. Greig et al. (2010) suggested a combined dissolved metals concentration of <2.5 mg/L and individual concentrations of dissolved Al and Fe of < 1 mg/L and Zn <0.01 mg/L. Similarly, Cavanagh et al. (2015) suggested that combined dissolved metals concentrations of <2 mg/L when combined with a pH of 4-6 would result in only a moderate impact to ecology. However, the authors are not aware of a formal analysis that has been undertaken for macroinvertebrates other than the work of Waters & Webster-Brown (2013) that provided a threshold for Al^{3+} of 0.42 mg/L within Stockton Streams. Unfortunately, data for Al^{3+} in Stockton streams is very sparse.

The detection of thresholds or change points in ecological data has a rich history with much debate over appropriate methods. As such we opted to take a 'multiple sources of evidence' approach to this assessment. Three different methods have been applied to inform recovery thresholds for BCM streams:

1. Bivariate change point analysis based on biotic indices.
2. Species specific distributions assessment using the AMDI, and
3. Threshold Indicator Taxa Analysis (TITAN).

To investigate thresholds in change in macroinvertebrate communities relative to water quality we compiled all the available data collected over the last 25 years for BCM streams (Table 2 and Figure 6). In Figure 6, monitoring sites are colour coded by AMDI impact class for the most recent sample collected (Gray & Harding, 2012; Table 12).

A total of 292 macroinvertebrate sample results were available for the current assessment. Some sites were visited repeatedly, whereas others only once. Due to the macroinvertebrate data being collected using a variety of different methods, the data set was reduced to presence /absence to remove the impact of variable methodology on the results. In addition, each data set was processed to a different level of taxonomic resolution. To standardise comparisons, the data was resolved to the taxa used for the calculation of the AMDI because that list was assumed to contain adequate information to determine thresholds (Gray & Harding, 2012).

Table 2: Macroinvertebrate and water quality data sources for BCM Streams.

Year	Source	No. samples	Notes
2003-2007	Gray & Harding, (2012)	60	Single extensive kick net
2010	Blakely, (2010)	12	Single extensive kick net
2008	Kitto, (2009); Kitto et al., (2015)	36	3 surber samples (0.04 m ² ; 500 µm mesh)
2009	Hogsden, (2013)	9	3 surber samples (0.04 m ² ; 500 µm mesh)
2013 - 2025	SENZ/BT/Bathurst Resources	116	Various methods. Consent and investigation monitoring
2020	Hogsden et al., (2020)	14	5 composite kick net samples (net 0.3 × 0.3 × 0.3 m with 250 µm mesh)
2024	Watson et al., (2024)	9	5 composite kick net samples (net 0.3 × 0.3 × 0.3 m with 250 µm mesh)
2024	Watson et al., (2024)	16	5 composite kick net samples (net 0.3 × 0.3 × 0.3 m with 250 µm mesh)
2025	Rose & Watson, (2025)	9	5 composite kick net samples (net 0.3 × 0.3 × 0.3 m with 250 µm mesh)
2025	Hogsden et al., (2025)	11	5 composite kick net samples (net 0.3 × 0.3 × 0.3 m with 250 µm mesh)
Total		292	

Water quality data was converted to mg/L, and values less than the laboratory detection limit were halved. Only pH and dissolved aluminium were universally available, with other metal concentrations being available for a much lower number of the sites/occasions. Habitat data was available with some data sets but was not comparable across the overall data array.

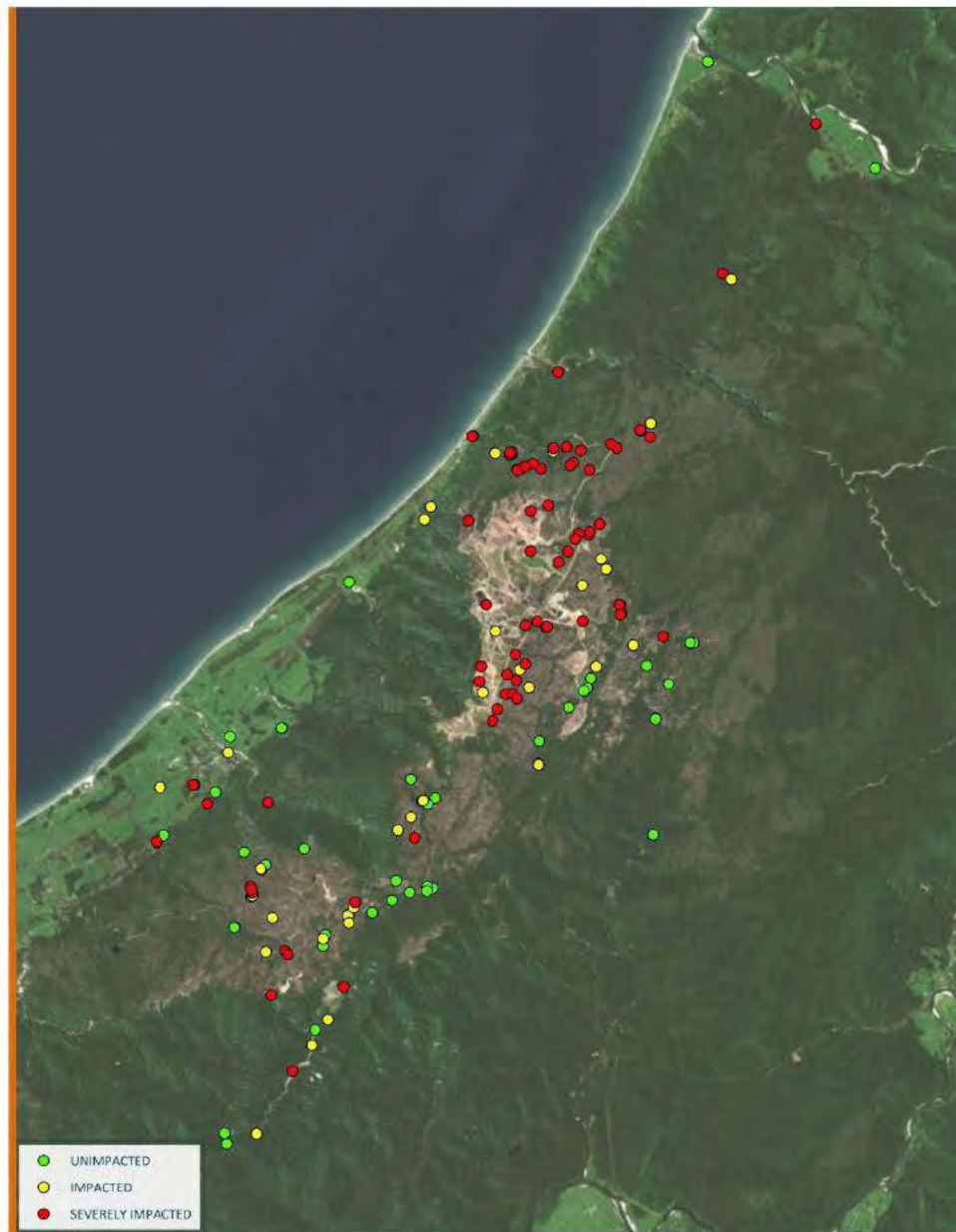


Figure 6. Locations of sites collated for macroinvertebrates and water quality across the Stockton and Denniston Plateaux. AMDI impact classifications are shown in Table 12

Sites with zero taxa, and taxa that occurred fewer than three times were removed from the analyses. Only sites with both pH and dissolved aluminium were retained to ensure a valid comparison between the pH and aluminium results across the whole data set was possible. The remaining data set had 57 macroinvertebrate species across 217 sites/occasions, with matching water chemistry data (Table 3). The pH ranged from 2.5 to 8.1, the latter figure being collected in a water treatment site subject to lime dosing, while dissolved aluminium had a minimum of 0.01 mg/L and maximum of 159 mg/L.

Table 3: Water quality summary statistics for 217 sites/occasions with matching macroinvertebrate data.

Variable	pH	Dissolved Aluminium (mg/L)
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Aluminium concentrations were log-transformed prior to analysis to assist visualisation. Separate GAMs were fitted for each index against both log(AI) and pH. Ninety five percent confidence intervals were derived from the model standard errors. Model fit was assessed using adjusted R^2 , and the significance of smooth terms (p-values), which were computed using approximate F-tests. A significant smooth term ($p < 0.05$) indicated a statistically significant non-linear relationship between predictors and response variables. All analyses and visualisations were conducted in R (Vers. 4.5.1) using ggplot2 for graphical output.

For the AMDI model, pH and log(AI) values corresponding to benchmark AMDI thresholds (20 and 40; Gray & Harding, 2012) were identified from the fitted curves.

All models resulted in highly significant relationships ($p < 0.001$), but there were differences in the proportion of variance explained (Table 5). The greatest amount of variation explained (R-sq.) was between AMDI and both pH and dissolved aluminium. In contrast the lowest degree of explanatory power was between MCI and pH. Other relationships, MCI and dissolved aluminium and all other indices against pH and aluminium, reported a relatively intermediate level of explanatory power based on adjusted R-sq. Aquatic macroinvertebrate indices universally increased with greater pH, and declined with greater dissolved aluminium (Figure 7 - Figure 10).

Table 5: Generalised additive model (GAM) diagnostics. P values are the significance of smooth terms. Adj. R^2 is the proportion of variance explained by the smooth terms.

Variable	pH	Dissolved Aluminium (mg/L)
AMDI	$p < 0.001$, R-sq.(adj) = 0.57	$p < 0.001$, R-sq.(adj) = 0.57
MCI	$p < 0.001$, R-sq.(adj) = 0.38	$p < 0.001$, R-sq.(adj) = 0.45
EPT	$p < 0.001$, R-sq.(adj) = 0.46	$p < 0.001$, R-sq.(adj) = 0.43
Richness	$p < 0.001$, R-sq.(adj) = 0.48	$p < 0.001$, R-sq.(adj) = 0.43
Indicators	$p < 0.001$, R-sq.(adj) = 0.49	$p < 0.001$, R-sq.(adj) = 0.43

The aluminium data set includes a number of very high concentrations (max 159 mg/L), that surprisingly had macroinvertebrate taxa present. It is possible that in some cases these taxa were represented by individuals that drifted downstream into effected reaches. Because the aluminium data has been log transformed and subsequently approximates a linear relationship with the macroinvertebrate indices, we can assume that the actual response of indices to aluminium is logarithmic. Changes in indices will occur rapidly at the extreme left of the plots (Figure 7 and Figure 9).

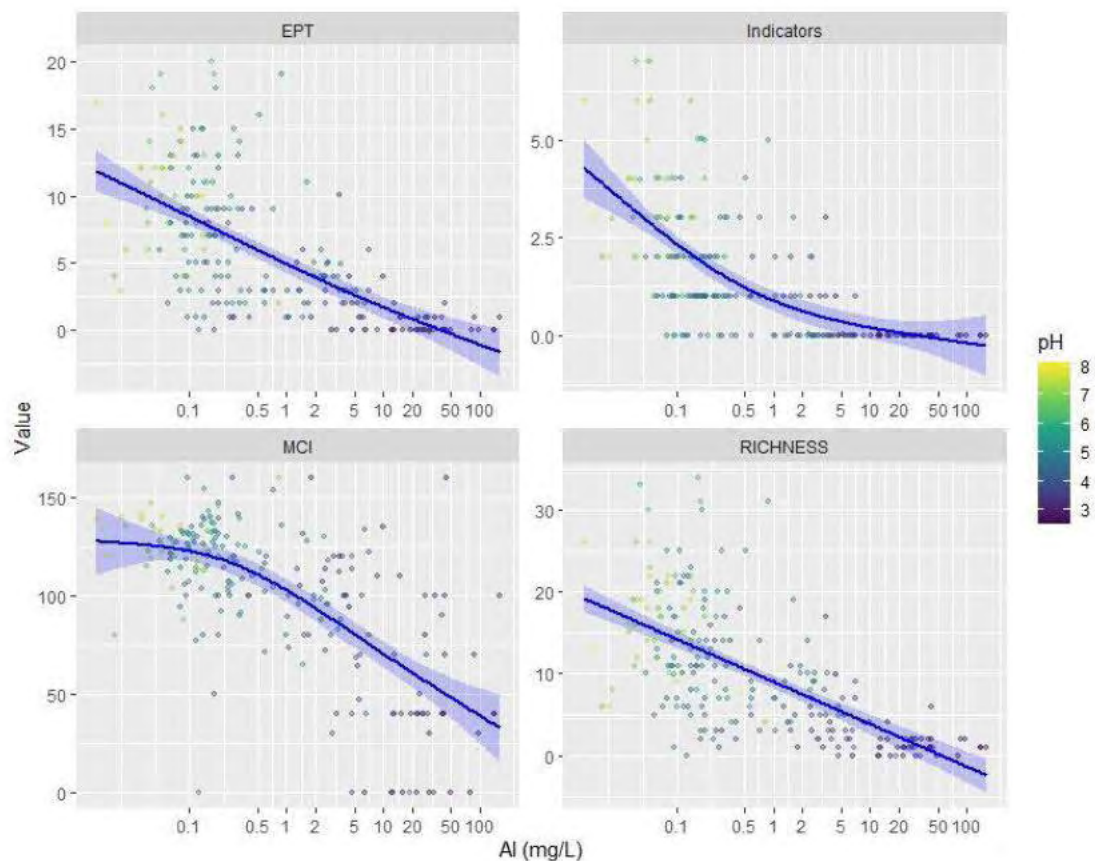


Figure 7. Relationships between biotic indices and log dissolved aluminium. GAM lines are fit with a 95% confidence interval ribbon. Corresponding pH values are shown by the colour ramp.

The indicators indices shows a closely linear relationship with pH, however, EPT, MCI, Richness and AMDI show a steeper, positive response at low levels of pH, with a flattening of the curve at above 5 or 6 (Figure 8). This result indicates that above a threshold point, the macroinvertebrate community is insensitive to changes in pH, while below that point pH has a stronger regulatory effect.

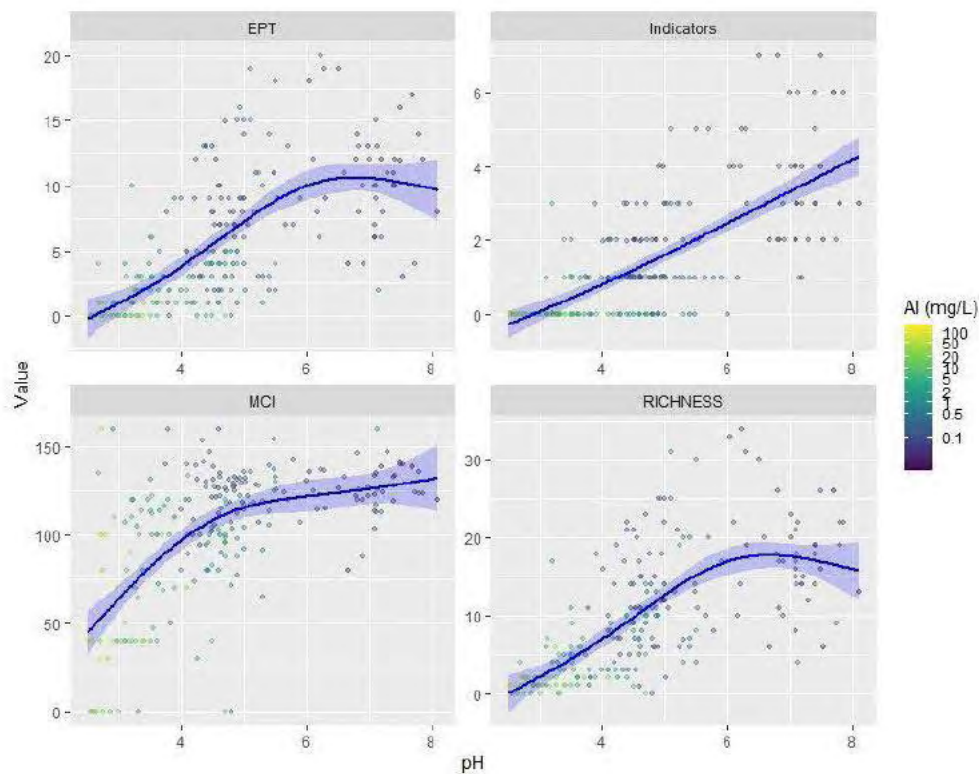


Figure 8. Relationships between biotic indices and pH. GAM lines are fit with a 95% confidence interval ribbon. Corresponding dissolved aluminium values are shown by the colour ramp.

While each index/water quality parameter contrast shows a significant GAM relationship, the AMDI relationships had the greatest explanatory power (Figure 9). The AMDI was developed specifically to detect the effects of AMD on stream macroinvertebrates and was built from data used, in part, in these analyses. Both the AMDI and MCI have associated thresholds for categories of water quality or impact (Gray & Harding, 2012; Stark & Maxted, 2004, 2007), however only the AMDI was designed specifically for effects associated with AMD. The MCI showed a lesser degree of explanatory power and has known drawbacks when applied in AMD streams, most likely due to this indicator being designed to demonstrate the impacts of organic pollution on macroinvertebrate communities.

Accordingly, the AMDI thresholds for impacted (>20) and unimpacted (>40) were used to determine water quality criteria for the recovery zone of streams effected by AMD. Dissolved aluminium concentrations indicative of a recovering stream (corresponding to AMDI scores of between 20 and 40) were shown to be 2.5 to 0.2 mg/L (Figure 9). The corresponding results for pH were 3.8 and 5.1 (Figure 10).

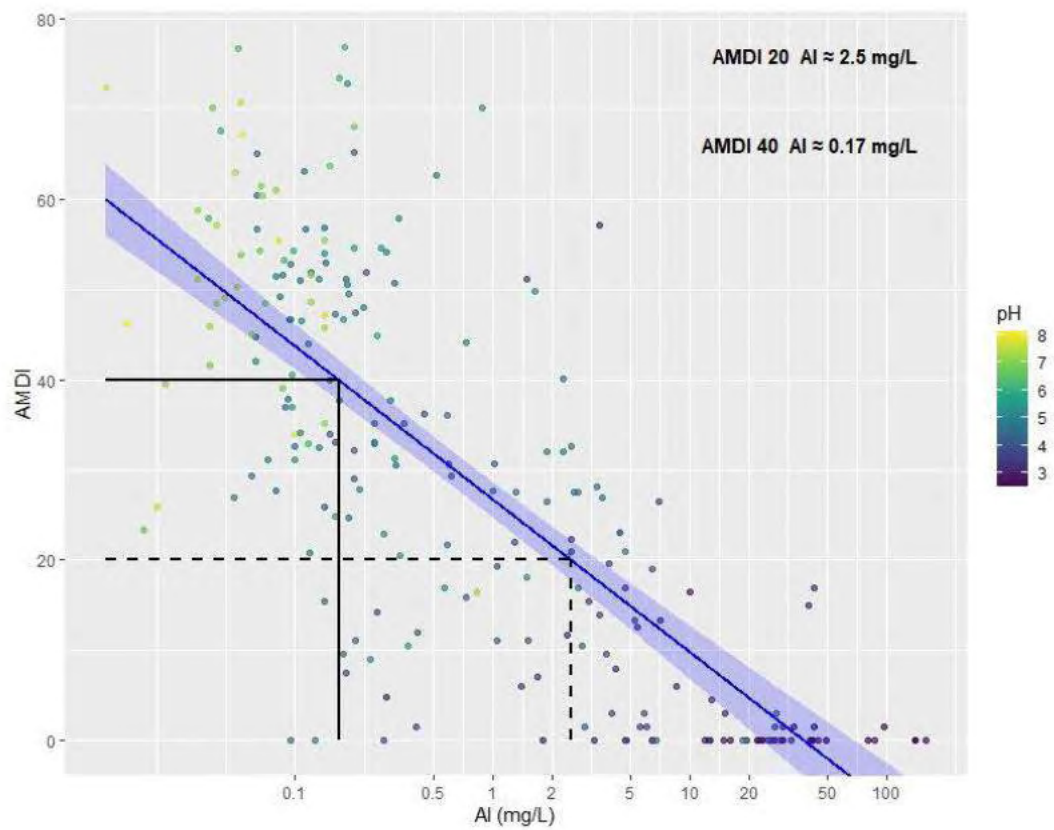


Figure 9. Relationship between AMDI indices and log dissolved aluminium. GAM lines are fit with a 95% confidence interval ribbon. Corresponding pH values are shown by the colour ramp.

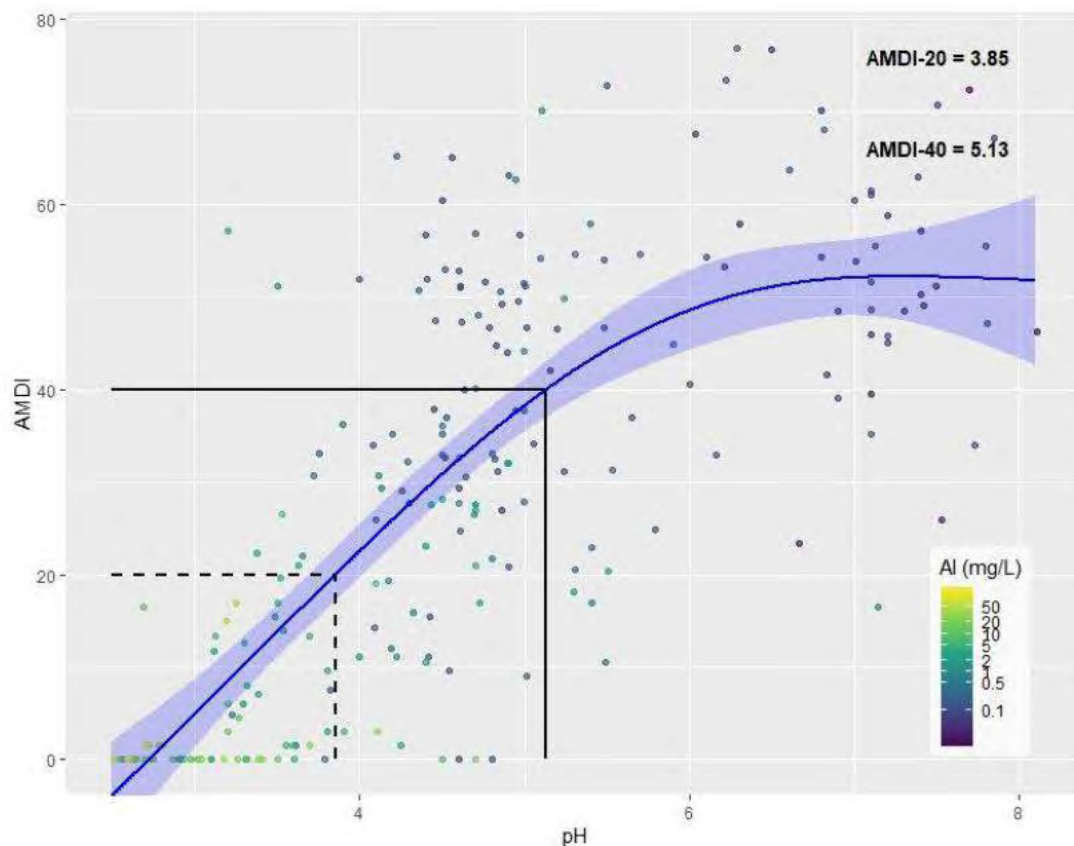


Figure 10. Relationships between the AMDI biotic index and pH. GAM lines are fit with a 95% confidence interval ribbon.

2.5.2. Taxa specific tolerance

In order to determine taxa specific distributions across gradients of pH and dissolved aluminium, boxplots of the associated water quality value from each taxa occurrence were created (Figure 11 and Figure 12). In these figures the green line shows the 10th (pH) or 90th (dissolved aluminium) percentile and species are ordered based on that figure. The horizontal dashed lines show the cumulative AMDI scores, calculated from the bottom of the plot, that correspond to the thresholds between 'severely impacted', 'impacted' and 'unimpacted' (Gray & Harding, 2012). Vertical black lines denote the pH that corresponds with the transition between AMDI categories. Numerals adjacent to the taxa names indicate the cumulative AMDI score with the inclusion of that taxa. Boxplots show the median, quartiles, outliers and whiskers according to Tukey's method.

Due to the potential when using presence absence data for occasional stray taxa to occur in an otherwise unsuitable site, the 90th (or 10th for pH) percentile of data for each taxa was calculated, and that figure assumed to represent a reasonable approximation of the species exclusion line as shown in Figure 5. The median value was similarly assumed to represent the species optimum line (specific to AMD streams) shown in Figure 5. Taxa boxplots were ordered according to the 90th (or 10th) percentile and the percentiles highlighted on the plots with a line. The cumulative AMDI score was calculated beginning with the taxa most tolerant to either pH or dissolved aluminium. The intersection between the thresholds in cumulative AMDI score pertaining to 'severely impacted', 'impacted' and 'unimpacted' and the species exclusion line were used to determine the water quality threshold for each parameter.

Taxa order based on the 10th percentile for pH indicated the taxa with a tolerance of low pH

considerably higher indicating that while taxa were present at a site, conditions may have been sub-optimal. A cumulative AMDI score of 20, the threshold between 'severely impacted' and

The steep 10th percentile line (green) above the AMDI threshold of 20 indicates a general tolerance to low pH among the taxa considered. This characteristic of aquatic macroinvertebrates on the West Coast and in BCM streams specifically has previously been noted as conveying a degree of resilience to AMD (Harding & Boothroyd, 2004; Winterbourn

Gray & Harding (2012) found that dissolved metals were a better predictor of macroinvertebrate communities than pH and based the AMDI on metal derived relationships. In BCM streams dissolved aluminium is the primary metal toxicant of concern and has been used here as a proxy for all metals (Waters & Webster-Brown, 2013).

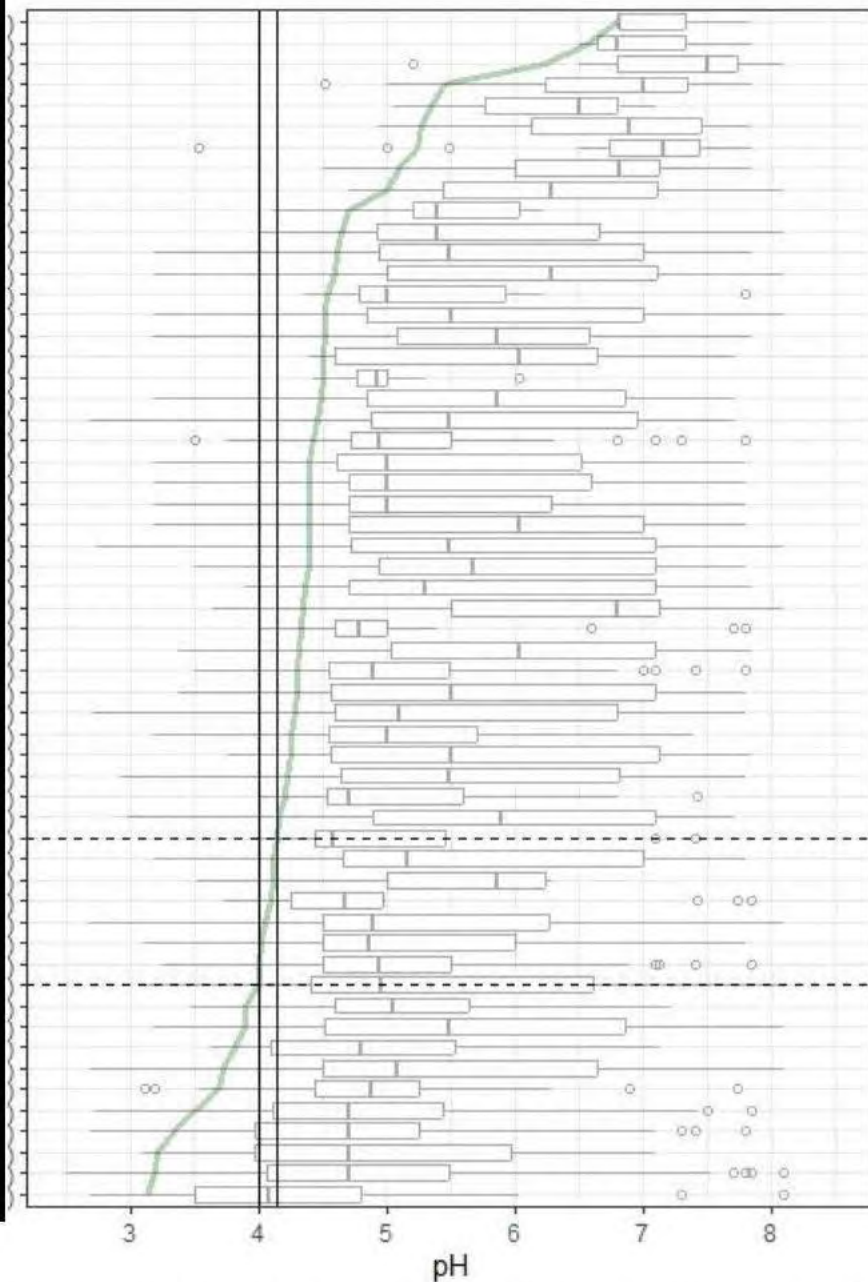


Figure 11. Boxplots of pH for each taxa occurrence. The Green line is the 10th percentile pH across which taxa were present and taxa are ordered based on that figure. The vertical black lines represent the intersection of the cumulative AMDI scores with the 10th percentile, indicating the thresholds between severely impacted, impacted and un-impacted. The bracketed numbers adjacent to each species are the cumulative AMDI with the addition of that species.

The taxa specific 90th percentile of dissolved aluminium coincided with a cumulative AMDI score of 20 at 2.8mg/L and 40 at 1.3 mg/L. Indicating exclusion above 2.8 mg/L and the beginning of comprehensive recovery at < 1.3 mg/L. Taxa tolerant to a dissolved aluminium concentration of >2.8 mg/L included some that were also observed in low pH waters. The

The 90th (or 10th) percentile is considered to represent a reasonable approximation of the species exclusion line for dissolved aluminium and pH, respectively. By extension, the

intersection between the cumulative AMDI score and the taxa specific percentile is considered to provide a suitable dissolved aluminium or pH value to determine the condition of the overall aquatic macroinvertebrate community. On that basis dissolved aluminium >2.8 mg/L and pH <4 (if derived from AMD, rather than natural processes) is likely to prevent the recovery of the aquatic macroinvertebrate community beyond a state of 'severely impacted' *sensu* Gray & Harding (2012). Similarly, a suitable threshold based on this analysis for a pathway towards an 'unimpacted' aquatic macroinvertebrate community has been demonstrated to be a dissolved aluminium at <2.8 mg/L and a pH of >4, with an unimpacted community occurring when dissolved aluminium is <1.3 mg/L and pH is >4.1.

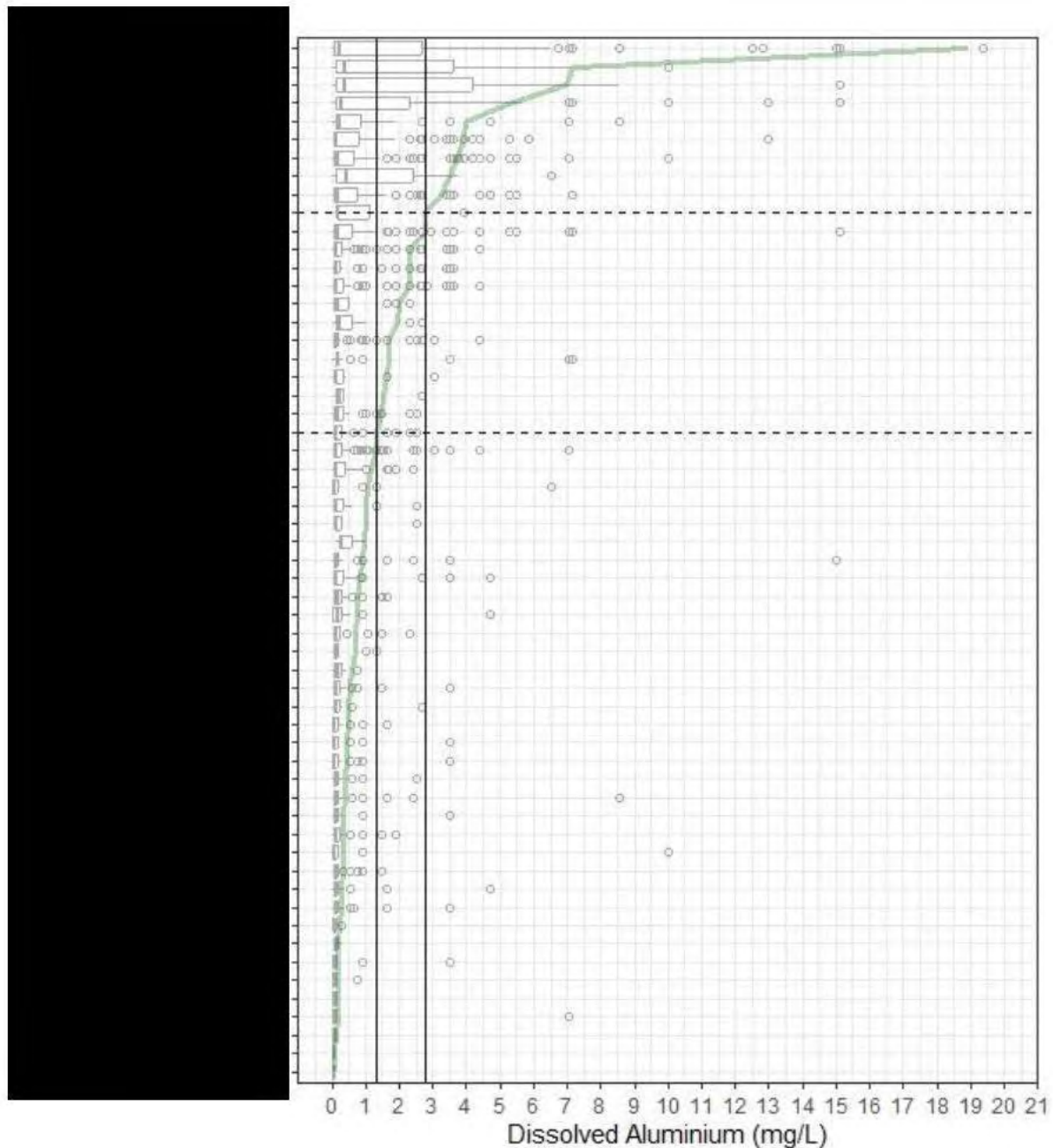


Figure 12. Boxplots of dissolved aluminium for each taxa occurrence. The Green line is the 90th percentile across which taxa were present and taxa are ordered based on that figure. The vertical black lines represent the intersection of the cumulative AMDI scores, indicating the thresholds between severely impacted, impacted and un-impacted, and the 90th percentile. The bracketed numbers adjacent to each species are the cumulative AMDI with the addition of that species.

2.5.3. Threshold Indicator Taxa Analysis

To investigate community composition changes, the R package TITAN2 was used to undertake threshold indicator taxa analysis (Baker & King, 2019). Threshold indicator taxa analysis is a method to determine the frequency of taxa occurrence, and to identify the point at which community composition changes along an environmental gradient. The method is robust to situations where taxa are replaced along a gradient, and where taxa are sequentially

lost, although species specific plotting is compromised by the absence of either increasing or decreasing taxa. TITAN detects a community change point by aggregating the responses of individual taxa, rather than change in metrics that represent the community. The specific responses of taxa that respond both negatively and/or positively to the environmental gradient are aggregated to determine the point along the environmental gradient that maximises collective change in the observed data. The analysis subsequently undertakes randomised permutations and bootstrap resampling. The bootstrap resampling technique provides confidence estimates of the community change point, taxa specific consistency in the response direction as 'purity', and the frequency of a strong response magnitude as 'reliability' that allow an assessment of the strength of conclusions (Baker & King, 2019). Random permutations are used to test the null hypothesis. Programme defaults for all settings were accepted, which included 500 bootstrap replications.

Outputs for the pH analysis showed the proportion of pure and reliable taxa within the data set to be 0.71 (Figure 13). The number of taxa that responded negatively to increasing pH was zero, while 41 taxa responded positively. This result indicates that rather than species replacement across the gradient of pH, species are simply lost as their tolerance to low pH is exceeded. This pattern has been observed by previous authors (Harding & Boothroyd, 2004; Winterbourn, 1998; Winterbourn & Collier, 1987).

The pH community change point based on pure and reliable, positively responding taxa was a pH of 4.4 and confidence intervals indicated a clearly defined threshold for macroinvertebrate communities at a pH between ~4 and 5.

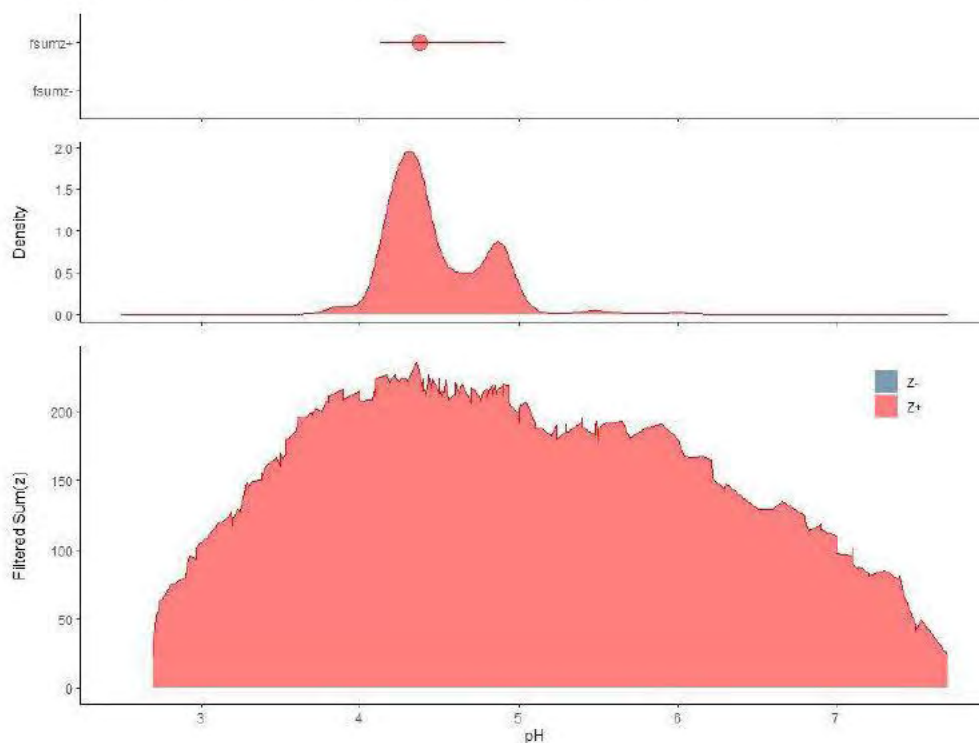


Figure 13. Bottom, magnitude of change among pure and reliable taxa increasing (z+) and decreasing (z-) along the gradient of pH. Peaks indicate relatively large community change. Middle, estimated probability density of the sum (z). A narrow spread indicates a high degree of precision. Top, observed sum(z) maxima with 95th percentile distributions derived from random permutations.

There were 30 pure and reliable taxa that decreased as dissolved aluminium increased and zero taxa that increased (Figure 14). The dissolved aluminium change point for decreasing taxa was 1.0 mg/L. The 95th percentile distributions around the change point were large and spanned between 0.25 and 4 mg/L. This result indicates a likely variation between pure and reliable taxa in their tolerance to dissolved aluminium such there is no single threshold that determines community change rather a high degree of change between 0.25 and 4 mg/L.

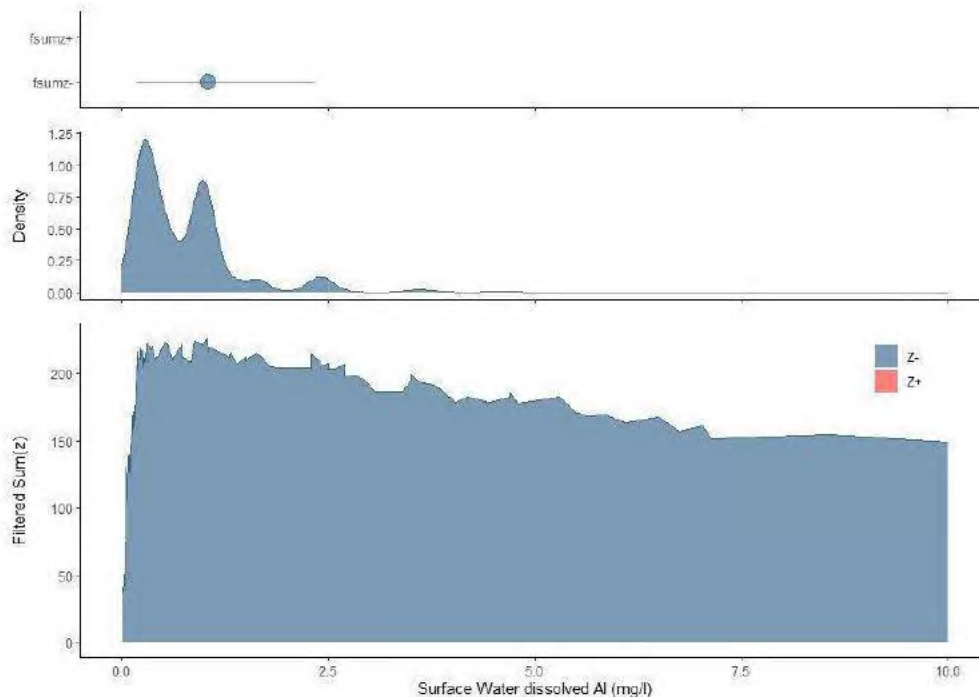


Figure 14. Bottom, magnitude of change among pure and reliable taxa increasing (z+) and decreasing (z-) along the gradient of dissolved aluminium. Peaks indicate relatively large community change. Middle, estimated probability density of the sum (z). A narrow spread indicates a high degree of precision. Top, observed sum(z) maxima with 95th percentile distributions derived from random permutations.

Threshold indicator taxa analysis using presence/absence data indicated that as AMD contamination increases, taxa sequentially disappear from streams. Nonetheless, several

identified in AMD streams on the Stockton Plateau with a pH < 3, conductivity > 900 μ S/cm and labile Al concentrations > 25 mg/L (Winterbourn, 1998; Winterbourn & McDiffett, 1996). This contrasted with overseas studies that found toxicity was reached at much lower levels of contamination, and may be explained by toxicity modifying factors or adaptation by acidophiles which has been reported in a number of mine drainage streams on the Stockton Plateau (Winterbourn, 1998).

2.6. Summary

These analyses have identified a range of potential thresholds for the effects of pH and dissolved aluminium on aquatic macroinvertebrate communities in BCM streams (Table 6). The results derived from these analyses are in broad agreement with those found by Greig et al. (2010) for fish (pH > 4.5 and Al < 1 mg/L), and present options for suitable thresholds for the planning of mine remediation into the future. The bivariate relationships between AMDI and

water quality provided the widest range of potential thresholds for the recovery zone. However, the thresholds between severely impacted and impacted, or the start of the recovery zone, were quite similar between bivariate and taxa specific methods being 2.5-2.8 mg/L dissolved aluminium and a pH of 3.8 to 4. Indicator analysis gives some insight into the rates of change in communities within the reported recovery zone. The maximum rate of change in community composition identified for macroinvertebrates was very similar to that proposed for the protection of fish in BCM streams (Greig et al., 2010). Because BCM stream water quality thresholds are required to cater for both fish and macroinvertebrates, the more conservative, but closely aligned, Greig (2010) values are considered suitable overall to represent the threshold of comprehensive recovery and for stream classification.

Table 6: Summary of ecological thresholds of pH and dissolved aluminium.

	pH	Aluminium
Bivariate relationships	AMD I impacted >3.4 AMD I unimpacted >5.1	AMD I impacted <2.5 mg/L AMD I unimpacted <0.2 mg/L
Taxa specific threshold	AMD I impacted >4 AMD I unimpacted >4.1	AMD I impacted <2.8 mg/L AMD I unimpacted <1.3 mg/L
Indicator analysis	Change point = 4.4	Change point = 1.0 mg/L
Greig et al. 2010	>4.5	<1 mg/L

Subsequent analyses in this report apply 1 mg/L and pH 4.5 as thresholds for the comprehensive recovery of aquatic communities in BCM streams. pH can naturally be lower than 4.5 in BCM streams, so the recommendation comes with the caveat that pH below 4.5 is acceptable provided it is the result of natural processes.

In terms of dissolved aluminium, the remainder of this report typically considers an annual 75th percentile <1 mg/L to be the specific summary statistic threshold for water quality recovery. This percentile allows for occasional exceedances over time as AMD discharges diminish, but ensures that the majority of samples will be <1 mg/L. The percentile approach, as opposed to a maximum or median, controls for the occurrence of outlier extreme values, while providing a representation of worst-case toxicant conditions. A conventional summary statistic for this situation is the 95th percentile, however that level of consistently low concentrations is more typically applied to the protection of otherwise healthy streams as opposed to tracking the gradual recovery of currently impaired systems. Irrespective of gradual changes in water quality over time actual recovery of streams will be determined by assessment of ecological communities guided by patterns in water quality.

These results can also be used to classify streams for management purposes. Our analyses of macroinvertebrate communities indicate that several taxa will occur at dissolved aluminium concentrations and pH beyond the described thresholds for comprehensive recovery, i.e. dissolved aluminium <2.8 but >1 mg/L. These streams are considered 'water quality recovering' but not yet recovered. Similarly, streams with a dissolved aluminium > 2.8 mg/L or pH <~4 would be considered to be 'water quality impacted'. The criteria used to classify streams are shown in Table 7 and referred to extensively in Sections 3 to 6.

Table 7: Stream classification based on derived thresholds of pH and dissolved aluminium.

Site / stream classification	pH (annual median)	Aluminium (annual 75 th percentile)
Water quality impacted	<4	>2.8 mg/L
Water quality recovering	>4 - <4.5	<2.8 - >1 mg/L
Water quality recovered	>4.5 unless due to natural processes	<1 mg/L

Management of aluminium toxicity based on measurements of dissolved aluminium alone presents problems due to speciation, complexation and other modifying factors (Waters & Webster-Brown, 2013). Variable concentrations of organic carbon and sulphates, that complex with aluminium, and pH that influence the speciation of aluminium, determine bioavailability and toxicity. Due to high chemical variability between BCM streams, particularly in pH and organic carbon, it is unsurprising that taxa occur across a broad spread of aluminium concentrations and at values otherwise assumed to be highly toxic (ANZG, 2018).

Similarly, due to the large range in natural pH and adaptation of some macroinvertebrate taxa to naturally occurring low pH levels, the use of pH metrics alone to manage effects is likely to be fraught. Ongoing monitoring of macroinvertebrates (and potentially fish), and water quality to gauge recovery of waterways will determine the success of mine remediation. While this report only considers aluminium, there are other toxic metals that derive from BCM and associated geology such as nickel, iron and zinc. The thresholds for pH and aluminium presented in this report are intended to address the gross effects of AMD contamination, however further nuance of thresholds in specific streams to other metals may be required to achieve full recovery in the future.

3. CURRENT WATER QUALITY AND AQUATIC ECOLOGY

3.1. Introduction

Streams draining the Buller Plateaux and coal measures range from unaffected by AMD to, in some cases, essentially devoid of life. The worst sites typically drain both historic and contemporary mine workings and include the effects of fire suppression activities to manage underground burning coal seams (GHD, 2026). A complete list of the waterways on Stockton Plateau likely to be impacted by AMD is included in O’Kane (2015) and shown in Figure 1, alongside key water quality monitoring sites. Effects, while generally commensurate with the degree of contamination, vary between waterways depending on their individual character and position in the landscape. This section of the report outlines a selection of case studies illustrating the spectrum of AMD affected streams and their ecological condition. GHD (2026) provide a complete review of the water quality of waterways draining Stockton Plateau. In this report case studies have focused on pH as the driver of dissolved metal concentrations generally, and typically only present dissolved aluminium monitoring data except where other contaminants were especially prominent. Dissolved aluminium is considered a suitable proxy for dissolved metals overall.

Nutrients may be derived from mining activities in the form of fertiliser applied to revegetation areas, sewage applied land or from explosives. In particular, ammoniacal-N and nitrate-N

derived from explosives may contribute to eutrophication of streams or toxicity at greater elevations. The implications of nitrogen loss to streams from explosives are considered by Hickey (2026d) for the Denniston Plateau developments and are considered directly applicable to Stockton. While not currently measured in the majority of Stockton streams, nitrogen species are proposed to be added to the water quality monitoring suite as part of the BPCP and included in performance and ecological monitoring, reporting and review.

To assess long-term trends in water quality, generalised additive models (GAM) were used to visualise non-linear trends in time series data. This was used instead of linear models as GAMs allow for flexible and non-linear relationships between time and response variables, as are common in these AMD data sets. Information about the underlying dynamics and patterns in a long-term dataset can be hidden when the trend is constrained to be monotonic. In addition, the AMD datasets had irregular sampling intervals over multiple years and GAMs allow for this irregularity. GAMs use smoothing functions to capture gradual or complex shifts in water quality, allowing a more accurate representation of underlying patterns.

3.2. St. Patrick Stream

St. Patrick Stream is a major tributary of Ngākawau River, draining a substantial area of historic and contemporary mining, including the Cypress Mine - adjacent to the Stockton Mine (Figure 1; Appendix 1). In addition, AMD from other catchments on the Stockton Plateau has been diverted to St. Patrick Stream during contemporary mining activities (O’Kane, 2015, Appendix 1). St. Patrick Stream receives much of its flow from Fly and Plover Creeks and is monitored at site S16 since 2004. O’Kane (2015) noted that water quality at the time of writing had improved since 1992.

Long term water quality monitoring indicates S16 has consistently been unsuitable to fish or aquatic macroinvertebrates with a pH <4.5 and dissolved aluminium >1 mg/L (Figure 15). Nonetheless, macroinvertebrate samples collected in 2008 and 2025 recorded some taxa. In 2008 two taxa were present, but in 2025 there were seven, albeit species known to be tolerant to AMD as indicated by the low AMDI scores on both occasions, 1.5 and 13 respectively.

Water quality since 2002 has shown an increase in AMD over time up to about 2019, where upon pH increased and there was a decline in dissolved aluminium.

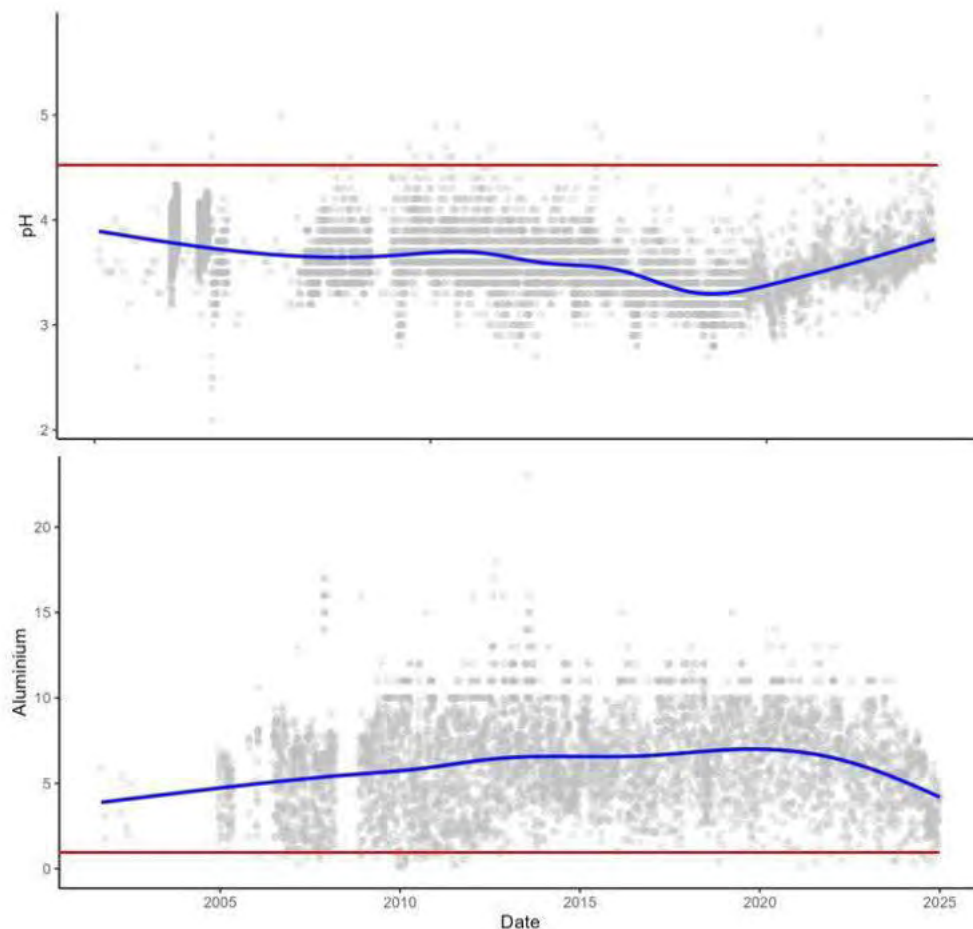


Figure 15. Long term water quality results for pH and dissolved aluminium (mg/L) measured at site s16. GAM smoothing function is shown in blue. Red lines show the lower and upper thresholds of pH and aluminium for fish and aquatic macroinvertebrate recovery.

Improvements in water quality at S16 are the result of active treatment based at McCabes sump treating Cypress, McCabes, and Fly Creek AMD. Additionally, there is approximately 289 ha of disturbed area to be rehabilitated over the next 10 years. Coal extraction in the catchment will likely cease in 2026 and no further overburden will be disturbed meaning no additional contributions to acidity or metal load. Further AMD treatment in the headwaters above S16 is planned in the near future and discussed in Section 4.3.

There is limited information pertaining to two tributary streams T35 and T31 that discharge downstream of S16. T31 has two water quality records from 2007. Dissolved aluminium was recorded at these sites at 1.7 and 1.4 mg/L, while pH was recorded as 3.38 and 3.29. T35 Stream had one record in 2007 where dissolved aluminium was 0.32 and pH was 4.36. Aquatic macroinvertebrates in T31 Stream on both occasions had low richness (4 and 5 taxa), and AMDI scores (7 and 6) indicative of severe impact. However, T35 Stream in 2007 contained 17 taxa, an AMDI score (50) indicative of 'no impact' and an equivalent EPT richness (13). T35 Stream provides clean water dilution when it discharges to St. Patrick Stream.

3.3. Mangatini Stream and Ngākawau River

3.3.1. Introduction

Mangatini Stream drains a significant portion of the Stockton Mine contemporary open cast workings, including diversions via cut off drains that carry AMD water away from other streams (GHD, 2026; O’Kane, 2015, Appendix 1). Mangatini Stream discharges into Ngākawau River in the lower reaches of Ngākawau Gorge.

Responding to concerns from the local community, it was acknowledged by Solid Energy New Zealand Ltd in 2004 that the Mangatini discharge was likely to be detrimental to the health of Ngākawau River, and in particular, the whitebait fishery (Elder et al., 2011). Solid Energy, committed to a programme of water quality remediation to achieve conditions designed to reinstate the fishery. This included:

- pH greater than or equal to 4.7 for 99% of the time.
- Dissolved aluminium less than 1 mg/L for 99% of the time.
- Turbidity no greater than 25 NTU based on a 30-day rolling median.

Water quality remediation planning began in 2005 with the aim of achieving water quality targets by 2010. Remediation treatments included sedimentation ponds, a water treatment plant, and active and continual limestone dosing of Mangatini Stream and the creation of the Mangatini sump (a 900,000 m³ settling pond). Full details of remediation are described by Pizey et al. (2007). Although Ngākawau River also receives AMD from St. Patrick’s Stream and Mine Creek, Mangatini Stream in 2005 was the most significant source of AMD going into Ngākawau River (Elder et al., 2011; Lindsay et al., 2007). Currently, Mine Creek contributes the largest untreated discharge.

3.3.2. Water quality

Monitoring of the effects of remediation is focused on water quality along Mangatini Stream and at site NR in Ngākawau River (Figure 1), but also fish populations in the headwaters of Ngākawau River. The lower Ngākawau River features a steep and rugged gorge that is predicted to prevent all but the most adept climbing fish from reaching the gentler headwaters

Water quality monitoring associated with Mangatini Stream remediation occurs at sites S14C immediately downstream of the treatment systems, S14B ~5 km downstream, but still on the Stockton Plateau, and at NR (or latterly NR2) on the Ngākawau River 2 km upstream of the coast (Figure 1). Site S14B is upstream of the confluence of unimpacted clean water tributaries Repo Stream and Weka Creek.

Remediation commenced around 2007, after the first Ngākawau River fish survey and resulted in an immediate increase in pH at all three sites (Figure 16). The pH in the Mangatini Stream at S14C increased, but the median value remained below the lower limit for fish and macroinvertebrates up until approximately 2018, while at S14B the pH was higher and closer to being suitable for macroinvertebrates and potentially fish. In Ngākawau River, after mixing, the pH was persistently greater than 4.5, and unlikely to preclude colonisation by fish based on the work of Greig (2010) and macroinvertebrates (this report). The implications for fish communities and migration are described below.

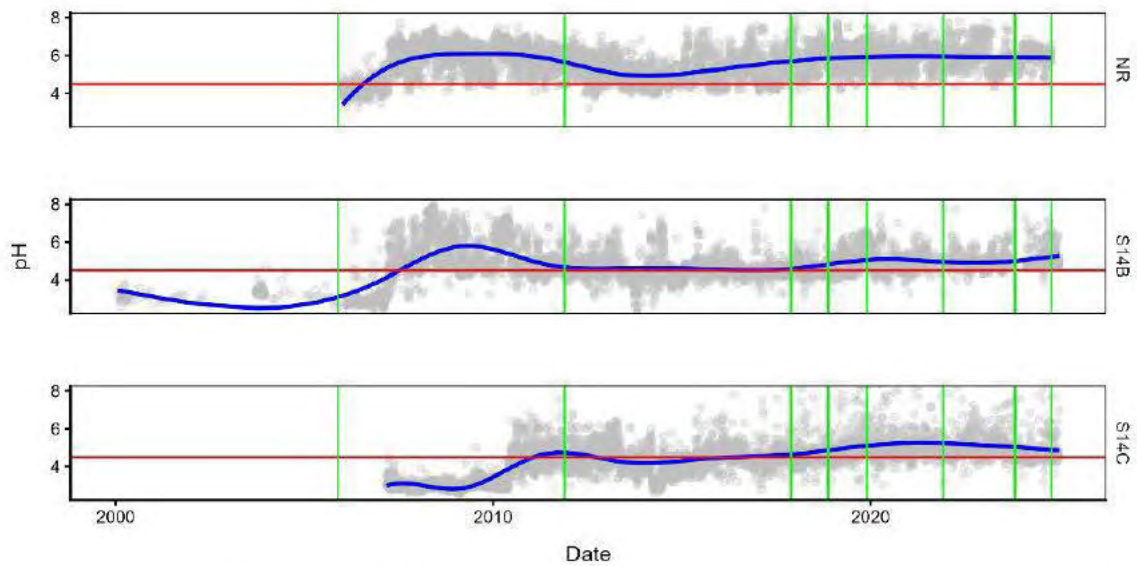


Figure 16. Daily (workday) pH in Mangatini Stream at S14C, S14B and Ngākawau River (NR) (moving downstream). GAM smoothing function is shown in blue. The occasions of fish surveys in the upper Ngākawau River are shown by green vertical lines (Hore, 2024), while the horizontal red line shows the lower threshold for the recovery of fish and macroinvertebrates (Greig et al., 2010; this report).

Dissolved aluminium responds to the increase in pH by showing a marked reduction at sites S14C and NR (Figure 17 and Figure 18). While site S14C remains typically above the threshold for fish and macroinvertebrates, NR is consistently below except during high flows and during a period around 2014 -2015 (Figure 18).

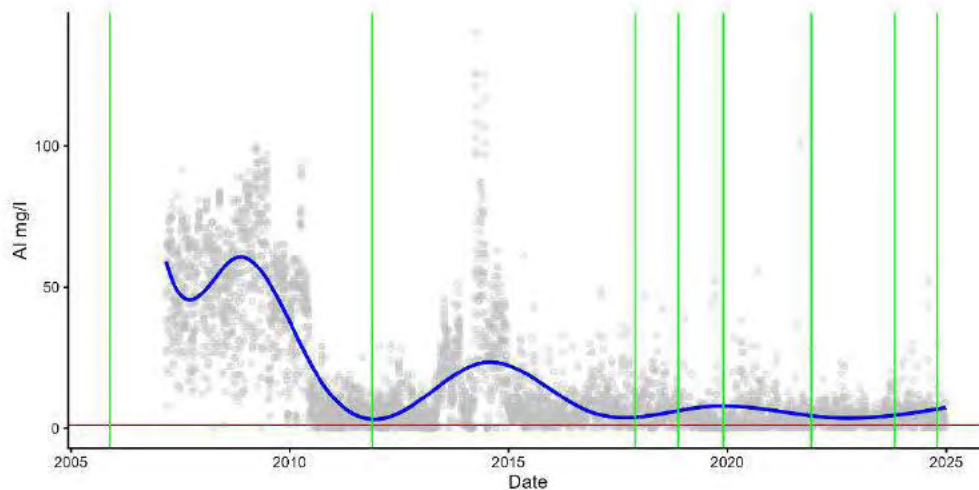


Figure 17. Daily dissolved aluminium (mg/L) in Mangatini Stream at S14C. GAM smoothing function is shown in blue. The occasions of fish surveys in the upper Ngākawau River are shown by green vertical lines (Hore, 2024), while the horizontal red line shows the putative upper threshold for the occurrence of fish (Greig et al., 2010).

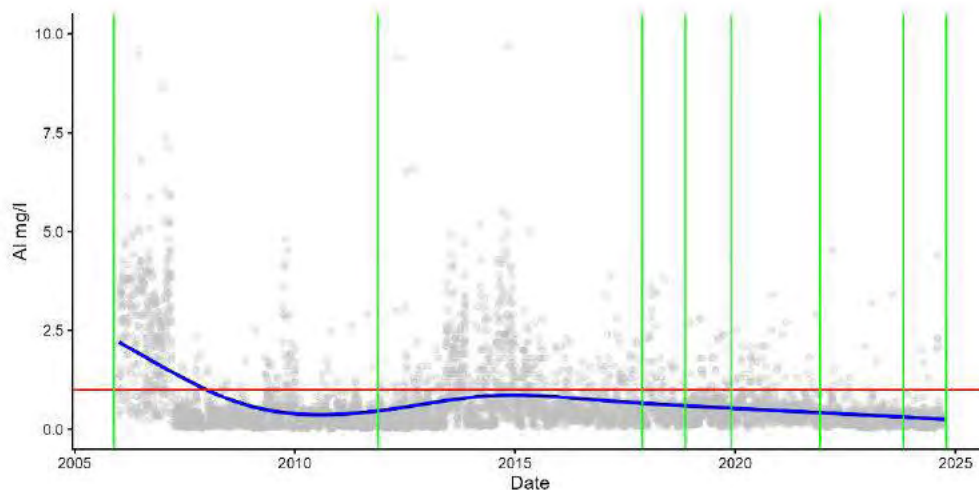


Figure 18. Daily dissolved aluminium (mg/L) in Ngākawau River at NR. GAM smoothing function is shown in blue. The occasions of fish surveys in the upper Ngākawau River are shown by green vertical lines (Hore, 2024), while the horizontal red line shows the putative upper threshold for the occurrence of fish (Greig et al., 2010).

Because the concentration of dissolved aluminium and pH at NR have been maintained below the ecological thresholds of 4.5 and 1 mg/l the river is generally considered to be suitable for fish and macroinvertebrates. Subject to the confirmation of ecological recovery there should be a shift from recovery focused water quality limits (1 mg/l dissolved aluminium) to protection focused limits (Hickey 2026a). In the absence of a single over-riding contaminant (Al) the potential effects of a wider suite of metals should be assessed. Bathurst maintain a long-term record of a full suite of metals dissolved in water at NR. Those metals can be compared to bioavailability adjusted thresholds developed by Hickey (2026a) for BPCP mines on the Denniston Plateau and at Mount Fredrick South. Those guidelines incorporate toxicity modifying factors (TMFs) dissolved organic carbon, pH and hardness (as CaCO_3) where those data are appropriate or use a default, e.g. for dissolved aluminium at pH <6.5. Following the ANZG (2018) approach waterways are initially assigned a level of protection based on their background level of contamination. The Ngākawau River is considered to be affected by AMD and so an 80% protection level is considered suitable (Figure 1). The protection level can be thought of as protection of that proportion of the less sensitive species from chronic (long-term) effects.

A comparison of measured values against 80% level of protection chronic effects criteria after adjustment for TMF's for all data subsequent to 2017 indicated that dissolved aluminium remains the primary stressor on ecological communities (Table 8). Dissolved aluminium after correction for TMF's exceeded the guideline values on 30% of occasions. Other contaminants of note were copper (14%), zinc (8 %) and cadmium (6%).

Ongoing improvements in water quality in the Ngākawau River mean that a subsequent comparison of 2024 and 2025 water quality indicate a lower degree of exceedance at site NR. During the preceding two years aluminium and cadmium both exceeded the 80% level of protection on 7% of occasions, while copper consistently met and the other metals exceeded on 1% or 2 % (zinc) of occasions.

Table 8: Summary statistics of metal concentrations at site NR on Ngākawau River alongside a comparison with 80% level of protection for chronic effects criteria after adjustment for toxicity modifying factors.

4 Jan 2017-5 Feb 2026

Metal	Zinc	Copper	Iron	Aluminium	Nickel	Cobalt	Manganese	Cadmium	pH	Hardness	Nitrate	Ammoniacal N
No. values	434	434	441	1900	434	434	434	433				
95th percentile (mg/L)	0.094	0.0037	0.420	1.2	0.021	0.0083	0.23	0.00020	7.0	97		
75th percentile (mg/L)	0.060	0.0012	0.220	0.53	0.014	0.0059	0.15	0.00010	6.4	59		
Median (mg/L)	0.042	0.0008	0.130	0.34	0.011	0.0043	0.11	0.00005	6.0	39		
5th percentile (mg/L)	0.014	0.00025	0.036	0.055	0.0032	0.0014	0.037	0.00005	4.8	14		
No. > GV	34	3	2	576	17	9	1	24				
Percentage	8%	14%	0%	30%	4%	2%	0%	6%				

3 Jan 2024-5 Feb 2026

Metal	Zinc	Copper	Iron	Aluminium	Nickel	Cobalt	Manganese	Cadmium	pH	Hardness	Nitrate	Ammoniacal N
No. values	83	84	85	437	83	83	84	83			8	9
95th percentile (mg/L)	0.081	0.0011	0.21	0.51	0.021	0.0074	0.22	0.00030	6.7	139		
75th percentile (mg/L)	0.044	0.00070	0.12	0.33	0.012	0.0046	0.14	0.00010	6.4	57		
Median (mg/L)	0.033	0.00055	0.036	0.19	0.0097	0.0036	0.10	0.00010	6.2	39	0.023	0.01
5th percentile (mg/L)	0.010	0.00025	0.036	0.035	0.0035	0.0013	0.037	0.00005	5.4	17		
No. > GV	2	0	1	31	1	0	1	6			0	0
Percentage	2%	0%	1%	7%	1%	0%	1%	7%			0%	0%

Note. There were limited dissolved organic carbon (DOC) measurements available, so a concentration of 2mg/L was assumed for calculations. pH and hardness values were available for each sample where a GV is calculated. Guideline values are derived based on the chronic toxicity method of Hickey (2026a). Below detect values were halved. There were insufficient nitrate-N or ammoniacal N data records to generate percentile statistics.

Turbidity in Ngākawau River at NR (data not shown) prior to remediation fell within the thresholds stipulated by consent conditions to restore the whitebait fishery (i.e. no greater than 25 NTU based on a 30-day rolling median). However, the onset of lime dosing resulted in a period of elevated turbidity at NR due to lime and complexing metals remaining in suspension. Turbidity remained elevated until treated AMD was directed into Mangatini Sump, allowing settling of suspended particles, prior to discharge to Mangatini Stream. Subsequently, other than during a short period in 2015, the 30-day rolling median has remained well below 25 NTU (Hore, 2024).

3.3.3. Sediment quality

Sediment samples for metal analyses were collected from site NR² (upstream of tidal influence and Mine Creek), two reference streams on the Stockton Plateau and the lime dosing sludge filter beds associated with the Mangatini Sump, in March 2026.

Sediment quality in New Zealand is assessed using a tiered approach whereby total recoverable metals from the <2mm sediment size fraction is compared to both a default Guideline Value (DGV) and Guideline Value – high (GV-high) criteria (ANZG 2018). The DGV represents a threshold below which there is considered to be a low risk of unacceptable effects, whereas an exceedance of the GV-high thresholds would be expected to result in an adverse toxicity effect. Note the ANZG (2018) does not provide guidelines for aluminium, iron, cobalt and manganese. While elevated iron in sediment is more typically considered detrimental to ecology due to smothering by flocs, the Ontario Ministry of the Environment (Canada) provide a toxicity DGV and GV-high equivalent of 20,000 and 40,000 mg/kg (Persaud et al., 1993). Those thresholds are generally thought of as being 'lowest effect level' and 'severe effect level' which is considered approximately commensurate with the ANZG DGV and GV-high categories, respectively.

In the reference sites, MT6 and S1, all metal concentrations fell below the DGVs (Table 9). However, at site NR iron, zinc and nickel all exceeded their DGV, but not the GV-high. At the observed concentrations there is a greater than low likelihood of non-lethal adverse effects occurring. Zinc, iron and nickel were all elevated above the GV-high equivalents within the sludge filter bed sediments.

However, these results cannot be inferred to indicate an unequivocal effect of the LDS on lower river sediment metal concentrations. In the absence of reference state sediment quality from the upper Ngākawau River it is not possible to determine the relative contribution of metals from the LDS discharge, other sources and natural back-ground levels. MT6 and S1 on the Stockton plateau sit within BCM rocks compared to the granites, granodiorite, gneiss and greywacke in the upper Ngākawau River. As such, they are not directly comparable reference sites for assessing downstream enrichment of the whole system, although it is reasonable to compare them to the LDS itself.

The Mangatini Stream is estimated to contribute 20% of the sediment load to the lower Ngākawau River and so there would be substantial dilution of any sediments emanating from the Mangatini Stream and mixing with metals bound to sediments derived from the upper Ngākawau River or St Patrick Stream. Additionally, prior to 2007 untreated AMD was discharged to the Mangatini Stream and Ngākawau River that may have resulted in residual

² Note access to NR was restricted by a slip in 2022 and monitoring has subsequently occurred at site NR2 which is ~500 m downstream. NR2 data must be cleaned to remove the influence of tides in excess of 2.5m.

metals being present in river sediments due to precipitation. Although the high-energy nature of the Ngākawau River limits long-term storage of fine sediments, depositional environments within the system may retain legacy and contemporary metal inputs.

Accordingly, sediment metal concentrations in the lower Ngākawau River are likely to reflect an unknown quantity from natural geological sources, historical discharges, and ongoing inputs, including from the Mangatini Sump and LDS discharge.

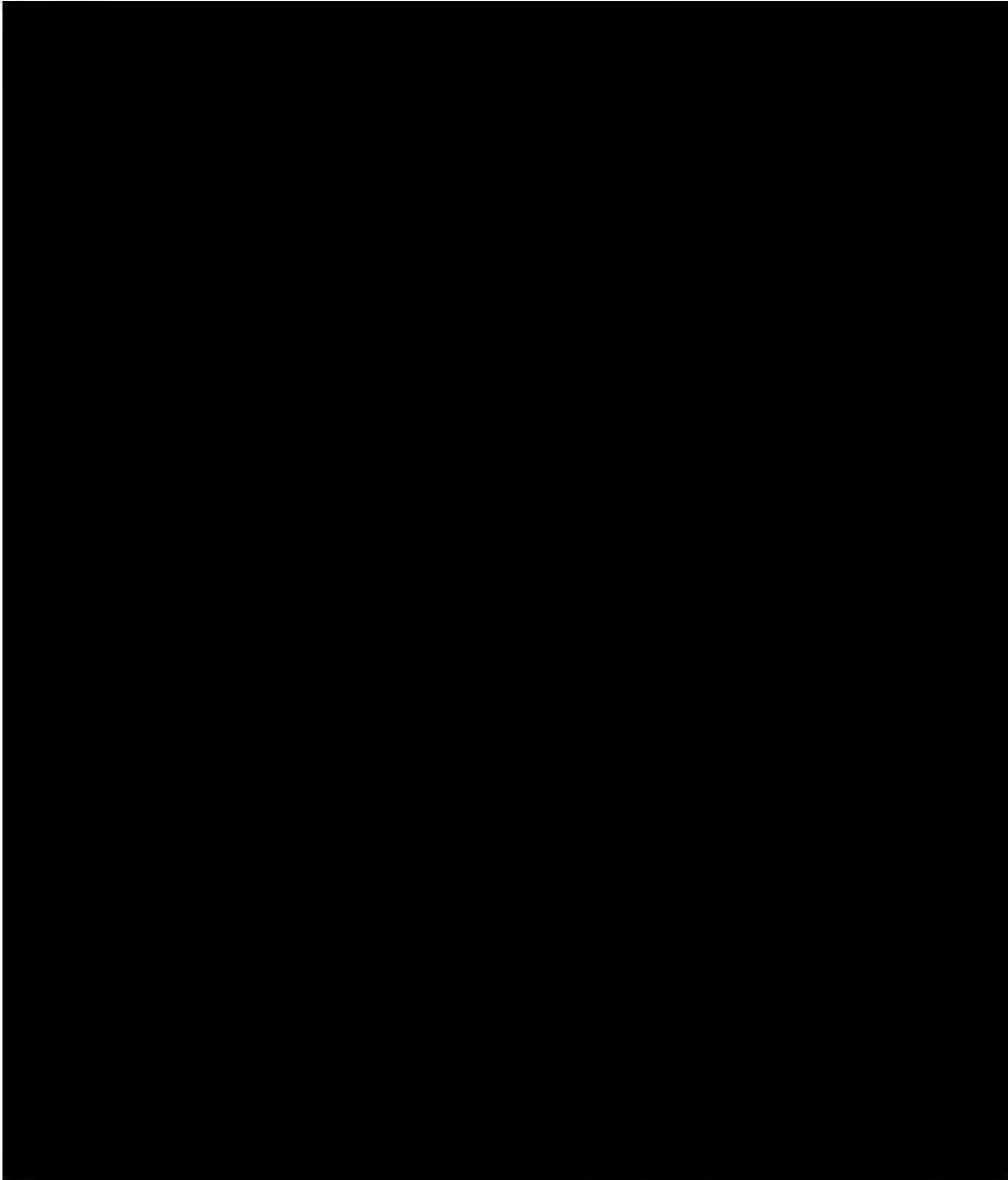
Table 9. Sediment metal concentrations (mg/kg dry weight) from two locations in the Ngākawau River at site NR (True Left Bank = TLB; True Right Bank = TRB), two reference sites on the Stockton plateau (MT6 and S1) and the Low-Density Sludge (LDS) filter bed in March 2026.

Threshold/site	Aluminium	Cadmium	Chromium	Cobalt	Copper	Iron*	Manganese		Nickel	Zinc
DGV	-	1.5	80	-	80	20,000	-		21	200
GV high	-	10	370	-	370	40,000	-		52	410
NR2 TLB	14500	0.18	20	25	16	25000	640		38	230
NR1 TRB	14400	0.19	20	38	17	24000	1060		39	240
MT6	2700	< 0.10	3	0.7	2	9000	24		2	11
S1	1770	< 0.10	4	0.6	<2	3800	21		<2	6
LDS Filter bed 1	93,000	0.64	26	47	39	50,000	390		167	1,010

Note. *DGV and GV-high are derived from the ANZG (2018) except for iron that is derived from the Ontario Ministry of the Environment (Canada) guidelines. <https://www.ontario.ca/document/guidelines-identifying-assessing-and-managing-contaminated-sediments-ontario/identification-and-assessment#section-1>. While dated, iron criteria provide a screening level thresholds for iron. Concentrations that exceed the DGV are show in bold. Concentrations that exceed the GV-high are show in red.

3.3.4. Ecology

It should be noted that the migratory pathway for fish into the Ngākawau River is also potentially affected by discharges from untreated Mine Creek. That topic is considered in Section 3.5, however result from fish surveys to date suggest that Mine Creek is not preventing the passage of fish currently.



Fish surveys of the lower Ngākawau River were undertaken in early 2026. The river mouth fish communities consisted of [REDACTED] (see Section 3.5). At site NR overnight trapping using fykes nets found numerous [REDACTED]

[REDACTED]
[REDACTED]

[REDACTED]

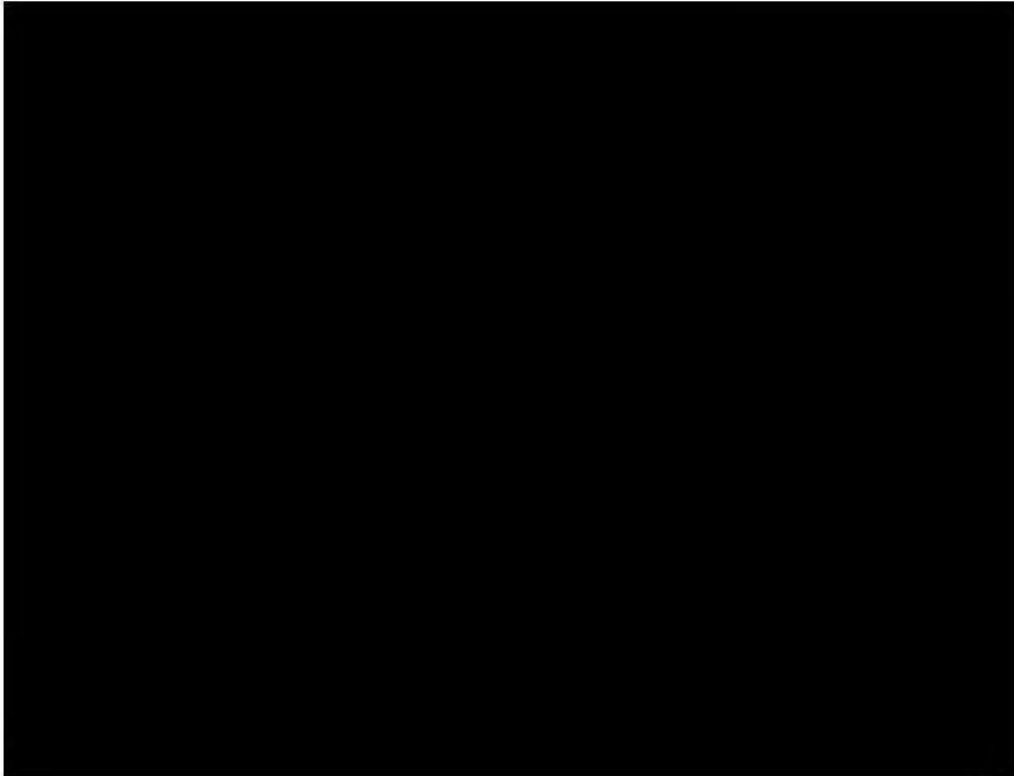


Figure 20. [REDACTED]

The lower Ngākawau River is difficult to sample for aquatic macroinvertebrates due to its size; however, macroinvertebrate data exists for two sites in the Mangatini Stream, S14C and S14B. Only a single sample is available from S14C, but ten for the downstream site S14B, occurring between 2015-24 (Figure 21, Table 10). At S14C in 2025 the pH was 5.3, while dissolved aluminium was 1.5 mg/L on the day of sampling. Across 17 occasions in the 23 days preceding macroinvertebrate sample collection the median pH was 4.7 while the dissolved aluminium was 6.7 mg/L. Only four macroinvertebrate taxa were present, none of which were considered indicator species (Table 4), resulting in an AMDI classification of 'severely impacted'.

At S14B the macroinvertebrate samples were all collected after the onset of water quality remediation and lime dosing in the Mangatini Stream. There was no metal data available over the sampling period, but over the nine years spanned by macroinvertebrate samples pH was relatively stable (Figure 16) ranging between 3.9 and 5.6. There were no significant relationships between macroinvertebrate indices and pH, although the response of AMDI to increasing pH does appear to be positive (Figure 21). While richness was low relative to a

[REDACTED]

Table 10: Relationships between macroinvertebrate health indices and pH at S14B on the Mangatini Stream between 2016 and 2024.

Macroinvertebrate index	Health category	R ²	p
AMD	Severely impacted/ impacted. Threshold = 20	0.347	0.073
MCI	Poor all sites <80	0.198	0.198
Richness	NA	0.235	0.155
EPT richness	NA	0.007	0.816

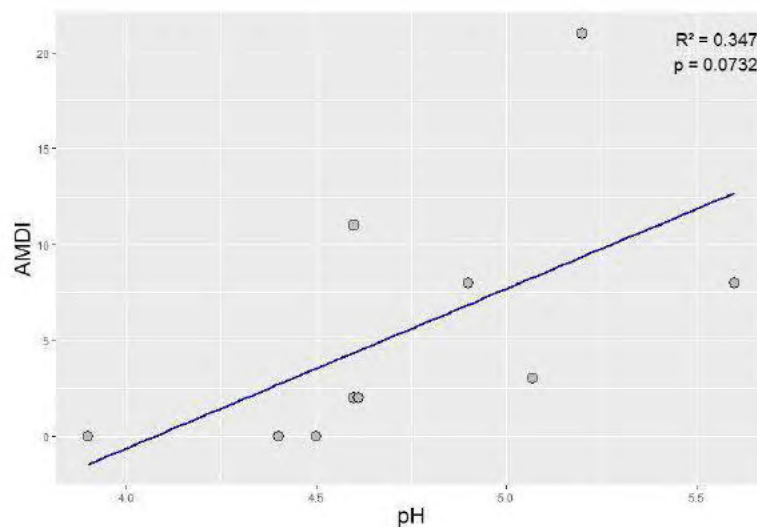


Figure 21. The relationship between AMDI and pH at site S14B on the Mangatini Stream between 2016 -24.

Downstream of S14B, AMD is diluted from the influx of clean water from Weka Creek and Repo Stream. While there is no contemporary macroinvertebrate data available for the lower Mangatini Stream before its confluence with Ngākawau River, it is likely that less tolerant macroinvertebrates will colonise the waterway as water quality continues to improve.

3.4. Millerton streams

3.4.1. Context

A number of smaller streams drain the western flanks of the Stockton Plateau and are collectively referred to as the Millerton streams. The key waterways involved from south to north are Rudolph, Twins and Granity streams which drain to the Tasman Sea, and Mine Creek which discharges to the tidal reaches of the Ngākawau River. Currently, Rudolph, Twins and Granity streams plus Mine Creek and their tributaries all receive AMD from historic underground workings and contemporary open cast mining (Figure 22, Appendix 1).

3.4.2. Water quality and ecology context

Regular water quality data is available from monitoring at various site locations along the waterbodies (Figure 22), other than Twins Stream where only sporadic information is available to date. Not all the available water quality is presented here for the sake of brevity, but

adequate information has been presented and discussed to characterise the current state of each waterway. Water quality has been compared to threshold values for ecology, specifically those suggested by Greig et al. (2010) and within this report.

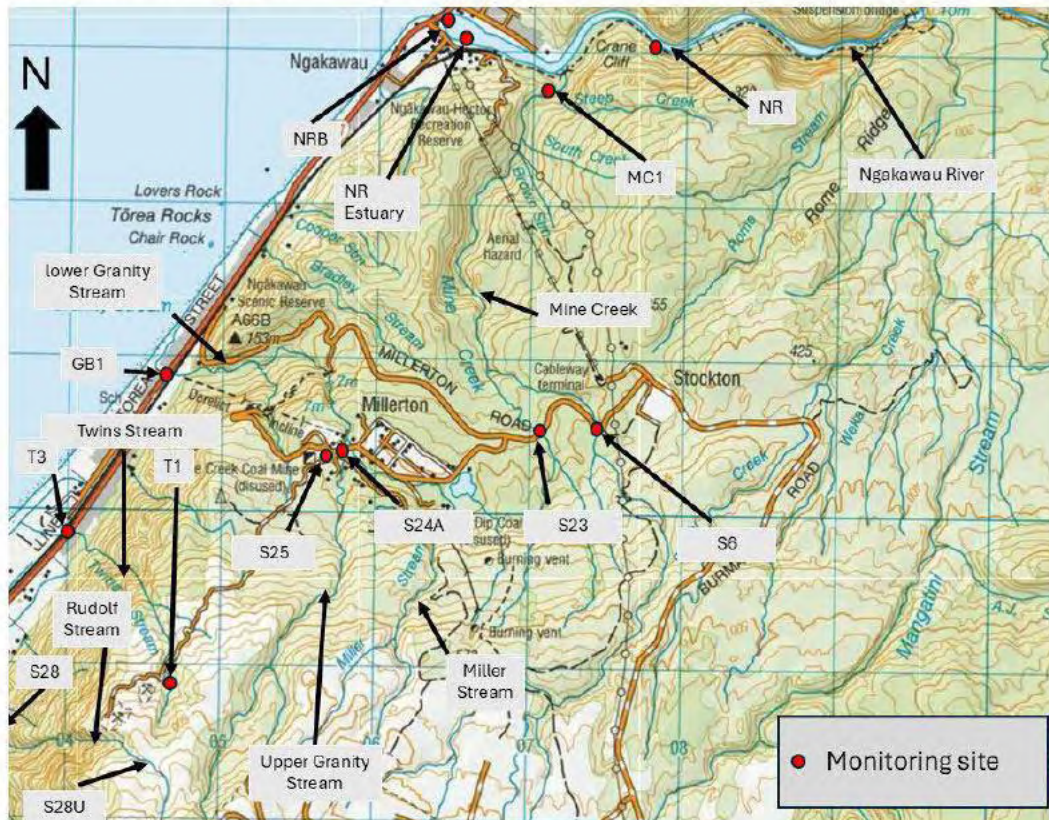


Figure 22. Map of the Millerton Streams showing major waterways and monitoring sites.

While not strictly a component of AMD, suspended sediments are commonly associated with mine runoff or the precipitation/flocculation of dissolved metals. This section presents data on turbidity (NTU) as a suitable and readily available measure of suspended sediments. NTU data are compared to a behavioural avoidance threshold for [REDACTED] above which fish were found to be averse to migration (Boubee et al., 2010). Data represents the last 5 years unless otherwise stated.

3.4.3. Upper Granity S25 and S24A

The Upper Granity Stream at S25 is above the confluence with Miller Stream (Figure 22). pH is currently at levels that would be likely to preclude colonisation by fish or macroinvertebrates (Figure 23). Similarly, both the median (6 mg/L) and Hazen 95th percentile (25.5 mg/L) concentrations of dissolved aluminium over the last 5 years are well in excess of ecological thresholds. The contamination in S25 is generally of a lesser magnitude than in Mine Creek in the adjacent catchment and Granity Stream downstream of the Miller Stream confluence.

Turbidity in Upper Granity Stream is highly variable as is typical of streams draining landscapes with frequent high rainfall (Figure 24). However, over the last five years, the rolling 30-sample median turbidity has remained below the 25 NTU behavioural avoidance threshold suggested by Boubee et al., (1997). That result indicates that, notwithstanding other

contamination, on at least 50% of days within each 30-day period turbidity in the stream is unlikely to deter the most sensitive galaxiid species from migrating inland.

Miller Stream is a tributary of the Granity Stream and is monitored at site S24A. Turbidity is low having a 5-year median of 0.9 NTU and Hazen 95th percentile of 9 NTU. However, median values for pH (2.61) and dissolved aluminium (88 mg/L) exceed the thresholds for ecological recovery such that ecological communities will likely be severely impacted.

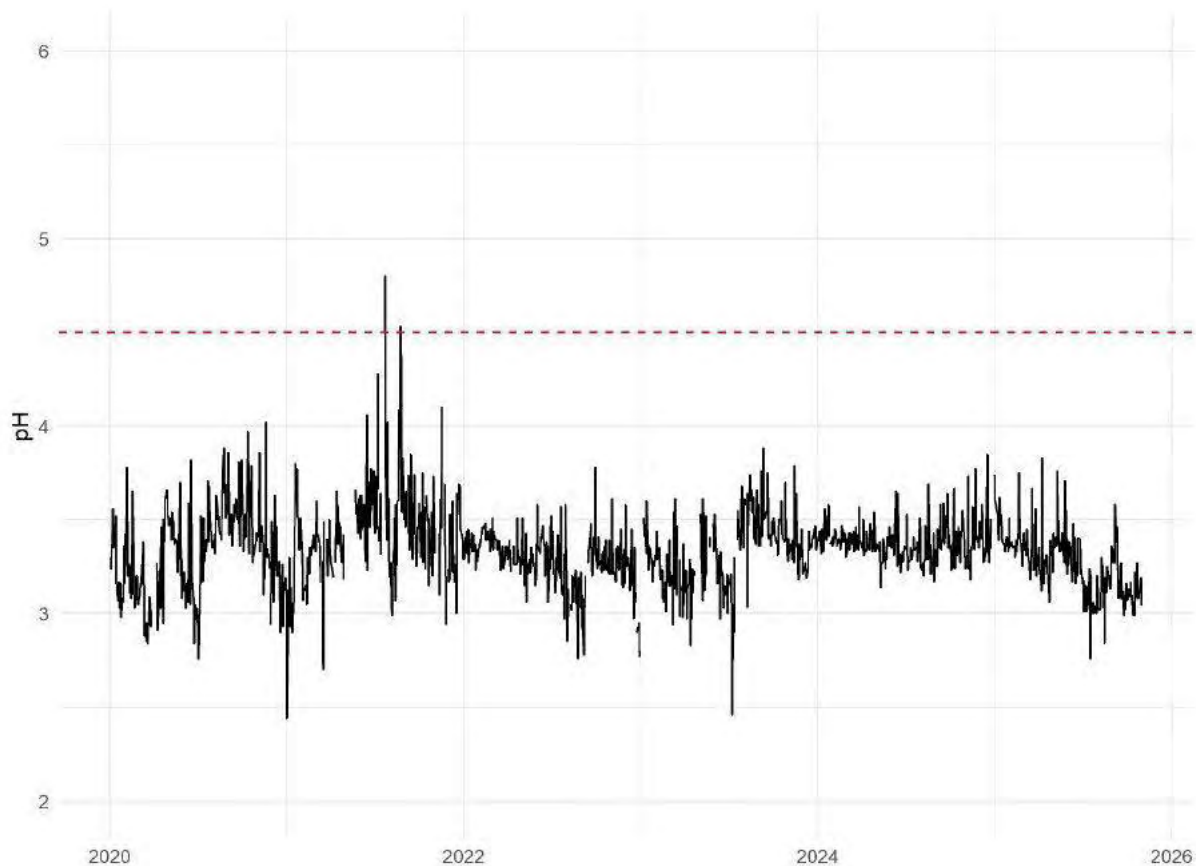


Figure 23. Daily pH from upper Granity Stream at S25. The horizontal red line denotes the lower limit for the occurrence of fish (Greig et al., 2010).

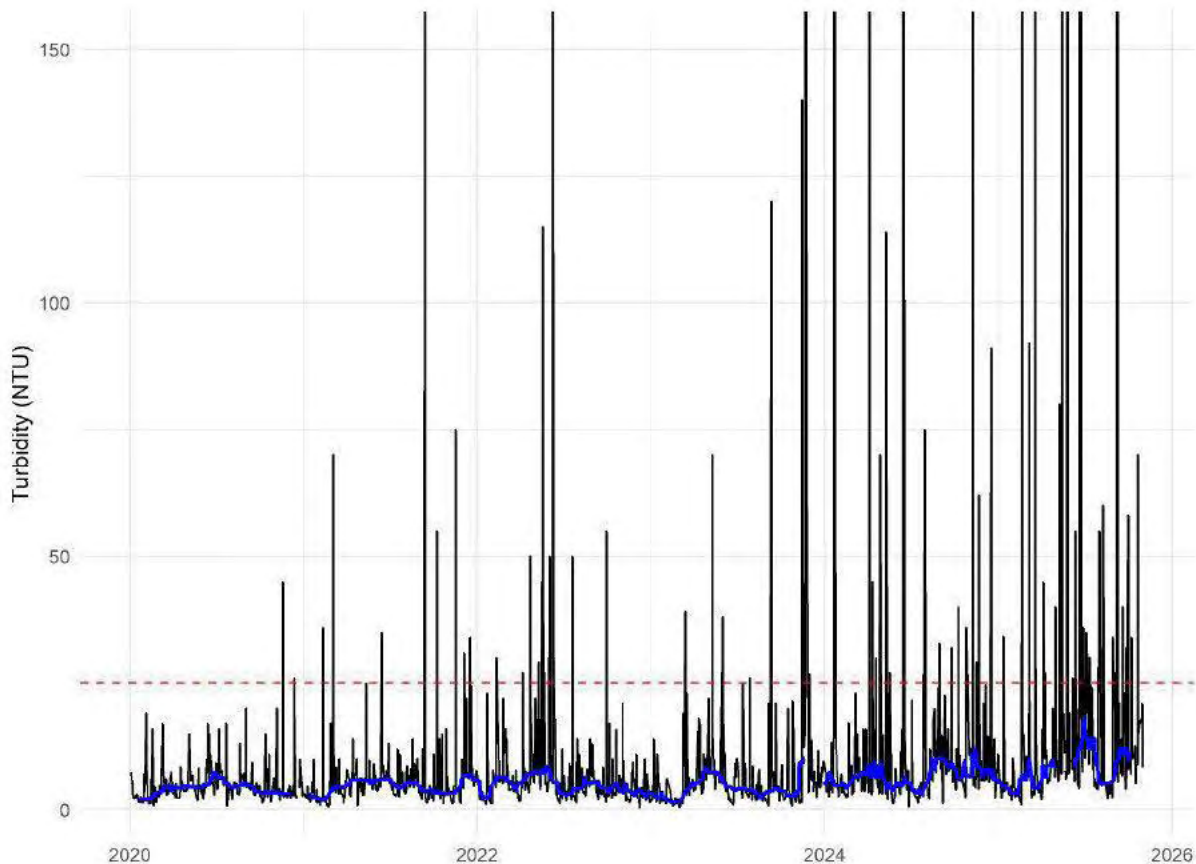


Figure 24. Turbidity (NTU) at S25. The horizontal dashed red line shows the 25 NTU threshold for [REDACTED] and the blue line shows the 30-day rolling median.

3.4.4. Granity Stream at SH67 (GB1)

Granity Stream at the SH67 bridge is influenced by both the upper Granity (S25) and Miller (S24A) Stream catchments. Granity Stream at the SH67 bridge is highly acidic having pH values persistently below 4 that would likely preclude either fish or macroinvertebrates from colonising the stream (Figure 25). Similarly, dissolved aluminium between 2018 and the present has remained above the 1 mg/L threshold for ecological recovery (Figure 26). Turbidity was typically below the threshold for behavioural avoidance suggested by Boubée et al., (1997) having a five-year median of 1.9 and Hazen 95th percentile of 30 NTU.

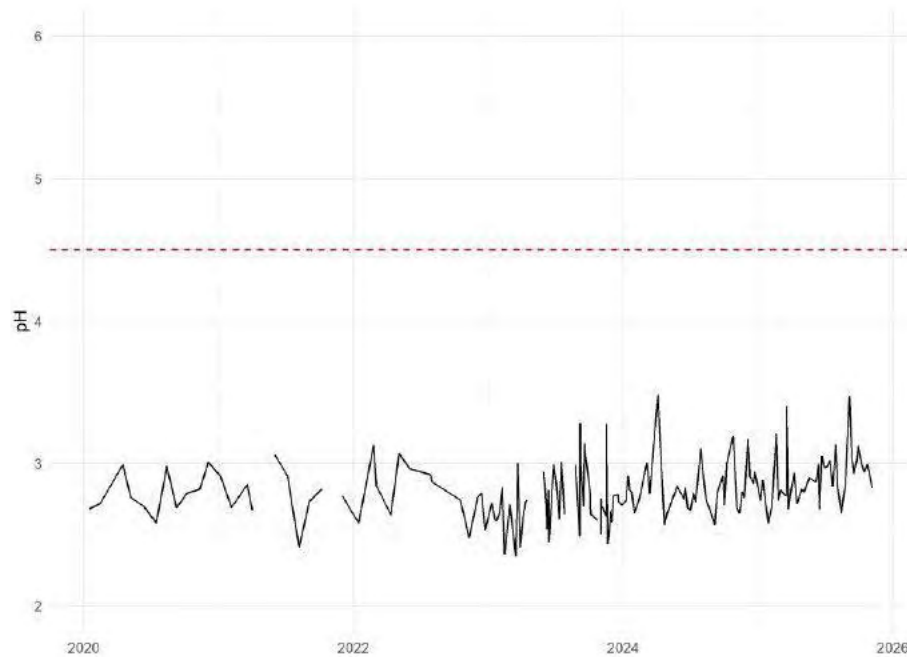


Figure 25. Daily pH from Granity Stream at GB1 between January 2020 and July 2025. The horizontal red line denotes the lower limit for the occurrence of fish (Greig et al., 2010).

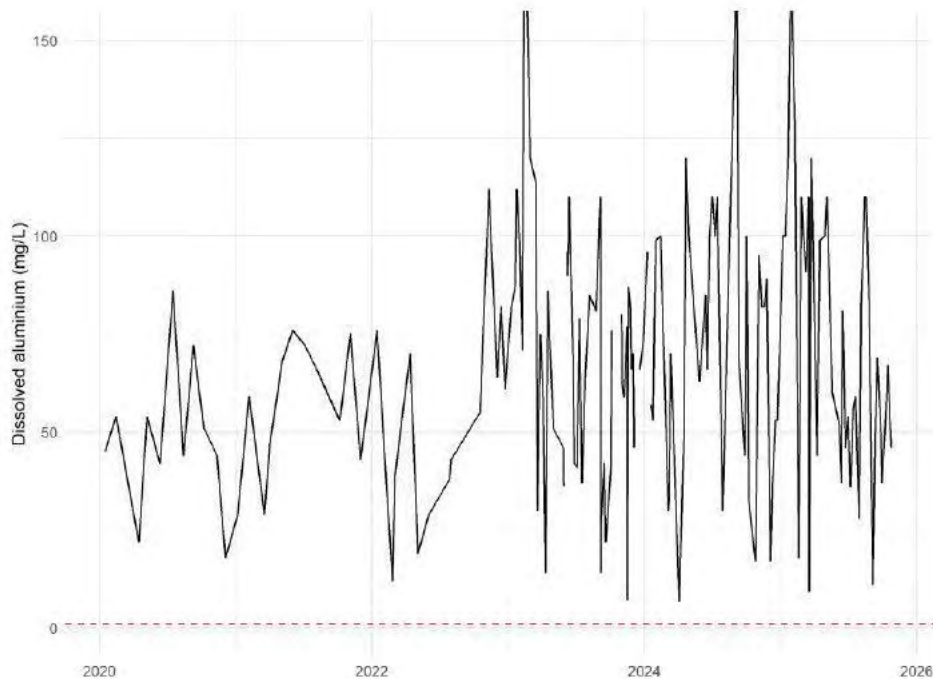


Figure 26. Dissolved aluminium in Granity Stream at GB1. The horizontal red line denotes the upper limit for the occurrence of fish (Greig et al., 2010).

3.4.5. Mine Creek

Mine Creek is monitored for water quality in two tributaries at sites S23 and S6 in the headwaters and MC1 immediately upstream of the confluence with the Ngākawau River (Figure 22). At S23 pH has been monitored daily since 2006, while routine dissolved

aluminium and iron monitoring began in 2022. The pH in Mine Creek at S23 is highly acidic and consistently below the threshold for native fish and macroinvertebrates on the West Coast (Greig et al., 2010; Figure 27). Dissolved aluminium (

Figure 28) and iron (data not presented) are similarly elevated above the threshold for ecological communities. Turbidity is typically low at S23 (median 0.7 and Hazen 95th percentile 30) other than occasional high values associated with elevated flow.

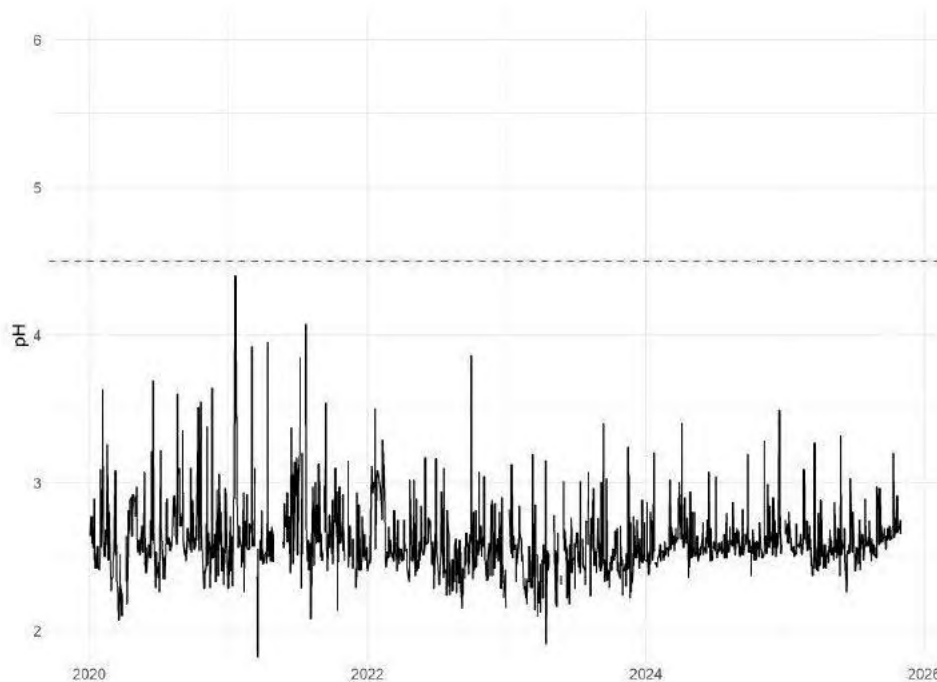


Figure 27. Daily pH from Mine Creek at S23. The horizontal red line denotes the lower limit for the occurrence of fish.

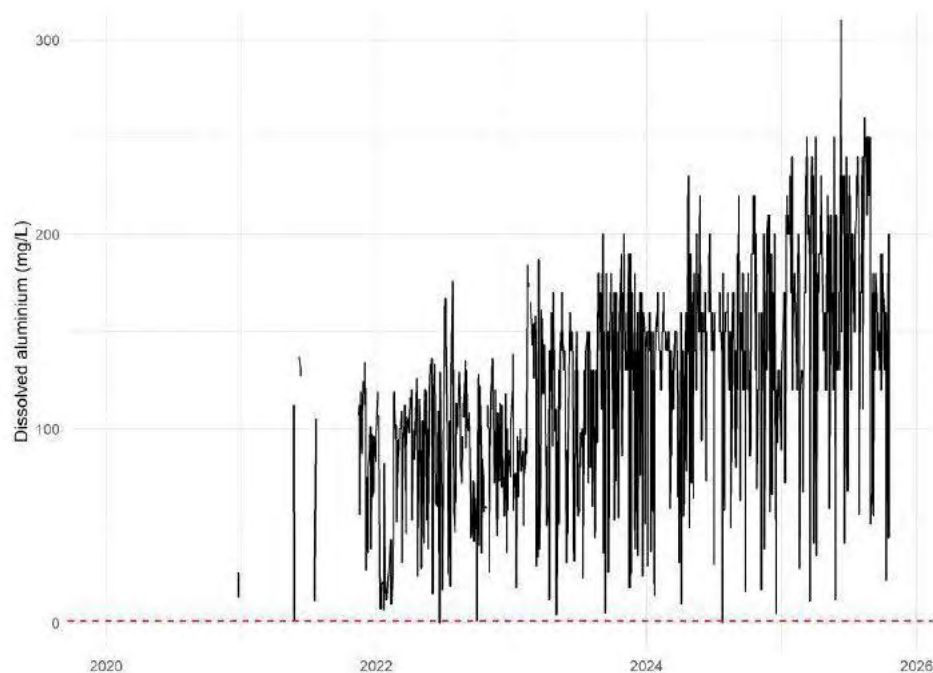


Figure 28. Daily dissolved aluminium from Mine Creek at S23. The horizontal red line denotes the upper limit for the occurrence of fish.

Site S6 has better water quality than S23. However, median pH (3.18) and dissolved aluminium (9.1 mg/L) both exceed the thresholds for ecological recovery (Greig et al., 2010; this report). The median turbidity at S6 is 1.9 NTU. Site access to MC1 was curtailed in 2021 due to a landslip and therefore summary statistics are based on the period 2020 -2021. Turbidity is similarly low having a median of 3.2 NTU and Hazen 95th percentile of 33 NTU. Nonetheless, the concentrations of dissolved aluminium (median 43 mg/L) and pH (median 2.96) are well in excess of thresholds for ecological recovery.

3.4.6. Twins Stream

There is limited recent regular water quality data from Twins Stream, but sporadic samples have been collected alongside macroinvertebrate samples between September and December 2025. T1 and T3 are the relevant sites for the Stockton Mine although it should be noted that T3 receives inputs from an adjacent mining operation and historic workings (Figure 22).

Between September and December 2025 twelve samples have been collected at T1 and eighteen at T3. At the upstream site T1 median aluminium was 6 mg/L while pH was 3.9. Both variables exceed the ecological thresholds for fish and aquatic macroinvertebrates. Median turbidity was 12.1 NTU.

At the downstream site T3 median dissolved aluminium was 1.975 mg/L, pH was 4.76 and turbidity was 9 NTU. The 75th percentile of dissolved aluminium was 2.3 mg/L indicating the site would be classified as 'water quality recovering'.

These results are generally more favourable than the results of regular monitoring collected between 2013 and 2021 where at T1 median turbidity, pH and dissolved Al were 3.1 NTU,

3.77 and 22 mg/L, respectively. At site T3 median turbidity was 13.1 NTU, pH was 4.45 while dissolved aluminium was 6.2 mg/L.

3.4.7. Rudolph Stream

Rudolph Stream does not receive discharges of contemporary AMD from the Stockton Mine but is subject to historic and neighbouring AMD discharges. However, the Buller Plateau Continuation Project does involve the diversion of ~ 9,000 m² of contaminated Rudolph catchment water into the Twins Stream catchment for treatment.

Water quality in Rudolph Stream at the State Highway in November 2025 indicted an absence of AMD, being circumneutral and having a dissolved aluminium concentration of 0.042 mg/L. However, because Rudolph Stream typically goes underground between its channel draining the hill and the State Highway culvert it is uncertain if the water being measured at base flow is derived from Rudolph Creek or not. Higher up on the stream site S28U had a median pH of 3.2 during 2024/25. Median dissolved aluminium over the same time period was 15 mg/L. Both proxy variables for the effects of AMD on ecological communities exceed their respective thresholds. Suspended sediments are low at S28U with median NTU values being 1 and 0.4, respectively.

3.4.8. Ngākawau River mouth

Ngākawau River mouth water quality is affected by contaminated tributaries above and within Ngākawau Gorge (St Patrick and Mangatini streams), Mine Creek which discharges directly into the tidal reach and the ocean (Figure 22). Water quality in the Ngākawau River upstream of Mine Creek (site NR) has improved since 2007 (Hore, 2024). The pH is typically greater than 4.5 (2021 – 2025 median 6.04; 5th percentile 4.93) and dissolved aluminium is generally less than 1 mg/L (2021 to 2025 median 0.29 mg/L; 95th percentile 1.1 mg/L).

The influence of Mine Creek is difficult to determine due to tidal flushing and uncertain dispersion dynamics in the estuary. The relative location of monitoring sites in the estuary are shown in Figure 29. Significantly more data exists at site NR Estuary, however due to concerns about the potential for this site to over-estimate effects on the river mouth because the Mine Creek plume hugs the left bank, water quality is now monitored from the centre of the bridge (site NRB).

Monitoring NR estuary occurs at low tide and amongst that data some influence on the Ngākawau River mouth can be observed from Mine Creek. Data (measured at the 'NR Estuary' site) indicates that pH in the mouth typically remains above 4.5 (Figure 30), but there are recurring spikes in dissolved aluminium (Figure 31) and iron (data not shown). In addition, due to the neutralising effects of Ngākawau River and sea water, precipitation and flocculation of metals occurs in the Mine Creek discharge plume (D Gray. Pers Obs). Precipitation and flocculation have potential effects on aquatic communities through both increased turbidity and smothering of habitat as well as causing aesthetic effects visible from the State Highway (Hogsden & Harding, 2012).



Figure 29. Locations of monitoring sites MC1, NRB and NR Estuary.

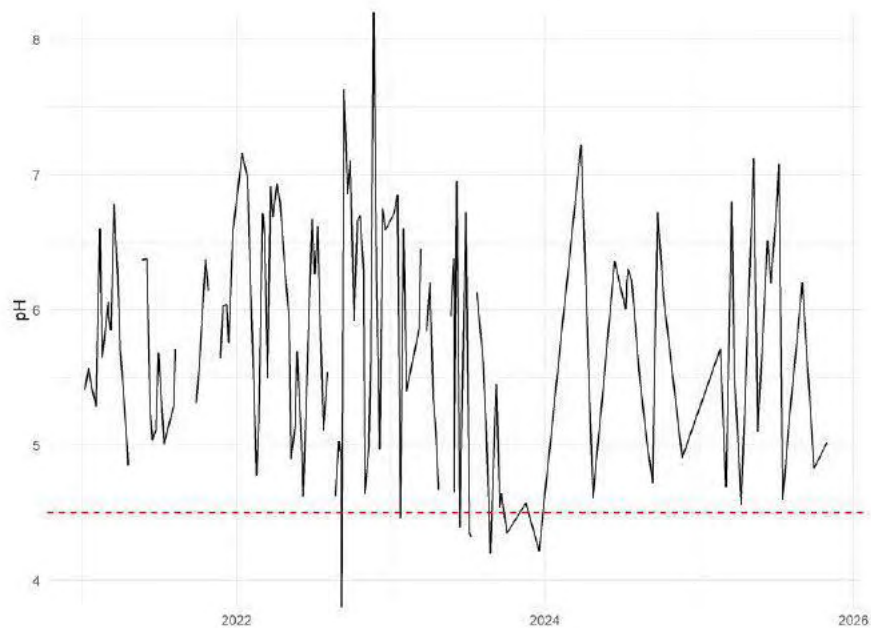


Figure 30. pH in Ngākawau River mouth (Site NR Estuary). The horizontal red line denotes the lower limit for the occurrence of fish.

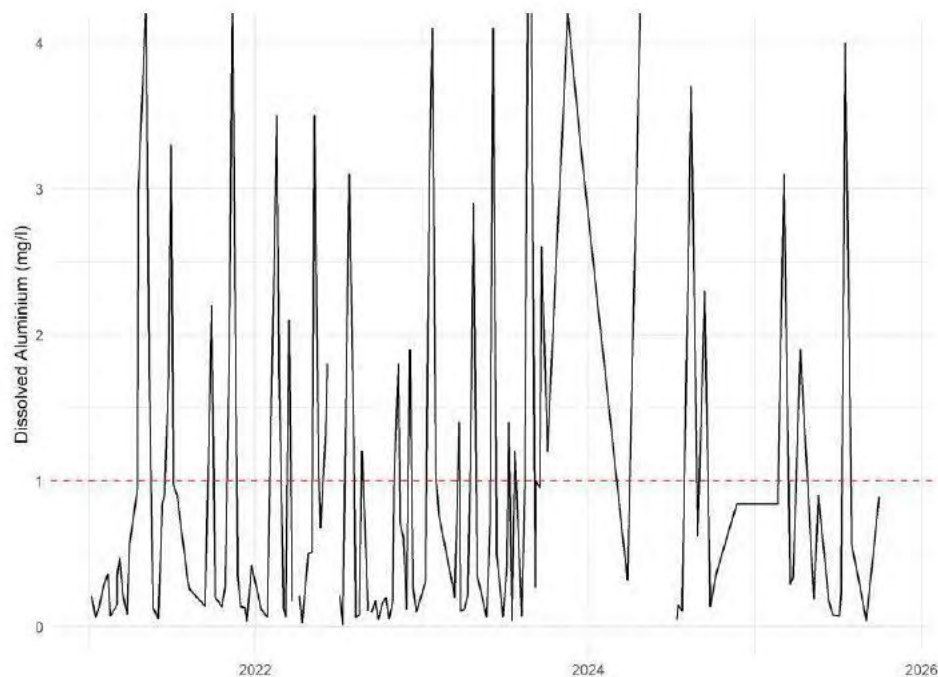


Figure 31. Dissolved aluminium in Ngākawau River Estuary (Site NR Estuary). The horizontal red line denotes the upper limit for the occurrence of fish.

Figure 32 shows a comparison of dissolved aluminium measured on the same day in Ngākawau River upstream of Mine Creek (Site NR2) and in the mouth downstream of Mine Creek (Site NR Estuary). Note this plot shows a suspected worst-case scenario within the Mine Creek plume on the true left bank of the Ngākawau Estuary at low tide in the absence of dilution from seawater. Aluminium in Ngākawau River at NR³ is typically below the 1 mg/L threshold for fish and macroinvertebrates, but exceeds that value at the NR Estuary site. More importantly there is no relationship between the two sites and 69% of results fall above the 1:1 line. This result suggests that Mine Creek is driving the high dissolved aluminium concentrations recorded at NR Estuary and potentially having a negative effect on ecological values in Ngākawau Estuary. The site exceeded the 75th percentile dissolved aluminium <1 mg/L criteria in 2022, 23 and 24.

³ Site NR was destroyed and access curtailed in 2021. Site NR2 has been used as a proxy subsequently but is occasionally affected by tidal fluctuations. The data record has been edited to remove any records potentially confounded by tidal fluctuations.

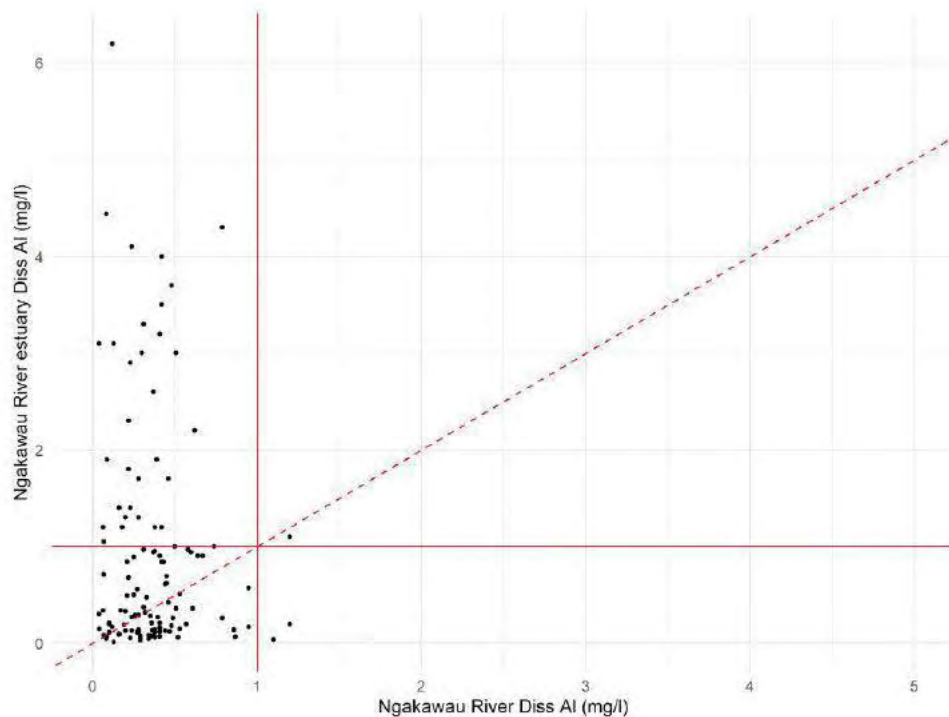


Figure 32. Dissolved aluminium in Ngākawau Estuary (Site NR Estuary) related to the samples collected at site NR upstream of Mine Creek. The solid red lines denote the upper limit for the occurrence of fish. The dashed red line shows the 1:1 ratio between the two variables. Note Ngākawau River data has been cleaned to remove tidally influenced samples based on a NIWA tide forecaster height of >2.5m

3.4.9. Millerton Streams flow

Flow information is available from Bathurst and third-party sources at various locations along the waterways. Sites with an adequate data record have been used to generate summary hydrology statistics to characterise flow (Table 11). Rudolph and Twins streams are the smallest of the streams, while Miller Stream at S24A and Mine Creek S23 are larger and similar in terms of flow. All streams experience flows in the order of tens of litres per second during the annual average driest seven days in each year. Heavy rain and a largely impervious catchment with thin soils and exposed bedrock result in flashy flows with high peak discharges (Figure 33). These flow regimes are typical of steep coastal catchments on the West Coast.

Table 11: Flow statistics (m³/s) for measured sites on the Millerton Streams. Except for Twins and Rudolph where flow statistics are estimated by Patrick et al., (2010). *Q50 floods.

Site	7d MALF ¹	Median	Max	Record
S24A (Miller)	0.052	0.17	8.23	1 Jan 2009 – 1 Jan 2024
S25 (Upper Granity)	0.010	0.04	17.13	1 Jan 2006 – 1 Jan 2024
S23	0.040	0.15	9.3	4 Oct 2011 – 28 May 2024
S6	0.009	0.09	5.7	25 May 2008 – 24 Oct 2023
Twins Stream	0.004	No data	5.3*	Modelled estimate
Rudolph Stream	0.005	No data	7.1	Modelled estimate

Note: The 7-day mean annual low flow (7d MALF) is the average of the lowest 7-day average river flows recorded each year over a period of record. This is a common statistic used to assess the effects of low flows on ecological communities.

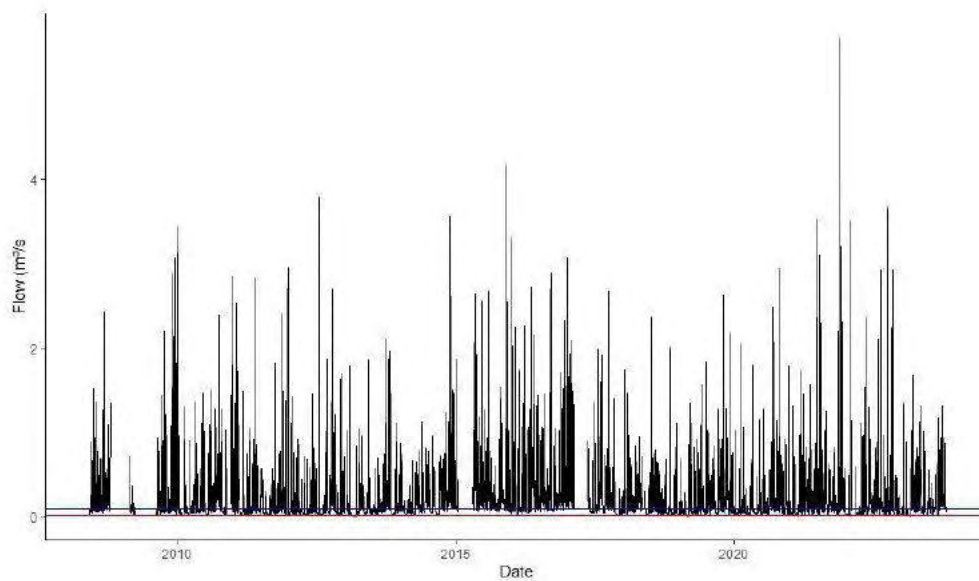


Figure 33. Daily mean flow (m³/s) at S6 between 2008 and 2023. The horizontal red line shows the 7d-MALF and the blue line shows the median flow. Note gaps in the data are due to equipment failure.

3.4.10. Millerton Ecology

Ecological information in the form of macroinvertebrate data for the affected waterways is available from a range of surveys done over the last 30 years. This information was recently reviewed by Gray (2023) whose findings confirmed the predicted occurrence of low species richness and abundance due to AMD.

The Acid Mine Drainage Index (AMDI) (Gray & Harding, 2012) was specifically developed to detect the effects of AMD on macroinvertebrate communities. It was shown to be more sensitive to those effects than other generic indices of stream health such as the Macroinvertebrate Community Index (MCI) (Stark, 1985). The index produces scores that range between 0 and 100 with associated water quality categories (Table 12).

Table 12. AMDI impact categories and scores.

Likely Water Quality	AMDI Range
Severely impacted	<20
Impacted	20-40
Unimpacted	>40

Table 13 applies the AMDI calculation to all available historic macroinvertebrate data for the Millerton streams and the Ngākawau River. Each stream was found to be currently, and for the most part historically, impacted or severely impacted by AMD other than a recent sample from Rudolph Creek at the State Highway.

Table 13. AMDI scores calculated from historic sources of macroinvertebrate data in the Millerton streams. See Figure 1 for sites.

Stream site	Instream consulting (2025)	Gray (2023)	BT (Various)	Kitto thesis (2007)	Gray & Harding (2012)	Suren & McKerchar (2001)	Harbrow (2001)	Anon (1989)
S6		Severely impacted: 17		Severely impacted: 0	Severely impacted: 0	Severely impacted: 13	Severely impacted: 13	Impacted: 21
S23		Severely impacted: 0		Severely impacted: 0	Severely impacted: 0	Severely impacted: 17	Severely impacted: 9	
S25		Severely impacted: 0			Severely impacted: 0	Severely impacted: 19	Impacted: 27	Severely impacted: 0
S24A		Severely impacted: 0			Severely impacted: 0			
GB1		Severely impacted: 2			Severely impacted: 0			
MC1					Severely impacted: 0			
Twins T1	Severely impacted: 3							
Twins T3	Impacted: 24							
Ngākawau u/s Mine Ck						Impacted: 25		
Ngākawau d/s Mine Ck						Severely Impacted: 6		
Upper Rudolph (S28U)			Severely Impacted (2013, 19, 21)					
Middle Rudolph (S28)			Impacted (2014,17), Severely impacted (2018)					
Rudolph at SH	Unimpacted (59)							

A search of the New Zealand Freshwater Fish Database (accesses October 2025) found that no fish have been recorded in Rudolph, Twins, or Granity streams or Mine Creek although only a very limited number of surveys have been recorded. [REDACTED]

3.5. Ngākawau River mouth ecology

River mouths are highly dynamic aquatic environments with typically diverse ecological communities at the interface between fresh and salt water. Mine Creek discharges into the lower Ngākawau River. Ngākawau River also receives (upstream) AMD contaminated water from the St Patrick Stream and, more notably, Mangatini Stream. Macroinvertebrate data was collected at the Ngākawau mouth up and downstream of the Mine Creek discharge by Suren & McKerchar (2001). Upstream of, and opposite, the Mine Creek confluence the AMDI score indicated the river was impacted by AMD having a score of 25. However, downstream of Mine Creek on the true left bank, the AMDI declined to 6 - Severely Impacted (*Sensu* Gray & Harding, 2012). It should be noted that the AMDI is an index designed for freshwater macroinvertebrates and is not configured to adjust for saltwater effects on aquatic communities. However, the results are considered to be indicative of a potential historic effect of Mine Creek on river health.

[REDACTED]

in Mangatini Stream has resulted in a renewal of fish migration to the headwaters of Ngākawau River. Under the current situation, the AMD influence via Mine Creek does not appear to prevent fish passage through Ngākawau River. It is assumed that fish are migrating during periods of diluted contaminants or using the salt-water wedge⁴ to avoid the Mine Creek discharge affected waters. However, the Mine Creek discharge has the potential to impact upon aquatic residents of the lower river.

[REDACTED]

Spot fishing in drains flowing from the settlement of Hector into on the true right of the Ngākawau River mouth found diverse fish communities [REDACTED] (D Gray, Pers. Obs. 2019)

⁴ A saltwater wedge is a dense layer of seawater that intrudes into a less dense freshwater river or estuary, flowing upstream along the bottom like a wedge, especially during low river flow. It forms because salt water is heavier than fresh water, creating distinct layers with minimal mixing, though the wedge's "toe" or leading edge gradually mixes with the fresh water above.

Surveys of sediment quality at the Ngākawau mouth were undertaken in early 2026 to assess the effects of water quality improvements since previous studies. Sediment quality in New Zealand is assessed using a tiered approach whereby total recoverable metals from the <2mm sediment size fraction are compared to both a default Guideline Value (DGV) and Guideline Value – high (GV-high) criteria. The DGV represents a threshold below which there is considered to be a low risk of unacceptable effects whereas an exceedance of the GV-high thresholds would be expected to result in an adverse toxicity effect. Across 10 samples collected from the left and right banks of the Ngākawau River downstream of Mine Creek metal concentrations all fell below the DGV other than for nickel at 3 sites (Table 14). Note the ANZG (2018) does not provide guidelines for aluminium, iron, cobalt and manganese. Whilst elevated iron in sediment is more typically considered detrimental to ecology due to smothering by flocs, the Ontario Ministry of the Environment (Canada) provide a DGV and GV-high equivalent of 20,000 and 40, 000 mg/kg. That DGV was exceeded on a number of occasions, but not the GV-high. Generally speaking, sediments in the river mouth would not be considered to represent a risk of toxicity to aquatic biota other than for Nickel. In the case of nickel at the observed concentrations there is a greater than low likelihood of non-lethal adverse effects occurring. Additionally, it is acknowledged that the area is highly dynamic and subject to regular flushing flows such that further sediment samples would be useful to confirm this conclusion.

Table 14. Sediment metal concentrations (mg/kg dry weight) from 10 sites in the Ngākawau River mouth collected in March 2026 compared to the ANZG (2018). Bold indicates an exceedance of the DGV. No sites exceeded the GV-high.

Metal	Min - max	DGV	GV high
Aluminium	5900 - 20000	-	-
Cadmium	<0.1	1.5	10
Chromium	9 -24	80	370
Cobalt	3.5 - 10.3	-	-
Copper	4 - 19	65	270
Iron*	11,800 – 34,000	20,000	40,000
Manganese	136 - 300	-	-
Nickel	8 - 25	21	52
Zinc	29 - 116	200	410

Note. *DGV and GV-high are derived from the ANZG (2018) except for iron that is derived from the Ontario Ministry of the Environment (Canada) guidelines. <https://www.ontario.ca/document/guidelines-identifying-assessing-and-managing-contaminated-sediments-ontario/identification-and-assessment#section-1>. While dated these iron criteria provide a screening level thresholds for iron. Concentrations that exceed the DGV are show in bold. Concentrations that exceed the GV-high are show in red.

3.6. Coastal Marine Area

Effects on the coastal and marine environment have been considered through the measurement of contaminants in the flesh of marine mussels in 2006/7 and 2025 (Shanahan, 2025). Mussels were collected down current of the discharge points of Granity Stream and the Ngākawau River on two occasions and at reference sites south of the Waimangaroa River in 2025 (Figure 34). Tissue metal concentrations were compared to food safety limits in New Zealand and international health-based guidance values (HBGV's). HBVG's included tolerable upper intake limits, provisional tolerable weekly intake levels, provisional tolerable monthly intake levels, safe levels of intake or benchmark doses (Shanahan 2025).

When compared to food safety standards cadmium, lead and mercury were all below the maximum recommended levels (Table 15). Total arsenic levels were greater than the food safety standards, but the testing undertaken did not differentiate between organic and inorganic forms, the former of which is less toxic. The US EPA concluded that an assumption of inorganic arsenic as 10% of total arsenic is reasonable (Shoof & Yagar 2007) such that mussel tissue metal concentrations in this study were well within food safety standards.



Figure 34. Mussel sampling locations relative to rivers draining the Stockton Plateau. From Shanahan (2025).

All tissue samples met the HBVG's for aluminium, cadmium, chromium, copper, lead, manganese, mercury, nickel, potassium, thallium and zinc. Iron and magnesium exceeded their respective HBVG's on all occasion and selenium exceeded at both reference sites and Dean Stream down current of the Ngākawau River.

All samples exceeded the iron HBVG, however it is worth noting that the HBVG is a safe level of intake rather than an upper limit. The magnesium HBVG was exceeded, but when ingested

as naturally occurring in food no toxic effects have been identified. Selenium was elevated up and down current of the AMD discharges which suggest that tissues concentrations are not related to mining. Despite exceeding the HBGV, concentrations were below the median for mussels tested for the New Zealand Total Dietary Study (MPI 2018).

Table 15. Summary of total metal concentrations in mussels (mg/kg) from sites north to south, left to right. Samples from 2006/2007 are highlighted in light blues. Bold indicates where results exceed the Food Standards for Australia and New Zealand. Underlined and grey indicate those results that exceed the HBGVs. From Shanahan (2025).

	Dean Stream		South 1		South 2		Reference 1	Reference 2
	2007	2025	2006 ¹	2025	2007 ²	2025	2025	2025
Aluminium	34	30	57	88	61	43	70	65
Arsenic	<u>2.2</u>	<u>1</u>	<u>2.3</u>	<u>1.27</u>	<u>3.3</u>	<u>1.31</u>	<u>1.07</u>	<u>1.11</u>
Cadmium	0.13	0.077	0.14	0.067	0.12	0.078	0.102	0.076
Calcium		1520	2500	1410	1200	480	860	820
Chromium	0.14	<0.19	0.14	0.2	0.17	<0.19	0.19	<0.2
Copper	1	0.8	1.1	0.89	1.2	0.86	1.08	1.03
Iron	<u>61</u>	<u>46</u>	<u>83</u>	<u>155</u>	<u>100</u>	<u>76</u>	<u>129</u>	<u>120</u>
Lead	0.1	0.055	0.15	0.115	0.18	0.074	0.167	0.16
Magnesium	<u>580</u>	<u>900</u>	<u>620</u>	<u>950</u>	<u>590</u>	<u>890</u>	<u>1030</u>	<u>920</u>
Manganese	1.1	1.2	2.6	3.7	2.3	1.34	3.1	3
Mercury	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Nickel	0.26	0.24	0.26	0.32	0.3	0.21	0.31	0.3
Potassium	2200	1420	2200	1250	2000	1420	1240	1430
Selenium	<u>0.5</u>	<u>0.52</u>	<0.3	0.36	0.4	0.35	<u>0.5</u>	<u>0.52</u>
Sodium	3800	6000	4300	6400	4400	6000	6700	6100
Thallium	0.0027	<0.005	0.0033	<0.005	0.0065	<0.005	<0.005	<0.005
Zinc	16	15.3	10	13.1	14	15.3	16.6	17.4
Notes: On each occasion an attempt was made to collect 12 mussels at each sites although the exact number was sometimes not recorded. ¹ based on 17 mussels ² based on 16 mussels								

Analyses indicated no significant differences between sites, however Shanahan (2025) noted that caution should be used due to the lack of replication in the available data. Additional sampling occurred in 2026 and reports are in preparation.

Arsenic, copper, cadmium and potassium differed between years with higher concentrations at all sites in 2006/7. Chromium, magnesium and sodium were higher at all sites in 2025. Chromium differences were likely driven by change in lab detection limits.

Three New Zealand studies were available for comparison. The New Zealand Total Dietary Study (MPI 2018), and studies that collected mussels from the Bay of Islands (Whyte et al. 2009) and Wellington Harbour (Milne, 2006). Concentrations in mussels collected by BRL from all sites combined were similar to those recorded elsewhere around the country (Figure 35).

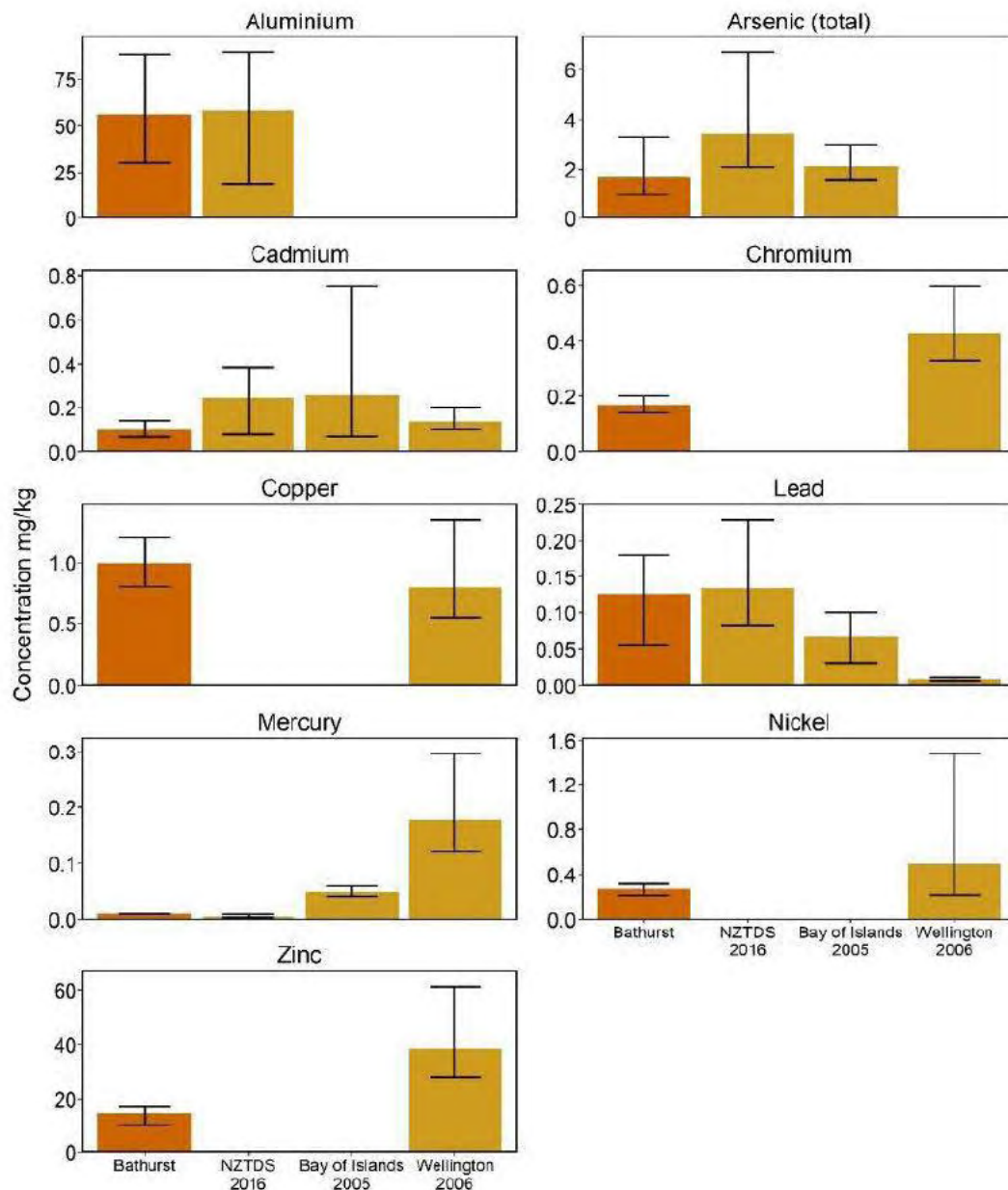


Figure 35. Comparison of mussels tissue metal concentrations between BRL (Orange) and other studies in New Zealand (yellow). Errors bars represent minimum and maximum values from each stud. From Shanahan (2025).

Concentrations of aluminium, arsenic, cadmium, lead and mercury were within the ranges observed by MPI (2018) and mussels from Wellington Harbour. Arsenic, cadmium, lead and mercury concentrations were comparable to those in the Bay of Islands. However, BRL mussels had a higher maximum arsenic and lead than the Bay of Islands.

Metal concentrations were typically below food safety standards and did not differ substantively over time or between sites down current of Granity stream, between Granity Stream and the Ngākawau River, or up current of the Ngākawau River.

3.7. Site 6W (Upper Waimangaroa)

Site 6W is a headwater site in the Waimangaroa River that receives AMD from the Stockton opencast mine, and historic workings discharging to the Herbert and Whirlwind stream (Figure 1, Appendix 1). The site is currently monitored as part of the Cypress Mine consents (Figure 36).

Water quality has been measured sporadically over the long term, although collections have become more regular since 2019. Aquatic macroinvertebrates and water quality are available between 2018 and 2025. Dissolved aluminium ranged between 1.0 mg/L and 4.4 mg/L, while pH ranged from 4.4 to 4.7. There were no particular trends over time in water quality, although the length of consistent record for the site is short.

Comparison of the aquatic macroinvertebrate and water quality data did not show any significant patterns, which is likely due to the consistency of water quality over the time period. Despite the sometimes-elevated dissolved aluminium, the number of taxa recorded ranged between 6 and 4, while the AMDI scores varied from severely impacted (10.3) to unimpacted (40.1). Observations at site 6W confirm the findings of the thresholds analyses presented in Section 2.5. Several macroinvertebrate taxa are able to persist despite elevated dissolved aluminium, however there are no fish in the upper Waimangaroa River.



Figure 36. Site 6W (18th April 2024) on the upper Waimangaroa River, draining the southern flanks of Stockton Plateau (Figure 1) (Image courtesy of Bathurst Resources).

3.8. Herbert and Whirlwind

The Herbert and Whirlwind streams drain the ridge between Mounts Frederick and Augustus and flow into the Waimangaroa River. The upper parts of these streams are diverted away from the Waimangaroa River into the Plover and St Patrick Streams and for treatment. The lower Herbert and Whirlwind Streams receive historic discharges of AMD some of which is treated by a mussel shell reactor in Whirlwind Stream. Both streams are monitored in their headwaters close to the points of AMD discharge, Whirlwind stream at S4 and Herbert Stream at UC2.

Site S4 shows highly variable pH that ranges either side of the ecological threshold of 4.5. Aluminium concentrations have only been recorded on 3 occasions in 2025 ranging between 0.09 and 5.9 mg/L with an intermediate value of 1.6 mg/L. Two of the three values exceed the ecological threshold, but additional data would be required to make a more formal assessment.

There is more information available for the untreated Herbert Stream at site UC2. The median pH for 2024/2025 was 3.3, while dissolved aluminium was 6.3 mg/L. Both water quality measures exceed the thresholds for ecological recovery.

Aquatic macroinvertebrate ecology data is available for Whirlwind Stream collected in 2007 as part of a Master's thesis (Kitto et al., 2015) and also the development of the AMDI (Gray & Harding, 2012). Samples were collected longitudinally along Whirlwind Stream but indicated that prior to the construction of the mussel shell reactor (2012), the stream was typically 'Severely Impacted' or, on occasion, 'Impacted' (*Sensu* Gray & Harding, 2012).

A mussel shell reactor is proposed for the Herbert Stream although that project sits outside the scope of the Buller Plateau Continuation Project (BPCP) and is being assessed by a Crown/LINZ AMD management project (Dec 2025-<https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>). Macroinvertebrate sampling of the Whirlwind Stream immediately upstream of its confluence with Cypress Stream is part of the proposed monitoring programme for the BPCP and is scheduled to begin in early 2026.

3.9. Rapid Stream

Rapid Stream is further detailed in assessments undertaken by ESNZ and RMA Science but is discussed here as an example of a different stream type. Rapid Stream drains a substantial area of historic Denniston mine workings between Waimangaroa and Whareatea Rivers (Hogsden et al., 2020). Rapid Stream headwaters receive AMD from an adit draining the abandoned Sullivan Mine (Figure 37). During a 2020 survey directly upstream of the adit, Rapid Stream was reported to have a pH of 4.5, within the natural range, an electrical conductivity of 36 $\mu\text{S}/\text{cm}$ and dissolved aluminium of 0.064 mg/L (Hogsden et al., 2020). These results indicate that the upper stream has clean water that supports a range of aquatic life. However, downstream of the adit pH fell to 3.3, conductivity increased to 564 $\mu\text{S}/\text{cm}$ and dissolved aluminium rose to 5.5 mg/L. ESNZ surveyed sites further downstream at 'upstream sandstone Creek', 'SH67' and on the flats close to the ocean. Water quality generally improved downstream as pH increased to 4.7 at the lower site, however dissolved aluminium remained elevated > 1 mg/L at all sites.



Figure 37. Abandoned Sullivan Mine adit discharging AMD to the headwaters of Rapid Creek. (Image by K. Hogsden 2016).

Repeat aquatic macroinvertebrate samples were collected at SH67 in 2007 and 2020 (Gray & Harding, 2012; Hogsden, 2020). In 2007 pH was 3.5 and dissolved aluminium 3.1 mg/L, whereas in 2020 pH was 4.12 and dissolved aluminium had decreased to 1.0 mg/L. Bathurst Resources data indicates a decline in estimated acidity between 2001 (248 mg/L) and 2020 (140 mg/L), suggesting that acid production in the underground mine may be decreasing over time, and water quality may continue to improve.

The macroinvertebrate community between 2007 and 2020 increased from 5 to 9 taxa respectively and the AMDI doubled from 15 to 31, taking the stream from the status of severely impacted to impacted. While these results are based on the comparison of a single pair of isolated samples, they do indicate potential improvement in ecosystem health in Rapid Stream over time that aligns with our analysis of water quality thresholds for macroinvertebrate health (Section 2.5).

[REDACTED]

However, in 2026 Instream surveyed Rapid Creek at SH75. The stream was at low flow, dissolved aluminium was measured at 1.5 mg/l and pH 4.1. Nonetheless, [REDACTED] were observed in the stream. Additional water quality data, collected by Bathurst, indicated that the water quality conditions observed by Instream

were typical of the stream during low flows, while aluminium was < 0.5 mg/L and pH >4.5 during elevated flows.

3.10. Cascade Creek longitudinal study

Cascade Creek is further detailed in assessments undertaken by ESNZ and RMA Science but is discussed here only as an example of a different stream type. In 2025 ESNZ undertook a longitudinal study of the Cascade Creek that drains off the eastern flanks of the Denniston Plateau. The existing Cascade and Escarpment Mines are in the headwaters of Cascade Creek. The Cascade Mine is closed, but historic workings still contribute AMD to the Cascade Creek. Hogsden et al. (2025) observed that Cascade Creek close to the mine was impacted by AMD and therefore a survey was commissioned to determine the longitudinal extent of effects on the stream. Additional ecological sampling downstream to immediately below the Rochfort Creek allowed the effects of a gradient of pH spanning from 4.1 to 7.5, and dissolved aluminium between 6.5 and 0.053 mg/L to be assessed. Aquatic macroinvertebrate communities were collected at 6 sites along Cascade Creek. The AMDI was indicative of severe or potential impacts until pH had increased above 5.5 and dissolved aluminium below 0.5 mg/L (Figure 38).

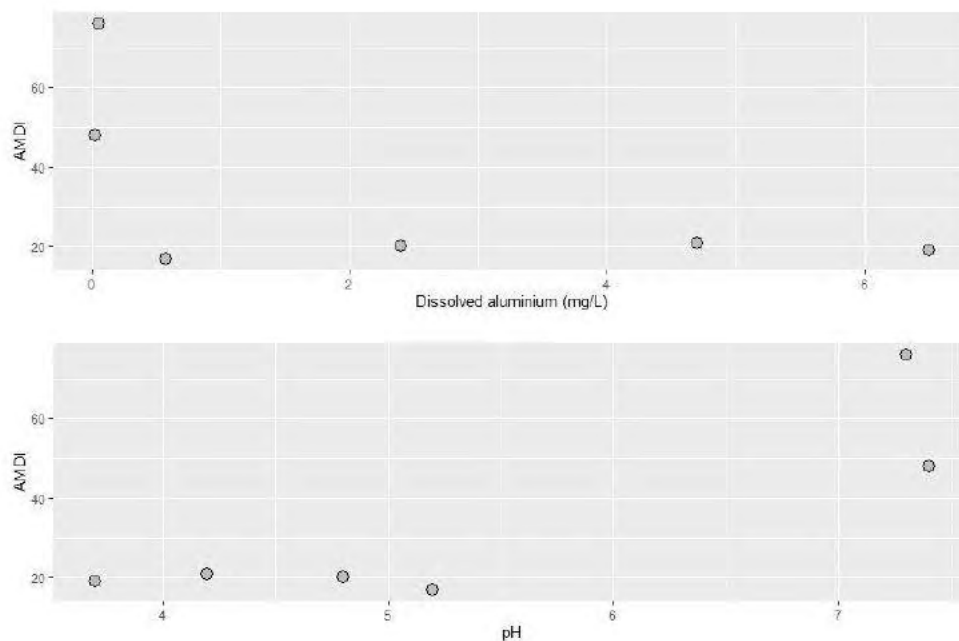


Figure 38. AMDI compared to pH and dissolved aluminium at longitudinal sites on Cascade Creek (Hogsden et al. 2025).

The authors observed aluminium precipitates at sites with dissolved aluminium of 2.4 and 0.57 mg/L and pH that shifted from 4.8 to 5.2. The more circum-neutral downstream sites with lower dissolved aluminium concentrations might be expected to contain a greater diversity of aquatic macroinvertebrates. However, it seems likely that precipitates and low dissolved organic carbon were resulting in effects on aquatic communities greater than might be expected other streams draining BCM.

3.11. Summary of current Stockton AMD

Figure 39 shows the inferred ecological condition of streams draining the Stockton Plateau based on water quality classifications and available biological information described in this report. Waterways such as Cascade and Rapid creeks are covered in the assessments undertaken by ESNZ and RMA Science and are discussed above only as examples of different stream types.

It should be noted that clean tributaries draining to impacted rivers may be effected by a chemical barrier to fish migration so effects may be manifest up as well as downstream of the discharge points.

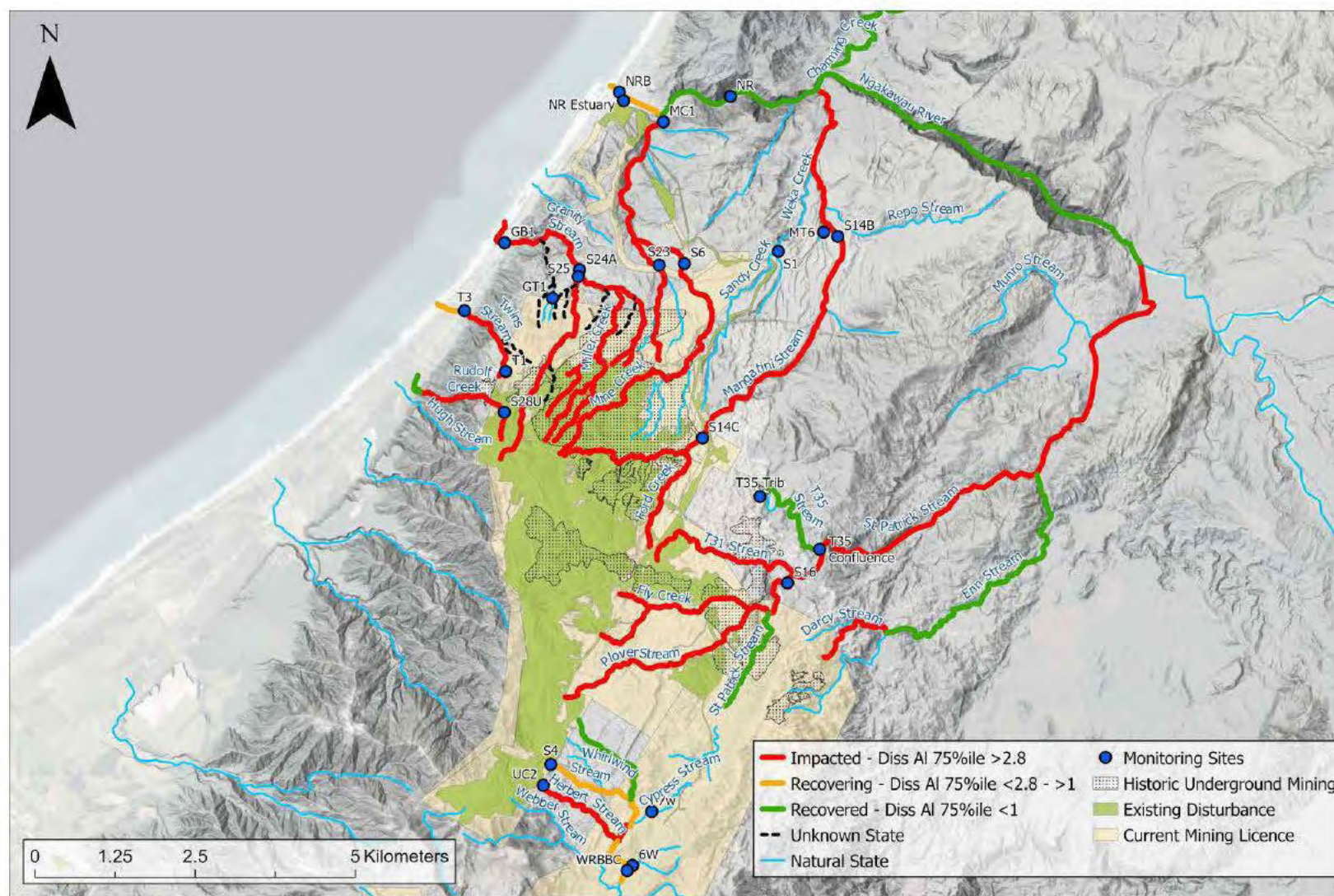


Figure 39. Current state of ecology on Stockton streams based on available water quality and ecology information. Classification thresholds for pH and dissolved aluminium from Table 7. Biological monitoring data described in text.

4. FUTURE STATE OF WATER QUALITY AND AQUATIC ECOLOGY

4.1. Introduction

Water quality remediation of BCM streams is a long-term process and planning extends eighty years into the future, approximately over three generations. There are various existing and proposed projects to address AMD as coal resources are exhausted and mine closure and rehabilitation proceeds (GHD, 2026; O’Kane, 2015).

Major projects focus on continued improvement in the tributaries that discharge to the Ngākawau River. While water quality in the Ngākawau River is greatly improved due to treatment of Mangatini and St. Patrick streams AMD there are further improvements to water quality to be made and the currently untreated discharge from Mine Creek to be addressed in the future (the latter being a Crown issue). Granity and Twins Streams, that discharge to the Tasman Sea, are also the subject of proposed mine water management meaning that all the AMD affected waterways draining the Stockton Plateau will feature some degree of water treatment.

4.2. BRL Water quality projections

BRL have developed water quality projections for future Stockton Mine AMD discharges under proposed BPCP water and AMD management strategies / plans. Dissolved Al was selected as the key indicator of AMD impacts for AMD modelling (justification discussed further in BRL 2026a, 2026b), for the following reasons:

- Major constituents of Stockton Mine AMD include hydrogen ion (measured as pH) and Lewis acidity (dissolved Al and Fe). During neutralisation (or dilution) pH increases causing precipitation of Fe and Al as amorphous hydroxides (and sometimes more complex minerals). Typically, Fe concentrations decrease sharply in the range pH 3-3.5, whereas Al concentrations decrease sharply between pH 4-4.5. This means that in partially neutralised or recovering streams Al is a more informative indicator for residual acidity / water quality recovery than Fe or total acidity.
- Al is routinely monitored at a wide range of sites across Stockton. This enables effective concentration comparisons across sites and mass balanced contaminant load models to be developed to simulate treatment and / or downstream mixing of AMD waters. The geochemistry of these processes is generally well understood and represented in models.
- Al is a common parameter used in previous AMD impact assessments / models across Stockton. This enables the key results of different technical studies to be incorporated into assessments.
- Al is one of the most commonly available measures of water quality at sites that have paired ecological data allowing the development of ecological recovery threshold criteria (as described in Section 2.5).
- The mass balance modelling approach is considered more reliable / representative for predicting Al concentrations than hydrogen ion concentration / pH.
- In general, the Al concentration recovery criteria are anticipated to be more difficult to achieve than the pH criteria, with the additional treatment required to minimise Al concentrations resulting in the pH criteria also being met.

4.2.1. Ecological recovery projections – St Patrick and Mangatini Streams

BRL (2026b) incorporated existing water quality datasets, scheduled rehabilitation, proposed changes to AMD treatment, and long-term acidity load decay to forecast future water quality in St Patrick Stream (at S16) and Mangatini Stream (S14B). These forecasts were for a period of 80-years (final simulation year 2106) and included the effects of proposed BPCP water and AMD management. Water and AMD management in the Mangatini and St Patrick catchments aimed to facilitate ecological recovery within the 80-year period.

The projected annual 75th percentile AI concentration met the comprehensive ecological recovery threshold of 1 mg/L either at the monitoring site (S14B) or somewhere in the downstream reach when additional dilution was incorporated (St Patrick stream below the T35 Stream confluence). The BRL (2026b) time-dependant ecological recovery trajectory will be used as a reference point for evaluating performance monitoring datasets and progress towards achieving the comprehensive ecological recovery goal in these catchments.

4.2.2. Betterment – Millerton Block streams

The Millerton Block was extensively disturbed by underground mining from 1890 to 1969, leaving an estimated 369.5 ha network of historic underground workings discharging AMD to multiple streams draining the Millerton Block (including Rudolph, Twins, Granity, Miller, and Mine Catchments). These streams do not currently meet ecological recovery thresholds.

Modern opencast mining in the Millerton Block was commenced by Solid Energy New Zealand Ltd in 2010 in the same areas as the historic underground workings. This has reduced the extent of the historic underground workings network to an estimated 271.2 ha in 2025 (with a further reduction in area to 182.5 ha by End of Mine Life (EOML) (2033) as part of the BPCP). Opencast mining has also enabled the removal of several remnant fires within the underground workings that had been burning uncontrollably since the 1970's.

In recent years, the Crown has been reviewing practicable economic alternatives to treat AMD on the Stockton Plateau. The current AMD management approach adopted and supported by iwi, the local councils and the Crown is to progressively improve impacted streams with the objective of sustaining mahinga kai values within 3 generations (or 80 years approximately).

To measure AMD improvement / betterment⁵ in light of the objective above, the BPCP has adopted 2010 as the reference point for the Millerton Block water quality for the following reasons:

- 50+ years of AMD discharge from the historic underground workings to the Millerton streams has in effect defined the environment up until the commencement of modern open cast mining in 2010;
- The 2010 reference point enables a high degree of separation between effects of new practices and contemporary AMD sources from the effects of remnant historic underground AMD sources that will remain outside the opencast disturbance footprint post BPCP;

⁵ 'Betterment' is defined as the process of active and progressive improvement of river health over the long-term. Definitions of betterment in the Millerton Block BPCP context and quantification betterment reference values are described in BRL (2026a).

- Acidity loads in 2010 were not influenced by the short-term AMD generation / effects from the use of pit water to cool or extinguish underground fires; and
- Sets the datum from which the trajectory of AMD improvement from contemporary activities can be sensibly measured.

BRL (2026a) AMD modelling suggests that ongoing AMD discharges from remnant historic underground workings (located outside the BPCP opencast mining disturbance footprint) will prevent water quality improving sufficiently to meet the thresholds for either ecological recovery beginning ($Al < 2.8$ mg/L) or comprehensive ecological recovery ($Al < 1$ mg/L). This applies to all AMD impacted streams draining Millerton Block throughout all Project phases (including to the end of the simulation period in year 2106). Accordingly, BRL have developed time-dependent betterment reference values for acidity load, acidity concentration, and Aluminum (Al) concentration at key sites (Twins Stream (T1), Granity Stream (S25), Miller Creek (S24A), Mine Creek (MC1); locations shown in Figure 22) have been developed to guide long term AMD management in these waterbodies. As discussed, the BPCP has adopted 2010 as the reference point for deriving betterment reference values. These betterment reference values show what acidity loads and acidity / Al concentrations would have been if:

- The contemporary (i.e., 2010 onwards) opencast mining in Millerton Block had not occurred;
- The Millerton Block historic underground workings had remained at their full 2010 areal extent (369.5 ha); and
- AMD continued to discharge from these historic workings without treatment.

The time-dependant BRL (2026a) betterment reference values for annual median Al concentration at T1, S25, S24A, and MC1 will be used as a reference point for evaluating performance monitoring datasets and progress towards achieving betterment in streams draining Millerton Block.

Predictions presented below provide estimates of dissolved aluminium at various sites. The threshold for water quality recovery has been set at an annual 75th percentile. That percentile was chosen to allow for occasional exceedances (25% of samples) that are likely to occur as AMD discharges diminish over long time periods. Note that these predictions are subject to change over time as further data is amassed and models refined. Comparison to future predictions over the course of the consent should be made to the most recent iteration of modelling.

4.3. St. Patrick Stream

As described in Section 3.2, St. Patrick Stream AMD loading has been reduced over the last 5 years by treatment through the McCabes Sump facility (Lime dosing plant 2 (LDP2)), and further improvements are planned incorporating Plover Creek AMD treatment. Various options exist to increase the level of treatment, particularly for high flows, as mining progresses and subsequently enters closure.

Based on the completion of remediation for 266 hectares within the St. Patrick catchment there is expected to be a reduction in acidity and dissolved aluminium at site S16 (Figure 40). Further gains are likely to be achieved through granite and soil capping of overburden, resulting in an estimated 23% reduction in acidity load and concentration from 2025 levels.

Treatment of Plover Creek from 2033 is expected to reduce S16 acidity load and concentration by a further ~21 % (compared to pre-treatment levels). Predictions based on the above treatment and a natural decay of ~0.62% per year indicate that S16 water would not achieve the threshold for dissolved aluminium for macroinvertebrates and fish after 80- years, but would come very close (BRL, 2026b, 2026c).

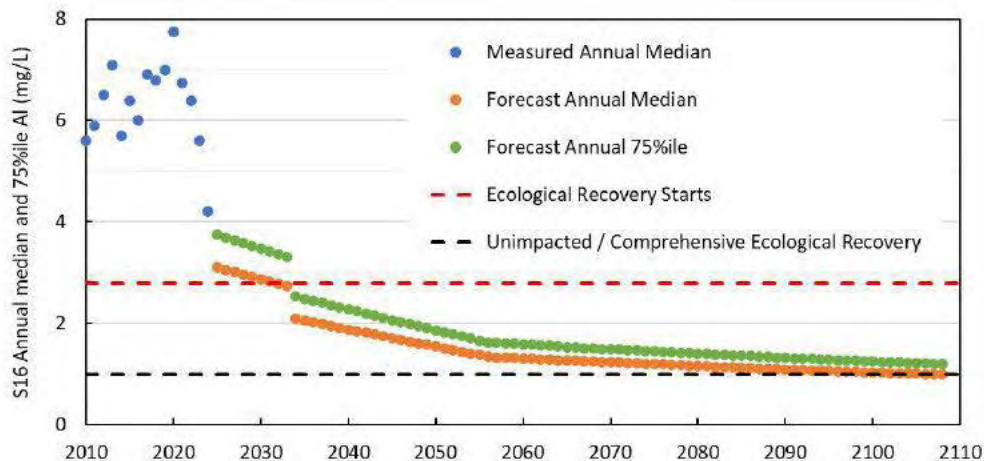


Figure 40. Measured (blue dots) and predicted dissolved aluminium concentrations at S16 on St. Patrick Stream (BRL, 2026b). The horizontal black line shows the 75th percentile threshold for fish and macroinvertebrate taxa.

S16 represents ~30 % of the total catchment of St. Patrick Stream suggesting that water quality at the St. Patrick Stream – Ngākawau River confluence may currently, or will soon, meet ecological thresholds. Approximately 1km downstream of S16 St. Patrick Stream confluences with T35 Stream whose inflow provides dilution (Figure 41). Based on relative sub-catchment areas and an assumption of negligible Al in T35 Stream water, dilution would result in a ~29% reduction in S16 Al concentrations downstream of T35 Stream (Figure 41).

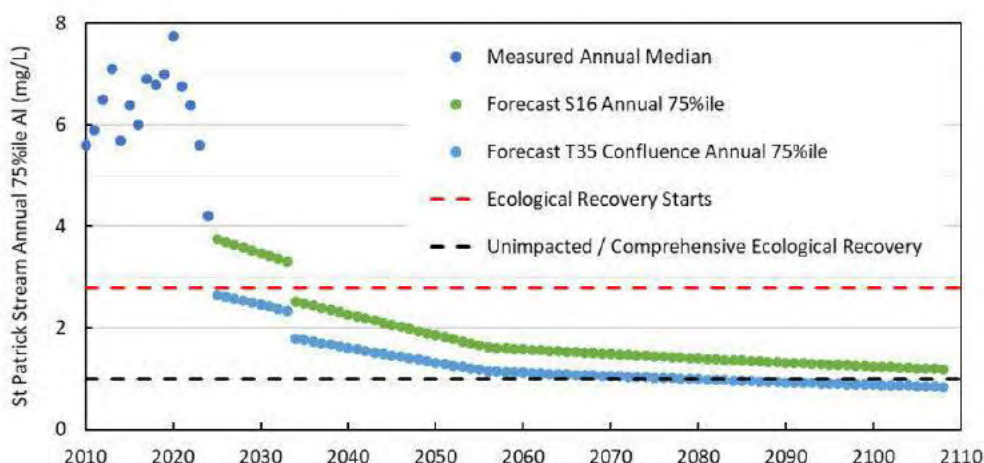


Figure 41. Measured (blue dots) and predicted dissolved aluminium concentrations showing dilution downstream of T35 Stream along the St. Patrick Stream (BRL, 2026b). The horizontal black line shows the threshold for fish and macroinvertebrate taxa.

Dilution by T35 Stream is forecasted to be sufficient to achieve the threshold for recovery of ecological communities 75% of the time in the St. Patrick Stream within 80 years (ref 2025 <https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>).

Several other large tributaries join the St. Patrick Stream between T35 Stream and the confluence with the Ngākawau River. In particular Erin Stream, which drains a large area of Pakihi and has high concentrations of dissolved organic carbon (DOC). DOC is a toxicity modifying factor for aluminium and other metals that reduces toxicity effects despite elevated dissolved concentrations. Accordingly, the St. Patrick Stream below Erin Stream is likely to undergo ecological recovery sooner than sites S16 and downstream of T35 Stream via dilution and toxicity modification.

As rehabilitation and treatment progresses over the next 10-years the recovering, and recovered reaches are envisaged to progress further upstream along St. Patrick Stream and improve connectivity for fish into non – AMD impacted tributaries such as Munro and Erin streams.

4.4. Mangatini Stream

While substantial remediation has occurred to date in Mangatini Stream (Section 3.3) further improvements are envisaged as rehabilitation and mine closure continues. Granite and soil capping, and clean water diversions during the rehabilitation of 270 Ha of disturbed ground in Mangatini Stream catchment are expected to result in a significant further reduction in AMD (BRL, 2026b). All AMD discharges to the Mangatini Stream above site S14C (Figure 1). Assuming a decay rate of ~0.62% per annum S14C is expected to approach the dissolved aluminium threshold for ecological recovery sometime after 2100 (Figure 42). The step change in water quality occurring in 2047 is due to the start of Millerton AMD treatment in MW16 Sump.

The downstream dilution factor between S14C and S14B is estimated to be ~2.5 and between S14C and Mangatini Falls is ~3. Based on rehabilitation, dilution and decay rates, dissolved aluminium at both sites S14B and Mangatini falls (directly upstream of the confluence with the Ngākawau River) will be suitable for fish and macroinvertebrates within the 80 year time frame and improve steadily over time (Figure 43).

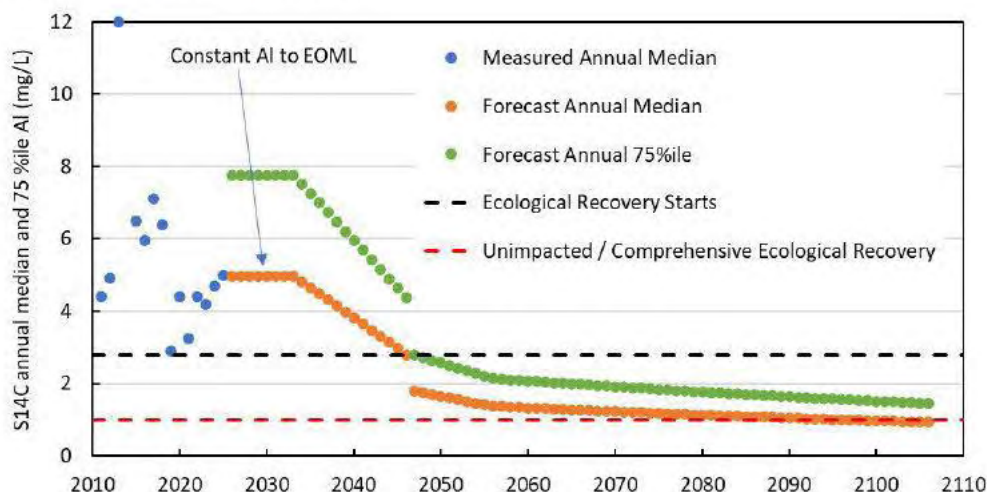


Figure 42. Median and 75 % dissolved aluminium at S14C on the Mangatini Stream. The horizontal red line shows the threshold for fish and macroinvertebrate taxa (BRL, 2026b). EOML = End of Mine life.

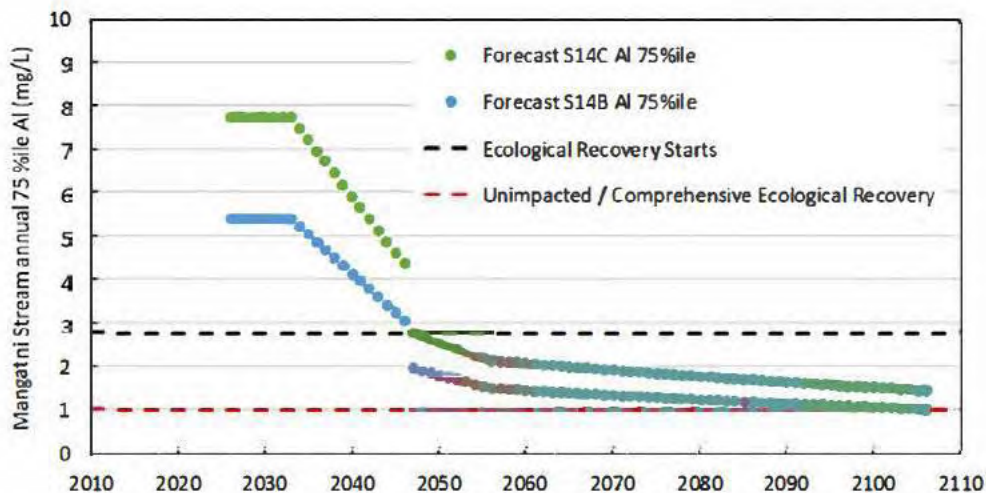


Figure 43. Predicted dissolved aluminium concentrations at S14B on Mangatini Stream (BRL, 2026b). The horizontal red line shows the threshold for fish and macroinvertebrate taxa.

While migratory fish species are unlikely to be able to navigate Mangatini Falls [REDACTED] [REDACTED] Many stream macroinvertebrates have a winged life stage that facilitates dispersal into rehabilitated streams (Kitto et al., 2015). [REDACTED] [REDACTED]

4.5. Ngākawau River at NR

The Ngākawau River at site NR is a key site for inferring effects of AMD on the migration of fish into the Ngākawau headwaters. Maintaining water quality within ecological thresholds is a focus outcome at this site. Site NR is likely to increase in AMD load (due to increased treatment residuals) during the operational phase as AMD is pumped from Millerton and fed into the Mangatini treatment system. That load will diminish at end of mine life and drop further when Millerton AMD begins to be treated in MW16 Sump from 2047 onwards.

Despite the increase above the current level of dissolved aluminium, site NR is forecast to stay within the 1 mg/L threshold (for the annual 75th percentile) for fish and macroinvertebrates.

4.6. Ngākawau River and mouth

The Ngākawau River at the State Highway bridge (Site NRB) is influenced by discharges of AMD from the St. Patrick Stream, Mangatini Stream, Mine Creek, and some other minor historic AMD sources (e.g., Charming Creek). While upstream of Mine Creek (at Site NR) the river typically meets ecological thresholds for dissolved aluminium, turbidity and pH, at sites downstream of the Mine Creek confluence water quality thresholds are exceeded, on occasion, during base flows due to the Mine Creek discharge. The river remains suitable for [REDACTED] presumably due to the tendency of fish to migrate during elevated flows that provide dilution and through avoidance of the Mine Creek plume which is thought to hug the true left bank. Fish may also be able to utilise the unmixed saltwater wedge which progress upstream past the mouth of Mine Creek. Implications for the resident aquatic fauna of the discharge into the Ngākawau River from Mine Creek were assessed in early 2026. [REDACTED]

The effects of Mine Creek on the Ngākawau River mouth are assumed to reduce substantially under the terms of the BPCP (Figure 44). Operational stage AMD management targeting the Millerton block is expected to reduce the load of contaminants to Mine Creek and the lower Ngākawau River and reduce any risk to migratory and resident fish (BRL, 2026a). Operational stage treatment is predicted to result in a general decline in the 75th percentile dissolved aluminium at the modelled NRB River⁶ site maintaining concentrations at a lower level than in the absence of treatment (Figure 44). However, aluminium concentrations remain elevated above the ecological threshold for recovery. Post end of mine life water management and treatment results in the modelled NRB River site meeting the ecological threshold by approximately 2034. These water quality improvements (coupled with upstream water quality remaining acceptable via the AMD management and treatment within the Mangatini and St Patrick catchments) will result in a reduction over time of any residual effect of AMD on the migration of fish through the Ngākawau River to the headwaters (Hore, 2024; Instream Consulting, 2025). Reductions in contaminant load will also be a positive outcome for resident ecological communities in the river mouth and the local coastal marine area. A recent survey found no obvious contamination or exceedance of food safety guidelines in marine mussel flesh either side of the Ngākawau mouth (Shanahan, 2025) and provisional results from a survey of the Ngākawau River mouth found the range of fish species that would be expected in that environment.

Currently, and during the operational phase, there is the potential for dissolved aluminium to have a negative effect on fish migration albeit currently only on 30% of measured occasions and based on targeting low tide when conditions would be worst (Figure 31; measured median 0.37 mg/L, min 0.012 mg/L, max 6.2 mg/L and 55th percentile 1.2 mg/L⁷). While on the basis

⁶ The 'NRB River' site is a modelled site which is theoretically located downstream of the Mine Creek confluence with Ngakawau River (i.e., in the Ngakawau Estuary tidal zone) but is modelled / analysed to remove any tidal dilution influence

⁷ Actual measured data at NRB/NR Estuary is presented in Figure 32

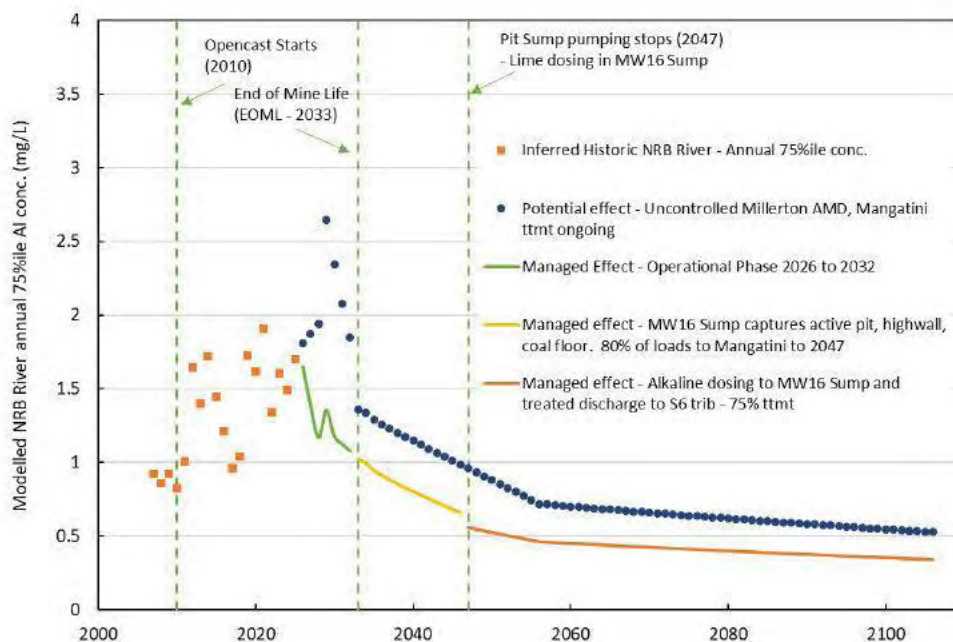


Figure 44. Predicted annual 75th percentile dissolved aluminium concentration (mg/L) at a modelled site located downstream of the Mine Creek / Ngākawau River confluence over 80 years. (BRL, 2026b).

4.7. Millerton and coastal streams

This section of the report makes an assessment of the ecological implications of a proposed scheme to manage contemporary AMD (captured within the proposed opencast disturbance footprint), but not the capture of historic discharge (outside of the proposed opencast disturbance footprint). However, this section should be read in the context of the intent of the Crown's long-term project to achieve mahinga kai values.

The basis of water quality predictions for the Millerton streams are presented in BRL (2026b). Those water quality predictions are assessed here in the context of water quality thresholds provided by Section 2.5 of this report. Specifically, annual 75th percentile concentrations of dissolved aluminium <2.8 mg/L are considered to represent the beginning of ecological recovery, whereas more comprehensive recovery is assumed to begin at <1mg/L. The BRL (2026a) modelled water quality projections for T1, S25, S24A, and MC1 do not meet thresholds for ecological recovery. The BRL (2026a) derived betterment reference values are instead used to guide long-term AMD management for waterbodies.

It is important to note that these assessments account for the effects of both historic and contemporary AMD on downstream monitoring sites (BRL, 2025a). However, it is assumed that the treatment of historic AMD required to achieve ecological recovery in streams discharging the Millerton Block will be dealt with through additional interventions by the Crown as part of its long-term monitoring strategy.

This assessment considers the proposed management of contemporary AMD within the opencast disturbance footprint, but not historic sources located outside the opencast disturbance footprint.

4.7.1. Rudolph Stream

There are considered to be no contemporary discharges of AMD to Rudolph Stream as contaminated water is diverted out of the catchment by a permanent cut-off drain. Nonetheless, the headwaters of the stream remains impacted by historic and neighbouring AMD discharges. The only effect of the BPCP is a reduction in flow from the additional ~1Ha of catchment being diverted (by construction of Twins Pit) resulting in a 7-d MALF (at the base of the catchment) declining from 0.005 to 0.0049 m³/s. These changes in flow are very small and under normal circumstances would not be considered to have a measurable effect on ecological values. Given the absence of ecological values in the upper Rudolph Stream the reduction in flow is not considered to have any ecological effects.

4.7.2. Twins Stream

Twins Stream at site T1 is currently considered to be impacted by AMD and has a degraded macroinvertebrate community. Annual median (and consequently 75th percentile; data not shown) dissolved aluminium is currently well in excess of 1 mg/L. Proposed water management and treatment is predicted to result in a steady decline of dissolved aluminium from the present condition, (derived from the 2013 – 2021 dataset, Figure 45), with annual median Al concentrations at T1 below betterment reference values (i.e., achieving the betterment objective) throughout the Operational, EOML, and Closure Phases. However, levels of aluminium are likely to remain above the ecological thresholds for recovery, and the Twins Stream is likely to require additional treatment, particularly of historic underground drainage to attain healthy ecological communities. Treatment of historic drainage sits outside of the BPCP.

Currently, site T3 at the State Highway shows some dilution of dissolved aluminium relative to the upstream T1 and a more diverse macroinvertebrate community. While site T3 is presently considered to remain ecologically impacted by AMD based on macroinvertebrates (Table 13) it is in the water quality recovery zone (<2.8 mg/L dissolved aluminium (this report)). Maintaining or improving the current levels of contemporary contamination at T3 is therefore an important focus during the operational phase. Post end of mine life reductions in dissolved aluminium are likely to result in continual ecological improvement such that site T3 will continue along the pathway to ecological recovery and there will be a reduction in the risk of any residual effects in the marine and coastal environment.

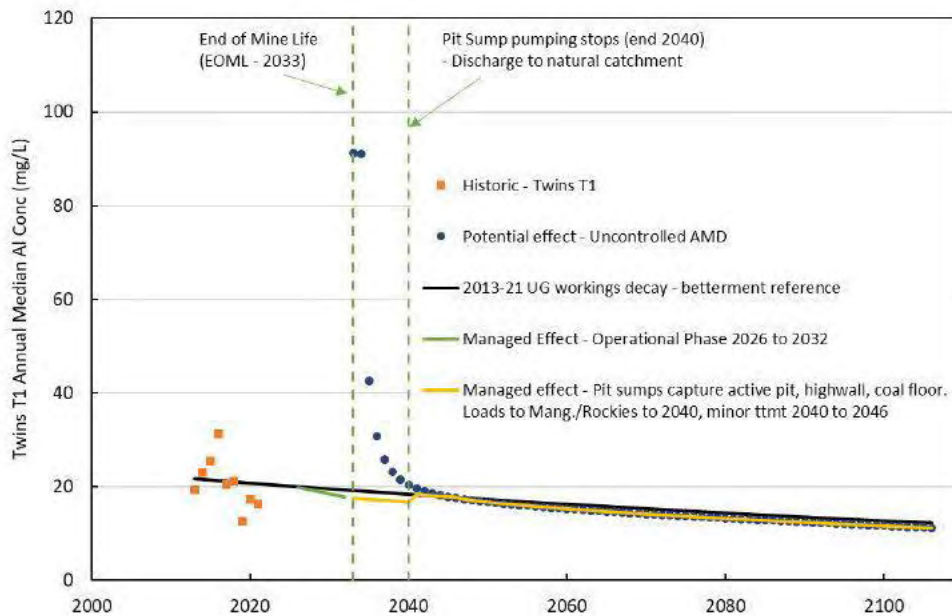


Figure 45. Predicted annual median dissolved aluminium concentration (mg/L) in Twins Stream at site T1 over 80 years (BRL, 2025a).

Flow in Twins Stream will be modified during the operational period as the AMD contaminated water will be collected in the Twins Sump and pumped out of the catchment for treatment. Following the end of operations (~2040), the sump will discharge to Twins Stream returning the flow to approximate natural levels (BRL 2026a). Long term flow monitoring is not available, so assessments of change are based on change in relative catchment area.

During the operational period, pumping of contaminated water is predicted to result in a substantial change in flow at T1 (-67%), but a lesser degree of change at T3 (-25%). During this period the water quality, particularly at site T1, is predicted to remain above ecological recovery thresholds. As a result, while the level of hydrological alteration predicted at site T1 would normally be considered likely to result in an ecological effect, in this circumstance no negative effects on aquatic ecology are considered likely. Given the removal of contaminated water from the catchment, despite reductions in flow of ~ 25% at T3, improved water quality is expected to accelerate the onset of ecological recovery faster than in the absence of treatment.

4.7.3. S25 Upper Granity Stream

Site S25 currently has elevated dissolved aluminium, low pH and severely impacted macroinvertebrate communities. Proposed water quality treatment will result in a steady improvement in water quality over the next 80 years, with annual median Al concentrations at S25 below betterment reference values (i.e., achieving the betterment objective) throughout the Operational, EOML, and Closure Phases. But water quality will not attain adequate levels to allow the recovery of ecological communities in that time period without further intervention, due to AMD discharging from remnant historic underground workings outside of the opencast disturbance footprint (Figure 46). Annual median dissolved aluminium (and consequently 75th percentile; data not shown) does not fall below the 1 mg/L threshold for ecological recovery.

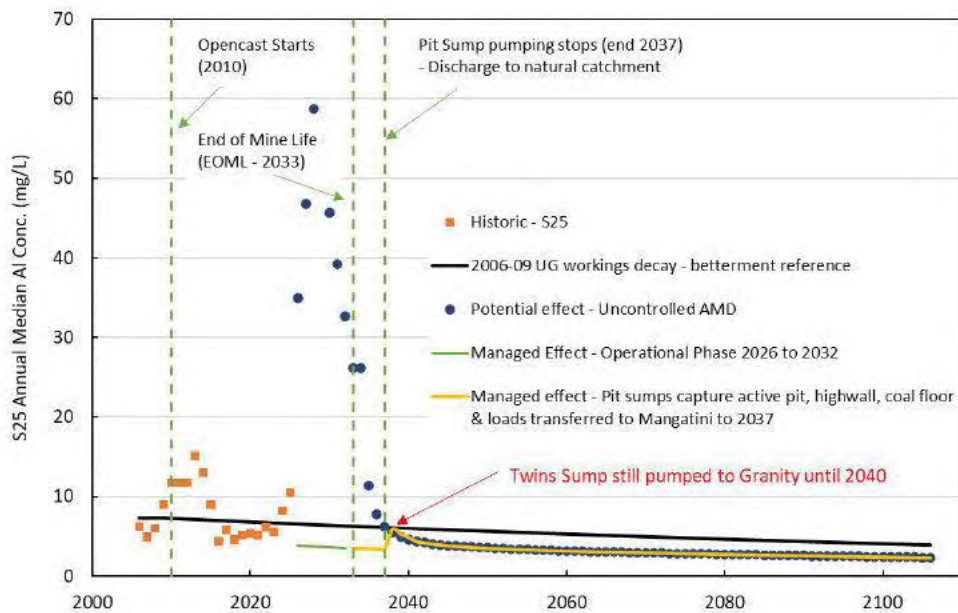


Figure 46. Predicted annual median dissolved aluminium concentration (mg/L) in Granity Stream at site S25 over 80 years (BRL, 2026b).

Lower quartile flows in Granity Stream at S25 are predicted to show a 38% reduction during the operational period, reducing to a 5% reduction post closure (Griffiths, 2026). While a 38% reduction in low flows would ordinarily have the potential to result in an ecological effect, the water quality at S25 is likely to preclude any ecological values from occurring during the operational and initial post closure periods. No ecological effects of flow alterations are envisaged at site S25.

4.7.4. S24A Miller Stream and lower Granity Stream

Miller Stream has markedly worse, and declining, water quality than S25 and commensurate macroinvertebrate communities. Modelled BRL (2026a) water and AMD management will remove a large proportion of contamination from the system by 2029 (after operational fire suppression ceases, opencast disturbance AMD diverted to Mine Pit area), with annual median Al concentrations at S24A falling below betterment reference values (i.e., achieving the betterment objective) throughout the remaining Operational Phase and during EOML and Closure Phases (Figure 47). Nonetheless water quality at S24A will remain unsuitable for aquatic life without additional intervention up to (due to remnant historic underground workings) and beyond full rehabilitation of the mine site draining to S24A. Annual median (and consequently 75th percentile; data not shown) does not fall below the 1 mg/L threshold for ecological recovery.

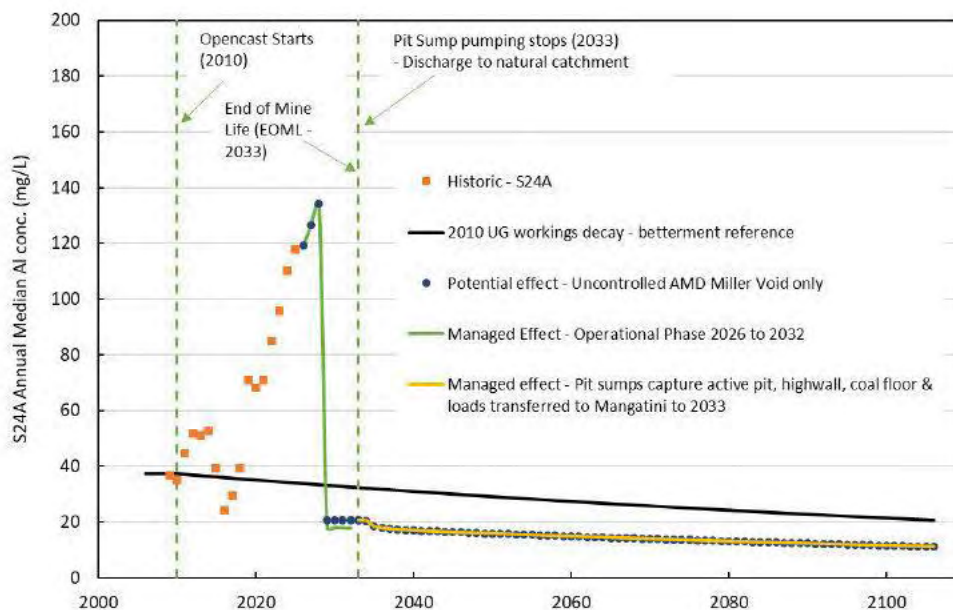


Figure 47. Predicted dissolved aluminium concentration (mg/L) in Miller Stream at site S24A over 80 years (BRL, 2026b).

Miller Stream and Granity Stream combine shortly downstream of sites S25 and S24A to form the lower Granity Stream. The lower Granity Stream is monitored at site GB1 at the State Highway. Although not explicitly modelled the combined contributions of Miller Stream and upper Granity Stream, and absence of any major clean water tributaries mean that site GB1 is unlikely to meet ecological thresholds. However, the overall load of AMD contamination to the ocean will gradually reduce over time reducing the risk of any residual effects on the coastal marine environment.

Lower quartile flows at S24A are predicted to show an ~31% reduction from observed during both the operational and post closure periods (Griffiths, 2026). Similarly to S25, water quality is likely to preclude any ecological values in this waterway during the operational and post closure periods without additional intervention. In the event that water quality does meet the ecological recovery thresholds recolonising aquatic fauna will adapt to the flow conditions that prevail. On balance the effects of continued poor water quality would be greater than a 30% reduction in flow at S24A. Smaller streams draining the Stockton plateau having equivalent, if subtly different, ecological values to larger waterways.

4.7.5. Mine Creek

Mine Creek is monitored in its headwaters at sites S6 and S23 and close to its discharge point into the Ngākawau River at MC1. Site S6 (as well as S23) are both elevated in dissolved aluminium and consequently have 'Severely Impacted' macroinvertebrate communities (*sensu* Gray & Harding, 2012). Under the proposed water management and treatment S6 will remain with elevated dissolved aluminium (Figure 48). Currently and under the proposed regime the waterway will not reach ecological thresholds.

Downstream and in combination with S23, site MC1 similarly does not reach ecological thresholds, with annual median Al concentrations at MC1 below betterment reference values (i.e., achieving the betterment objective) throughout the EOML and Closure Phase. While the MC1 Al concentration betterment reference values are not met through the Operational Phase

the dissolved aluminium concentrations are considerably reduced from the current condition. Mine Creek will likely require additional intervention to achieve an unimpacted ecological state.

The operational phase discharges from Mine Creek into the lower Ngākawau River are likely to present a finite period of increased risk to the recruitment of migratory fish to the headwaters of that river. Effects will be dependent on mine scheduling, the timing of rehabilitation and efficacy of treatment. Contaminant concentrations in Mine Creek have been increasing over recent years, although there is currently no evidence of an impact to fish recruitment into the Ngākawau River (Crichton, 2025). However, Mine Creek is resulting, on occasion during baseflows, in an elevation of dissolved aluminium at site NRB/NR Estuary above the ecological thresholds proposed by Greig et al. (2010) and this report.

Close scrutiny of increases in contemporary contaminant loads from Mine Creek to NRB/NR Estuary are recommended over the term of the BPCP, in particular during the fish upstream migration period between August and November. It is recommended the Ngākawau fish survey be repeated at annually during the operational period. Implications for the resident aquatic fauna of the discharge into the Ngākawau River from Mine Creek was assessed in early 2026. Provisional results indicate that the fish species present include those that would be expected to occupy a river mouth of this type.

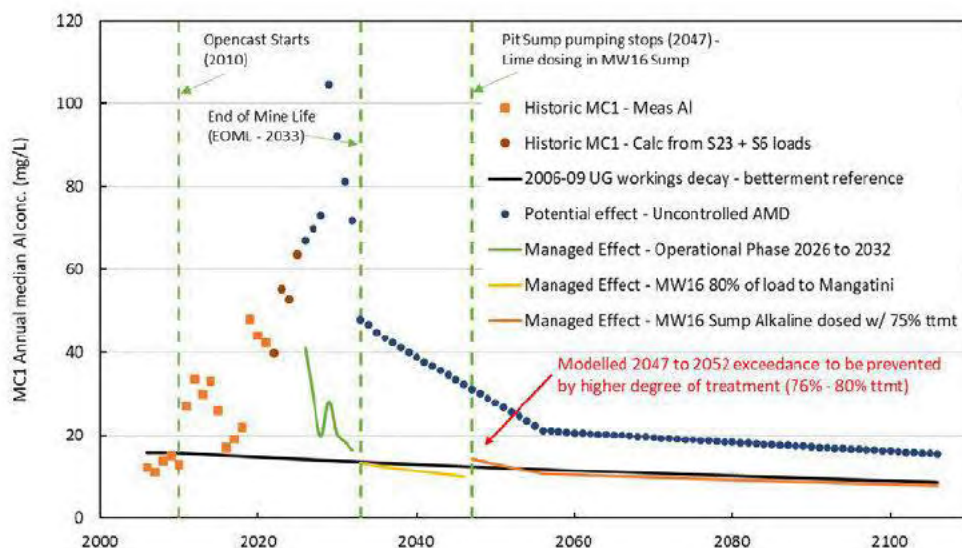


Figure 48. Predicted annual median dissolved aluminium concentration (mg/L) in S6, a tributary of Mine Creek, over 80 years (BRL, 2026b).

Lower quartile flows in the Mine Creek headwaters will be altered due to pumping of contaminated water into the Mangatini catchment and the re-configuration of drainage networks. Site S23 low flows remain as observed during the operational period but see an 85% reduction post closure. S6 low flows are predicted to decline by -34% during the operation period but increase by 233% post closure. While not explicitly modelled flows at MC1 in the lower Mine Creek are assumed to return to an equivalent level once pumping to Mangatini ceases post closure. Neither stream is predicted to meet the ecological recovery thresholds within 80 years unless further intervention occurs. In the absence of any ecological values no effects will occur due to changes in flow during that period. In the event that either stream does achieve ecological recovery thresholds recolonising biota will adapt to the flow regime that prevails at time. Accordingly, while there are no ecological 'effects' of flow

alterations envisaged in Mine Creek the two headwater sites may have subtly different ecological characteristics from those which occurred pre mining.

4.8. Summary map of future Stockton AMD effects

shows the inferred ecological status of waterways, based on water quality, in 80 years-time (i.e. 2106). Note transition points between classifications points are based on current monitoring sites or dilution calculation points. Actual transition points are likely to be further upstream and coincide with tributary inputs. Improved water quality in main stem rivers and streams will also open up otherwise clean tributaries to migratory fish. Further note that these predictions are subject to change over time as further data is amassed and models refined. Comparison to future predictions over the course of the consent should be made to the most recent iteration of modelling.

Key outcomes of the proposal are the recovery of 8.6 km of the St. Patrick Stream below T35 tributary, 2.7 km of the Mangatini Stream below S14B and the Ngākawau River below Mine Creek (Table 16). A further 8 km of Mangatini Stream and 2 km of St. Patrick Stream move from impacted to recovering status. There is no change in status of the Millerton streams under this proposal, however a change is expected from the Crown's proposed long term management strategy (Ref 2025- <https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>). The BPCP does not include any improvements in the upper Waimangaroa, although there are projects being developed to further address AMD in both Herbert and Whirlwind streams.

Stream status is based upon measured and modelled water quality and ecological information where available, as defined in Table 7. These results are presented visually in Figure 39 and Figure 49.

Table 16. Current and future (2107) stream extents affected by AMD					
Current State (metres of stream length).					
	Impacted	Recovering	Recovered	Unknown	Total
Erin Stream	2373		4774		6255
Mangatini Stream	11634				11634
Millerton Streams	28851	469	389	6252	35961
Ngākawau River		934	9140		10074
St. Patrick Stream	20887		1902		22789
T35 Stream			1844		1844
Upper Waimangaroa River	2136	3237	1821		7194

Future state (2107)					
	Impacted	Recovering	Recovered	Unknown	Total
Erin Stream	1481		4774		6255
Mangatini Stream		8842	2793		11634
Millerton Streams	28851		1088	6023	35961
Ngākawau River			10074		10074
St. Patrick Stream	8425	3825	10540		22789
T35 Stream			1844		1844
Upper Waimangaroa River	2136	1118	3940		7194

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4.9. Ecological impact summary

4.9.1. Methodology

The three-part classification used to illustrate current and future stream state (Figure 39 and respectively) can be translated into an assessment of ecological values as set out in the Ecological Impact Assessment (EcIA) Guidelines (Roper-Lindsay et al., 2018). As shown in Table 17, in terms of mining impacts rivers considered impacted (75th percentile dissolved aluminium >2.8 mg/L) are considered to have negligible ecological values. Recovering streams (75th percentile dissolved aluminium >1 mg/L and <2.8 mg/L) would still feature depauperate fish and macroinvertebrate communities, despite reaching the point where more diverse aquatic life is able to colonise. These streams would generally be considered to have low ecological values. Recovered streams (75th percentile dissolved aluminium <1 mg/L) may contain moderate to high ecological values depending on residual levels of contamination. Natural state streams are assumed to have high or very high ecological values by virtue of the absence of mining related impacts. It is important to note that this assessment does not account for the potential for metals bioaccumulation in biota to affect mahinga kai values. The assessment of background and impact metal bioaccumulation is underway as January 2026.

Table 17. Translation between EcIA ecological value classes from (Roper-Lindsay et al., 2018) and water quality classes derived in this report.

Water Quality Class	EcIA Ecological Value
Impacted	Negligible
Recovering	Low
Recovered	Moderate - High
Natural State	High - Very High

It is recognised that lowland reaches of some “natural state” rivers can be influenced by activities other than mining, which may affect their values. It is also acknowledged that the relative value of natural state streams can vary, depending on the species and ecological communities present, often dictated by physical barriers to fish migration. This assessment of water quality class and ecological values is restricted to the effects of mining in AMD affected streams and there is limited influence of other activities on the majority of these waterways.

The EcIA format is applied to determine the level, magnitude and direction of an effect of a proposed activity on ecological values, and any mitigation measures that may be applied to reduce potential negative effects. The significance of any residual effect, post mitigation, is then assessed to determine the need for further mitigation or offset. In the current situation the effects of the BPCP and elapsed time are universally positive, and the focus of the assessment shifts to the magnitude of change. In this assessment we have either compared to the ecological recovery trajectory for St Patrick Stream (at S16) and Mangatini Stream (at S14B) or betterment reference values⁸ for T1, S25, S24A, and MC1 to determine the adequacy of waterway rehabilitation (Table 18). For example, in St Patrick Stream residual effects are

⁸ It should be noted that betterment targets are subject to revision as a greater volume of data is amassed to refine predictive models.

determined by comparison of predicted 75th percentile dissolved aluminium after 80 years to the threshold for ecological recovery (1 mg/L). Conversely, in the Granity (S25) and Mine creeks (MC1) context we compare dissolved aluminium to the betterment reference line which represents the Bathurst contribution to AMD as opposed to Crown liability from remnant historic underground workings.

Table 18. Classification and justification of the current state of river and stream reaches affected by AMD. Note bioaccumulation of contaminants in biota and effects on mahinga kai values have not been incorporated into this assessment.

River or stream	Reach	Monitoring site(s)	Current water quality class / ecological value	Change	Future water quality class / ecological value: Residual effects
Ngākawau	Downstream of Mine Creek	NRB	Recovering / moderate ecological value: This reach is affected by the currently untreated discharge from Mine Creek resulting in occasional exceedances of the ecological threshold for dissolved aluminium. Qualifies for moderate ecological value because the water quality monitoring is undertaken at low tide representing worst case and provisional results indicate healthy fish communities.	Positive change	Recovered / Moderate to high: Treatment of Mine Creek discharge achieves ecological thresholds in the Ngākawau River mouth. Residual risk to fish migration reduced and water quality becomes more suitable for resident species. No residual Bathurst effect*
Ngākawau	Between St Patrick Stream and Mine Creek inc. Mangatini	NR	Recovered / moderate to high ecological value: Significant dilution of the St Patrick and Mangatini Stream treated discharges result in dissolved aluminium and pH that meet ecological criteria. Provides migratory pathway for fish to the headwaters. Water quality remains affected by residual AMD and is dependent on ongoing treatment success.	Positive change	Recovered / High ecological value: No further risk to fish migration. Ongoing improvement to water quality will increase suitability of river for resident aquatic species. No residual Bathurst effect.
Mangatini Stream	The entire Stream including Ford Creek	S14B and S14C	Impacted/negligible ecological value: Elevated contaminants and low pH.	Positive change	Upstream of S14B recovering /downstream of S14B recovered / low to moderate ecological value , respectively. Ongoing improvements to water quality and downstream dilution enhances suitability for aquatic species. Residual effects upstream of S14B but improving.
Mine Creek	The entire Stream	MC1, S6 and s23	Impacted/negligible ecological value: Elevated contaminants and low pH.	Positive change	Impacted/negligible ecological value: Elevated contaminants and low pH in the absence of Crown intervention. Waterway meets MC1 AI concentration 'Betterment' reference value. No residual Bathurst effect
St Patrick Stream	The main stem inc. Fly Creek and Plover Stream	S16	Impacted/negligible ecological value: Elevated contaminants and low pH.	Positive change	Downstream of T35 confluence recovered / moderate ecological value , due to dilution. Between T35 Stream confluence and S16 recovering / low ecological values . Fly Creek and Plover Stream remain Impacted/negligible ecological value . Ongoing treatment and downstream dilution achieve ecological thresholds in the lower reaches

River or stream	Reach	Monitoring site(s)	Current water quality class / ecological value	Change	Future water quality class / ecological value: Residual effects
					while impacted headwaters will require greater time to recover. Residual effect upstream of T35 confluence but improving.
T31 Stream	The entire stream		Impacted/negligible ecological value: Elevated contaminants and low pH.	Positive change	Recovering / Low ecological values: Ongoing rehabilitation and decay reduces contamination but do not meet the thresholds for ecological recovery. Residual effect but improving.
T35 Stream	The entire stream		Recovered / High: Low contaminants and natural pH. Macroinvertebrates indicate limited AMD impact	Positive change	Recovered / High: Ongoing reduction in contaminants and natural pH due to decay will result in ongoing increase in ecological values towards natural state. No residual Bathurst effect
Upper St. Patrick Stream	The entire stream		Recovered / Unknown assumed high: Low contaminants and natural pH.	Positive change	Recovered / Unknown assumed high: Low contaminants and natural pH. No residual Bathurst effect
Erin Stream	Excluding Darcy Stream		Recovered / High: Low contaminants and natural pH. [REDACTED]	Positive change	Recovered / Very High: Ongoing reductions in contaminants due to decay and ecological communities approaching natural state. No residual effects.
Darcy Stream	The entire Stream		Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities.	Positive change	Impacted/ negligible: Despite ongoing decay the absence of treatment is assumed to result in continued elevated contaminants and impacted macroinvertebrate communities. No specific modelling undertaken. This Residual effect but improving.
Whirlwind Stream	South Branch	S4	Recovering/ Low: Elevated contaminants and impacted macroinvertebrate communities. Ongoing water quality treatment.	Positive change	Recovered/ Unknown: Assumed to no longer receive AMD discharge due to treatment but sits outside the BPCP. No available ecological data or water quality. No residual Bathurst effects and improving.
Whirlwind Stream	North Branch		Recovered/ Unknown: No longer receives AMD discharge. No available ecological data or water quality.	Positive change	Recovered/ Unknown: Assumed ongoing improvements due to decay. Sits outside the BPCP. No residual Bathurst effect
Herbert Stream	The entire Stream	UC2	Impacted/Negligible: Receives untreated AMD. Elevated contaminants and low pH.	Positive change	Impacted/ negligible: Stream remains impacted by AMD and proposed treatment sits outside BPCP. Positive change due to decay only. Residual effect but improving.

River or stream	Reach	Monitoring site(s)	Current water quality class / ecological value	Change	Future water quality class / ecological value: Residual effects
Upper Waimangaroa	Between Herbert and Webber confluences	6W and WRBBC	Recovering/Low: Elevated contaminants and impacted macroinvertebrate communities. Ongoing water quality treatment.	Positive change	Recovering/Low: Elevated contaminants and impacted macroinvertebrate communities. Ongoing water quality treatment. Positive change due to enhanced treatment and decay. Residual effect but improving.
Granity Stream	The entire stream including Miller Stream	S24A, S25, GB1	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities	Positive change	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities. Treatment and water management reduces contaminants but does not meet ecological thresholds. Waterway meets AI concentration betterment reference values at S24A and S25. No residual Bathurst effect.
Twins Stream	Upstream of T3	T1	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities.	Positive change	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities. Treatment and water management reduces contaminants but does not meet ecological thresholds. Waterway meets AI concentration betterment reference value at T1. No residual Bathurst effect.
Twins Stream	Downstream of T3	T3	Recovering/ low: Elevated contaminants and impacted macroinvertebrate communities. Recovering due to dilution.	Positive change	Recovered/Moderate: Reduced contaminants and less impacted macroinvertebrate communities. Ongoing water quality treatment. Positive change due to enhanced treatment and decay. Waterway assumed to meet 'Betterment'. No residual Bathurst effect.
Rudolph Stream	Upstream of SH67	S28U	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities.	Positive change	Impacted/ negligible: Elevated contaminants and impacted macroinvertebrate communities. AMD derived from historic and neighbouring mines. Water management reduces contaminants but does not meet ecological thresholds. No residual Bathurst effect.

Notes* Bathurst are liable for a portion of total AMD discharging to the environment. Residual effects due to AMD outside of Bathurst's liability are not considered within this assessment.

4.9.2. Residual effects

It is evident that after 80 years, residual effects of AMD persist, particularly in the Twins and Granity Streams, Mine Creek (Millerton Streams) and the headwaters of Mangatini and St Patrick Streams. In the Millerton Streams each waterway (i.e., T1, S25, S24A, and MC1 is considered to achieve a level of 'Betterment'⁹ relative to annual median AI concentration betterment reference values such that residual effects sit outside Bathurst's liability. Full recovery of water quality and ecological condition will require further Crown investment to address legacy discharges (BRL, 2026a).

Similarly, the headwaters of St Patrick and Mangatini Streams will continue to be affected by untreated historic AMD unless those discharges are subsequently addressed or enough time elapses that natural decay reduces contaminant levels.

Effects of bioaccumulation of the contaminants in biota on mahinga kai values have not been formally assessed here however that research is underway.

5. MONITORING AND REPORTING

5.1. Introduction

Incremental changes in water quality and ecology can be tracked over time through monitoring, reporting and testing against thresholds or modelled predictions¹⁰. Monitoring design considers the location, periodicity and focus of sampling as well as suitable thresholds for reporting. Because there are long time frames and a broad range of AMD impact to BCM streams a staged, an adaptive monitoring design is appropriate. The following monitoring and reporting format is envisaged to apply to the Stockton streams over the next 80 years and beyond the time frame of the BPCP permits.

Monitoring sites for ecology and water quality are considered to be routine or remote, and include reference and impact sites (Figure 51). Routine sites are monitored for water quality at least monthly and may have associated compliance or performance assessment. Remote sites are sampled for water quality on an annual basis throughout and used as context for the ecology assessments. Water quality status at remote sites is based on dilution relationships with routine sites. Annual water quality sampling of the comprehensive suite will occur at remote sites to developed the dilution relationships, however it is noted that additional information may be required prior to each 6-yearly review to ensure the dilution relationships provide a rigorous assessment of water quality.

5.2. Water quality impacted streams

In impacted streams with highly elevated metal contaminants and low pH, such as Granity Stream or Mine Creek, water quality monitoring of the key basic contaminants (Table 19) should occur monthly at routine sites, and annually at remote sites. Data from remote sites

⁹ It should be noted that betterment targets as subject to revision as a greater volume of data is amassed to refine predictive models.

¹⁰ Note that these predictions are subject to change over time as further data is amassed and models refined. Comparison to future predictions over the course of the consent should be made to the most recent iteration of modelling.

should be used to develop dilution relationships with monthly sites based on the difference in flow. It is noted that additional information may be required from remote prior to each 6-yearly review to ensure the dilution relationships provide a rigorous assessment of water quality.

The resulting synthetic records at the remote sites can be used to determine water quality status.

Water quality monitoring is to gauge the performance of water treatment and land rehabilitation. When contaminant concentrations reach the thresholds for annual dissolved aluminium 75thiles <2.8 - >1 mg/L and median pH >4¹¹ streams on three consecutive years they are considered to be recovering based on water quality (Table 7).

Water quality monitoring in impacted streams should consist of a basic suite of AMD indicators (Table 19).

Table 19. The basic water quality monitoring suite.

pH
Electrical Conductivity
Sulfate
Dissolved Aluminium
Dissolved Zinc
Turbidity

Ecological monitoring is less informative until water quality begins to improve. Streams are expected to show severely impacted ecological communities (AMD I <20). Ecology monitoring should occur every six years in impacted streams. Ecological monitoring in impacted streams should include bryophyte species richness (Hogsden & Hickey 2025).

5.3. Water quality recovering streams

Waterways with three consecutive annual median pH >4¹² and 75th percentile dissolved aluminium results <2.8 - >1 mg/L are considered recovering, based on water quality. Macroinvertebrate taxa are expected to indicate the streams are classed as impacted (AMD I 20-40, EPT richness¹³ <8).

Recovering streams (based on water quality) should continue to undergo basic water quality monitoring weekly at routine sites. However, comprehensive monthly water quality monitoring should also begin to accumulate information on the occurrence of all toxic elements, modifying factors and nutrients (Table 20). Remote site water quality sampling of the comprehensive suite continues to occur annually.

¹¹ pH values lower than 4 are acceptable provided they arise via natural processes and are not accompanied by elevated AMD markers.

¹² pH values lower than 4 are acceptable provided they arise via natural processes and are not accompanied by elevated AMD markers.

¹³ The assessment of EPT richness should be based on the AMD I species list because the thresholds presented here were derived from comparisons of AMD I to EPT (Gray & Harding 2012; Appendix 2).

Table 20. The comprehensive water quality monitoring suite.

pH
Electrical Conductivity
Temperature
Sulfate
Dissolved aluminium (Al)
Dissolved zinc (Zn)
Dissolved iron (Fe)
Dissolved nickel (Ni)
Dissolved copper (Cu)
Dissolved cobalt (Co)
Dissolved cadmium (Cd)
Dissolved chromium (Cr)
Dissolved manganese (Mn)
Calcium (Ca)
Magnesium (Mg)
Dissolved Organic Carbon (DOC) ^a
Turbidity
Nitrate NO ₃ -N, Nitrite NO ₂ -N
Ammonia NH ₄ -N

^aMeasured as DNPOC = dissolved non purgeable organic carbon

Ecological monitoring should continue on a six-year rotation and performance testing against ecological thresholds for macroinvertebrate communities be undertaken (Figure 50). Ecological monitoring in recovering streams should include bryophyte species richness (Hogsden & Hickey 2025).

5.4. Recovered streams

Streams with three consecutive annual median pH >4.5¹⁴ and 75th percentile dissolved aluminium <1 mg/L may be classified as 'water quality recovered' but must also subsequently meet ecological criteria.

Performance assessment of suspended and deposited solids, sediment quality, the full suite of metals and nitrogen (nitrate-N and ammoniacal-N) should be considered at this stage by

¹⁴ pH values lower than 4.5 are acceptable provided they arise via natural processes and are not accompanied by elevated AMD markers.

comparison to the guidelines of Hickey (2026a, c & d) and ANZG (2018) or any subsequent/additional update of that information. Criteria for comparison should be based on both a reference site and specific threshold criteria.

Water quality monitoring and reporting should proceed as per recovering streams. Ecology monitoring of recovered streams should be repeated every 3 years and tested against AMDI and EPT richness, and appropriate nominated reference streams¹⁵, and other ecology thresholds including but not limited to fish and bryophytes. Ecological recovery should be determined by meeting the ecological thresholds and comparability with reference sites on three consecutive rounds. Failure to meet the ecological thresholds on any occasion triggers an investigative response.

1. Meet ecological criteria (Figure 50)
Proceed until three consecutive rounds (9 years) of monitoring meet ecological thresholds.
2. Fail to meet ecological criteria on any occasion.
Resample within 12 months and compare to thresholds.
3. Meet ecological criteria
Proceed until three consecutive rounds (9 years) of monitoring meet ecological thresholds.
4. Resample fails to meet criteria.
Instigate investigation to determine the cause of degraded ecological communities. Investigation to include, at a minimum, comparison of ecological data to water and habitat quality information. If site is determined to have failed due to habitat conditions not associated with mining impacts the result may be deemed a pass. Additional periods of, or more intensive, monitoring may be required. On the basis of the investigation determine additional water treatment or rehabilitation, and a working time frame to meet criteria and any variation to monitoring and compliance regime. Agree next steps with regulatory authority. To prevent cyclical failure to comply and investigation, realistic and reasonable alternative timelines and monitoring periodicity should be agreed with the regulatory authority.

Ecological monitoring in recovered streams should additionally include bryophyte species richness, fish and the abundance of kōura. Fish monitoring should be restricted to those sites where fish are able to gain access past instream physical barriers or where populations of non-diadromous species are present or have been re-introduced. We recommend that species diversity or abundance thresholds for the recovery of fish communities are developed. That process would require the development of fish occurrence predictions based on downstream terrain and comparison to suitable reference sites.

Kōura are highly sensitive to AMD, and in many streams previously affected are likely to have been entirely extirpated. Kōura may require re-seeding into streams unless they are present in unaffected tributaries. Kōura abundance should be compared to reference sites with comparable habitat. Kōura monitoring should involve standardised hand searching, spotlighting or trapping to support electric fishing which is ineffective in physically complicated streams.

¹⁵ The assessment of EPT richness should be based on the AMDI species list because the thresholds presented here were derived from comparisons of AMDI to EPT (Gray & Harding 2012; Appendix 2).

5.5. Ongoing water and sediment quality compliance

After the achievement of ecological recovery at a site there should be ongoing monthly comprehensive water quality and compliance reporting trends. Essentially, water quality should not decline from the state commensurate with ecological recovery as a result of mining related discharges. Compliance should be based on comparison to formal trend analysis to ensure that water quality does not decline. This monitoring should continue while active or passive treatment requiring maintenance is ongoing.

5.6. Mahinga kai suitable streams

In streams that are considered water quality and ecology recovered (ecological thresholds met for three consecutive rounds) ecological monitoring may cease (Figure 50). However, bespoke (timed to coincide with a 12-month period prior to tissue sampling) comprehensive monthly water quality monitoring should occur to inform tissue testing of mahinga kai.

Mahinga kai and recreational harvest species should be agreed with local runanga and community. Tissue testing of mahinga kai is for the purpose of comparison of contaminant concentrations to food safety standards and reference stream conditions. Reference streams will be chosen based on the species present and impact streams for comparisons. Pass criteria are 3 consecutive rounds (on a 3-year repeat periodicity) of concentrations lower than the food safety standard or reference condition, whichever is the greater. A fail would result in an investigation analogous to step 4 in the monitoring of recovered streams. A plan to address the source of contamination and new timeframes should be agreed with the regulatory authority and monitoring continue.

Likely candidate species for testing are eel, mature galaxiids and kōura (freshwater crayfish).

5.7. Closure

Once all active and passive water quality treatment has ceased and mahinga kai tissue contaminant concentration thresholds are met monitoring may cease.

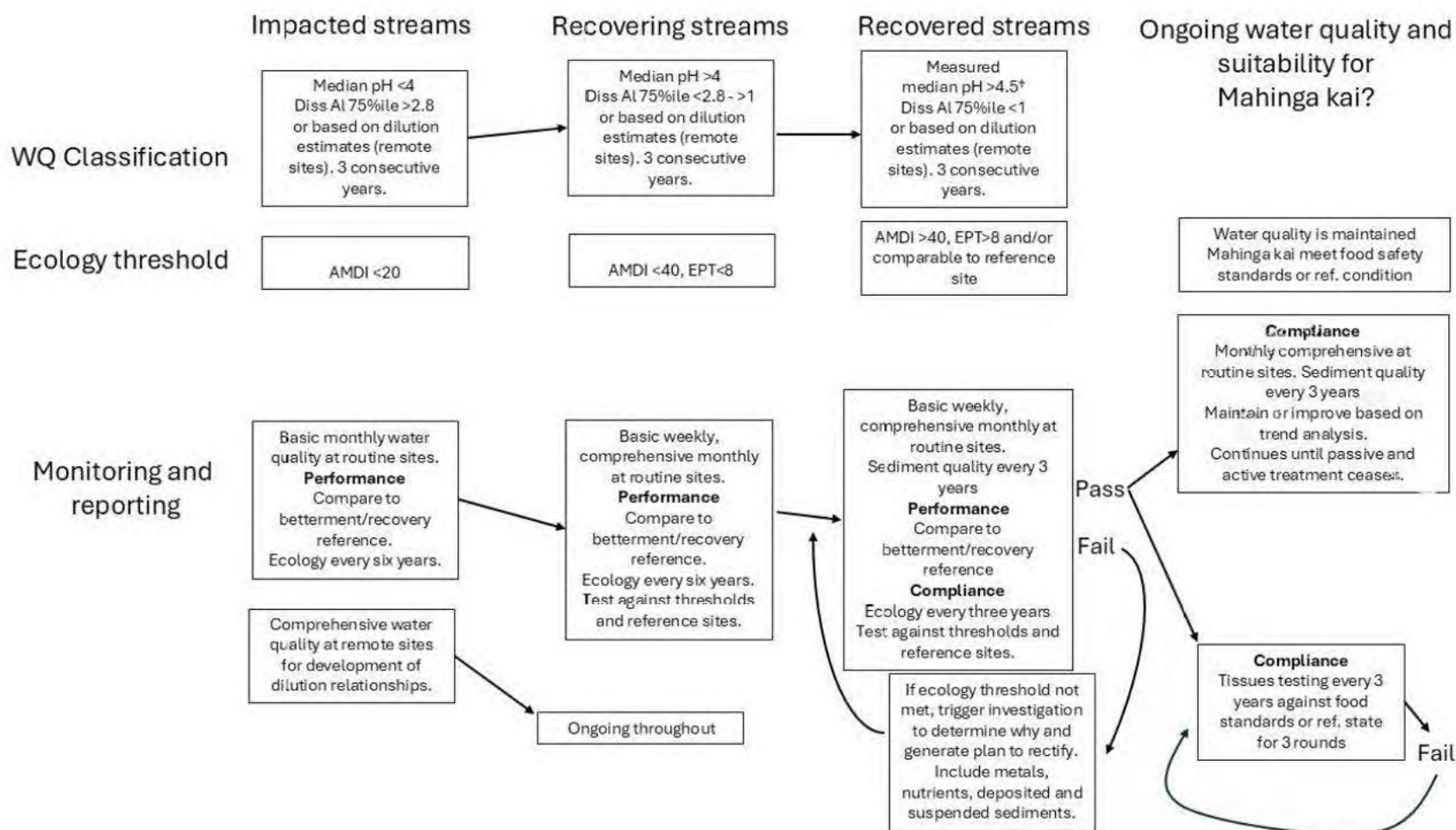


Figure 50. Schematic of staged monitoring design for ecology and water quality across a gradient of stream recovery. [†] Unless caused by natural processes. Note the inclusion of reference sites in threshold testing in 'Recovered' streams. Monitoring suites and periodicity described here and are considered a minimum standard. Performance and compliance monitoring may require additional sampling.

5.8. Currently healthy or protected streams

There are a number of streams, predominantly on the Denniston Plateau currently not affected by mining, but which might in the future receive contaminated discharges (Hickey, 2026b; Hogsden, 2020, 2025; Hogsden & Jellyman, 2026). Those streams require a different approach to the one described above because effects that do occur may be immediate rather than manifest over the long time periods of recovery. Those streams require protection and that topic has been addressed by Hogsden & Jellyman (2026) and Hickey (2026 a & b).

Protected streams require routine (at least monthly) monitoring of the comprehensive suite of water quality analytes and annual ecology monitoring to ensure that any changes to stream health are rapidly picked up and addressed. Monitoring results should be routinely compared to the thresholds developed for the protection of streams within the context of reference sites.

5.9. Reference sites

Reference sites are important to ensure that any changes in monitored impact sites are the result of changes due to the mining activity, rather than broader variation in all streams, for example the effects of a long dry period. Reference sites on both the Stockton and Denniston plateaux are able to serve that purpose for the mines on either landform. These streams should be sampled routinely for both water quality and ecology to allow comparison to impact sites. Reference sites should be sampled at least monthly for water quality (comprehensive suite) and every 5 or 3 years for ecology depending on the status of impact site they are being compared with. However, if the reference site is proposed to form the basis for comparison to turbidity at an impact site sampling would need to be weekly, daily or be continuous (Hickey 2026c). Reference sites are shown on Figure 51. Note additional sites are described by ESNZ and RMA Science for the proposed plateaux mines.

5.10. Ecology methods

Water quality should be sampled according to the appropriate National Environmental Monitoring Standard (NEMS) (Hicks, 2025; Milne, 2020). Those standards provide guidance for collection, processing and archiving of environmental data. Key considerations are the detection levels provided for various contaminants, particularly when considering trace elements at reference sites.

Macroinvertebrates shall be collected according to Milne (2022a). While quantitative sampling, using equipment such as the Surber sampler, is conventionally used for consent compliance monitoring there are a number of reasons why the NEMS kick net approach is preferred. Firstly, the biological metrics being used to infer ecological health in AMD affected streams are based on the presence or absence of species rather than their relative or absolute abundance. Accordingly, there is no increase in certainty to be gained from collecting quantitative data. Secondly, the streams draining Stockton Plateau are highly diverse in terms of physical habitat. Streams beds may be boulder bedrock, sand or organic material. There are no quantitative sampling techniques suitable for consistently sampling that range of substrate. Finally, the majority of previous sampling undertaken in AMD streams has used kick net methodology.

Routine fish community sampling will be undertaken using a single pass electric fishing technique encompassing the full range of habitats within a ~50 m reach. Fish will be identified, measured and returned to the water. However, due to the behaviour of species present and habitat diversity of many streams including overhung banks, bouldery substrates and woody debris electric fishing should be substituted with additional methods at a subset of sites. At large river sites, such as NR and those considered suitable for kōura spotlighting, trapping or hand searching (kōura only) should be undertaken.

Bryophyte sampling will occur at a sub-set of sites. Sampling will be carried out by hand picking each distinct moss species/form present within a 50 m reach. Samples will be placed in zip lock bags and chilled for transport to the laboratory.

Habitat characteristics can be assessed using an array of standard methods (Harding, 2009; Milne, 2022b). Key information to collect include the major drivers of macroinvertebrate communities including substrate, sedimentation, periphyton and flow heterogeneity. In AMD affected streams the occurrence and degree of precipitation is also likely to have a strong influence on aquatic communities. We suggest an assessment analogous to that used for periphyton (Biggs & Kilroy, 2000; Milne, 2022b) whereby the cover of precipitation is denoted by colour (e.g. orange or metallic) and thickness (thin mat/film (<0.5 mm, medium mat 0.5- 2 mm and thick mat >2 mm mats).

5.11. Monitoring sites

Ecological monitoring locations are proposed to be included along each AMD affected stream (Figure 51). These sites and specific details are reviewed and tabulated by GHD (2026). Discrete discharges to a waterbody are typically monitored upstream and downstream of the discharge point. However, in the case of a diffuse contamination emanating from an extensive activity, such as an open cast mine, there is no single point upon which to focus monitoring. In that situation monitoring typically occurs at sites that have already been monitored, been used to model future water quality conditions or represent key values, such as a confluence with another water body, swimming hole or fishing access point.

An understanding of the accumulation of flow and contaminants above and below the monitoring point can allow predictive mapping of conditions for consent compliance. Dilution factors between accessible, regularly monitored sites and remote less frequently visited spots allow a more comprehensive assessment of change in water quality and ecology along the full length of affected water body.

Monitoring sites on the Stockton Plateau are located to allow an assessment of changes in water quality and ecology over time. There are sites on each major waterway draining the Stockton Plateau typically in the headwaters close to the mine and in the lower reaches prior to discharge to the Tasman Sea or another major river. Intermediate sites are proposed downstream of large tributaries that provide significant dilution, e.g., Repo Stream flowing into the Mangatini Stream or Erin Stream on the St. Patrick Stream.

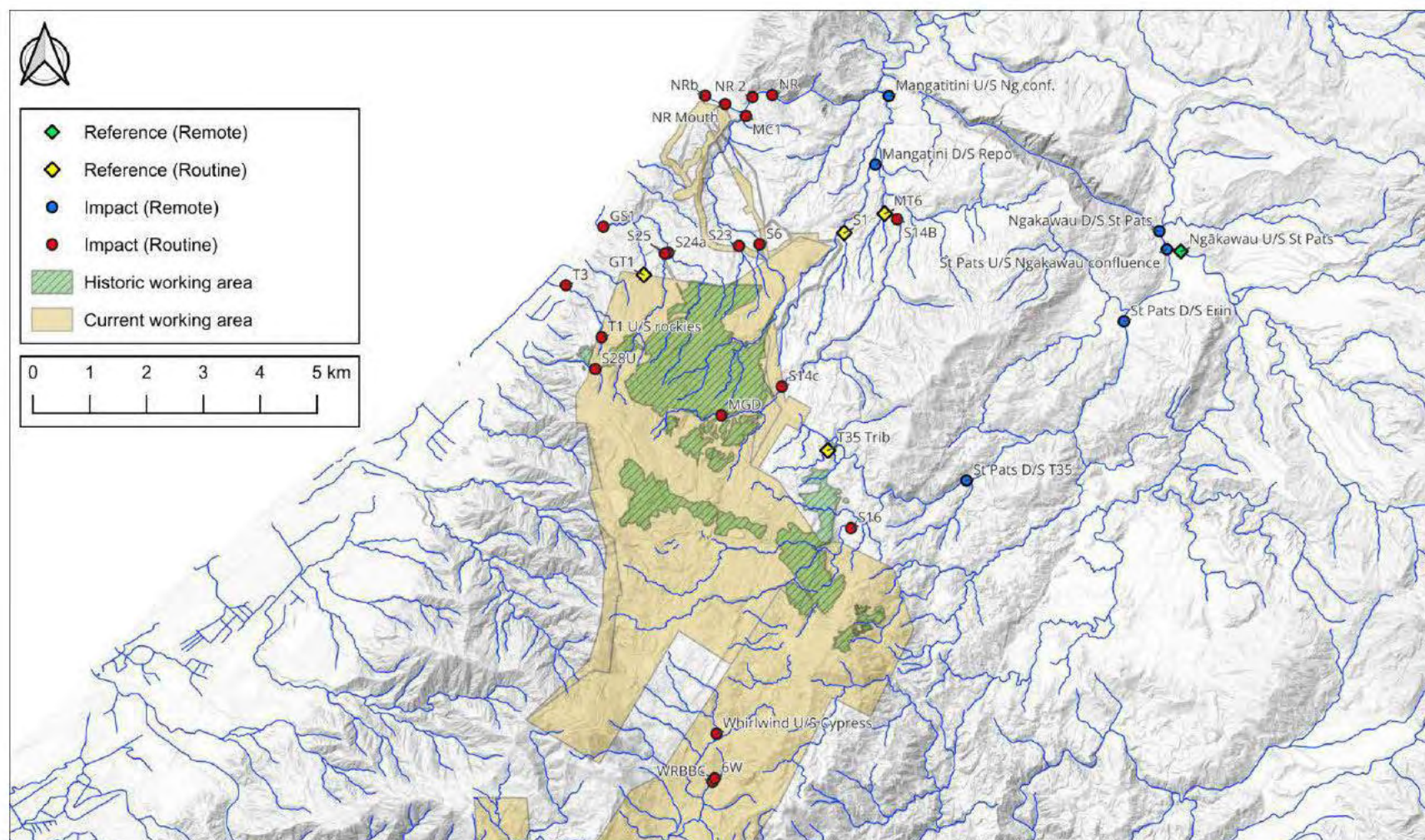


Figure 51. Proposed sites for current state and ongoing longitudinal sampling in rivers and streams associated with the BPCP. Note additional sites are proposed by ESNZ and RMA sciences.

6. WATER QUALITY COMPLIANCE AND PERFORMANCE

6.1. Introduction

Bathurst requires compliance and performance reporting conditions for the term of their FTA BPCP application. Water quality monitoring will serve to provide context for ecological information, but also gauge compliance with water quality limits and progress relative to 'Betterment'¹⁶ targets over time. Quantitative comparisons with measured data will include:

1. Consent compliance limits will be applied at a subset of monitoring sites;
2. Modelled water quality recovery values will be compared to a subset of performance monitoring datasets (specifically annual median and 75th percentile AI concentration at S16 and S14B); and
3. Modelled betterment reference values will be compared to a subset of performance monitoring datasets (specifically median annual AI concentration at T1, S25, S24A, and MC1).

While the approach to water quality monitoring periodicity described in Section 5 is considered suitable for comparison to six yearly ecological data, water quality compliance and performance often requires more regular sampling. Where different, sampling periodicity provided in the below section should take precedence over less regular sampling recommended in Section 5.

The following section presents analyses and rationale for water quality monitoring and limits at various sites on the Stockton BPCP sub-area based on ecological criteria and/or maintaining or improving water quality as part of the long-term management of AMD. The proposed approach is in alignment with the concept of 'Betterment' (<https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>) and proposed compliance and monitoring at the associated Escarpment Extension and Mount Frederick South sub-areas.

'Betterment' requires that activities have a positive contribution to ongoing river health rather than merely avoiding or mitigating adverse effects. 'Betterment' requires active improvement of river health over the long-term. Water quality data collected over time will be used to inform the six-year review and progress against the 'Betterment' targets illustrated in plots in Section 4.

Water quality criteria are described for key sites on the Stockton sub-area. At other streams/locations draining Stockton currently considered "water quality impacted" or "recovering" from AMD it is recommended that performance monitoring (monthly) occur until such time as the waterway is classed as "water quality recovered".

6.2. Methods

Data analyses presented here to derive compliance limits use a five-year benchmarking period of water quality data to represent the likely state over the next five years, unless otherwise stated (Table 21). The specific time periods were chosen because that period of time was

¹⁶ It should be noted that 'Betterment' targets as subject to revision as a greater volume of data is amassed to refine predictive models.

considered by Bathurst to be most comparable to the envisaged water quality over the next six years. In summary there are limited changes expected in the water quality of St. Patrick Stream at S16 and so the immediately preceding 5 years was used as a benchmark. In contrast, sites S14B, S14C (Mangatini Stream) and NR and NRB (Ngākawau River) are expected to show short term declines in water quality due to the pumping of Millerton AMD to the Mangatini catchment for treatment potentially causing an increase in residual Al loads. The proposed benchmark period for those sites is 2017-2021.

*Table 21. Data usage for the derivation of compliance reporting limits. * NA indicates no benchmark period was applied.*

River	Site	Benchmark period	Notes
Ngākawau River	NR2	2017-2021	Due to proposed pumping of Millerton water to Mangatini.
Ngākawau River	NRB	NA*	Limited data available; performance only.
Mangatini Stream	S14B and MGD	2017-2021	Due to proposed pumping of Millerton water to Mangatini.
Mine Creek	MC1	NA	Limited data due to restricted access; performance.
Granity and Miller streams	S25 & S24B	NA	Operational phase water quality uncertain; performance.
Rudolph Stream	S28U	NA	No Bathurst discharge, historic workings only.
Twins Stream	T1	NA	Limited data set available; full record used
St Patrick Stream	S16	2020-2025	Due to consistent improving trends only last 2 years data record used to set limits.
Herbert Stream	S4	NA	Performance only
Whirlwind Stream	UC2	NA	Performance only

The benchmark approach does not drive improvements within the river but maintains the level of effects as at the benchmarking period. Accordingly, to align with 'Betterment' a further recommendation is that every six years there is a review of the water quality compliance criteria in the light of the stage and extent of operations at Stockton. This review would address the topic of incrementally greater stringency in compliance limits, most particularly following the completion of coal extraction and formation of final landforms, and secondly the completion of site rehabilitation.

Benchmarking data were typically derived from daily (weekday) sampling. Available continuous sensor data for turbidity and pH was checked and found to not be suitably reliable for compliance purposes. Issues arose because of sensor drift and maintenance issues and data were found to deviate from grab samples.

Analyses examine statistics derived from benchmarking water quality data against a range of summary statistics and thresholds commonly used to manage discharges. Effort has been made to align the approach made in this section with compliance and response criteria recommended for streams on the nearby plateaux streams by Hickey (2026c). Contaminants are compared against the 75th and 95th percentiles. The 75th percentile of dissolved aluminium is used in this report to indicate the threshold between 'water quality recovering' and 'recovered' but does not necessarily indicate ecological recovery. The 95th percentile is a more stringent statistic that allows for fewer exceedances and is conventionally used for the protection of species, rather than recovery from a grossly impaired state as found in Stockton AMD streams. Both the 75th and 95th (or 5th and 25th for pH) percentile statistics serve to control for the influence of outliers, unlike a maximum or minimum value, whilst also providing a representation of worst-case conditions for toxicants.

Bathurst have requested that some sites or parameters be treated as performance rather than compliance. Performance sites or parameters are generally those with a lesser degree of certainty about specific water quality over the first six years of the consent. While performance monitoring data is assumed to be reported and discussed as part of site compliance there are no specific water quality limits associated. However, performance sites and data will be considered in the six yearly reviews.

In general, the most ecologically protective statistics are those with the lowest level of contamination or rolling statistics across a shorter time period, e.g., 7 samples as opposed to 15 or 30. However, due to the complexity around operational phase water management Bathurst have requested that rolling median compliance is assessed using a fifteen-sample rolling median based on daily (weekday) grab sampling rather than the more stringent option of 7-samples. This provides greater operational flexibility during a period of significant changes to water and AMD management on site. Fifteen sample medians still represent a short-term, event responsive, rolling median criteria for compliance assessment and more stringent compliance concentration limits than currently exist. The identification of water quality events using the rolling median approach will help drive continual improvement and fine tuning of water management.

6.3. Site NR on Ngākawau River

6.3.1. Dissolved aluminium at NR

Maintaining dissolved aluminium below 1 mg/L for the majority of the time is considered a suitable compliance criteria for site NR to maintain a state of chemical recovery from AMD impacts.

During the benchmark period (2017-2021) the concentration of dissolved aluminium at NR was relatively constant with an overall median of 0.44 mg/L (Figure 52; green line). The annual Hazen 75th percentile was below 1 mg/L (dashed red line) at site NR in each of the 5 years. The annual Hazen 95th percentile, exceeded 1 mg/L in 4 out of the 5 years.

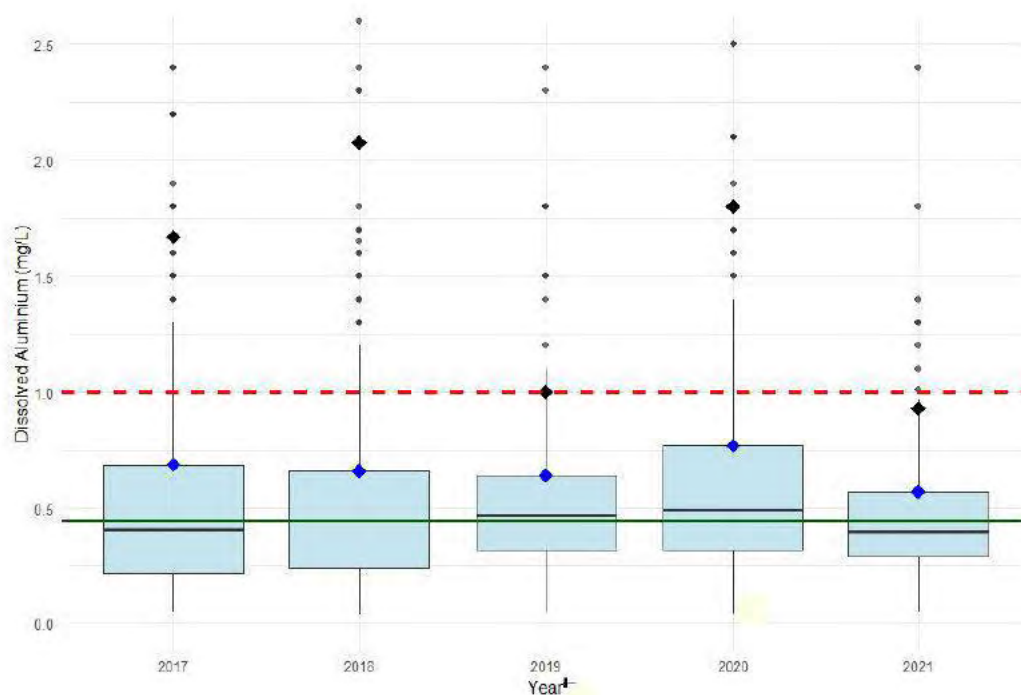


Figure 52. Annual boxplots of dissolved aluminium at site NR on Ngākawau River. The horizontal red line shows the upper threshold for fish occurrence. The horizontal green line shows the overall median value for the data set. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 \times \text{IQR}$. Outliers are points outside the whiskers. The blue and black diamonds show the Hazen 75th and 95th percentiles, respectively.

Dissolved aluminium at NR has occasional spikes that exceed the ecological threshold, but are unlikely, due to their transient nature, to represent a complete barrier to fish migration. To maintain fish passage, it is important to ensure that periods of elevation in dissolved aluminium are relatively short. A 7-sample rolling median dissolved aluminium at NR exceeded 1 mg/L on several occasions during the benchmarking period. A 15-sample rolling median of dissolved aluminium at NR over the five-year benchmark period is typically below 1 mg/L (Figure 53). Bathurst proposes a fifteen-sample rolling median based on daily (weekday) grab sampling for a compliance statistic to manage for short periods of elevation that would trigger a prompt management response / investigation. The use of such a statistic would allow a timelier response as opposed to the annual percentile approach that is more suited to compliance reporting and review.

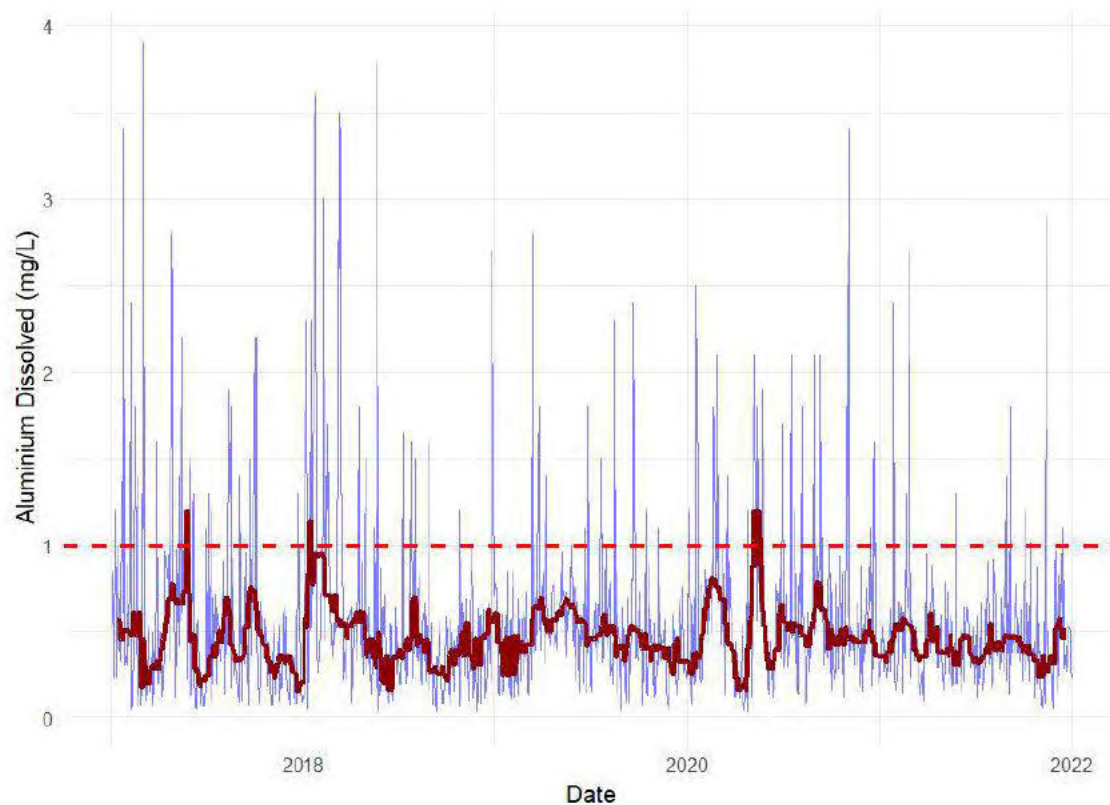


Figure 53. Daily (blue) and fifteen-sample rolling median (red) dissolved aluminium at NR on Ngākawau River between 2017 and 2021. The dashed red line shows the upper limit for the occurrence of fish and macroinvertebrates.

Bathurst propose a compliance statistic for dissolved aluminium at NR as an annual 75th percentile of ≤ 1 mg/L accompanied by a 15-sample rolling median of < 1 mg/L. A breach of the rolling median would instigate an investigation seeking to determine cause(s) and a suitable response. The percentile statistic would be reported annually and compiled in a six yearly water quality and ecology review. Sampling would be based on a daily (weekday) grab sample.

Water quality at NR during the highest tides may be affected by seawater and the backing up of Mine Creek water. Data collected during those circumstances should be excluded from analyses and reporting. To date predicted tide height has been used to exclude the influence of both effects.

6.3.2. pH at NR

Similarly to dissolved aluminium, pH is a useful proxy for AMD. pH data is derived from daily (weekday) grab samples, as sensors have proved extremely difficult to maintain. Greig et al. (2010) suggested that a pH > 4.5 would be a suitable target for the occurrence of fish, while this report found a similar value for macroinvertebrates. Over the benchmark period pH at NR has consistently met the pH > 4.5 threshold in terms of the annual 5th percentile other than in 2017 (Figure 54). Accordingly, the proposed annual compliance statistic for site NR is a 5th percentile > 4.5 . The pH for this site would naturally range between 4.5 and 7.5 based on water quality data collected in the upper catchment (Instream consulting, 2025). Accordingly, rather than a compliance statistic based around the median, an upper limit of 7.5 based on

the 95th percentile of annual data is proposed. This limit would manage for the risk of treatment activities increasing pH beyond the natural range for the river based on samples collected upstream of St Patrick Stream. Hogsden and Hickey (2025) proposed an upper limit for pH of 7 for the protection of acidophile bryophytes. However, that is considered appropriate for naturally acidic streams on the plateaux as opposed to the Ngākawau River which is naturally more circumneutral at NR. Figure 54 shows the annual 95th percentile over the benchmark period which was consistently met and so is proposed as the compliance statistic for this site.

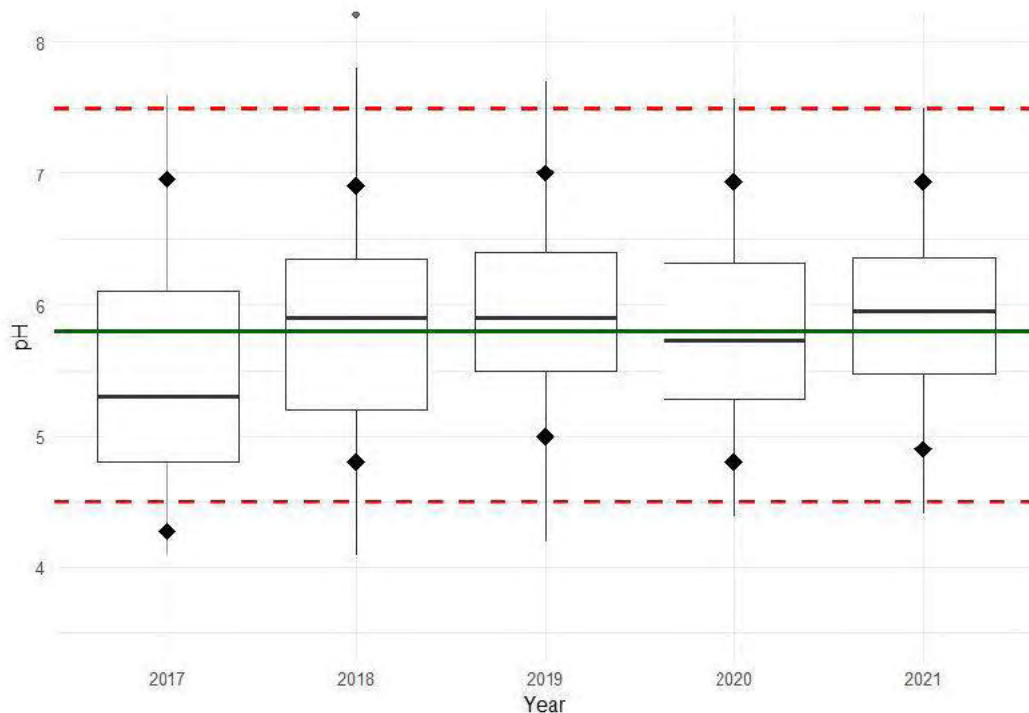


Figure 54. pH at site NR on Ngākawau River. The bottom horizontal red line shows the lower threshold for fish occurrence. The upper horizontal red line shows the putative upper natural limit based on water quality data collected in the upper catchment. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within 1.5 * IQR. Outliers are points outside the whiskers. The full black diamonds show the Hazen 5th and 95th percentiles. The horizontal green line shows the overall median.

A 7-sample rolling median of pH at NR is shown in Figure 55. The rolling median falls below the lower threshold for short periods in 2017 indicating the potential for pH to result in an effect on fish migration. While it is understood that treatment at the Mangatini Sump and lime dosing station can be adjusted to prevent pH falling below 4.5, Bathurst propose a fifteen-sample rolling median based on daily (weekday) grab sampling for a compliance statistic to allow for operational uncertainty over the next 6 years. The 15-sample rolling median is consistently between pH 4.5 and 7.5.

It is proposed that a 15-sample rolling median >4.5 and <7.5 is used as compliance statistic to trigger a prompt response to a short-term change in water quality as a compliment to the less reactive annual compliance statistics approach. Sampling should be based on a daily (weekday) grab or handheld meter sample.

Water quality at NR during the highest tides may be affected by seawater. Data collected during those circumstances should be excluded from analyses and reporting. To date predicted tide height has been used to exclude the influence of both effects.

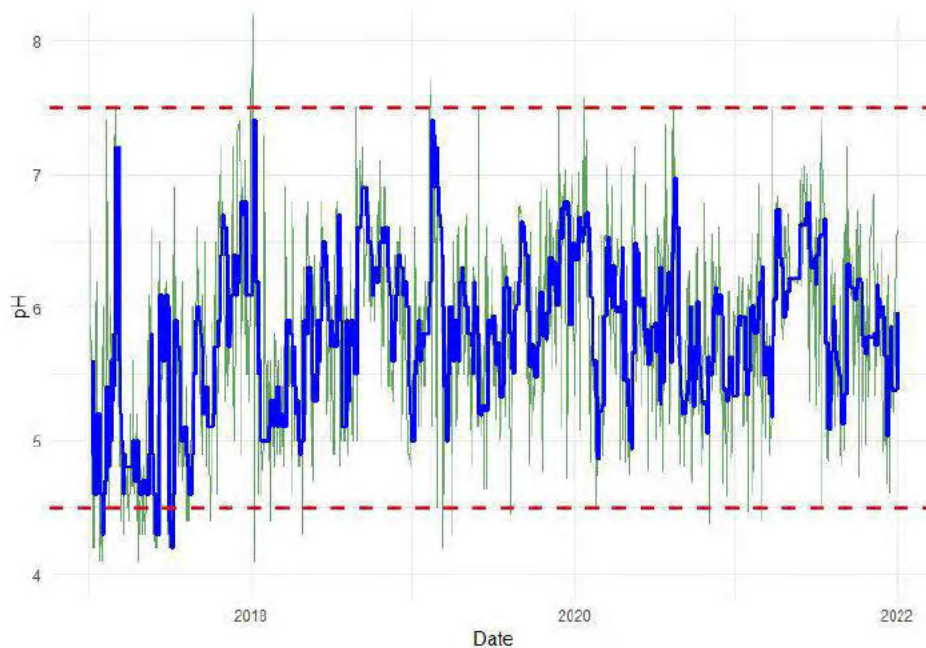


Figure 55. pH at site NR on Ngākawau River between 2017 and 2021. The moving blue line shows the 7-sample rolling median, while the lower dashed red line shows the lower limit for the occurrence of fish and the upper dashed line the assumed upper natural extent of pH.

6.3.3. Turbidity at NR on Ngākawau River

Turbidity in rivers is managed to regulate the acute effects of short-term spikes and chronic effects of longer-term average conditions (Hickey, 2026c). Accordingly, Hickey (2026c) recommends the use of annual median and 95th percentile statistics that are compared to either a benchmark condition or a reference state.

There is no suitable reference site comparable to the Ngākawau River for suspended sediments. Therefore, Bathurst have recommended using NR water quality data from the time period 2017 to 2021 as indicative of the likely effects of the remaining Operational Phase (2027-2033) at NR.

Turbidity buffers above the benchmark overall summary statistics are required to ensure that annual statistics can be consistently compliant in each year but also derive from recommendations by Reid & Quinn (2011) to inform sediment guidelines for the West Coast associated with alluvial gold mining. Their review suggested limiting the average increase in turbidity to <5 NTU to protect macroinvertebrate abundance in gravel bed rivers on the West Coast. If the focus is more on macroinvertebrate richness, they suggest limiting turbidity to a <20 NTU increase above reference.

In the absence of a reference site, using the benchmark (2017 to 2021) plus a buffer for the Ngākawau River will likely maintain those levels of effects of turbidity on ecology.

Hickey (2026c) applied Reid & Quinn (2011) buffers of <5 NTU to the median and <20 NTU to the 95th percentile, albeit to turbidity in reference state streams on plateau streams. In the absence of a reference stream for the Ngākawau River and given the ecological values present we recommend the more stringent proportional buffer of < 20% increase from either median or 95th percentiles.

Based on grab water samples between 2017 and 2021 site NR has a five-year median of 8 NTU (plus 5 NTU buffer = 13 NTU or plus 20% of the median = 9.6 NTU).

During the benchmark period the annual median value each year has been less than the overall median plus the 5 NTU or 20% (Figure 56).

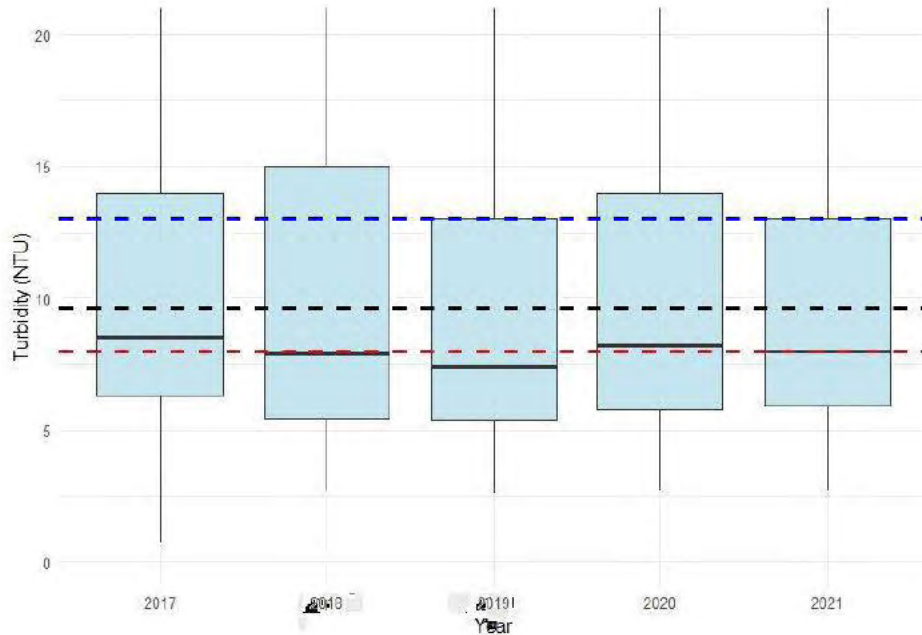


Figure 56. Annual boxplots of turbidity (NTU) at site NR on Ngākawau River between 2017 and 2021. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 * IQR$. Outliers are points outside the whiskers. The horizontal red line shows the 5-year median, the black line the five-year median plus 20 % buffer and the blue line shows the 5 NTU buffer.

The five-year Hazen 95th percentile turbidity at NR is 40 NTU (60 with the 20 NTU buffer; 48 with the 20% buffer) (Figure 57). The annual Hazen 95th percentiles over the reference period all fall within the five-year median plus 20 NTU buffer. However, the 95th percentile for 2017 exceeds the 95th percentile plus 20% buffer. It is important to note here that these results have not been corrected for exclusion from extreme flow events (>1 In 10-year floods) (Hickey 2026c).

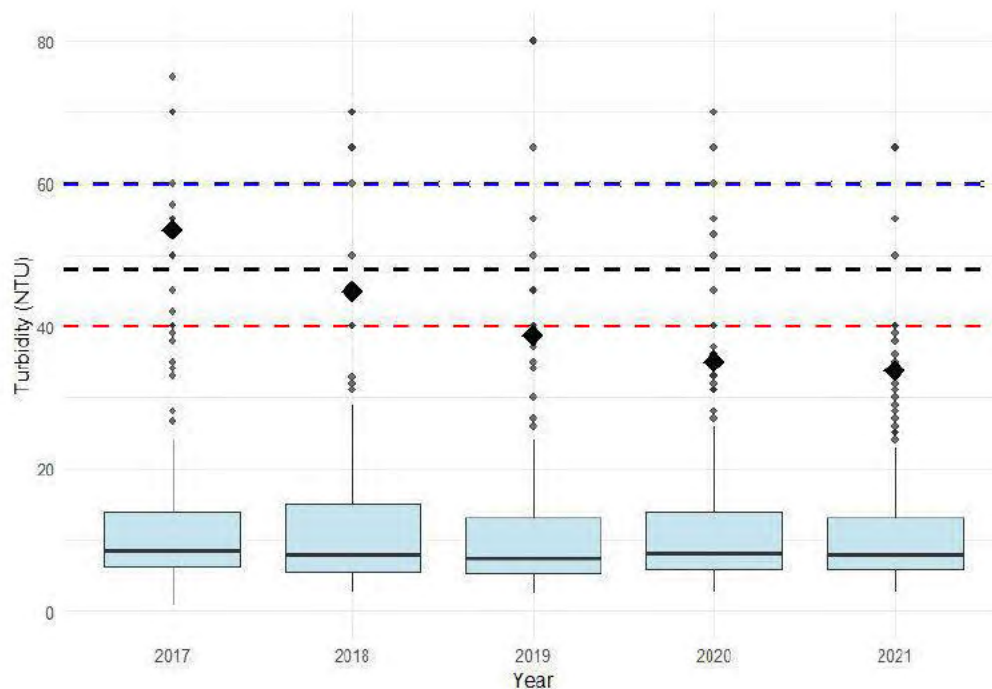


Figure 57. Annual boxplots of turbidity (NTU) at site NR on Ngākawau River between 2017 and 2021. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within 1.5 * IQR. Outliers are points outside the whiskers. The horizontal red line shows the 5-year Hazen 95th percentile, the black line the 95th percentile plus 20% and the blue line shows the 20 NTU buffer. The black diamonds show the annual Hazen 95th percentile.

Previous turbidity criteria for site NR on the Ngākawau River have focused on the behavioural effects of suspended sediment on migratory fish. The [REDACTED]

Using the five years of grab sample data from 2017 to 2021 the river spent 9% of the time (164 days) at an NTU of greater than 25 NTU. However, migrating fish have a short window of opportunity to access a river before they starve or are predated by larger fish. As such, it is the duration of events that exceed the threshold rather than the summation of exceedances that are critical. Event duration can be monitored and managed through the use of rolling statistics that describe the number of days of exceedance across a specified window of time.

Figure 58 shows a rolling 7-sample turbidity (NTU) median alongside the raw data. The horizontal red line shows the threshold for the behavioural avoidance of banded kokopu. We consider one week is the preferred ecological limit on the duration a fish might be expected to wait out a high flow/turbidity event. In the Ngākawau River at NR during the benchmark period the rolling 7-sample median has breached 25 NTU on a number of occasions most notably in 2018. During those periods there was the potential that elevated turbidity was dissuading [REDACTED]

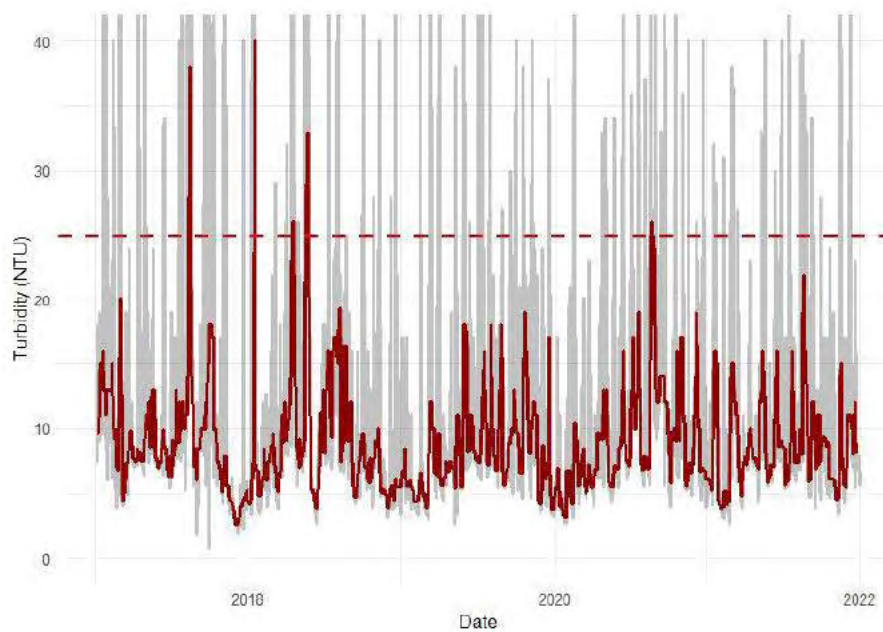


Figure 58. Seven sample rolling medians based on daily (weekday) grab samples at site NR on Ngākawau River. The horizontal red line shows the threshold for the behavioural avoidance of banded kokopu. Note the vertical axis has been truncated to focus on detail.

A 15-sample rolling median <25 NTU is a more permissive statistic for the management of elevated turbidity. Figure 59 applies a 15-sample rolling median and there are no of breaches to the 25 NTU threshold.

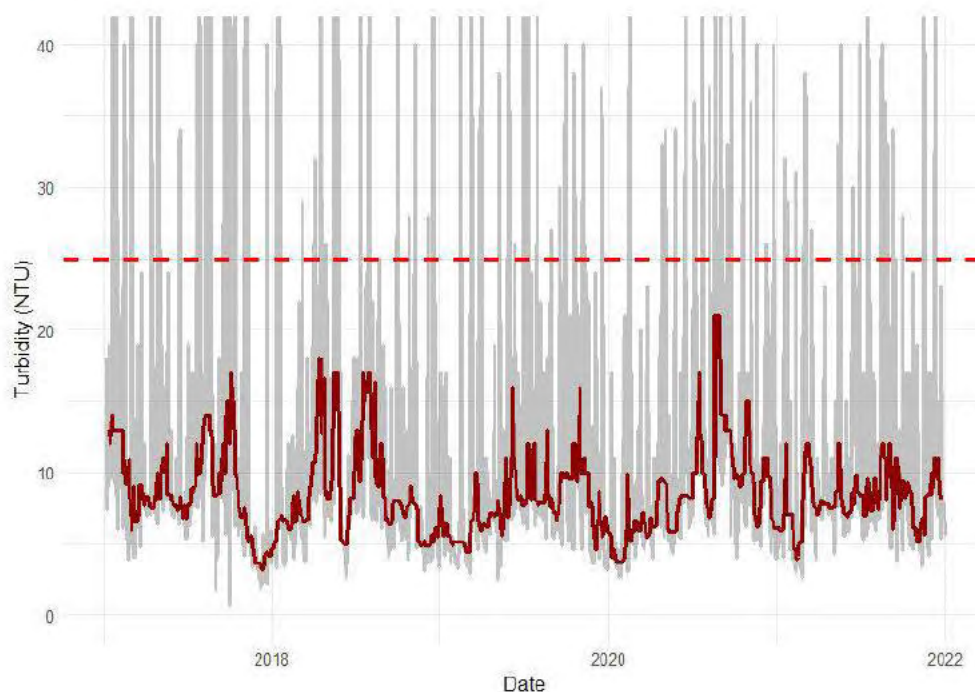


Figure 59. Fifteen sample rolling median based on daily (weekday) grab samples at site NR on Ngākawau River. The horizontal red line shows the threshold for the behavioural avoidance of banded kokopu.

A 7-sample turbidity rolling median of <25 NTU based on daily grab sample data for the protection of banded kokopu, is considered the preferred compliance threshold for site NR.

However, it is accepted that there may be a short-term operational period when Millerton AMD is being treated and discharged to the Mangatini Stream that may result in a sub-optimal water quality. Hence the choice of 2017-2021 for the benchmarking period. In the interests of supporting longer term plans for water treatment at Stockton a 15-sample rolling median is considered an acceptable compromise and is proposed here. It is noted that the previous compliance statistic at NR was a 30-sample rolling median, so the proposed 15-sample compliance statistic is a doubling of stringency.

While extended durations of elevated suspended sediment have the potential to impact upon

[REDACTED]

[REDACTED]

[REDACTED]

In combination a suite of statistics based on daily (weekday) grab sample data are proposed. Compliance limits of an annual median < 9.6 (rounded up to 10) NTU and an annual Hazen 95th percentile < 48 NTU will be accompanied by a limit of a rolling 15-sample median <25 NTU. These compliance limits will ensure turbidity at NR in the Ngākawau River does not cause undue mortality or behavioural avoidance of fish within the context of long-term water management. The annual median and 95th percentile statistics apply a <20% increase over the benchmark period. A breach of the maximum or 15-sample rolling median performance statistics should trigger an investigation into the cause(s) and a suitable response.

Water quality at NR during the highest tides may be affected by seawater. Data collected during those circumstances should be excluded from analyses and reporting.

6.3.4. Nitrogen at NR on Ngākawau River

Nitrogen species (N), nitrate-N and ammoniacal -N, may derive from activities associated with mining and rehabilitation. There is only a very short record (8 and 9 samples, respectively) of either N species available that is inadequate to generate summary statistics or posit suitable compliance limits. Concentrations of both nitrate-N (median 0.01, min 0.007, max 0.587 mg/L) and ammoniacal-N (median 0.0225, min 0.005, max 0.02 mg/L) are typically low in the Ngākawau River. However, Bathurst proposes the application of the current national “bottom line” standards described in the National Policy Statement – Freshwater Management (NPS-FM) as a suitable interim compliance limit (MfE 2020). NPS-FM nitrate-N and ammoniacal-N thresholds are based on managing potential toxicity effects and not eutrophication. Site NR currently meets the national bottom-line criteria for nitrate-N and ammoniacal-N (pH adjusted) based on the limited data available.

6.3.5. Ngākawau River NR summary

The proposed compliance statistics at site NR on Ngākawau River vary between those specifically tailored to an ecological threshold, e.g. 1 mg/L dissolved aluminium, and statistics designed to maintain the state of water quality relative to the benchmark period (2017-2021).

Annual statistics such as the median or a percentile are appropriate for annual or six yearly reporting and review, whereas the shorter-term rolling medians are better suited to trigger a response.

The proposed statistics are met during the benchmark period of water quality data and are aligned with the proposed approach to compliance for the proposed Escarpment Extension

and Mount Fredrick South mines (Hickey, 2026a and b). In the case of turbidity, annual median and 95th percentiles are not based on an ecologically derived threshold such as a reference state. The statistics derive from a summary of the benchmark period and as such aim to maintain the level of effect observed at that time. It is assumed that there are effects on turbidity at NR derived from current and ongoing mining, but in the absence of a suitable reference site it is difficult to appropriately parse those effects from natural turbidity sources.

The 15-sample rolling median turbidity, pH and dissolved aluminium are a compromise between the requirements of mine management and migratory fish. While a 7-sample rolling window would be preferable from an ecological perspective, it is noted that the previous turbidity limit for site NR allowed a 30-sample rolling time period. A 15-sample window represents an increase in the stringency of water quality management at NR that is more suitable for native fish but should be considered transitional.

This report proposes that a river should be considered 'water quality recovered' once the aluminium (75th percentile <1 mg/L) and pH (>4.5) thresholds are met, but further adjustments to treatment or time elapsed for decay may be required to achieve ecological recovery or mahinga kai suitability (Figure 50). Analysis of ecology information and a broader suite of water quality data may be required to determine the factors limiting ecological recovery in the future. Any review of water quality limits should also consider a transition to the more nuanced and protective suite of thresholds proposed by Hickey (2026c) for plateaux streams once Al and pH criteria are achieved.

6.4. Ngākawau River Estuary/Bridge

Water quality at the Ngākawau Estuary/Bridge (sites NR Estuary and NR Bridge, Figure 1) is influenced by the water quality at NR, the intervening discharge from Mine Creek and the ocean. The site is key to the migration of fish into the Ngākawau River and also provides habitat to resident ecological communities. NR Estuary/Bridge are difficult sites to monitor due to the influence of tidal ingress, ocean swells and incomplete mixing of Mine Creek water. Samples at NR Estuary were collected at low tide with every effort made to avoid the influence of sea water. Data presented here was collected between June 2021 and December 2025 and the average number of days between samples was 12. This bench marking time period is considered likely to best approximate the next 6 years. However, it is important to note that future monitoring will occur at NR Bridge as this site is hoped to be more suitable to represent fully mixed Ngākawau River and Mine Creek water.

Plots of water quality collected on the same day at both NR Estuary and NR2 illustrate the effect of Mine Creek. The plots indicate that there are occasional effects on pH at NR Estuary from Mine Creek that exceed the threshold of <4.5 (Figure 60 and Figure 63). Furthermore, both turbidity and dissolved aluminium are routinely worse at NR Estuary than at NR2 and more commonly exceed the ecological thresholds (Figure 60, Figure 61 and Figure 62). These patterns are considered to be attributable to the Mine Creek discharge. It is of note that while thresholds at NR Estuary are exceeded, over the same period there has been no evidence derived from annual fish surveys in the Ngākawau headwaters of a reduction in fish recruitment.

Water quality samples at NR Estuary are collected at low tide and therefore represent the worst-case water quality. Tidal ingress or elevated flows in the river would create dilution and more suitable water quality for fish. The propensity of the Mine Creek plume to hug the true

left bank might also create opportunities for fish passage along the true right bank. Similarly, the unaffected and denser saltwater wedge would push upstream beneath the freshwater and beyond the Mine Creek confluence and potentially provide a pathway for migrating fish.

This result suggests that while worst case situation water quality data indicates a potential effect on fish that there is a resident population.

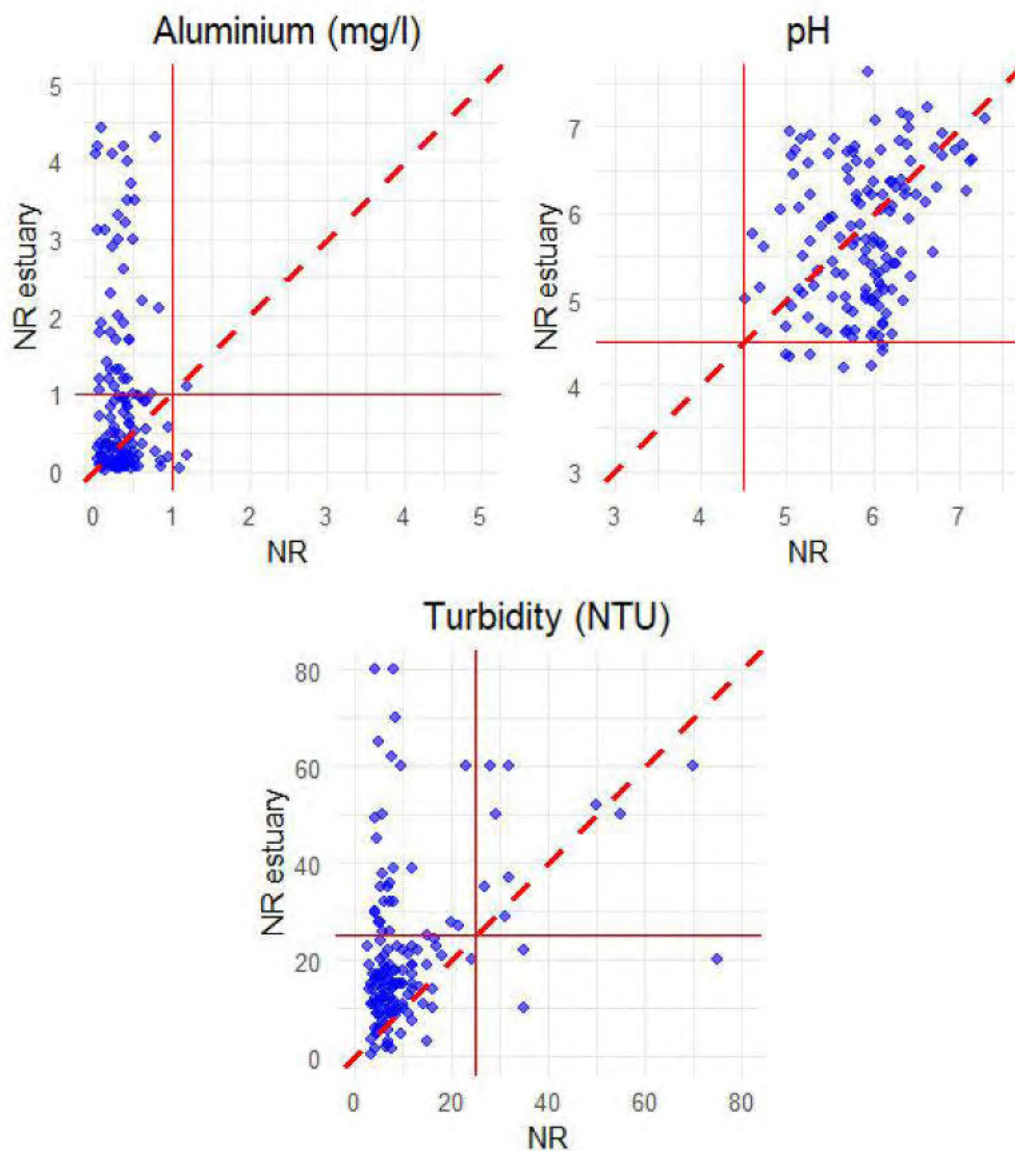


Figure 60. Water quality compared between NR and NR Estuary. The diagonal line shows the 1:1 point between the two sites. Horizontal and vertical lines are the ecological thresholds for each water quality variable.

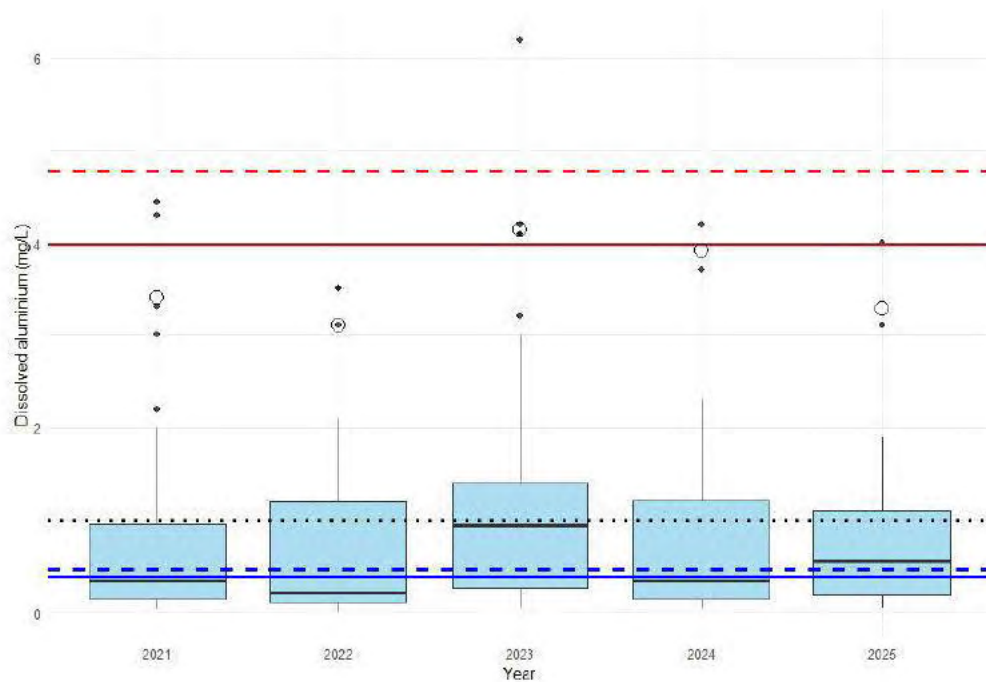


Figure 61. Boxplots of dissolved aluminium at site NR Estuary. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 \times \text{IQR}$. Outliers are points outside the whiskers. The blue and red solid lines show the overall median and 95th percentile, while the dashed lines are the same plus 20%. The dotted black line shows the threshold for the protection of fish. The hollow black circles show the annual 95th percentiles.

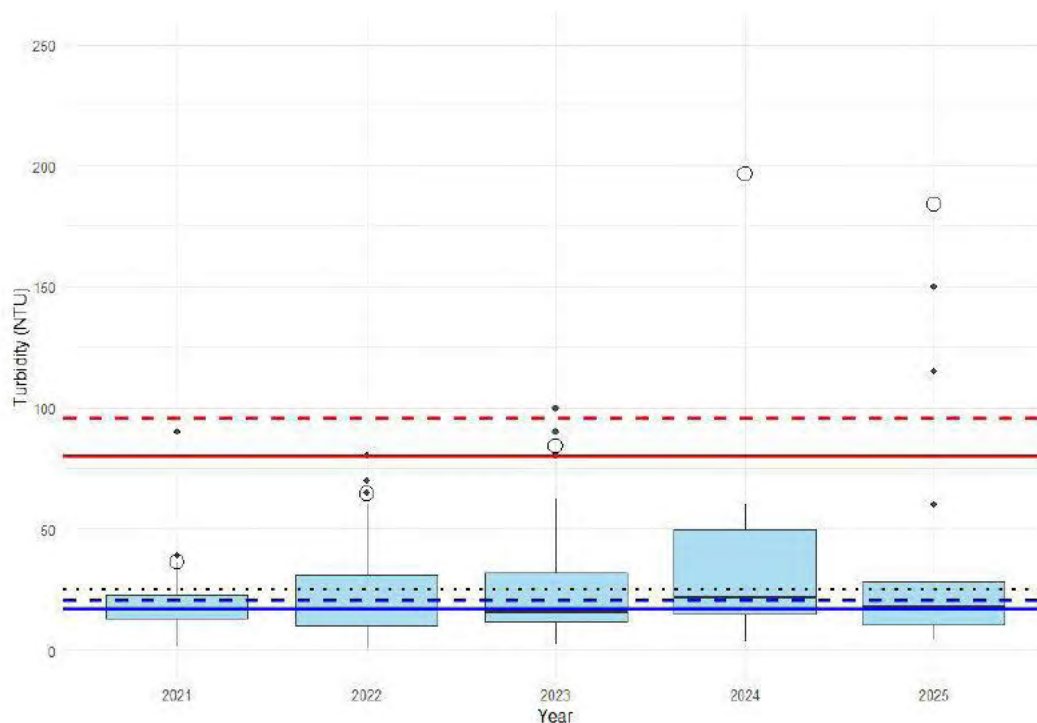


Figure 62. Boxplots of turbidity at site NR Estuary. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 \times \text{IQR}$. Outliers are points outside the whiskers. The blue and red solid lines show the overall median and 95th percentile, while the dashed lines are the same plus 20%. The dotted black line shows the threshold for the protection of fish. The hollow black circles show the annual 95th percentiles.



Figure 63. Boxplots of pH at site NR Estuary. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 * IQR$. Outliers are points outside the whiskers. The blue and red solid lines show the overall median, 5th and 95th percentile. The dotted black line shows the lower threshold for the protection of fish. The hollow black circles show and the annual 5th percentiles.

There are several technical constraints that limit the development of a water quality compliance statistic.

1. Mine Creek water quality over the ensuing operational period cannot be predicted to an appropriate level to create compliance limits for the estuary,
2. Data collected at sites NR estuary and NRB indicates that the sites are compromised by incomplete mixing of Mine Creek water,
3. Saltwater is present in the majority of samples collected.

Given the absence of an effect on fish migration due to the Mine Creek discharge and the technical constraints with setting a suitable water quality compliance limit at NRB, Bathurst propose to monitor and report water quality at site NRB as a performance site rather than for compliance purposes.

However, Bathurst proposes an effects-based ecological compliance framework at Ngākawau River mouth comprising two complementary components:

1. Verification that fish passage has been maintained, through annual monitoring of fish recruitment to the headwaters of the Ngākawau River; and

2. Verification that ecological community condition at the Ngākawau River mouth has been maintained, through annual monitoring of resident fish and macroinvertebrate communities.

These complementary monitoring programmes assess different ecological endpoints that may be affected by the Mine Creek discharge, namely fish recruitment and passage, and ecological community condition within the river mouth.

Compliance with ecological outcomes will be assessed through evaluation of temporal change in ecological community condition. Compliance will be achieved where there is no statistically and ecologically significant decline in fish or macroinvertebrate community condition attributable to the consented activity. Because there is currently only a single baseline data point and ecological communities are inherently variable and responsive to a range of stressors, within and outside the control of Bathurst, compliance will require an annual attributive assessment to determine:

1. Whether negative changes exceed the expected range of natural temporal variation,
2. Whether the observed change, that exceeds the expected range of natural temporal variation, is ecologically meaningful,
3. Whether the consented activity has materially contributed to the observed ecological change.

The attribution assessment shall take account of the different ecological processes represented by each monitoring component. In particular, changes in fish recruitment will be interpreted in the context of factors influencing migration and recruitment success, whereas changes in resident fish and macroinvertebrate communities will be interpreted in the context of changes in conditions within the river mouth.

The first two years of monitoring shall be used to establish temporal variability and refine the interpretation of ecological trends. Local reference sites should be incorporated into the monitoring programme to assist in distinguishing activity-related effects from broader environmental change. Monitoring results shall be interpreted in the context of the growing monitoring record rather than solely against the initial baseline survey.

The attribution assessment shall be undertaken by a suitably qualified and experienced freshwater ecologist, taking into account the monitoring record, relevant environmental conditions, and any other plausible stressors operating within the catchment.

Where the consented activity is determined to have materially contributed to an ecologically significant decline, Bathurst shall prepare and implement an adaptive management response in consultation with the consent authority that is proportionate to the magnitude and nature of the attributed ecological effect.

6.5. Mangatini Stream

6.5.1. Introduction

Mangatini Stream has elevated metals and low pH due to residual untreated acidity and aluminium discharging from Mangatini Sump and untreated AMD tributaries (e.g., Ford Creek). On occasion the site also has elevated turbidity partially due to the lime dosing used

to manage AMD. The stream is considered 'water quality impacted' and has low ecological values based on macroinvertebrate samples (Section 3.3.4). However, Mangatini Stream is one of the key tributaries reporting to site NR in the Ngākawau River and contingent on the maintenance of fish passage to the Ngākawau River headwaters. Due to the current state of the stream, ecologically based water quality compliance limits are not recommended. However, annual median and percentile assessments will inform any deviation in water quality from the benchmark period and ongoing review of compliance monitoring.

The appropriate benchmarking period for the Mangatini Stream is 2017 to 2021 (the same as the NR benchmarking period). This period is considered to most closely resemble the potential future effects of pumping Millerton AMD into the Mangatini catchment for treatment, particularly the 2017/2018 period when Millerton loads pumped to Mangatini were greatest.

There are two sites on the stream, the upper S14C and the downstream S14B. At S14C mixing processes downstream of untreated Ford Creek and the Mangatini Sump are still occurring meaning the site is less suitable for compliance than S14B.

S14B is downstream of the mixing zone and accordingly the most suitable to assess water quality. However, only pH and turbidity are currently collected at S14B, so dissolved aluminium should be monitored and reported from site S14C until a suitable benchmarking period of dissolved aluminium collection is achieved at S14B. Thereafter, monitoring at S14C may cease until site S14B shows an improved water quality status, whereupon further monitoring at S14C would be required to support ecological monitoring (i.e. pH and dissolved aluminium).

6.5.2. pH at Mangatini Stream site S14B

pH at site S14B during the benchmarking period ranged between 3.29 and 7.8 during a period when at the receiving site, NR, the pH value was typically compliant with ecological thresholds (Figure 64 and Figure 65). Maintaining the lower boundary of pH at S14B at commensurate or higher levels over the ensuing six years is considered a suitable approach to maintaining the chemically recovered status of the Ngākawau River. The overall 5th percentile (4.2) was met during the benchmark period in 3 of the 5 years. However, Bathurst propose a 5th percentile pH of 4 as an annual compliance statistic to provide an operational buffer between 2017/18 values (when Millerton loads treated at Mangatini were greatest) and compliance concentrations.

The upper range of pH at S14B is of lesser importance unless it exceeds the natural range of pH at site NR (~7.5) or the upper limit of pH 7 for acidophile bryophytes (Hogsden & Hickey, 2025). Acidophile bryophytes are present in the Mangatini Stream and so 7 is proposed for the upper level (95th percentile) of pH compliance at S14B.

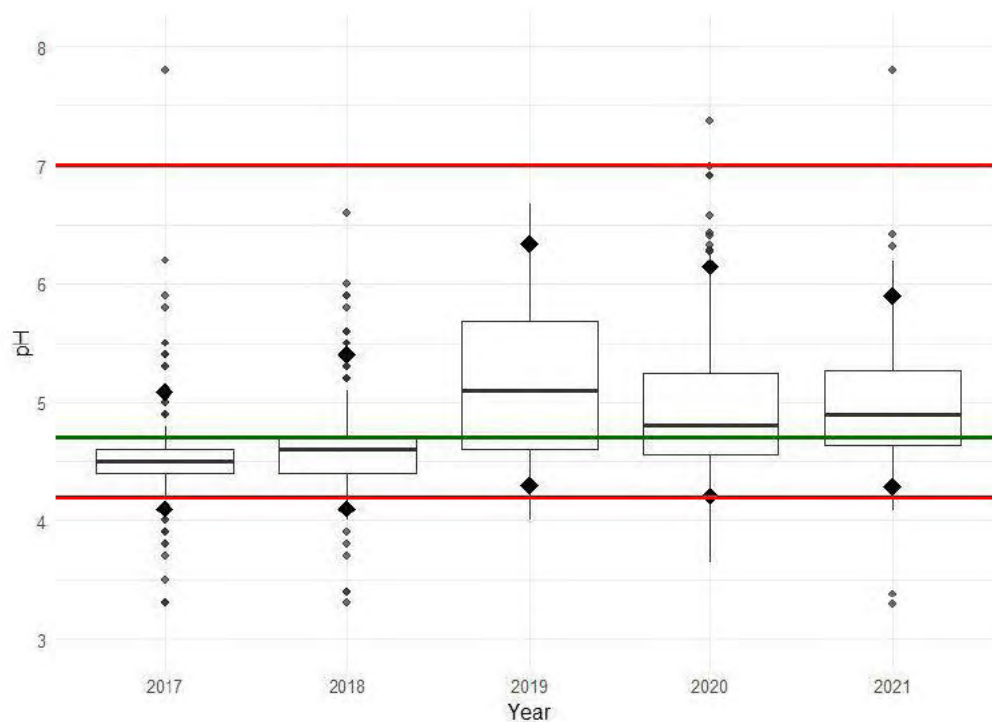


Figure 64. pH at site S14B on the Mangatini Stream between 2017 and 2021. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within 1.5 * IQR. Outliers are points outside the whiskers. The lower horizontal red line shows the 5-year Hazen 5th percentile, while the upper line is the proposed upper compliance statistic for the protection of acidophile bryophytes (7). The black diamonds show the annual Hazen 5th and 95th percentiles. The green line shows the overall median value.

A short-term summary statistic is a useful trigger to respond to any issues with the treatment system. Accordingly, Bathurst propose a 15-sample rolling median that remains between 4.0 and 7 provides a suitable compliance statistic. Figure 65 shows the rolling 15-sample median at S14B over the benchmark period. The 15-sample rolling median is consistently between the bounds of the proposed compliance statistics.

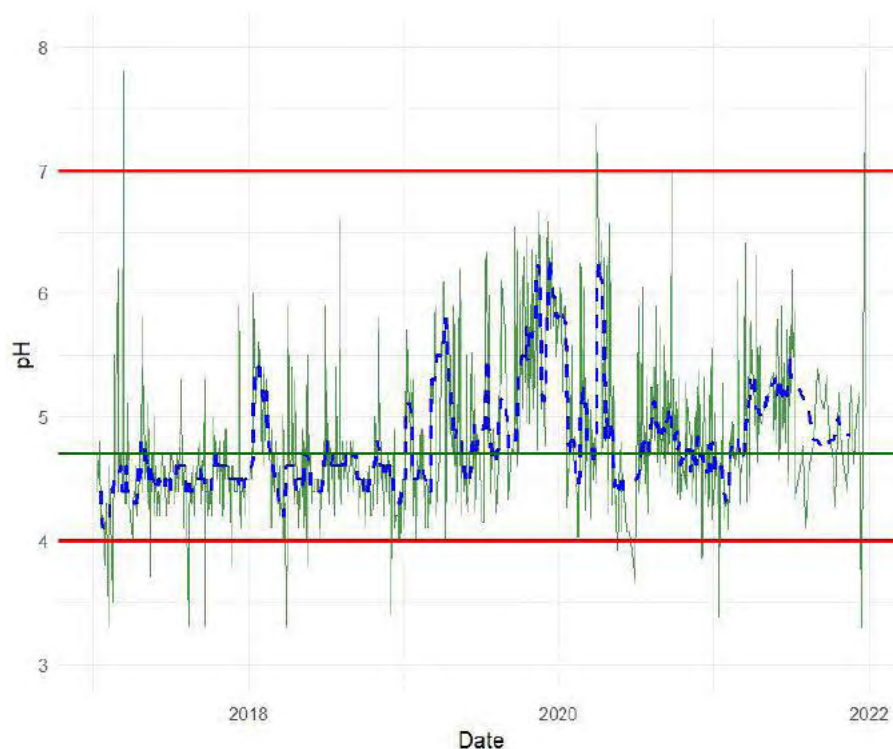


Figure 65. pH at site S14B on the Mangatini Stream between 2017 and 2021. The moving green line shows the raw data while the blue line is the 15- sample rolling median. Gaps in the data set have been interpolated for ease of viewing. The horizontal solid red lines show the lower proposed compliance statistic of 4 and the upper proposed compliance statistic for protection of acidophile bryophytes (7). The horizontal green line shows the overall median value.

6.5.3. Turbidity at Mangatini Stream at site S14B

Turbidity at S14B is highly variable within and between years (Figure 66); min = 0.3 NTU, max = 5600 NTU) with particularly high values in 2017. Both annual medians and 95th percentiles exceed the overall summary statistics plus a 20% buffer by a considerable margin in 2017 and the rolling 7-sample medians also exceeds the 95th percentile plus 20% (Figure 67). 2017 appears to have been an extreme year for turbidity at S14B and also causes the 15-sample rolling median to exceed the 95th percentile plus 20% (Figure 68), although the 30-sample rolling statistic is compliant (Figure 69).

Bathurst have indicated that turbidity at site S14B is currently managed through their lime dosing bypass consent (RC06206) and Bathurst propose to roll over the conditions governing the activity therein. Accordingly, no compliance statistics are provided here.

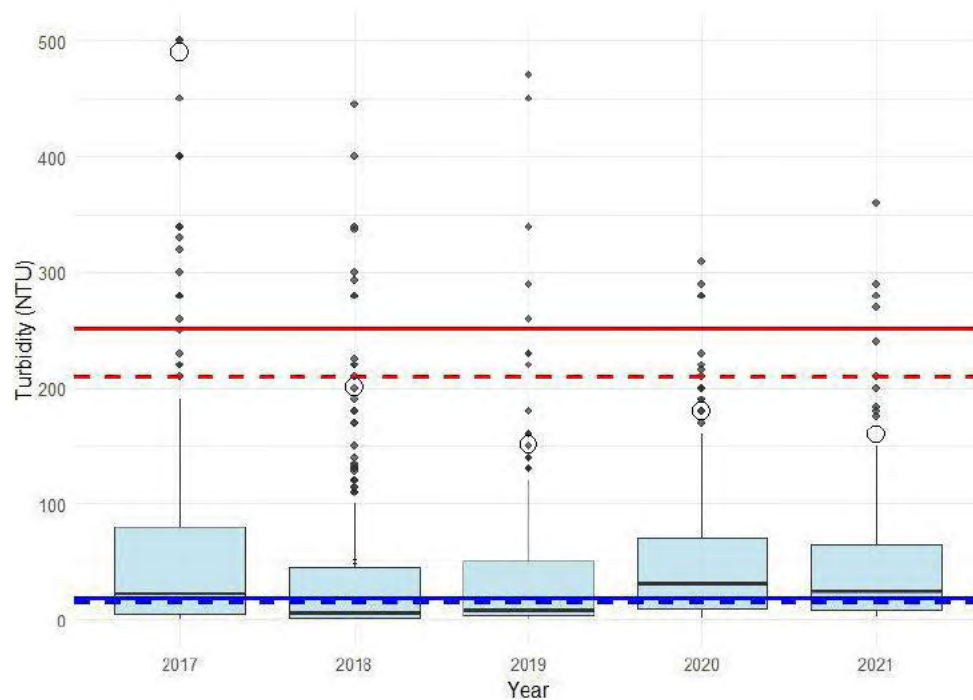


Figure 66. Turbidity at site S14B on the Mangatini Stream between 2017 and 2021. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 \times$ IQR. Outliers are points outside the whiskers. The horizontal solid red line shows the 5-year Hazen 95th percentile, while the dashed line is the 95th percentile plus 20%. The black circles show the annual Hazen 95th percentile.

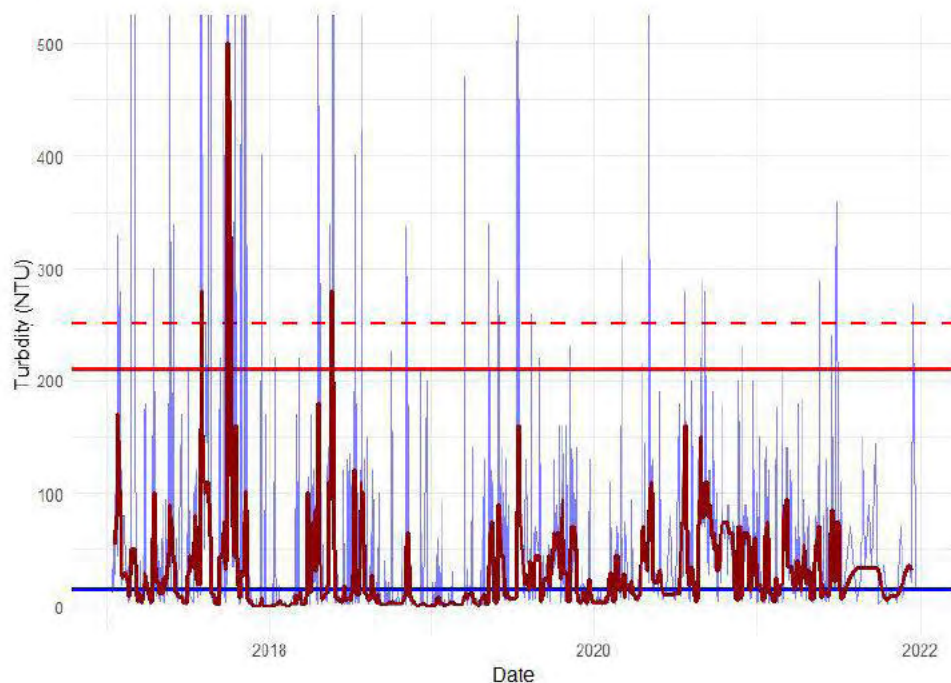


Figure 67. Turbidity at Mangatini Stream at site S14B. The moving red line shows the 7-sample rolling median, while the blue line is the raw data. Note the y axis has been truncated to focus on the key area of the plot. The solid red and blue lines are the overall 95th percentile and median, while the dashed red line is the 95th percentile plus a 20% buffer.

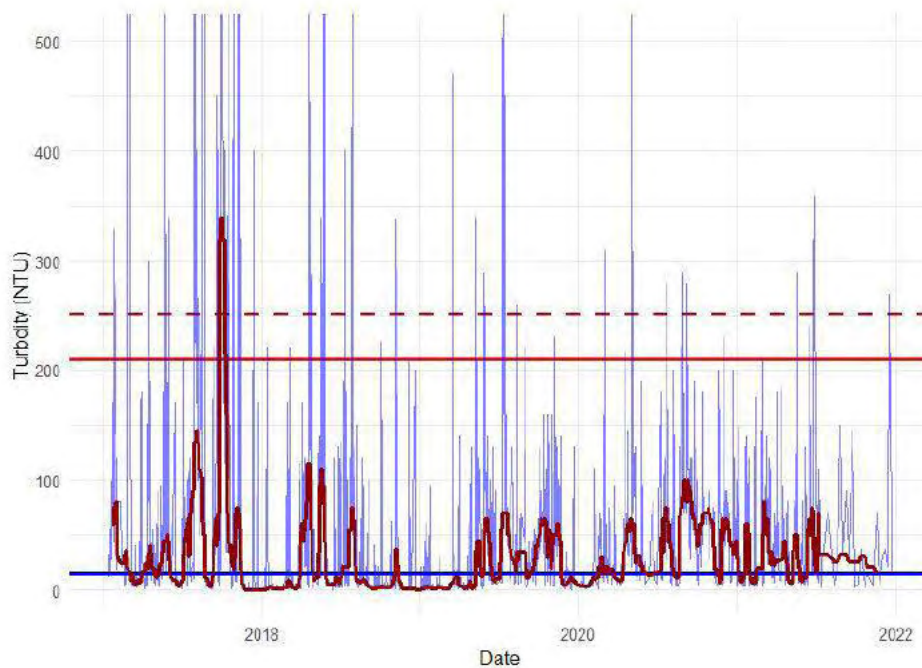


Figure 68. Turbidity at Mangatini Stream at site S14B. The moving red line shows the 15-sample rolling median, while the blue line is the raw data. Note the y axis has been truncated to focus on the key area of the plot. The solid red and blue lines are the overall 95th percentile and median, while the dashed red line is the 95th percentile plus a 20% buffer.

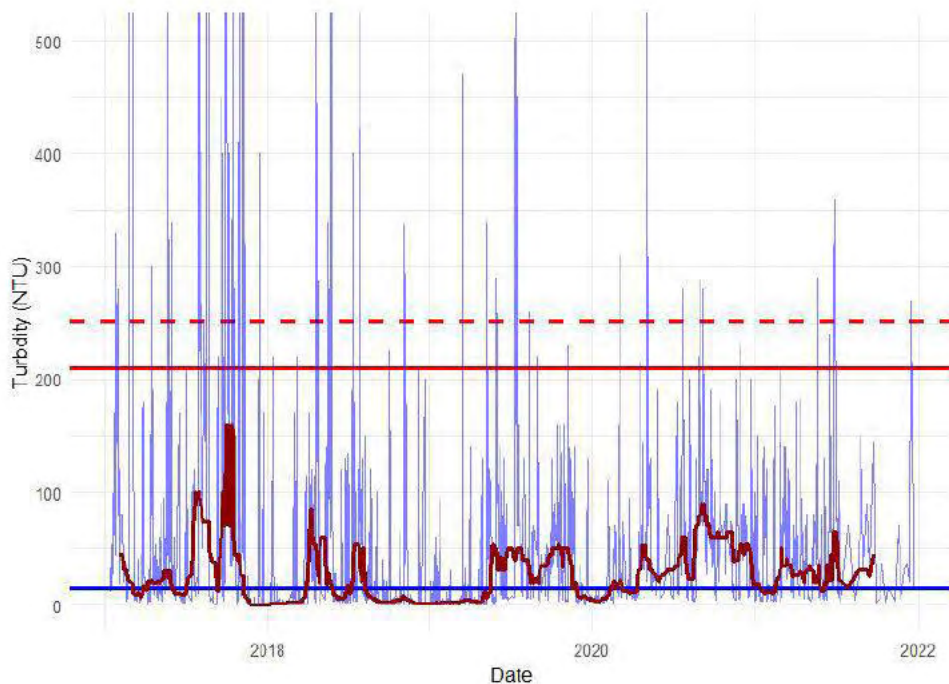


Figure 69. Turbidity at Mangatini Stream at site S14B. The moving red line shows the 30-sample rolling median, while the blue line is the raw data. Note the y axis has been truncated to focus on the key area of the plot. The solid red and blue lines are the overall 95th percentile and median, while the dashed red line is the 95th percentile plus a 20% buffer.

6.5.4. Dissolved aluminium at Mangatini Stream at site S14C

Dissolved aluminium at S14C is highly variable over time due to the influence of variable residual untreated acidity / aluminium discharging from Mangatini Sump, the untreated Ford Creek, and ongoing mixing processes downstream of Mangatini treatment facilities. There is potentially further variability due to the influence on S14C of additional Millerton water being pumped to the Mangatini catchment for treatment in the near future. Accordingly, Bathurst have determined that S14C should not be used as a performance site for dissolved aluminium. Rather the Mangatini Sump Decant (site MGD) is proposed as an interim performance site until an adequate data record for site S14B is available. Site MGD is shown on Figure 51.

Measured annual median and 75th percentile S14B Al concentration data will also be compared against time dependant recovery trajectory values to track water quality improvement.

6.6. Mine Creek at MC1

Future water quality during the operational period is difficult to predict at MC1 due to the influence of contemporary mining schedules and uncertain pathways of historic underground drainage pathways. In addition, due to access issues, there is no contemporary water quality data available at MC1 since 2021. Bathurst propose that pH and dissolved aluminium be monitored and reported at this site once access is regained, particularly with reference to site NR Estuary, but without compliance limits, at least during the operational period. However, Bathurst do propose a turbidity limit of a rolling 15-sample median <25 NTU.

Measured annual median MC1 Al concentration data will also be compared against the time dependant MC1 betterment reference values to track water quality improvement as a result of proposed BPCP Millerton Block water and AMD management strategies.

6.7. Granity and Miller streams

Operational phase water quality at S25 and S24B are uncertain due to the unpredictably of mine scheduling and historic underground drainage pathways. In addition, the level of contamination at these sites is such that there are very limited ecological values. Accordingly, it is proposed that these sites are monitored regularly for dissolved aluminium and pH (at least monthly), but that no compliance limits are applied. However, Bathurst do propose a compliance limit of a median < 25 NTU turbidity across 15-samples based on a daily (weekday) sample. Monitoring and reporting at these sites should be subject to six yearly review.

Measured annual median S25 and S24A Al concentration data will also be compared against time dependant betterment reference values to track water quality improvement as a result of proposed BPCP Millerton Block water and AMD management strategies.

6.8. Rudolph Stream

Rudolph Stream is currently governed by an existing consent (RC89038 - V6), with consent conditions based on historic underground workings discharges. RC89038 - V6 requires weekly sampling of Total Suspended Solids (TSS) and Acidity. The compliance limits are TSS < 30 mg/L and acidity < 285 mg/L as CaCO₃ are both based on a monthly mean. The BPCP proposes to bring this consent into line with other sites by applying new compliance limits of

an annual median 30 mg/L of dissolved aluminium (Figure 70) and a 15-sample rolling median of 25 NTU for site S28U.

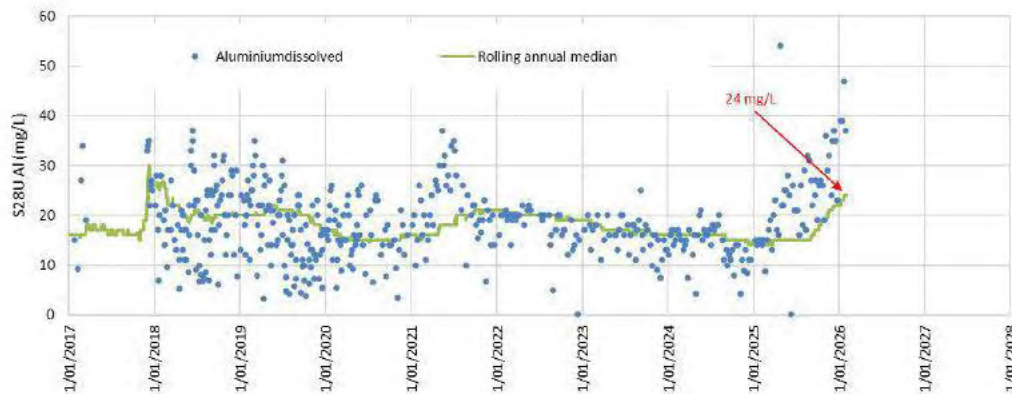


Figure 70. Aluminium concentration at site S28U on Rudolph Stream.

The small portion of Rudolph Catchment that is permanently diverted to Twins Catchment (through construction of Twins Pit) is not expected to affect compliance in Rudolph Stream.

6.9. Twins Stream

Current AMD effects at T1 are likely due to discharges from historic underground mining areas. Previously, Bathurst did not require a consent for discharge to Twins Stream. New opencast mining disturbance in the Twins T1 Catchment is proposed, and accordingly Bathurst require a discharge consent for Twins Stream at T1. Twins Stream (below T1 and above T3) is also subject to discharges from neighbouring mines.

The downstream site T3, on Twins Stream, is approaching 'Recovering' status based on dissolved aluminium concentrations. Accordingly, ecological values are likely to begin increasing over time. As such, Bathurst propose compliance limits at the upstream T1 site. The data record at Twins Stream is too sparse to use a benchmarking approach so the full sporadic data set has been used (Figure 71). Based on the information that is available Bathurst have proposed that at site T1 based on weekly sampling the annual median dissolved aluminium will be <28 mg/L and the rolling 15-sample median turbidity <25 NTU.

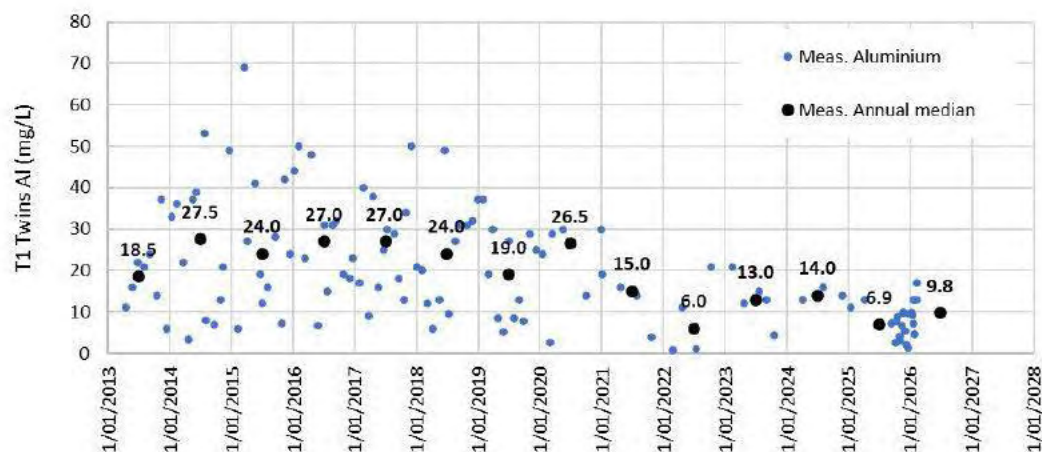


Figure 71. Dissolved aluminium in Twins stream at site T1 since 2013.

Measured annual median T1 Al concentration data will also be compared against the time dependant T1 betterment reference values to track water quality improvement as a result of proposed BPCP Millerton Block water and AMD management strategies.

The Crown via LINZ are currently assessing the optimal management for Historic AMD in Twins Stream (<https://www.treasury.govt.nz/publications/information-release/stockton-acid-mine-drainage>).

6.10. St. Patrick Stream at S16

Site S16 in the St. Patrick Stream currently exceeds ecological thresholds for recovery, but because it contributes to NR that does support ecological values, it is important to manage water quality with compliance limits.

6.10.1. Dissolved aluminium

Dissolved aluminium at S16 is greater than the ecological threshold for macroinvertebrates and fish (>1 mg/L). However, over the last 5 years there has been a consistent decline in the annual medians (Figure 72). Bathurst have indicated that they don't envisage any increase in contamination at S16, but that the future trajectory of dissolved aluminium is uncertain. Accordingly, they propose that the annual median and 95th percentile compliance limits are set at the overall median and 95th percentile plus a 20% buffer, of 5 and 8 mg/L, respectively. Those statistics are based on a summary of the previous 2 years data at S16.

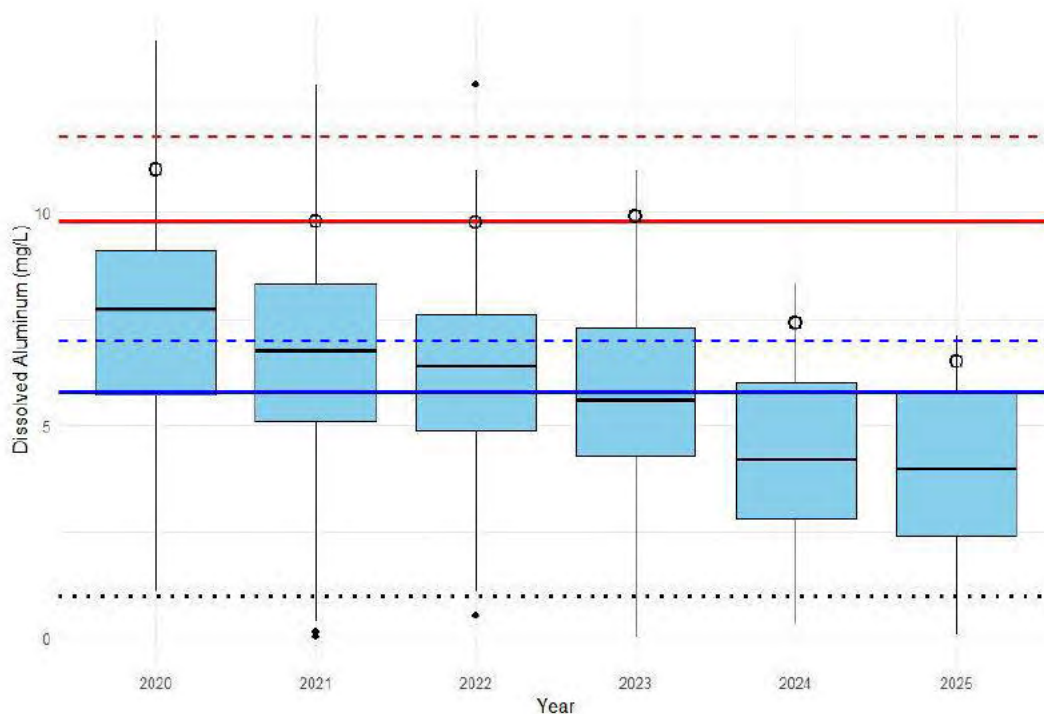


Figure 72. Boxplots of dissolved aluminium at site S16 on St. Patrick Stream. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within 1.5 * IQR. Outliers are points outside the whiskers. The blue and red solid lines show the overall median and 95th percentile. The dashed lines show the median and 95th percentile plus a 20% buffer. The dotted black line shows the upper threshold for the protection of fish. The hollow black circles show and the annual 95th percentiles.

To manage for short duration elevation that is out of character for this site, Bathurst propose a 15-sample rolling median of 8 mg/L (the overall 95th percentile plus 20%) (Figure 73). That figure has been consistently complied with over the benchmark period for St. Patrick Stream (2021 to 2025) and will serve to indicate if anything has changed for the worse at site S16.

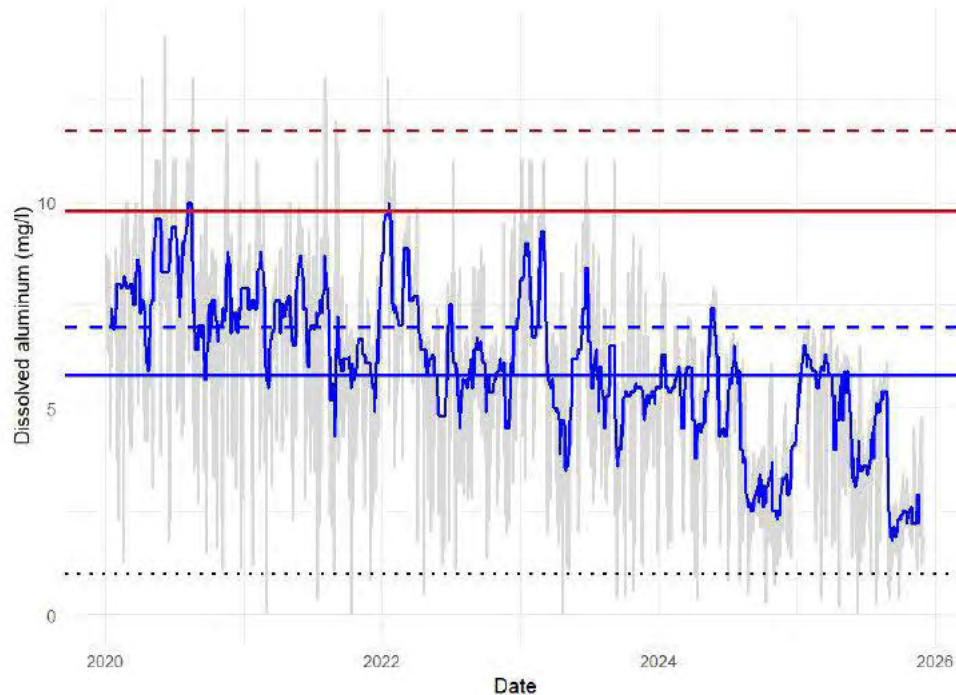


Figure 73. Fifteen sample rolling median dissolved aluminium (blue) over raw data (grey) for site S16 on St. Patrick Stream. The solid blue and red lines show the median and 95th percentile, while the dashed lines show the same plus a 20% buffer. The dotted black line shows the upper limit for the protection of fish and macroinvertebrates.

Measured annual median and 75th percentile S16 Al concentration data will also be compared against time dependant recovery trajectory values to track water quality improvement.

6.10.2. pH

pH at site S16 shows an increase commensurate with the declines in dissolved aluminium (Figure 74). The majority of values are below the lower limit for fish and macroinvertebrates, while all values are within the upper limit for the protection of acidophile bryophytes (Greig et al., 2010; Hogsden & Hickey, 2025). A median value is not appropriate for pH, rather an upper and lower value are required due to effects on fish and macroinvertebrates at low pH and acidophile bryophytes at high pH. An upper value of 7 has been recommended for bryophytes and we suggest this number be adopted for the upper 95th percentile and 15-sample rolling median. The upper value of 7 is beyond the maximum value in the data set (pH 6.5).

pH at S16 is relatively stable and Figure 74 shows that the site is compliant annually with an overall 5th percentile minus a 10% buffer (2.9). However, because pH at S16 has been increasing consistently over time Bathurst propose that a summary statistic based on the last two years of data that is a lower limit of 3.4 for the annual 5th and rolling median.

As a short-term statistic to manage events Bathurst propose the rolling 15-sample median within the pH range of 3.4 to 7 is adopted. The site was compliant with that range during the benchmark period (Figure 75).

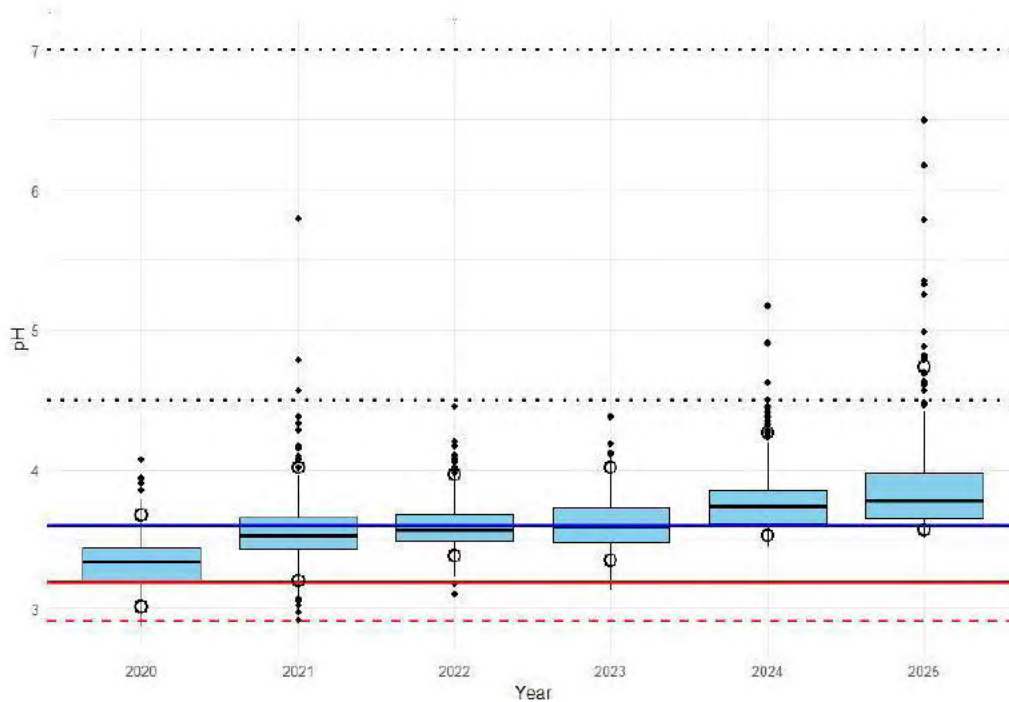


Figure 74. Boxplots of pH at site S16 on St. Patrick Stream. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within $1.5 * IQR$. Outliers are points outside the whiskers. The blue and red solid lines show the overall median and 5th percentile. The dashed red line shows the 5th percentile minus 10%. The lower dotted black line shows the lower threshold for the protection of fish, the upper dotted black line shows the upper threshold for the protection of acidophile bryophytes. The hollow black circles show the annual 5th and 95th percentiles.



Figure 75. Fifteen sample rolling median pH at S16 on St. Patrick Stream. The solid red and blue lines represent the 5th percentile and median, respectively. The dashed red line is the 5th percentile minus 10%. The dotted black line is the lower limit for protection of fish and macroinvertebrates.

6.10.3. Turbidity

Turbidity is variable over time, but relatively constant between years (Figure 76). The river tends to run clear and the majority of the time would be suitable for the migration of sensitive galaxiid species, notwithstanding other water quality parameters. As such this site is considered to be close to a reference state for turbidity. Accordingly, Bathurst have suggested the use of the Reid & Quinn (2011) and Hickey (2026c) approach of allowing an absolute 5 and 20 NTU buffer on the median and 95th percentile values at each site, respectively.

The site is compliant with both median and 95th percentiles plus a 5 and 20 NTU buffer, 6.9 NTU and 44 NTU, respectively (Figure 76).

In terms of short-term elevation in turbidity a rolling 15-sample median is compliant with the 95th percentile without the need for a buffer (Figure 77). Bathurst propose that a rolling 15-sample statistic of <24 NTU is applied at this site for compliance.

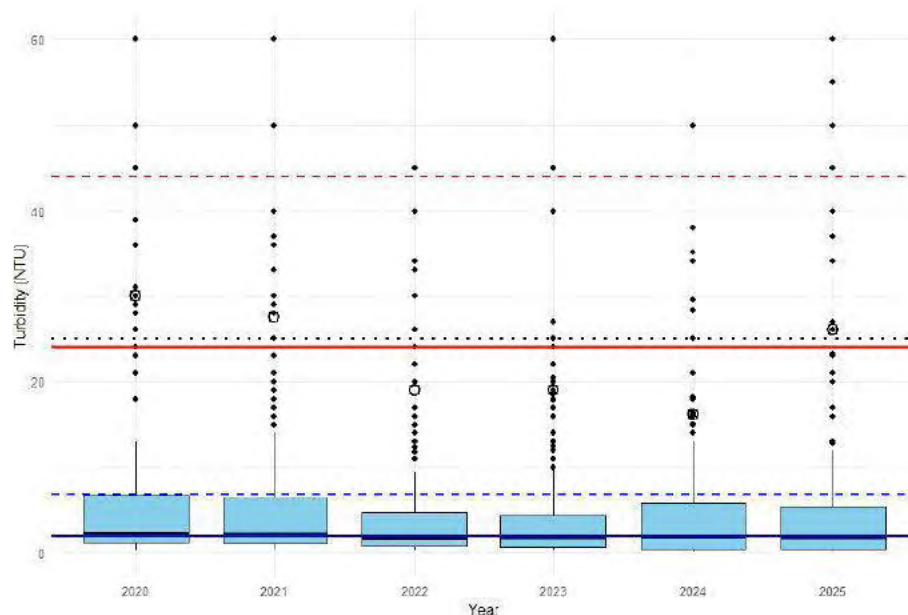


Figure 76. Boxplots of turbidity at site S16 on St. Patrick Stream. The box plot shows the median plus the interquartile range (IQR) and the whiskers extend to the smallest and largest values within 1.5 * IQR. Outliers are points outside the whiskers. The blue and red solid lines show the overall median and 95th percentile. The dashed lines show the median and 95th percentiles plus 5 and 20 NTU, respectively. The dotted black line shows the annual 95th percentiles.

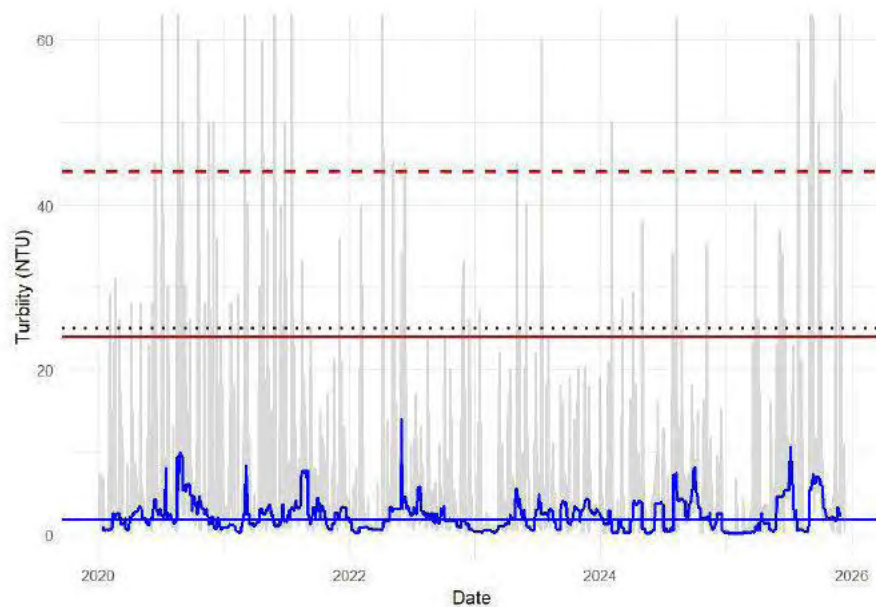


Figure 77. Fifteen sample rolling median turbidity at S16 on St. Patrick Stream. The solid red and blue lines represent the 95th percentile and median, respectively. The dashed red line is the 95th percentile plus 20 NTU.

6.11. Herbert and Whirlwind streams

Herbert and Whirlwind streams drain to the Waimangaroa River from the flanks of the ridge between Mt. Augustus and Frederick. The majority of this area has no active mining and is under various stages of rehabilitation. Primary AMD discharges emanate from historic underground workings and seepages from rehabilitated landforms. Due to the historic mining component in the AMD drainage to these waterways ongoing treatment is proposed in partnership with the Crown (LINZ) and Iwi and not addressed as part of the BPCP. Monthly performance monitoring only is proposed at sites S4 and UC2.

6.12. Ngākawau Coal Handling Facility

S32B monitors the treated water discharge from the Ngākawau coal handling facility. The discharge may be elevated in some contaminants, but its effects on the Ngākawau River mouth are very difficult to distinguish from the Mine Creek discharge due to tidal dynamics and overlapping mixing zones. There is no change to the level of effects expected due to this discharge and Bathurst propose to roll over the conditions within consent number RC01104.

6.13. Reference sites

Finally, four reference water quality sites are included to provide context for the AMD sites and inform review (Figure 51). Sites S1 in Sandy Creek and MT6 stream/site are tributaries of the Mangatini Stream, GT1 drains into Granity Stream and T35 Trib flows to the St Patrick Stream. These sites will be sampled monthly for a two-year period to establish current state conditions and thereafter sampled according to the periodicity and analyte suites being used at the AMD sites with which they are intended to be compared, e.g., GT1 with S25 or S6.

6.14. Ecological monitoring

The format of ecological monitoring in response to variable water quality between sites is described in Section 5 and is designed to track the recovery of water ways beyond the BPCP Fast-track approval and over the next 80 years. However, it is assumed that subsequent permissions for resource use will align with this proposed monitoring framework. Water quality status determines the periodicity and reporting criteria for ecology monitoring.

6.15. Compliance and performance summary

Bathurst has proposed limits or performance monitoring at sites that discharge to the Ngākawau River or upper Waimangaroa River or directly to the Tasman Sea (Table 22 and Table 23).

Compliance and performance monitoring and reporting is focused primarily on dissolved aluminium, pH and turbidity as key indicators of effects in impacted and recovering waterways although other measures are included. In recovered waterways the full suite of metals, nutrients and sediment should be compared to the thresholds of Hickey (2026a, c and d) or subsequent/additional thresholds by way of performance reporting.

As water quality improves at various sites and ecology is considered to be recovered there should be a transition to compliance monitoring and reporting assessing the full suite of metals, nutrients, deposited and suspended sediments and their ecological effects as proposed by Hickey (2026a, c and d). That transition is described in Section 5. An assessment against metal criteria (Hickey 2026a) was provisionally undertaken in Section 3.3.2 and indicated that at site NR2 aluminium remained the primary toxicant, but that both copper and zinc might also play a role in regulating aquatic ecological communities.

It is recommended that a review clause is included in conditions that revisits water quality thresholds every six years in the light of activities on the mine, antecedent water quality (waterway classification) and ecology monitoring. This review will include a specific comparison with progress against the ecological recovery trajectories (at S16 and S14B) and betterment reference values (at T1, S25, S24A, and MC1) illustrated in Section 4 for each site.

At sites draining the Stockton Plateau, such as Mine Creek Granity, Twins, Rudolph, Herbert and Whirlwind streams, where water quality precludes ecological values, we recommend monthly or weekly water quality sampling and annual performance reporting until such time as the streams become 'water quality recovering', whereupon a more strict and specific compliance and reporting regime should ensue. The water quality recovery status at each performance monitoring site should be determined at each six yearly review.

6.15.1. Compliance criteria.

Table 22. Water quality monitoring regime and compliance statistics for sites draining the Stockton Plateau. These statistics are variously intended for the maintenance of water quality or the recovery and protection of fish and macroinvertebrates. Percentile and median values inform annual reporting, while rolling medians trigger a more immediate response. See Figure 51 for site locations.

Site details (code)	Sampling regime	Analyte (units)	Annual 5 TH percentile	Rolling Annual median (unless specified)	Annual upper percentile	Rolling median
Ngākawau River NR2 ^a	Daily weekday	Turbidity ^a (NTU)		< 10.0 ‡	<48.0 (95 th) ‡	<25 (15 samples)*
		Dissolved aluminium (mg/L)			<1 (75 th) §	<1 mg/L (15 samples) §
		pH	>4.5§		<7.5 (95 th)*	>4.5 & < 7.5 (15 samples) §*
	Weekly	Nitrate N (mg/l)		<2.40	<3.5 (95 th)	
	Weekly	Ammoniacal N (mg/l) ¶		<0.69 assuming a pH of 6	<1.1 (95 th) assuming a pH of 6	
NR2 ^a – During LDS discharge	Continuous	Turbidity (NTU)	a) Adhere to the operating regime and monitoring procedures set out in the Mangatini Sump Management Plan; and b) Comply with the turbidity limits as set out in Table 1.			
			Table 1: Flow conditions at S14B and turbidity at NR2 during LDS discharge			
			Flow Percentile band (%)	Flow rates S14B (m ³ /s)	LDS discharge to stream	Turbidity averaged over 8 hours NR Two (NTU)
			95+	7.349+	Yes	n/a
			90–95	3.373 to 7.349	Yes	100
			80–90	1.672 to 3.373	Yes	50
			70–80	1.139 to 1.672	Yes	25
			0–70	0 to 1.139	No	25
Mangatini Stream S14B	Daily weekday	pH	>4.0‡		<7 (95 th)*	>4 & < 7 (15 samples)*‡
Mine Creek MC1	Daily weekday	Turbidity (NTU)				<25.0 (15 samples)*

Site details (code)	Sampling regime	Analyte (units)	Annual 5 TH percentile	Rolling Annual median (unless specified)	Annual upper percentile	Rolling median
St. Patrick S16	Daily weekday	Dissolved aluminium (mg/L)		<5‡	<8 (95 th) ‡	<8 (15-samples) ‡
		pH	>3.4‡		<7 (95 th)*‡	>3.4 & < 7 (15 samples) *‡
		Turbidity (NTU)		<6.9‡	<44 (95 th) ‡	<24 (15-samples) ‡
Twins Stream T1	Weekly	Dissolved aluminium (mg/l)		<28‡		
		Turbidity (NTU)				<25 (15 samples)*
Rudolph Stream S28U	Weekly	Turbidity (NTU)				<25 (15 samples)
		Dissolved aluminium (mg/L)		30‡		
Granity Stream S25	Daily weekday	Turbidity (NTU)				<25 (15 sample)*
Miller Stream S24a	Daily weekday	Turbidity (NTU)				<25 (15 sample)*

Note: ^a >1 in 10 year flood events should be excluded for annual statistics for turbidity (i) *Indicates an ecologically based limit for the protection of biota or indicative of the natural state of the waterway; (ii) ‡ site-specific value based on monitoring data. Limits are based on expected performance of treatment and water management systems within the constraints of the benchmarking period; (iii) § Ecological recovery water quality target (Exec. Summary Table 1). (iv) ¥Ammoniacal N should be corrected for pH and be less than the national bottom line listed in National Policy Statement – Freshwater Management (MfE 2020). Annual median compliance assessment and pH correction as detailed by MfE (2018). (v) Ω Site NR2 is subject to seawater intrusion and backing up of Mine Creek water at tide heights > 2500mm based on the NIWA tide forecasting model (<https://tides.niwa.co.nz/>). Data collected during tidal cycle periods exceeding 2500mm should be excluded.

6.15.2. Performance monitoring scope

Performance monitoring is proposed to track long term water quality at Stockton Mine. Performance monitoring is also used to track long term improvements in water quality, as a pathway to ecological recovery by marking progress relative to recovery thresholds. Once performance monitoring indicates that waterways have reached “recovered” status based on water quality, compliance limits should be developed that reflect water quality protection guidelines and ecological thresholds, and subsequently mahinga kai values. While performance site data is reported and discussed as part of site compliance reporting, in general there are no specific water quality limits or targets associated with these sites. Table 23 outlines the sampling regime and analytes to be covered by performance monitoring. This table is subject to revision at each six yearly review at the discretion of the regulatory authority. The six yearly review is envisaged to assess any change in water way status and instigate additional monitoring or compliance requirements on that basis.

Table 23. Water quality monitoring regime and performance analytes (and the associated basic or comprehensive suites) for sites draining the Stockton Mine. This table is subject to revision at each six yearly review at the discretion of the regulatory authority. Sites that achieve water quality recovered status to begin comparison against 80% toxicity guidelines values of Hickey (2026a) and develop water quality and ecology compliance thresholds. See Figure 51 for site locations. Sampling will be either the full basic or comprehensive suite of analytes plus any additional analytes listed below.

Site details	Sampling regime	Suitable reference site	Reporting Analytes
Ngākawau River NRB	Daily weekday		Dissolved aluminium, pH, EC, turbidity
	Weekly (Comprehensive suite)		*¥ Ammoniacal-N, Nitrate-N, turbidity Dissolved aluminium (Al), EC, pH, Dissolved zinc (Zn), Dissolved iron (Fe), Dissolved nickel (Ni), Dissolved copper (Cu), Dissolved cobalt (Co), Dissolved cadmium (Cd), Dissolved chromium (Cr), Dissolved manganese (Mn), Calcium (Ca), Magnesium (Mg), Dissolved Organic Carbon (DNPOC) for comparison to bioavailability guidelines developed by Hickey (2026a).
Ngākawau River NR2 ^Ω	Weekly (comprehensive suite)	Ngākawau River US of St. Patricks Stream	*Dissolved aluminium (Al), EC, pH, Dissolved zinc (Zn), Dissolved iron (Fe), Dissolved nickel (Ni), Dissolved copper (Cu), Dissolved cobalt (Co), Dissolved cadmium (Cd), Dissolved chromium (Cr), Dissolved manganese (Mn), Calcium (Ca), Magnesium (Mg), Dissolved Organic Carbon (DNPOC) for comparison of metal concentrations to bioavailability guidelines developed by Hickey (2026a)
Mangatini Stream S14B	Daily weekday	S1, MT6 and T35 Trib	Dissolved aluminium, turbidity, pH
	Weekly (basic suite plus)		EC, Dissolved Iron Ammoniacal-N, Nitrate-N
	Continuous - during LDS discharge event		pH, EC, turbidity
Mangatini Stream MGD ^ê	Weekly (basic suite plus)	NA	Dissolved aluminium
Mine Creek MC1	Weekly (basic suite plus)	GT1	Dissolved aluminium and iron, pH, EC
	Monthly (basic suite plus)	GT1	Ammoniacal N, Nitrate-N
St. Patrick S16	Weekly (basic suite plus)	S1, MT6 and T35 Trib	EC, Dissolved Iron, Ammoniacal N, Nitrate N
Twins Stream T1	Weekly (basic suite plus)	GT1	EC, pH, Dissolved Iron, Ammoniacal-N, Nitrate-N
Rudolph Stream S28U	Weekly (basic suite plus)	GT1	EC, pH, Dissolved iron, Ammoniacal-N, Nitrate-N

Granity Stream S25	Monthly (basic suite plus)	GT1	Dissolved aluminium, Dissolved Iron pH, EC, Ammoniacal-N, Nitrate-N
Miller Stream S24a	Monthly (basic suite plus)	GT1	Dissolved aluminium, Dissolved Iron, pH, EC, Ammoniacal-N, Nitrate-N
Whirlwind Stream S4	Monthly (basic suite plus)	T35 Trib or Denniston site	Dissolved aluminium, Dissolved Iron pH, EC, Ammoniacal-N, Nitrate-N, turbidity
Herbert Stream UC2	Monthly (basic suite plus)	T35 Trib or Denniston site	Dissolved aluminium, Dissolved Iron, pH, EC, Ammoniacal-N, Nitrate-N, turbidity
MT6 (Mangatini Trib., GT1 (Granity Stream), T35 Trib (T35 Stream), S1 (S1 Stream— reference sites	Monthly (comprehensive suite)		Dissolved aluminium and iron, pH, EC, Ammoniacal-N, Nitrate-N, turbidity

Notes: (i) Ω Site NR2 is subject to seawater intrusion and backing up of Mine Creek water at tide heights > 2500mm based on the NIWA tide forecasting model. Data collected during tidal cycle periods exceeding 2500mm should be excluded (<https://tides.niwa.co.nz/>). *Comprehensive water quality suite at trace detection limits (Table 20). ¥ Assessment of water quality against freshwater guidelines is only suitable when salinity <0.5 ppt. è Site MGD is a discharge to the Mangatini Stream rather than the stream itself.

6.15.3. Ecological recovery trajectory / betterment reference values

BRL have developed quantitative forecasts (using AMD modelling) of long-term water quality at key sites in AMD impacted catchments. This includes:

- Forecasting an Al concentration recovery trajectory at key St Patrick (S16) and Mangatini (S14B) catchment sites, where water quality improvements sufficient for ecological recovery are possible within the 80-year period under the BPCP; and
- Forecasting Al concentration betterment reference values for waterbodies draining Millerton Block (specifically at sites T1, S25, S24A, and MC1), where additional AMD management infrastructure (beyond what is proposed in the BPCP) would be required for ecological recovery.

BRL have extracted 5-yearly forecast Al concentration values (commencing 2027) from the AMD models developed for Millerton Block (BRL 2026a) and Mangatini / St Patrick Catchment (BRL 2026b) (Table 24). A subset of the water quality performance monitoring dataset should be compared against recovery trajectory / betterment reference values to track long term progress. Quantitative betterment targets are not applied to performance reporting for any other sites or parameters.

Table 24. Modelled ecological recovery trajectory / betterment reference value AI concentration forecasts for comparison with performance monitoring data. Note that these predictions are subject to change over time as further data is amassed and models refined. Comparison to future predictions over the course of the consent should be made to the most recent iteration of modelling. Grey shading indicates recovering stream status.

Project stage (year)	Calendar year (year)	Forecast annual median or 75 th percentile AI concentration (mg/L)			
St Patrick / Mangatini Catchment – Recovery Trajectory					
		S16 Annual Median	S16 Annual 75 th ile	S14B Annual Median	S14B Annual 75 th ile
Commenced	2027	3.0	3.6	3.5	5.4
6	2032	2.8	3.4	3.5	5.4
12	2038	1.9	2.4	2.9	4.5
18	2044	1.7	2.1	2.2	3.4
24	2050	1.5	1.9	1.2	1.8
30	2056	1.3	1.6	1.0	1.5
36	2062	1.3	1.6	0.9	1.4
42	2068	1.2	1.5	0.9	1.4
48	2074	1.2	1.5	0.8	1.3
54	2080	1.2	1.4	0.8	1.2
60	2086	1.1	1.4	0.8	1.2
66	2092	1.1	1.3	0.7	1.1
72	2098	1.0	1.3	0.7	1.1
78	2104	1.0	1.2	0.7	1.0
Millerton Block – Betterment reference values					
		T1 annual median	S25 annual median	S24A annual median	MC1 annual median
Commenced	2027*	20.0	6.5	33.6	14.2
6	2032*	19.3	6.3	32.6	13.8
12	2038	18.6	6.1	31.4	13.2
18	2044	18.0	5.9	30.2	12.8
24	2050	17.3	5.6	29.1	12.3
30	2056	16.7	5.4	28.1	11.8
36	2062	16.1	5.2	27.0	11.4
42	2068	15.5	5.0	26.0	11.0
48	2074	14.9	4.9	25.1	10.6
54	2080	14.4	4.7	24.2	10.2
60	2086	13.8	4.5	23.3	9.8
66	2092	13.3	4.3	22.4	9.5
72	2098	12.8	4.2	21.6	9.1
78	2104	12.4	4.0	20.8	8.8

* Note: Millerton Block water and AMD management strategies are not expected to meet betterment reference values during the Operational Phase – Achieving Betterment only applies from EOML (2033) onwards. It should be noted that betterment targets are subject to revision as a greater volume of data is amassed to refine predictive models.

6.15.4. Sediment quality monitoring

Sediment quality monitoring is proposed to measure the effects of AMD on aquatic ecology in water quality recovered sites relative to reference sites, ecological data and the ANZG (2018) (Figure 50). The only site that currently qualifies for that assessment is NR on the lower Ngākawau River (Table 25).

Reporting of sediment metal concentrations at site NR (or any other recovered status waterway) are proposed to be for performance purposes (Figure 50). However, because water quality recovered sites will be managed through compliance against ecology thresholds, any negative effect of sediment metals will be managed via that mechanism.

Performance reporting of sediment quality should compare to ANZG (2018) guidelines, reference condition and ecological monitoring results. After, ecological recovery sediment monitoring (every three years) will be a compliance reporting requirement determined by the absence of a negative trend in metal concentrations.

Table 25. Sediment quality sampling regime for the Ngākawau River for performance monitoring of effects of the Low Density Sludge (LDS) high flow discharge to Mangatini River. See Figure 51 for site locations.

Site details	Water quality status ^a	Reporting type	Sampling regime	Focus ^b	Assessment thresholds
Ngākawau River U/S St. Patrick Conf.	Reference	Reference	Every 3 years – 2 samples true right bank (TRB) and true left bank (TLB)	Sediment Quality - Total recoverable Co, Cu, Fe, Mn, Zn, Al, Sb, Cr, Ni, Ag, Sn, As, Cd, Pb, Hg, Tl from <2mm and <63µm size fractions. Grain size distribution.	Comparison to ANZG (2018) DGV and GV-high in the context of reference state ^c and ecological data Performance reporting only
Ngākawau River NR	Recovered	Performance	Every 3 years - 2 samples TRB and TLB		

Notes: ^a See Table 7 for waterway status classifications and Table 26 for current status. ^bTrace level chemical analysis. ^cAs per <https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants>. DGV -default guideline value below which there is a low likelihood of ecological effects. GV-high (guideline value high) indicates a threshold above which there is a high likelihood of ecological effects.

LDS monitoring

It should be noted there are various sources of contaminants in streams draining the Stockton Plateau that may be manifest in sediments in the lower Ngākawau river. These include background geology, general AMD discharges (contemporary and historic) and the LDS discharge. To inform the relative influence of each source on the lower river, in particular the LDS which is a sediment discharge, it is recommended that an investigation is undertaken to attribute sediment metals to a source. This investigation would occur in the event that routine sediment monitoring results are deemed to be a limiting factor for ecological recovery.

A similar approach is recommended at any other water quality recovered site where sediment volume or quality is considered to be limiting ecological recovery and sediment source is uncertain.

Sediment metal source sampling should be contextualised with suitable reference sites, e.g. the Ngākawau River upstream of Mangatini and upstream of St Patricks Streams.

6.15.5. Ecological monitoring

Finally, based on current water quality status, the required ecological monitoring of sites as described in Section 5 is provided in Table 26. Sites WRBBC and 6W are currently monitored routinely for water quality in relation to the Cypress Mine consents and sit outside of the BPCP FTA. Consequently, they do not appear on compliance or performance water quality Table 22 or Table 23. However, because they are part of the ecology monitoring for the BPCP FTA they are listed in Table 26 and considered as routine sites due to ready access and regular water quality monitoring.

Table 26. Ecological monitoring sites, current site status, accessibility, sampling regime, focus and reporting thresholds. Note fish monitoring occurs at water quality recovering sites that are physically accessible to fish. Macroinvertebrates to include specific methods to assess the abundance of kōura (freshwater crayfish) where present. Reference sites to be monitored at the periodicity of the impact sites for they provide context, e.g. Ngākawau River U/S St. Patrick conf. is monitored every 3 years for comparison to NR2. Sampling may occur more regularly than prescribed to suit the rates of change in water quality at each site. See Figure 51 for site locations.

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
Ngākawau River U/S St. Patrick Conf.	Reference site for NR2 and St. Patrick Stream	Remote	Reference	Every three years		Macroinvertebrates, fish, periphyton, bryophytes and habitat	NA
Ngākawau River Mouth	Recovering	Routine	Performance	Every three years ^c		Macroinvertebrates, fish and habitat	Compliance reporting, no ecologically significant degradation from baseline after attribution
Ngākawau River NR	Recovered	Routine	Compliance	Every three years	Ngākawau River U/S St. Patrick	Macroinvertebrates	Compliance reporting AMD<40, EPT >8 and comparable to reference sites or regional species pool.
						Fish	Compliance reporting Diversity and abundance comparable to reference sites or regional species pool.
						Habitat (biophysical) including sediment deposition, sediment quality.	Context
Mangatini Stream U/S Ngākawau conf.	Recovering	Remote	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat ^b	Performance reporting only
Mangatini Stream D/S/ Repo Stream	Recovering	Remote	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mangatini Stream S14B	Impacted	Routine	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mangatini Stream S14C	Impacted	Routine	Performance	Every six years	MT6	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
St. Patrick Stream U/S Ngākawau conf.	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick Stream D/S Erin	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick Stream D/S T35	Impacted	Remote	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
St. Patrick S16	Impacted	Routine	Performance	Every six years	S1, MT6 and T35 Trib	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek MC1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek S6	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Mine Creek S23	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream GS1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream S25	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Granity Stream S24A	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only

Site details	Water quality status ^a	Accessibility for water quality	Water quality reporting type	Sampling regime	Suitable reference site	Focus	Reporting thresholds
Twins Stream T1	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Twins Stream T3	Impacted	Routine	Performance	Every six years	GT1	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
Whirlwind U/S Cypress	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
WRBBC	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
6W	Impacted	Routine	Performance	Every six years	T35 Trib or Denniston site	Macroinvertebrates, periphyton, bryophytes and habitat	Performance reporting only
MT6, GT1, T35 Trib, S1	Reference sites for Mangatini and Millerton	Routine	Reference	Every six years	NA	Macroinvertebrates, periphyton, bryophytes and habitat	NA
Upper Ngākawau River fish survey	Reference	Remote	Compliance	Every three years ^c	NA	Fish	Maintenance of fish passage to the headwaters. Compliance reporting for site NRB in lieu of water quality compliance at that site.
St Patrick tributaries fish survey	Reference	Remote	Performance	Every six years	Upper Ngākawau River fish survey	Fish	Establishment of fish passage to the unimpacted tributaries

Notes: ^a Water way status defined in Table 7. ^b Fish monitoring to commence once waterway reaches recovered status at sites fish can physically access. ^c Upper Ngākawau fish survey is recommended to occur annually for the first six years of the permit due to various changes planned to water quality management in the Mine Creek and Ngākawau River catchments during that period. Thereafter, there is an option on review to shift to every three years. Ngākawau mouth ecology survey to occur annually in lieu of water quality compliance at site NRB.

6.16. Conclusions

Contemporary and historic coal mining on the Stockton and Denniston Plateaux have resulted in Acid Mine Drainage (AMD) to waterways. Unimpacted Brunner Coal Measures (BCM) streams have highly diverse and distinctive ecological communities, but AMD can result in adverse effects on their ecology. Because BCM streams are naturally acidic and elevated in dissolved metals, ecological communities have some adaptive resistance to AMD. Consequently, standard water quality guidelines are not suitable and site-specific thresholds are required to inform effects monitoring and mine planning.

Thresholds for ecological recovery in BCM streams have been developed for fish, but an equivalent for aquatic macroinvertebrates was not otherwise available. In this report an assessment of the available aquatic macroinvertebrate data for BCM streams indicates that initial recovery of macroinvertebrate communities may begin at a pH of >3.8 and dissolved aluminium concentration of <2.8 mg/L. Comprehensive recovery is more likely to be achieved at a pH of >4 and dissolved aluminium < 1.3 mg/L. However, this report uses the similar thresholds developed for fish by Greig et al. (2010), >4.5 pH and <1 mg/L dissolved aluminium to guide water management and consenting. In BCM streams, natural pH can be <4.5, and therefore where low pH is the result of natural processes, levels < 4.5 are considered acceptable.

Water management to remediate the effects of AMD is highly complex due to the terrain, climate and extensive historic underground mine workings. However, efforts to date indicate that AMD effects on ecology can be managed and minimised, and the available information suggests remaining effects have a finite duration. Predictions of future water quality indicate that several rivers will show a recovery of ecological communities moving progressively upstream. Ongoing recovery will be driven by active and passive treatment and natural decay. Water quality 'betterment' has also been used to guide water and AMD management in the streams draining Millerton Block (as opposed to ecological recovery). In the absence of the BPCP, water quality in several streams is predicted to be worse than that which currently exists over the medium and long term due to the ongoing discharge from historic workings at the BPCP proposed to remove.

This report presents a proposed monitoring and reporting programme to gauge the efficacy of water treatment, mine rehabilitation, ecological recovery and inform compliance. The intensity and focus of ecological monitoring is structured to vary with the degree of current water quality impact and waterway recovery status. In severely impacted streams monitoring is restricted to a basic suite of AMD indicator water quality parameters and six yearly ecology assessments, but during latter stages as contaminant levels decrease and life returns, more intensive water and sediment quality, and ecology monitoring is introduced. Testing against water quality and ecological thresholds provides a gateway between stages of recovery and the eventual cessation of monitoring. Monitoring and review will continue until waterways are both ecologically recovered and metal contamination in edible species are suitable for human consumption or comparable to reference site values.

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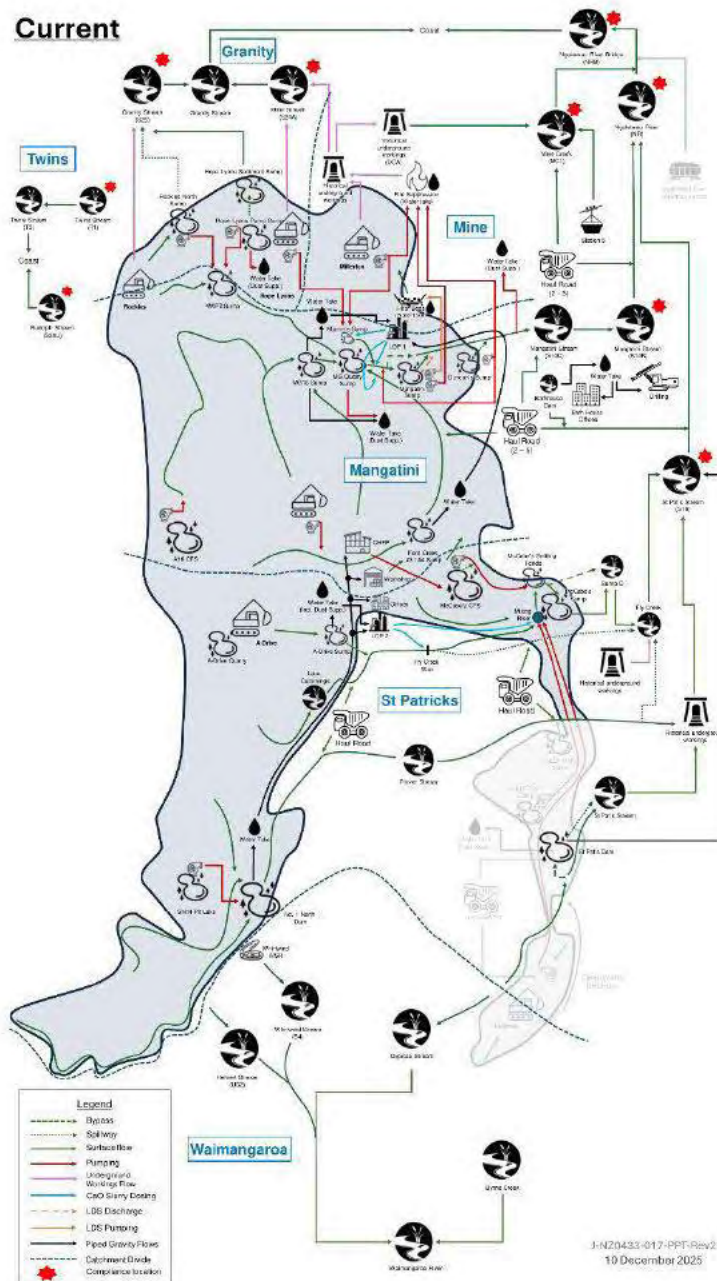
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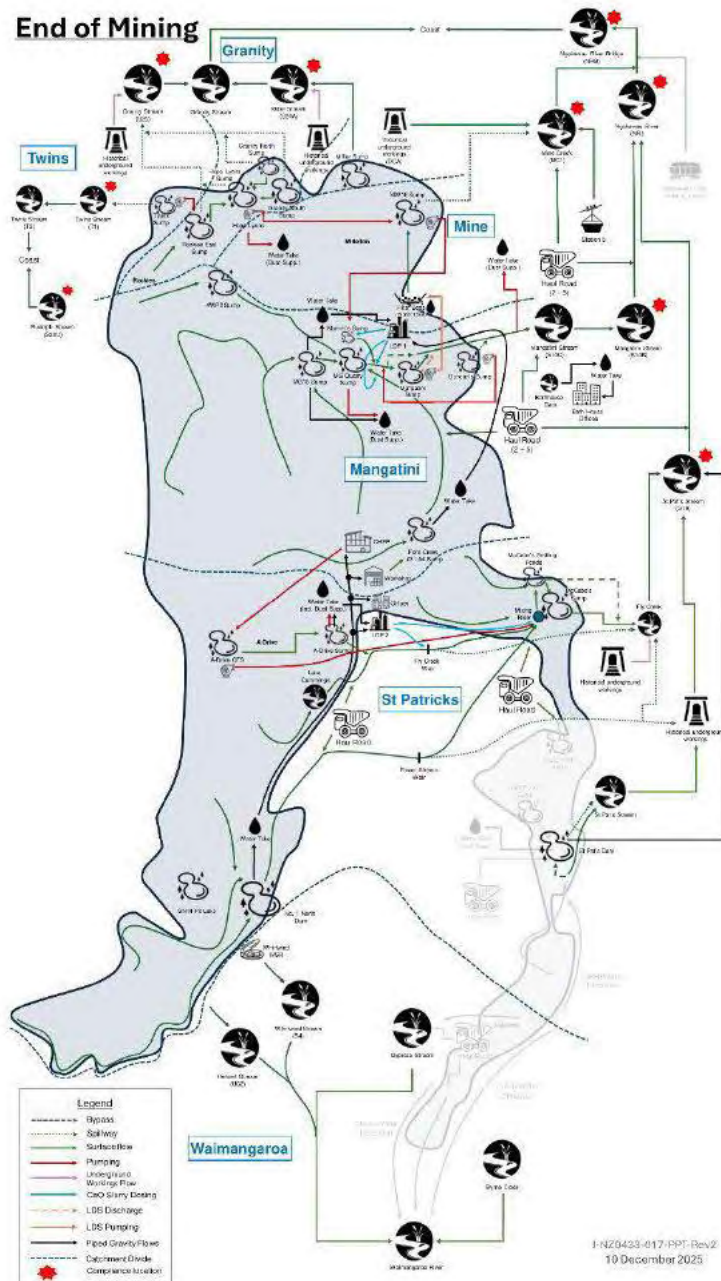
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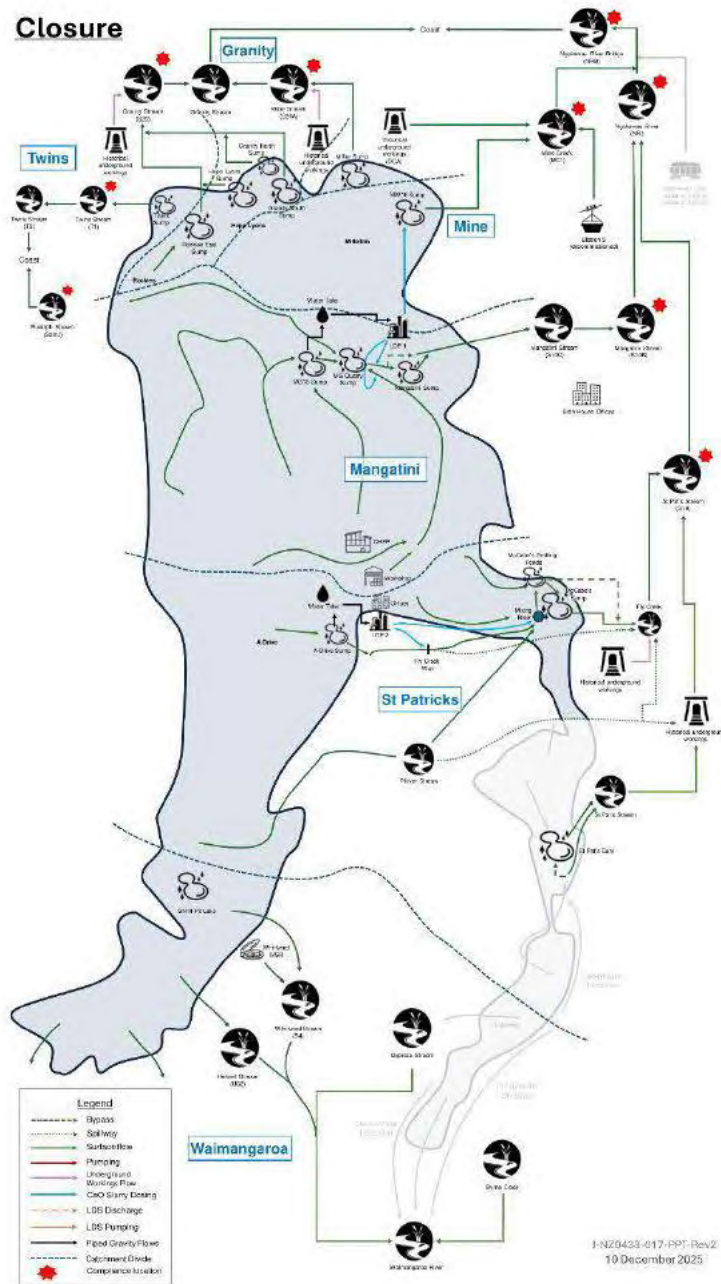
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APPENDIX 1: PROCESS FLOW DIAGRAMS FOR DIFFERENT PHASES OF STOCKTON MINE.







APPENDIX 2: RELATIONSHIP BETWEEN AMDI AND EPT RICHNESS

The relationship between AMDI and EPT Richness used to generate EPT thresholds for ecological recovery. The analyses used a linear regression to predict EPT Richness. Predictions were rounded to the nearest whole number.

