



WEST COAST
REGIONAL COUNCIL

**Trends in West Coast River Monitoring
Catchments – Water Quality and Land Cover:
2024**

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Trends in West Coast River Monitoring Catchments – Water Quality and Land Cover: 2024

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Summary of trends in river water quality

Patterns in West Coast waterway quality from 2009-2024 were investigated using flow corrected trend analysis and a rigorous process was utilised to determine whether trends were robust. There was a wide range of land cover types and activities among the sites assessed, with agriculture being the most widespread and dominant form of anthropogenic influence. Mining and exotic forestry were also significant.

Changes in land cover and selected anthropogenic activities were evaluated at a regional level to provide some insight into possible drivers of water quality change. An overall reduction in indigenous vegetation was substituted over time with an increase in human land use (1996-2023). This was led by an increase in agricultural development, particularly in the Grey Valley. In most catchments, proportional land cover change was not substantial.

Most monitoring sites had at least one significant trend from the suite of water quality attributes assessed. Sites rarely had a consistent pattern when the site had multiple trends, i.e., all improvement or decline. However, the number of declining trends for a site was significantly positively correlated with the amount of anthropogenic land cover in the sites catchment.

Agricultural land use has intensified across several West Coast catchments, and this has corresponded with some of the most obvious deteriorating trends observed in water quality. Multiple activities and land uses were often present in each catchment. Water quality improvement or deterioration for each site will have been influenced by management practices undertaken by single operations within each catchment, as well as factors that are part of more widespread trends like regional stocking rates, more efficient use of nutrients, and larger, more efficient farming units.

Land used for mining increased by 126%, (2290 ha), drawing land that was primarily indigenous forest. This increase was driven by the 2004-2012 coal mining boom and hard rock gold mining near Reefton. Council monitoring provides examples of suspended sediment increases in response to mining development. It is harder to track changes in exotic forestry within smaller catchments because of the crop rotation cycle (~28 years), and the range of interim land cover types that can exist over this period. Regionally exotic forestry accounted for 1.8% of land cover, increasing by 2% from 1996 to 2023.

Water quality trends were assessed across a range of water quality attributes. Observed increases in nitrate (13% of sites) corresponded with more pastoral development. Fewer sites showed increasing trends for Total Nitrogen (TN) (TN, 4% of sites), with a broader range of causal factors likely driving this. Ammonia improved at 17% of sites, mirroring national trends, where there has been a net improvement in the management of point source discharges. However, ammonia deteriorated at 13% of sites suggesting that ammonia can still be increased in some catchments as a result of agricultural intensification, point source pollution, and in some instances, changes in indigenous forest dynamics. Detail at site catchment level has been presented.

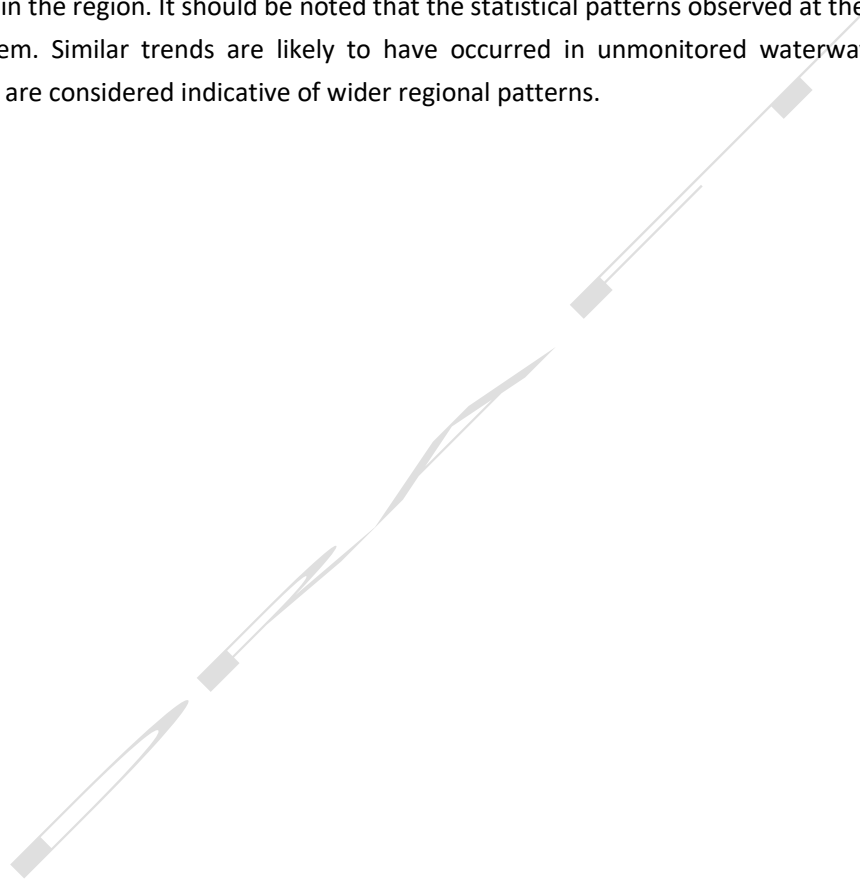
Significant increases in dissolved reactive phosphorus (DRP) occurred at 17% of sites. These were more likely at sites with a higher percentage of agricultural land cover in their catchment. Improvement in DRP (7%), are the likely result of better nutrient and effluent management, as well as changes to stocking rates. Only 2% of sites showed worsening trends in total phosphorus (TP). Suspended sediment is a source of TP and these sites also had worsening clarity, which is the measure of suspended sediment specified in the NPSFM. Concentrations of TP improved at a quarter of sites (26%), and were often consistent with clarity and turbidity improvement, indicating again that TP changes at

some sites were linked to particulate sources. However, as with total nitrogen (TN), it should be noted that many factors can influence total nutrient fractions.

Some West Coast water bodies have naturally reduced water clarity, despite a lack of suspended particulate material, due to dissolved organic carbon (brown colouration). Beyond this natural colouration, suspended material, e.g. fine sediment, was the cause of reduced clarity and elevated turbidity. Approximately one quarter of sites showed deteriorating trends for clarity with a fewer number improving (13%).

E. coli concentrations showed deteriorating trends at 17% of sites and improving trends at 13% of sites. None of the observed trends coincided with obvious changes in land cover. Changes in point sources (e.g. dairy effluent ponds, human wastewater treatment), and diffuse sources such as run-off from paddocks, could be responsible.

The number of monitoring sites within the Council network represents only a very small proportion of waterways within the region. It should be noted that the statistical patterns observed at these sites will not be exclusive to them. Similar trends are likely to have occurred in unmonitored waterways, thus results at monitored sites are considered indicative of wider regional patterns.



1. Introduction

This assessment is guided by the requirements of the National Objective Framework (NOF) and includes, where available, relevant attributes for compulsory values under the National Policy Statement for Freshwater Management (NPS-FM) 2020.

Section 3.19 of the NPSFM covers the assessment of trends. It stipulates:

(1) In order to assess trends in attribute states (that is, whether improving or deteriorating), every regional council must:

- (a) determine the appropriate period for assessment (which must be the period specified in the relevant attribute table in Appendix 2A or 2B, if given); and
- (b) determine the minimum sampling frequency and distribution of sampling dates (which must be the frequency and distribution specified in the relevant attribute table in Appendix 2A or 2B, if given); and
- (c) specify the likelihood of any trend.

(2) If a deteriorating trend is more likely than not, the regional council must:

- (a) investigate the cause of the trend; and
- (b) consider the likelihood of the deteriorating trend, the magnitude of the trend, and the risk of adverse effects on the environment.

(3) If a deteriorating trend that is the result of something other than a naturally occurring process is detected, any part of an FMU to which the attribute applies is degrading and clause 3.20 applies.

(4) If a trend assessment cannot identify a trend because of insufficient monitoring, the regional council must make any practicable changes to the monitoring regime that will or are likely to help detect trends in that attribute state.

River water quality has been routinely monitored in the West Coast region since 1998. Monitoring at several sites began then, with other sites being added later. The most significant change since then isn't the number of additional sites added to the program, but the increase in sampling frequency from quarterly to monthly. This has allowed the West Coast Regional Council (WCRC) to undertake more comprehensive analysis of its river monitoring datasets.

Trend analyses of data collected from West Coast waterways can help us determine if river quality and health is improving, deteriorating, or remaining stable over time. This is crucial for evaluating the effectiveness of environmental policies, land use changes, and pollution control measures. Trends inform regulatory actions, investment in infrastructure (e.g., effluent management systems), and prioritization of catchment management efforts.

Where the WCRC has enough data, collected at a high enough sampling frequency, trend analyses at those monitoring sites was undertaken. Results from trend analyses can be put in context with potential 'causes' or 'drivers' of these changes. Examples include changes in land use, or the nature of anthropogenic activity, within

catchments. These drivers are often not well measured and subsequently not well understood. There are spatial datasets that document land cover types across the region, including those that are natural and those that are anthropogenic. Additionally, Statistics New Zealand have data that can provide insights into the activity of some of the primary industries that are widespread in the region.

The WCRC monitoring program has sites with varying degrees of anthropological activity and land cover in their catchments. A small number of sites have no known or obvious anthropological activity or catchment land cover. Catchments with no anthropological activity or land cover can help Council investigate potential changes that result from influences that are unrelated to human activity. An example of one such influence is the Southern Oscillation Index. The Southern Oscillation Index (SOI)—a key measure of the El Niño–Southern Oscillation (ENSO)—can influence trends in water quality, particularly through its influence on climate-driven hydrological changes. Such climate variability makes a significant contribution to water quality trends (Snelder et al. 2021). Note that analysis of the SOI is beyond the scope of this report.

2. Landcover and other indicators of changing catchment pressures

The drivers of water quality change are often underrepresented compared with the information we gather to assess water quality condition and impacts (Song & Frostell 2012). The Council does not collect specific data to be used to evaluate potential drivers of water quality change. Instead we have utilised available regional data sets to help infer potential drivers of water quality change. These include patterns in land cover, and economic statistics associated with the region’s main primary industries.

The Land Cover Database (LCDB) is a digital map that classifies Aotearoa’s land cover using satellite imagery from different years to show changes over time. It works by analysing satellite photos to categorise the landscape into land classes, such as vegetation types, built environments, and water bodies.

The LCDB program has a reliable and consistent technical framework, and provides valuable historical data. The latest version of LCDB (version 6.0) provides a series of ‘snapshots’ of land cover in the form of maps derived from satellite imagery across the country, covering the dates: 1996, 2001, 2008, 2012, 2018 and 2023. At each snapshot, the satellite images are analysed and land cover types are assigned to detailed classes, such as ‘urban area’, ‘exotic forestry’, and ‘gorse and broom’. Continued monitoring of land cover in Aotearoa is dependent on the LCDB being updated at regular intervals (about 5-yearly) on an on-going basis.

For the purposes of evaluating potentially influential impacts on water quality from anthropogenic land use, LCDB land cover classes were grouped into either anthropogenic or non-anthropogenically impacted land cover types. This was used for investigating potential links between changes in water quality attributes and changes in human activity within a catchment.

Table 1. LCDB land cover classes were grouped into either anthropogenic or non-anthropogenically impacted land cover types.

Landcover type	Designation	Landcover type	Designation
Built-up Area (settlement)	Anthropogenic	Flaxland	Natural
Deciduous Hardwoods	Anthropogenic	Gravel or Rock	Natural
Exotic Forest	Anthropogenic	Herbaceous Freshwater Vegetation	Natural
Forest - Harvested	Anthropogenic	Indigenous Forest	Natural
Gorse and/or Broom	Anthropogenic	Lake or Pond	Natural
High Producing Exotic Grassland	Anthropogenic	Landslide	Natural
Low Producing Grassland	Anthropogenic	Manuka and/or Kanuka	Natural
Mixed Exotic Shrubland	Anthropogenic	Matagouri or Grey Scrub	Natural
Orchard, Vineyard or Other Perennial Crop	Anthropogenic	River	Natural
Surface Mine or Dump	Anthropogenic	Sub Alpine Shrubland	Natural
Transport Infrastructure	Anthropogenic	Tall Tussock Grassland	Natural
Urban Parkland/Open Space	Anthropogenic	Estuarine Open Water	Natural
Short-rotation Cropland	Anthropogenic	Herbaceous Saline Vegetation	Natural
Alpine Grass/Herbfield	Natural	Permanent Snow and Ice	Natural
Broadleaved Indigenous Hardwoods	Natural	Sand or Gravel	Natural
Fernland	Natural		

2.1. Changes in land cover: The West Coast region

The main increases in anthropogenic land use/land cover by area within the West Coast region, from 1995 to 2023, involved increases in exotic grassland (9% increase, 14,633 ha), and mining/dumps (126% increase, 2290 ha, Table 1).

Exotic grassland is separated into high and low producing. High producing grassland accounts for 90% of all grassland on the West Coast. Increases in the low producing portion accounting for 10% of all new grasslands (1995-2023).

A range of land cover types were converted to high producing pasture from 1995-2023. Roughly half were from land covers with anthropogenic connections (e.g. exotic forest, gorse/broom scrub), and the other half indigenous land cover (e.g. native vegetation types). Around 10% came through improving low producing grassland.

New land used for mining and dumps drew mainly (79%) from indigenous forest and other indigenous land cover types. Urban development increased by 17% (501 ha), while exotic forestry remained similar, with a small increase of 2% (778 ha).

Herbaceous freshwater vegetation and flax cover decreased by 497 ha (2.5%) and 115 ha (5%), respectively. These vegetation types are normally (but not exclusively) associated with wetlands. This potentially represents a 612 ha, or 2.8%, reduction in wetland habitats over the ~27 year period, based on changes to vegetation land cover. This differs to estimates based on the LCDB wetland category, which is not determined solely via specific land covers. LCDB calculates the extent of freshwater inland wetlands using herbaceous freshwater vegetation, flaxland, and the addition of a non-land cover 'WETContext' flag that identifies all sites that are edaphically wetlands despite having a land cover that does not explicitly identify with wetlands. In this way, environments such as swamp-forests and wet heathlands can be recognised as wetlands while retaining their formal land cover class (Dymond et al. 2021).

According to LCDB West Coast had a decrease of 173 hectares of wetlands between 2018 and 2023, and by 978 hectares since the 1996 survey period (Statistics NZ).

Table 2. Changes in land cover classes in the West Coast Region from 1995 to 2023. Medium land cover classes are used from the New Zealand Land Cover Database, Version 6. Green classes are natural.

Land cover type	Total hectares in 2023	Percent of West Coast land cover 2023	Change from 1995-2023 hectares	Change from 1995-2023 percent
Cropping & horticulture	35	0.002%	-13	-26%
Exotic forest	41,365	1.80%	778 ¹	2%
Exotic grassland	174,945	7.60%	14,633	9%
Exotic scrub/shrubland	14,942	0.65%	-5600	-27%
Mines & Dumps	3,698	0.16%	2063	126%
Urban	3,542	0.15%	501	17%
Sub total	238,527	10.36%	12,326	
Indigenous forest	1,447,938	62.9%	-7787	-0.53%
Indigenous scrub/shrubland	172,061	7.5%	-3503	-2.00%
Natural bare / lightly vegetated surfaces	176,414	7.7%	-675	-0.38%
Other herbaceous vegetation	65,981	2.9%	-619	-0.93%
Tussock grassland	201,628	8.8%	-21	-0.01%
Sub total	2,064,023	89.6%	-12,605	

2.2. Changes in land cover among monitored catchments

Larger proportional changes in land cover are more likely to influence water quality where those land covers are strongly linked to water quality attributes. Larger changes in catchment land cover were evident in smaller catchments for the obvious reason that fewer hectares required altering in order to change the proportion of land cover classes across a catchment. The opposite was the case when evaluating catchments with the largest amounts of change in hectares, where large catchments accumulate the most change by hectares.

Sites that have been regularly monitored by the Council range in size. Ninety six percent of sites had catchments under 50,000 ha, with the smallest covering just 163 ha (a small spring fed stream in Whataroa). Three sites are located near the downstream extent of large catchments, including the Haast, Grey and Buller Rivers (100,000 – 600,000 ha). The number of land cover classes also varied across catchments. Smaller catchments were typically characterized by low land cover diversity, with as few as two classes, whereas larger catchments contained up to 28 land cover classes.

The waterways included in WCRC's monitoring program ranged from catchments that had no anthropogenic land cover to those that were almost entirely dominated by anthropogenic activity (Figure 1). Five percent of monitored catchments showed a reduction in anthropogenic land cover of more than 1%. Larger anthropogenic reductions involved smaller catchments, where exotic forest or pasture regenerated into fern, Manuka, and native broadleaf species. Twenty percent of monitored catchments showed an increase in anthropogenic land cover of at least 1% between 1996 and 2023. The majority involved conversions to pasture, primarily from indigenous forest, but also scrub and wetland land cover types.

¹ Land used for exotic plantation forestry normally transitions through different landcover classes involving making it hard to quantify long-term net-change in land used for plantation forestry.

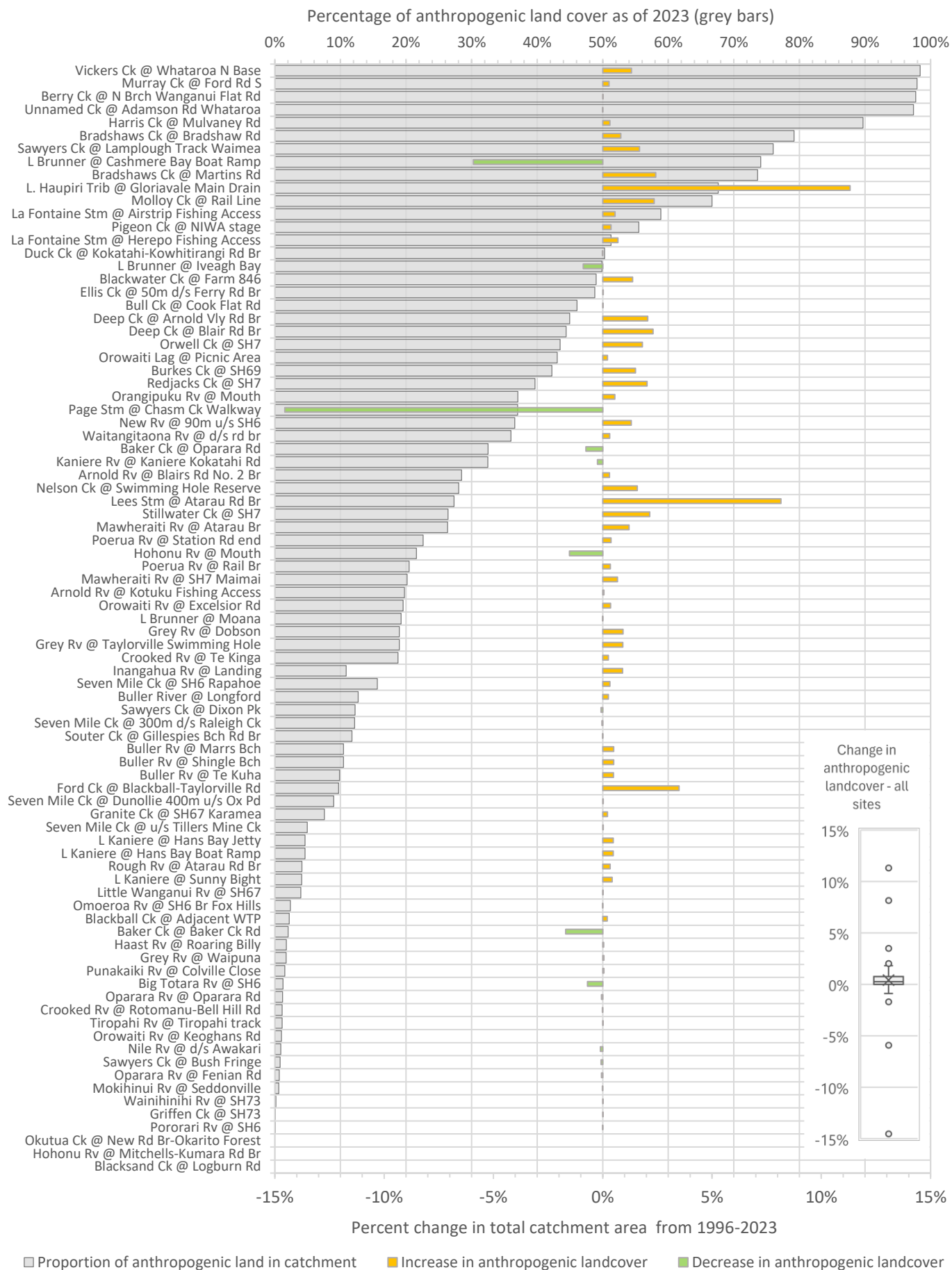


Figure 1. Percentage of anthropogenic land cover and change across the range of WCRC monitoring sites. Bottom right, distribution of anthropogenic land cover change among sites

2.2.1. Land cover change: Extent in hectares

Exotic plantation forestry contributed to land-cover change by at least 1% of catchment area at 15% of sites. However, cyclical transitions associated with establishment, growth, harvesting, and replanting makes change hard to quantify in detail. Exotic forestry accounted for less than 10% of land cover among 90% of monitoring sites, with 10% of these sites having 8-48% exotic forestry land cover in their catchments.

The Grey River catchment, one of the largest in the region, exhibited substantial land cover change between 1996 and 2023. High producing exotic grassland increased by 5,158 ha, representing 1.4% of this catchment's total area. Low producing grassland increased to a lesser extent by 1000 hectares. Some of the main land cover classes utilised for conversion to pasture included: Indigenous Forest (-2230 ha), Gorse and Broom (-1636 ha), Manuka and Kanaka (-730 ha), and Indigenous Hardwood (-400 ha). Exotic forestry also contributed a significant component, but the exact quantities are unclear. In the Grey catchment, the land used for Surface Mines and Dumps increased by 292 ha as of 2023, a seven-fold increase since 1996.

The Buller River catchment is larger than the Grey, so absolute changes are smaller relative to catchment size. Overall, changes were smaller in both hectares and as a proportion of the overall catchment size. Indigenous Forest decreased by 1400 ha, and Gorse/Broom decreased by 952 ha. High Producing Exotic Grassland increased by 764 ha. In this catchment, the land used for Surface Mines and Dumps increased by 484 ha, more than doubling from 1996 to 2023.

As most monitored catchments were smaller than the Buller and Grey, we have reported on proportional land cover changes relative to catchment size rather than refer to the area in hectares.

2.2.2. Land cover change: Proportion of total catchment area

Among catchments monitored by Council, the maximum proportional change in any specific land cover class ranged from an 18% reduction² to an 11% increase³. Both catchments were small (~300 ha); hence these changes did not represent large amounts of land cover.

Land cover was evaluated at a total of 84 monitoring sites. These included small catchments with only two land cover class types, up to the Buller River with 28 types. Across all catchments this amounted to the evaluation of 1132 land cover permutations. For most there was not a large degree of change apparent, relative to overall catchment size. The list below shows how many specific land cover types in monitored catchments changed by categorical degrees of significance (1-10% of total catchment area altered from 1996 to 2023):

- **0.4%** changed by >10%
- **1.6%** changed by ≥5%
- **4%** changed by ≥2%
- **7%** changed by ≥1%

Land cover changes of at least 1% of total catchment area have been listed in Appendix 2. This is to provide context to water quality and aquatic health trend assessments.

² Page Stm @ Chasm Ck Walkway, high producing exotic grassland

³ Lake. Haupiri Trib @ Gloriavale Main Drain, high producing exotic grassland

2.3. Changes in agricultural and economic indicators

2.3.1. Fertilizers

The amount of nitrogen fertilizer used across Aotearoa has increased more than seven-fold (62,000 - 458,000 tonnes) from 1990-2018 (Statistics New Zealand 2019). Nitrogen use has increased over time due to the intensification of dairy farm systems in combination with an increased area in dairying.

Over a shorter and more recent period—aligned with our water-quality trend analysis (2009–2024)—nitrogen use rose from roughly 300,000 tonnes in 2009 to a peak of about 460,000 tonnes in 2019, before declining to around 380,000 tonnes by 2024 (Fertiliser Association 2024).

A similar pattern in phosphorus fertilizer consumption occurred from 2009-2024. The year 2009 saw a large reduction in phosphorus fertilizer use, dropping from 170,000 tonnes (2008) to 114,000 tonnes (2009). This increased to 140,000 tonnes in 2010, staying at similar levels until 2023-2024 when it dropped again, this time to ~114,000 tonnes (Fertiliser Association 2024). Reduced phosphorus use has been driven by increased cost relative to returns from produce, as well as more strategic use including the use of nutrient budgets (Fertilizer Association 2021).

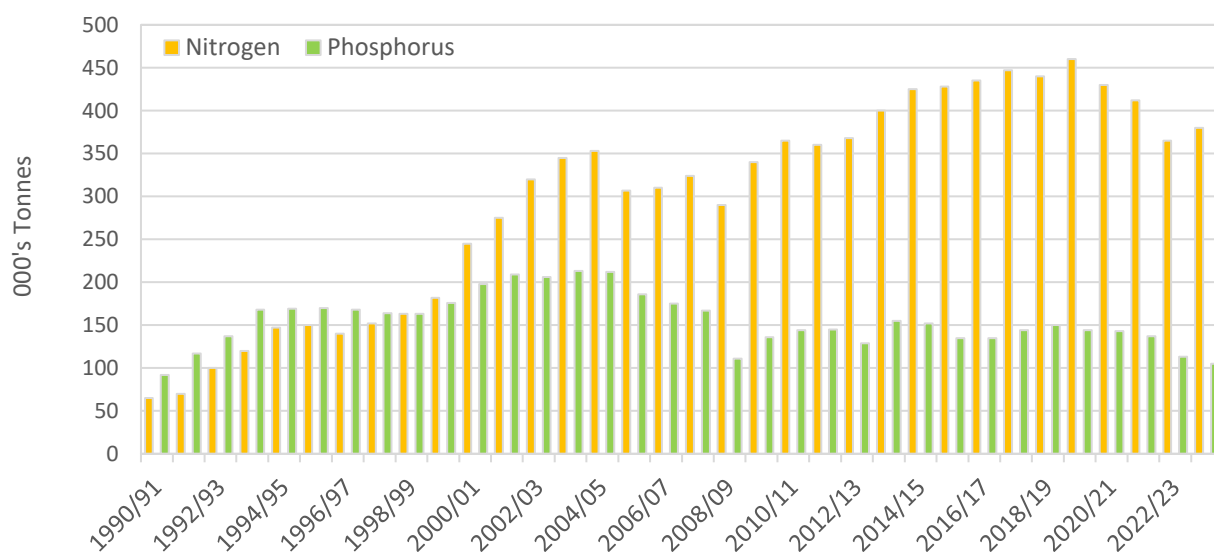


Figure 2. Annual nitrogen and phosphorus fertiliser used in New Zealand. Adapted from data provided by Fertiliser Association, NZ.

2.3.2. Irrigation

As of 2022, 6% of agricultural land in Aotearoa was irrigated. Of this, 84% was located in the South Island, with 63% in Canterbury. From 2002 to 2022, the area of irrigated land doubled. This was primarily associated with dairy farming, where irrigated land tripled over this period.

The West Coast is one of Aotearoa's wettest regions, meaning irrigation has historically been minimal compared to Canterbury, Otago, or Hawke's Bay. IrrigationNZ notes that irrigation growth in Aotearoa occurs primarily in dry regions (East Coast, Central Otago), and not in high-rainfall areas like the West Coast. Because the West Coast does **not** typically suffer from summer moisture deficits, there has been minimal development of irrigation compared with Canterbury, which has undergone major irrigation expansion driven by dairy intensification.

Because irrigation on the West Coast does not contribute significantly to the national tally, it has been omitted from region-level reporting in earlier assessments. Public datasets (2002–2019) do not report irrigated-area values for the West Coast specifically, implying that the area was extremely small or negligible.

In 2022 there was a total of ~2,543 ha irrigated land on the West Coast. Most of this spans from the mid-Grey Valley up and through to around Reefton. Additional pockets occur in the Maruia Valley, with other scattered pockets near Lake Brunner, Barrytown and Karamea (Dark 2020). Centre pivots & linear moves were the primary forms of irrigation used on the West Coast (1,790 ha), with travelling/sprayline systems making up the remainder (753 ha). Historically, the West Coast had little in the way of irrigated land (likely close to zero or very low). However, with increasing weather extremes associated with climate change, there is an increasing need to mitigate short dry spells and maintain pasture consistency. A good example of this is the presence of an irrigation scheme at the southern end of the Lake Brunner catchment (Inchbonnie)⁴, which in some years has an annual rainfall of over 5 m.

2.3.3. Stocking rates

Evaluating changes in stock numbers has been used for evaluating trends in agricultural intensity (Figure 3). West Coast dairy cattle numbers peaked in 2014, then dropped to 152,000 in 2019, approximately 20,000 animals higher than 2001. Most cattle are associated with dairy herds, with beef stock numbers having remained stable since 2001, with 31,000 head of stock in 2019. Over the same period sheep numbers have continued their historic decline (92,000 to 21,000), while deer have dropped slightly from 34,000 to 22,000.

There have been a number of changes in the nature of dairy farming across Aotearoa, which are also mirrored on the West Coast. Dairy stocking rates increased through the 1980's and 1990's, peaking around 2014 (annual mean 2.87 cows/ha). After remaining reasonably consistent (with a dip in 2016), national mean stocking rates dropped to 2.74 cows/ha in 2025. For the same year stocking rates were 2.92 cows/ha in the South Island and 2.21 cows/ha on the West Coast (DairyNZ 2025). Likely reasons for a lower stocking rates on the West Coast include: high rainfall affecting pasture management, less irrigation, and smaller farms (397 stock units vs. 448 for the national average).

Consolidation of farming units has continued. The overall number of farms on the West Coast (including dairy) shrank from 837 to 609 farms between 2002 and 2022 (StatsNZ 2024). Dairy herd sizes steadily increased across the country (DairyNZ 2025). Overall, this demonstrates the dairy trend for higher production per cow with less cows per hectare.

⁴ Areas of irrigated land can be viewed via the Ministry for the Environment Data Service - Irrigated land area, raw, 2020 update <https://data.mfe.govt.nz/layer/105407-irrigated-land-area-raw-2020-update/services/csw/>

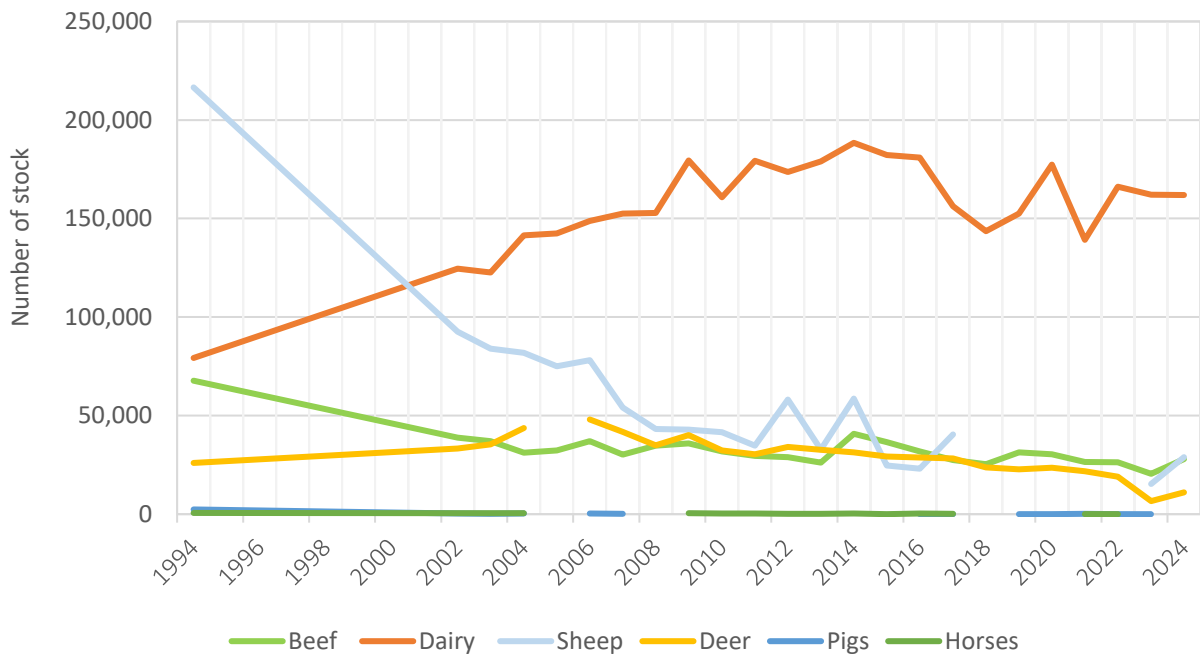


Figure 3. Stock numbers in the West Coast region from 1996 to 2024.

2.3.4. Employment across industry

The West Coast depends heavily on the primary industries for regional income. Many of these can have an impact on water quality and ecosystem health. The number of jobs in the primary industry sectors has been used as one of several proxies for activity, and subsequently, potential pressure on freshwater resources.

Agriculture is the largest employer out of all the primary industries (Figure 4). The number of jobs in this sector has slowly declined in the last ten years, with the peak occurring around a similar time as maximum stock numbers in 2014. The forestry and fishing sectors are relatively small in comparison and have been reasonably stable for the last 15 years.

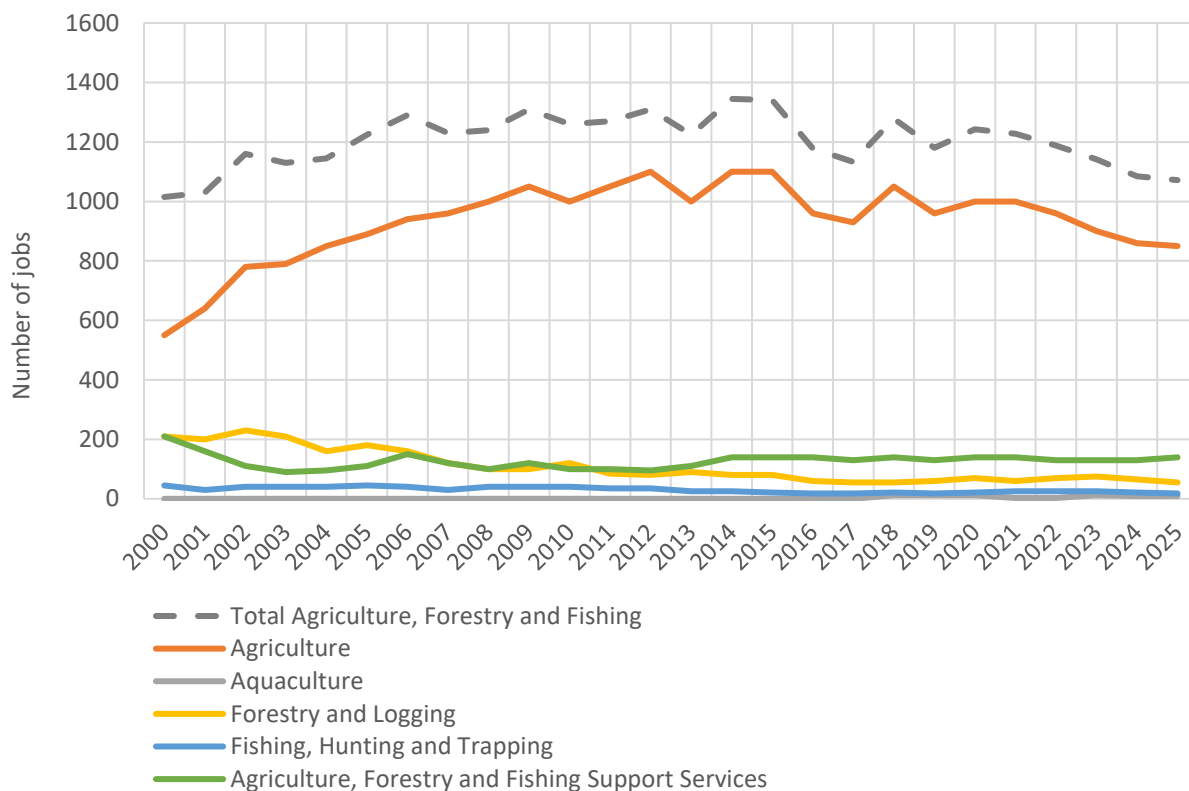


Figure 4. Number of jobs in the primary industries, within the West Coast region, from 2000 to 2025.

Mining is a significant regional industry that can influence West Coast waterways and is the second largest employer out of the primary industries, after farming. Many of the surface water monitoring sites within the WCRC program have mining occurring within their catchments. While land disturbance associated with mining tends to be more pronounced, the land area used for agriculture is 50 times greater. In this document the number of mining related jobs have been used as one indicator of mining activity (Figure 5). This compliments previous land cover assessments, and is potentially indicative of the activity's intensity, thus more relevant for more immediate effects such as sediment contributions to waterways.

Rising from 2000, mining activity peaked in 2012, then slumped to 2004 levels by 2017. From here there was a slow, steady increase that has continued up to 2025. Strong coal prices resulted in the 2012 peak, with the subsequent price slump leading to substantial downsizing at several large coal mines. Unlike agriculture, mining tends to be more concentrated, covering a smaller area, so it is difficult to extrapolate how changes in mining intensity have influenced regional water quality.

Mining influence is more likely in catchments north of the Waitaha River, where the majority of mineral resources reside. Some 20% of WCRC monitoring sites were influenced by some form of mining. Clarity is an attribute that is used as a surrogate for quantities of suspended sediment. This is the primary attribute relevant to mining impacts. Of the sites with significant clarity trends, 38% contained mining in their catchments. Of these 6% had improving clarity with 25% declining. It should be noted that all these catchments had other land cover types present like agriculture and urban development.

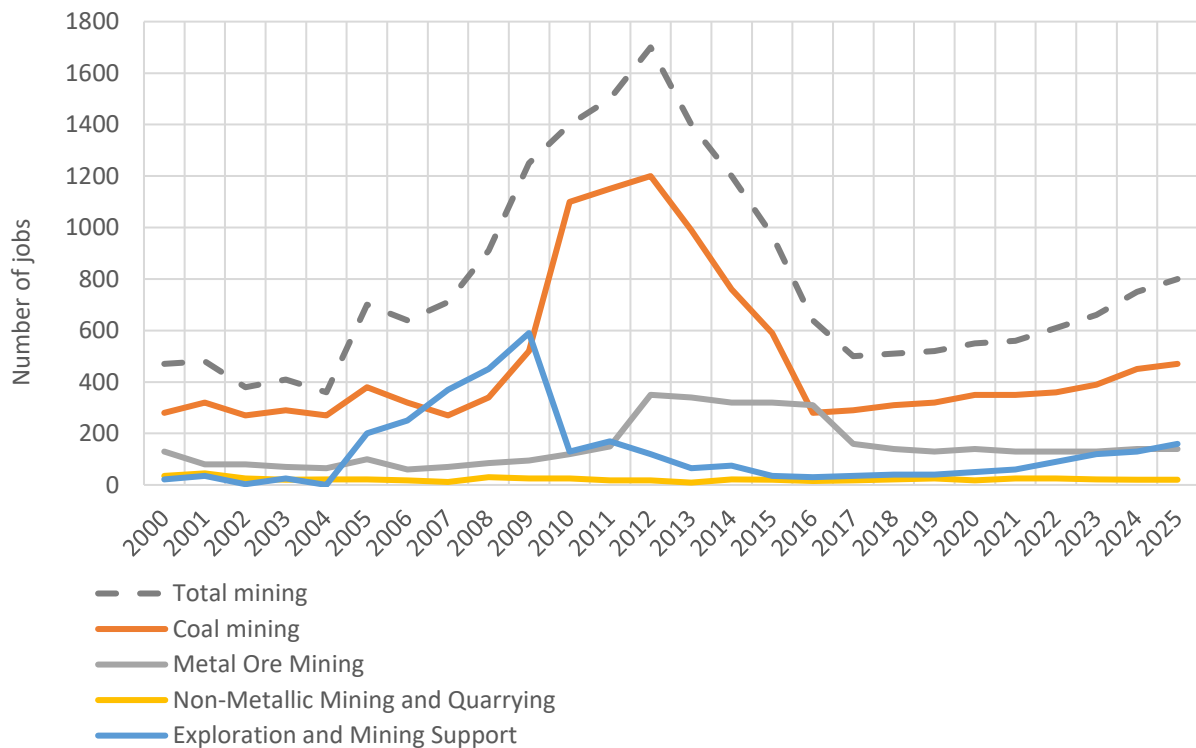


Figure 5. Number of jobs in the mining industry, within the West Coast region, from 2000 to 2025.

3. Trends in water quality attributes

3.1. What are the water quality attributes

This report uses six water quality attributes for trend analysis. We provide a brief explanation here of what each one of these is and their relevance.

Total Nitrogen is a measure of all organic and inorganic forms of nitrogen in the water. High total nitrogen causes of eutrophication in lakes, estuaries and coastal waters leading to algal blooms.

Ammonia is one form of nitrogen found in waterways. At high levels, it's toxic to aquatic fauna. Even at lower concentrations, it can still contribute to the growth of plants and algae.

Nitrate is another common form of nitrogen present in aquatic environments. Like ammonia, it can contribute to growth of in-stream plant and algae biomass, but at high concentrations it becomes toxic to aquatic fauna.

Total phosphorus (TP) is a measure of all types of phosphorus present. It includes the phosphate that is stuck to soil (sediment) as well as **dissolved reactive phosphorus (DRP)** which is more readily available for plants. TP is an important measure because most phosphate enters our rivers attached to sediment via run-off.

Phosphorus is an essential nutrient contributing to the growth of algae and other aquatic plants in freshwater systems but can cause nuisance algal growth when concentrations are too high.

Clarity is the measure used to represent suspended sediment. Fine sediment suspended in the water affects clarity, aquatic life, and recreational enjoyment. It can: affect feeding behaviour for some aquatic organisms (they can't see their food); make it harder for fish to breathe (clogs up gills); reduce amenity value (murky water is less pleasant for swimmers); smother habitats on the streambed; and carry nutrients like phosphorus. Fine sediment enters waterways through erosion, surface runoff from the land, streambanks, and some discharges. Land use and management practices can have a big effect on erosion and run-off of sediment, but natural features like slope, soil type, and rainfall also play a role.

E. coli is used as an indicator of faecal contamination from sources like livestock, birds, or untreated wastewater discharges. High levels are a concern as they suggest a greater risk of other harmful bacteria or pathogens in the water that could make people sick.

Electrical conductivity (EC) is a critical water quality metric because it acts as an immediate indicator of dissolved salts, minerals, and contaminants. It measures water's ability to pass an electrical current, where higher conductivity reveals higher concentrations of ionized substances like chloride, nitrate, or heavy metals.

For more detail refer to the LAWA website <https://www.lawa.org.nz/>

3.2. Analytical procedure for determining trends

Trend analysis investigates whether water quality has changed over time. Physical and chemical measures of water quality can be influenced by flow as well as patterns associated with seasons. An example of the latter is changing algal growth and oxygen regimes in response to seasonal variation in temperature and sunlight. River flow rate - when a water quality measurement is made - can affect many measures because water quality attributes are subject to either dilution (decreasing concentration with increasing flow), or run-off (increasing concentration with increasing flow) (Smith et al. 1996). Different mechanisms may dominate at different sites so that the same water quality variable (e.g., *Escherichia coli*), can exhibit positive or negative relationships with flow (Snelder et al. 2016). Adjusting a measurement to account for the effect of flow increases the likelihood of detecting a trend with certainty if the measurement is related to flow. In this report flow adjusted analyses were given priority for site/measurement combinations that had a statistically significant relationship to flow.

Trend analysis was undertaken using Time Trends software (Jowett 2025). Seasonality was assessed using the Kruskal-Wallis One-Way Analysis of Variance test. Trends that had statistically significant seasonal patterns were evaluated using the Seasonal Kendall trend test. If significant seasonality was not observed then the Mann-Kendall trend test was used. When a meaningful trend was detected, the raw data was assessed to ensure that the data was not subject to changes in laboratory methods, low detection limits, and inconsistencies with flow adjustment. Changes in lab detection limits over time were accommodated by raising data with lower detection limits to the same threshold as those data with a higher threshold. Various methods were used when deriving flow data to correspond with water quality attribute sample data. This relied upon using stage/flow relationships at the same site or using flow relationships between different sites. If there was evidence of step changes in the data, or inadequacies with flow estimates, the trends were discarded.

A 15-year period of monthly sampling, incorporating 180 samples, was used per attribute for each site. Trend magnitudes tend to decrease with increasing time-period length, with trend magnitudes estimated for shorter periods unlikely to persist over longer periods (Snelder 2019). We chose the longest possible period to maximise statistical rigor. The NPSFM stipulates in Section 3.19 (2) that trends should be considered if they are 'more likely than not'. This is adapted from criteria used by the Intergovernmental Panel on Climate Change (IPCC 2023), which specifies 'more likely than not' as a probability of >50-100% chance of occurrence. We chose a more conservative threshold of 95%, to remain consistent with previous reporting, and to ensure we have high confidence in the trends we are reporting on.

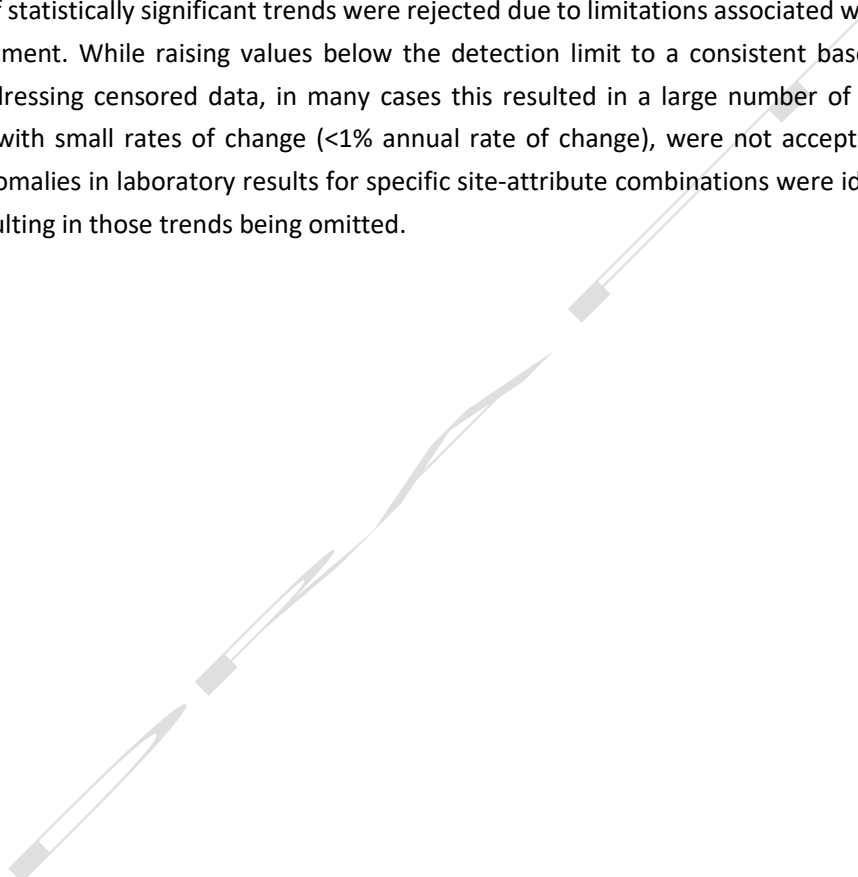
How important a rate of change is will vary depending on a range of factors like the current state of a water quality attribute, and how close it is to a threshold that is considered unsatisfactory (Larned et al. 2015). For example, a 10% per year nitrate increase would represent a lot more nitrate in a stream if concentrations were 5 mg/L, compared to a stream with concentrations of 0.05 mg/L. We have used 1% of the median annual rate of change as a minimum to indicate a meaningful change rate, as per traditional methods (e.g., Ballantine et al. 2010).

In this report, the term ‘trend’ refers to a trend with a probability equal to or greater than 95%, a p-value equal or less than 0.05, and a percent rate of change of at least 1% per annum.

We have explored river water quality trends for a range of water quality attributes: turbidity, electrical conductivity, TN, TP, ammoniacal nitrogen, water clarity, DRP, *E. coli*, and nitrate. These attributes had relevant and suitable time series datasets for trend analysis.

There can be difficulties achieving high accuracy with turbidity measurements, particularly at low levels when the measurement error margin becomes a more significant factor. Recent work by NIWA has also highlighted inconsistencies among different devices (Davies-Colley et al. 2020). While clarity is affected by non-particulate material, it is a better surrogate measure of suspended sediment given the difficulties of measuring turbidity, and often low particulate loads. Exceptions are those waterways with very high coloured dissolved organic matter, but this is a problem mainly when comparing different sites rather than the same ones over time.

Forty percent of statistically significant trends were rejected due to limitations associated with detection limits and flow adjustment. While raising values below the detection limit to a consistent baseline is a common method for addressing censored data, in many cases this resulted in a large number of identical censored values. Trends with small rates of change (<1% annual rate of change), were not accepted. In some cases, unexplained anomalies in laboratory results for specific site-attribute combinations were identified within the time series, resulting in those trends being omitted.



3.3. Trends in water quality attributes

For each individual attribute evaluated, the majority of sites showed no meaningful trend from 2009 to 2024. TN consists of all nitrogen forms found in waterways. TN increased at 4% of monitoring sites and improved at 17% of them (Figure 6).

Some 13% of monitoring sites displayed increasing trends in nitrate (Figure 6). These sites were all in the 'A' category (best) for nitrate toxicity, although nearly all exceeded the 0.015-0.03 mg/L dissolved inorganic nitrogen algal bloom threshold (MfE 1992). A similar number of sites showed improving nitrate levels (15%).

Ammonia improved across 17% of West Coast sites with 13% showing significant deterioration (Figure 6).

DRP is a component of TP. For TP, 26% of sites improved while 2% deteriorated (Figure 6). A smaller proportion of sites showed improvement in DRP (7%), with 17% indicating deterioration.

Clarity improved at 13% of sites and declined at 21% of them (Figure 6). Four sites (17%) had declining trends for *E. coli* and three (13%) were improving (Figure 6). Electrical conductivity increased at 11% of sites and dropped at 2% of them (Figure 6).

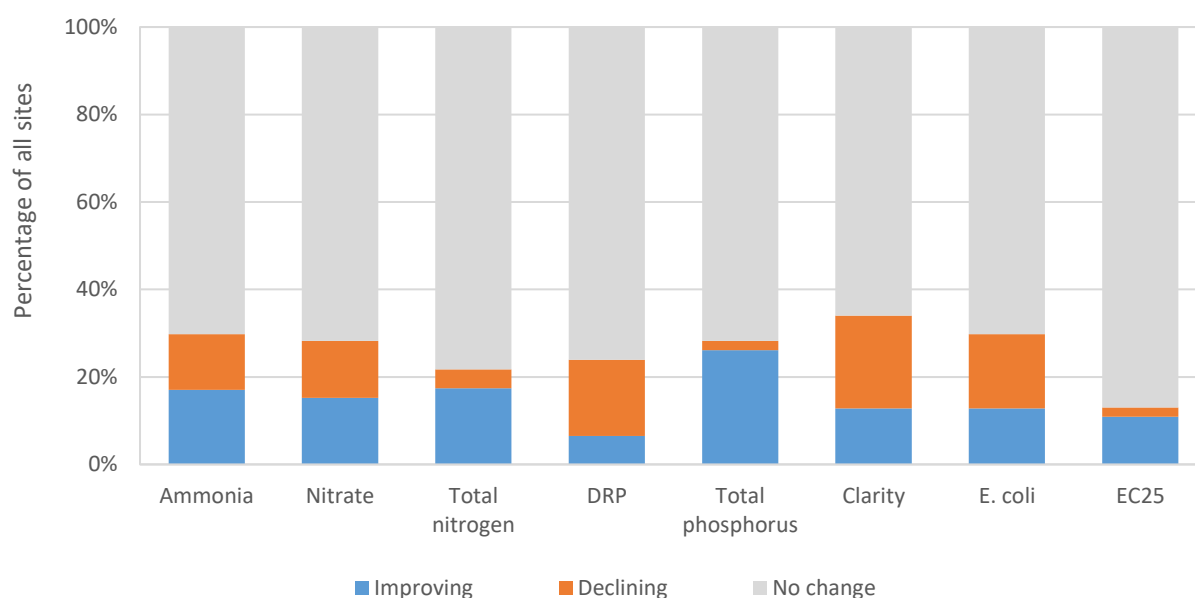


Figure 6. Proportion of West Coast river sites that have significant trends for selected water quality attributes, from 2009 to 2024. DRP stands for dissolved reactive phosphorus. EC25 stands for electrical conductivity, standardized to 25 degrees Celsius.

Some attributes had a larger number of sites with declining trends (e.g. DRP, clarity, *E. coli*), while other attributes had more sites that were improving (e.g. ammonia, nitrate, TN, TP, electrical conductivity), (Figure 6, Table 3). Overall, with trends for all attributes added together, approximately half were in a declining direction and the other half improving.

When evaluating the number of significant trends by individual attribute (Figure 6), it would appear that the majority of sites did not have any significant trends at all. However, this was deceiving - of the 47 sites assessed, 39 of them had at least one significant trend (Figure 7). Only 17% of sites had no significant trends at all, with the remaining sites having between one and five significant trends (Figure 7). Among the sites with significant trends there was no relationship between the amount of anthropogenic land cover and the

total number of trends per site ($r=0.13$, $p=0.43$, Pearson correlation). However, there was a significant positive relationship between the amount of anthropogenic land cover and the number of declining trends per site ($r=0.4$, $p=0.009$, Pearson correlation).

Among sites with significant trends there was no clear relationship between the number of trends observed at a site and the type or direction of the trend (improving or declining), with trends generally distributed evenly between both directions (Table 3). When grouped by catchment, sites with multiple improving and declining trends were distributed across several river systems. In the Grey River catchment, improving trends were observed at Crooked River (Te Kinga; five improving trends) and Pigeon Creek (NIWA stage), while declining trends were identified at Molloy Creek (Rail Line). In the Seven Mile Creek catchment, multiple sites exhibited improving trends, including sites at SH6 Rapahoe, downstream of Raleigh Creek, and upstream of Ox Ponds at Dunollie. In the Whataroa River catchment, Vickers Creek (Whataroa North Base) showed four declining trends. In the Buller River catchment, both Bradshaws Creek (Martins Road) and Burkes Creek (SH69) exhibited three declining trends. In the Lake Haupiri catchment, a tributary at Gloriavale Main Drain showed three improving trends.

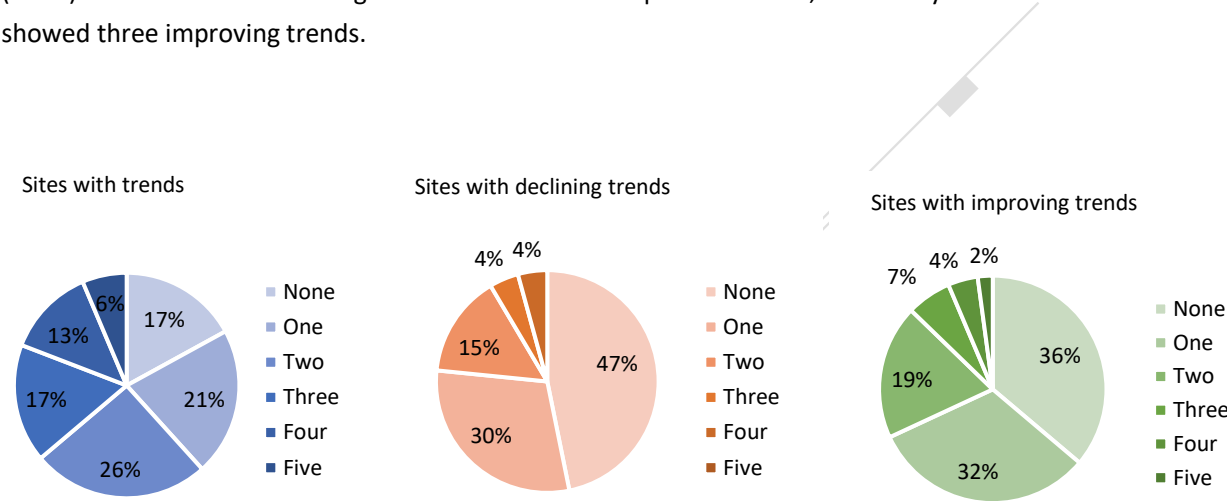


Figure 7. Proportion of sites with zero to five trends, broken into categories for: any trend; a declining trend only; or an improving trend only.

Table 3 Summary of trend testing for up to 15 years of data collected at West Coast water quality sites. The data period analysed is in most cases from winter 2009 to autumns end in May 2024. Only trends with a confidence level of 95% certainty have been reported in the table below. The percent annual change (PAC) reflects the percentage change of the median per year. A minimum PAC of 1% per year was required for a trend to be considered meaningful and reported in the table below. The PAC scale goes out to +/- 10%, with a yellow bar indicating deterioration, and a blue bar indicating improvement. The National Policy Statement for Freshwater Management's (NPSFM) National Objectives Framework (NOF) water quality state is included for attributes where it applies, with 'A' representing high quality, down to 'E' for lowest quality.

Water quality attribute	Site	Anthropogenic landcover	N	Period	PAC		Median	Units	NOF State
Clarity	Hohonu Rv @ Mitchells-Kumara Rd Br	0%	138	17/06/09-21/05/24	-1.97		10.37	m	A
Clarity	Buller Rv @ Te Kuha	10%	173	08/06/09-11/03/24	1.89		1.50	m	D
Clarity	Sawyers Ck @ Dixon Pk	12%	115	25/06/09-20/05/24	1.71		1.48	m	A
Clarity	Seven Mile Ck @ SH6 Rapahoe	16%	199	14/07/09-26/03/24	-1.75		1.50	m	A
Clarity	Crooked Rv @ Te Kinga	19%	139	17/06/09-21/05/24	2.83		3.35	m	A
Clarity	Hohonu Rv @ Mouth	21%	108	17/06/09-21/05/24	-2.52		3.91	m	A
Clarity	Poerua Rv @ Rail Br	23%	135	17/06/09-21/05/24	1.44		3.60	m	A
Clarity	Arnold Rv @ Blairs Rd No. 2 Br	28%	127	17/06/09-13/05/24	-1.5		3.34	m	A
Clarity	Page Stm @ Chasm Ck Walkway	37%	105	30/06/10-09/05/24	-3.1		1.39	m	B
Clarity	Orangipuku Rv @ Mouth	37%	105	17/06/09-21/05/24	-1.23		5.48	m	A
Clarity	Burkes Ck @ SH69	42%	118	23/06/09-02/05/24	-9.46		0.90	m	D
Clarity	Duck Ck @ Kokatahi-Kowhitirangi Rd Br	50%	119	29/06/09-10/05/24	3.98		8.08	m	A
Clarity	La Fontaine Stm @ Airstrip Fishing Access	59%	60	09/07/09-23/05/24	-1.15		3.56	m	A
Clarity	Molloy Ck @ Rail Line	66%	119	24/06/09-13/05/24	-1.74		3.55	m	A
Clarity	L. Haupiri Trib @ Gloriavale Main Drain	68%	75	26/07/11-21/05/24	3.63		3.10	m	A
Clarity	Bradshaws Ck @ Martins Rd	74%	115	16/07/09-08/05/24	-4.19		1.30	m	D
DRP	Sawyers Ck @ Bush Fringe	1%	116	25/06/09-20/05/24	2.01		0.010	mg/L	B
DRP	Orowaiti Rv @ Keoghans Rd	1%	114	16/07/09-08/05/24	-2.78		0.000	mg/L	A
DRP	Baker Ck @ Baker Ck Rd	2%	112	17/07/09-10/04/24	1.55		0.000	mg/L	A
DRP	Grey Rv @ Dobson	19%	173	08/06/09-12/03/24	-2.94		0.000	mg/L	A
DRP	Mawheraiti Rv @ SH7 Maimai	20%	118	23/06/09-02/05/24	3.61		0.010	mg/L	B
DRP	Poerua Rv @ Rail Br	23%	141	17/06/09-21/05/24	1.59		0.010	mg/L	B
DRP	Burkes Ck @ SH69	42%	118	23/06/09-02/05/24	-8.52		0.000	mg/L	A
DRP	Deep Ck @ Arnold Vly Rd Br	45%	121	24/06/09-13/05/24	3.43		0.010	mg/L	B
DRP	Bradshaws Ck @ Martins Rd	74%	114	16/07/09-08/05/24	3.2		0.010	mg/L	C
DRP	Bradshaws Ck @ Bradshaw Rd	79%	114	16/07/09-08/05/24	3.13		0.010	mg/L	C
DRP	Vickers Ck @ Whataroa N Base	98%	59	09/07/09-27/04/23	2.19		0.010	mg/L	D

Summary of trend testing for up to 15 years of data collected at West Coast water quality sites continued.

Water quality attribute	Site	Anthropogenic landcover	N	Period	PAC	Median	Units	NOF State
E. coli	Sawyers Ck @ Bush Fringe	1%	116	25/06/09-20/05/24	6.3	6.3	50 E. coli/100L	E
E. coli	Ford Ck @ Blackball-Taylorville Rd	9%	116	23/06/09-2/05/24	3.45	3.45	20 E. coli/100L	A
E. coli	Crooked Rv @ Te Kinga	19%	139	17/06/09-21/05/24	-8.51	-8.51	30 E. coli/100L	B
E. coli	Grey Rv @ Taylorville Swimming Hole	19%	64	5/03/21-25/03/24	-26.59	-26.59	34 E. coli/100L	E
E. coli	Orowaiti Rv @ Excelsior Rd	20%	121	16/07/09-8/05/24	-1.9	-1.9	240 E. coli/100L	E
E. coli	Nelson Ck @ Swimming Hole Reserve	27%	318	23/06/09-2/05/24	-1.99	-1.99	70 E. coli/100L	B
E. coli	Arnold Rv @ Blairs Rd No. 2 Br	28%	130	17/06/09-13/05/24	-3.4	-3.4	22 E. coli/100L	A
E. coli	La Fontaine Stm @ Herepo Fishing Access	51%	59	9/07/09-27/04/23	4.91	4.91	130 E. coli/100L	E
E. coli	Pigeon Ck @ NIWA stage	56%	96	24/07/12-21/05/24	6.78	6.78	130 E. coli/100L	E
E. coli	La Fontaine Stm @ Airstrip Fishing Access	59%	60	9/07/09-23/05/24	4.09	4.09	155 E. coli/100L	E
E. coli	Molloy Ck @ Rail Line	66%	118	24/06/09-13/05/24	-3.16	-3.16	175 E. coli/100L	E
E. coli	Harris Ck @ Mulvaney Rd	90%	118	29/06/09-10/05/24	3.93	3.93	340 E. coli/100L	E
E. coli	Unnamed Ck @ Adamson Rd Whataroa	97%	74	9/07/09-23/05/24	4.65	4.65	264 E. coli/100L	E
E. coli	Vickers Ck @ Whataroa N Base	98%	59	9/07/09-27/04/23	5.45	5.45	125 E. coli/100L	E
EC25	Hohonu Rv @ Mitchells-Kumara Rd Br	0%	140	17/06/09-21/05/24	-1.32	-1.32	47 uScm	-
EC25	Seven Mile Ck @ Dunollie 400m u/s Ox Pd	9%	60	14/07/09-26/03/24	-2.47	-2.47	112 uScm	-
EC25	Seven Mile Ck @ 300m d/s Raleigh Ck	12%	60	14/07/09-20/05/24	-2.48	-2.48	120 uScm	-
EC25	Hohonu Rv @ Mouth	21%	137	17/06/09-21/05/24	-2.31	-2.31	45 uScm	-
EC25	Page Stm @ Chasm Ck Walkway	37%	106	17/07/09-09/05/24	-1.17	-1.17	226 uScm	-
EC25	Burkes Ck @ SH69	42%	119	23/06/09-02/05/24	2.92	2.92	160 uScm	-
Nitrate	Crooked Rv @ Rotomanu-Bell Hill Rd	1%	139	17/06/09-21/05/24	-1.91	-1.91	0.04 mg/L	A
Nitrate	Seven Mile Ck @ Dunollie 400m u/s Ox Pd	9%	60	14/07/09-26/03/24	-4.07	-4.07	0.03 mg/L	A
Nitrate	Ford Ck @ Blackball-Taylorville Rd	9%	118	23/06/09-2/05/24	3.96	3.96	0.09 mg/L	A
Nitrate	Seven Mile Ck @ 300m d/s Raleigh Ck	12%	61	14/07/09-20/05/24	-3.44	-3.44	0.04 mg/L	A
Nitrate	Seven Mile Ck @ SH6 Rapahoe	16%	60	14/07/09-26/03/24	-3.75	-3.75	0.04 mg/L	A
Nitrate	Crooked Rv @ Te Kinga	19%	138	17/06/09-21/05/24	-1.78	-1.78	0.11 mg/L	A
Nitrate	Arnold Rv @ Blairs Rd No. 2 Br	28%	130	17/06/09-13/05/24	1.51	1.51	0.14 mg/L	A
Nitrate	Duck Ck @ Kokatahi-Kowhitirangi Rd Br	50%	119	29/06/09-10/05/24	1.11	1.11	0.84 mg/L	A
Nitrate	Molloy Ck @ Rail Line	66%	119	24/06/09-13/05/24	4.47	4.47	0.58 mg/L	A
Nitrate	L. Haupiri Trib @ Gloriavale Main Drain	68%	83	22/07/10-21/05/24	-1.13	-1.13	0.81 mg/L	A
Nitrate	Bradshaws Ck @ Martins Rd	74%	114	16/07/09-8/05/24	-2.19	-2.19	0.36 mg/L	A
Nitrate	Harris Ck @ Mulvaney Rd	90%	118	29/06/09-10/05/24	1.67	1.67	0.38 mg/L	A
Nitrate	Vickers Ck @ Whataroa N Base	98%	59	9/07/09-27/04/23	1.12	1.12	0.44 mg/L	A

Summary of trend testing for up to 15 years of data collected at West Coast water quality sites continued.

Water quality attribute	Site	Anthropogenic landcover	N	Period	PAC	Median	Units	NOF State
TN	Seven Mile Ck @ 300m d/s Raleigh Ck	12%	61	14/07/09-20/05/24	-1.37	0.25	mg/L	-
TN	Seven Mile Ck @ SH6 Rapahoe	16%	60	14/07/09-26/03/24	-2.59	0.23	mg/L	-
TN	Crooked Rv @ Te Kinga	19%	138	17/06/09-21/05/24	-1.01	0.19	mg/L	-
TN	Arnold Rv @ Kotuku Fishing Access	20%	129	17/06/09-13/05/24	-1.09	0.20	mg/L	-
TN	Mawheraiti Rv @ SH7 Maimai	20%	119	23/06/09-2/05/24	-1.31	0.45	mg/L	-
TN	Baker Ck @ Oparara Rd	32%	113	17/07/09-9/05/24	-2.29	0.43	mg/L	-
TN	Pigeon Ck @ NIWA stage	56%	221	9/06/09-21/05/24	-2.44	0.35	mg/L	-
TN	Molloy Ck @ Rail Line	66%	119	24/06/09-13/05/24	1.2	0.75	mg/L	-
TN	L. Haupiri Trib @ Gloriavale Main Drain	68%	83	22/07/10-21/05/24	-2.58	0.96	mg/L	-
TN	Vickers Ck @ Whataroa N Base	98%	59	9/07/09-27/04/23	1.31	0.52	mg/L	-
TP	Orowaiti Rv @ Keoghans Rd	1%	114	16/07/09-8/05/24	4.37	0.01	mg/L	-
TP	Ford Ck @ Blackball-Taylorville Rd	9%	118	23/06/09-2/05/24	-3.02	0.01	mg/L	-
TP	Sawyers Ck @ Dixon Pk	12%	115	25/06/09-20/05/24	-1.57	0.02	mg/L	-
TP	Seven Mile Ck @ SH6 Rapahoe	16%	60	14/07/09-26/03/24	-1.58	0.02	mg/L	-
TP	Crooked Rv @ Te Kinga	19%	138	17/06/09-21/05/24	-3.32	0.01	mg/L	-
TP	Grey Rv @ Dobson	19%	172	8/06/09-12/03/24	-2.13	0.01	mg/L	-
TP	Poerua Rv @ Rail Br	23%	141	17/06/09-21/05/24	-2.61	0.02	mg/L	-
TP	Baker Ck @ Oparara Rd	32%	113	17/07/09-9/05/24	-3.75	0.03	mg/L	-
TP	Duck Ck @ Kokatahi-Kowhitirangi Rd Br	50%	119	29/06/09-10/05/24	-4	0.01	mg/L	-
TP	La Fontaine Stm @ Herepo Fishing Access	51%	59	9/07/09-25/01/24	-2.59	0.01	mg/L	-
TP	Pigeon Ck @ NIWA stage	56%	221	9/06/09-21/05/24	-2.95	0.03	mg/L	-
TP	Harris Ck @ Mulvaney Rd	90%	118	29/06/09-10/05/24	-3.15	0.03	mg/L	-
TP	Murray Ck @ Ford Rd S	98%	118	29/06/09-12/04/24	-4.12	0.02	mg/L	-
Ammonia	Orowaiti Rv @ Excelsior Rd	1%	114	16/07/09-8/05/24	-2.58	0.03	mg/L	B
Ammonia	Okutua Ck @ New Rd Br-Okarito Forest	9%	74	9/07/09-23/05/24	1.71	0.01	mg/L	A
Ammonia	Baker Ck @ Baker Ck Rd	9%	112	17/07/09-10/04/24	5.16	0.01	mg/L	A
Ammonia	Pigeon Ck @ NIWA stage	12%	219	9/06/09-21/05/24	-3.58	0.01	mg/L	C
Ammonia	Seven Mile Ck @ 300m d/s Raleigh Ck	16%	61	14/07/09-20/05/24	-3.8	0.08	mg/L	B
Ammonia	Seven Mile Ck @ SH6 Rapahoe	16%	60	14/07/09-26/03/24	-4.75	0.05	mg/L	B
Ammonia	La Fontaine Stm @ Herepo Fishing Access	20%	59	9/07/09-27/04/23	-2.65	0.01	mg/L	A
Ammonia	Bradshaws Ck @ Martins Rd	42%	114	16/07/09-8/05/24	5.87	0.03	mg/L	A
Ammonia	Burkes Ck @ SH69	51%	119	23/06/09-2/05/24	9.88	0.01	mg/L	B
Ammonia	Orowaiti Rv @ Keoghans Rd	56%	114	16/07/09-8/05/24	-5.54	0.02	mg/L	A
Ammonia	Molloy Ck @ Rail Line	66%	119	24/06/09-13/05/24	3.27	0.01	mg/L	A
Ammonia	Ford Ck @ Blackball-Taylorville Rd	66%	118	23/06/09-2/05/24	-2.56	0.04	mg/L	A
Ammonia	Bradshaws Ck @ Bradshaw Rd	74%	114	16/07/09-8/05/24	3.11	0.05	mg/L	A
Ammonia	Seven Mile Ck @ Dunollie 400m u/s Ox Pd	79%	60	14/07/09-26/03/24	-8.52	0.01	mg/L	A

4. Discussion

4.1. The role of changing land cover

Most monitoring sites had at least one significant trend in a water quality attribute. There were no consistent patterns in the nature or direction of trends when a site had several, although the number of declining trends coincided with sites that had more anthropogenic land cover.

Few catchments associated with monitoring sites had any substantial changes in anthropogenic land cover. Four times as many increased opposed to decreased by at least 1% of total catchment area, but only 5% of sites changed in either direction by more than 3.5%. This reflects a region that is predominantly public conservation land, where other land available for development is physically hard to utilise. Additionally, development pressure is low based on the region's small population and modest scale of primary industry indicators presented in this report. Small changes in LCDB land cover may not reflect land-use intensification or changes in management within a catchment that influence water quality attributes.

Most monitoring sites had a portion of indigenous land cover within their catchments, usually in their headwaters. The main anthropogenic land cover classes to increase were exotic grasslands, 90% of which were high producing. High producing exotic grassland has higher contaminants loss per hectare compared to low producing. Agricultural intensification has been underway in parts of Aotearoa since the late 1970s, as indicated by increased stocking rates and yields; increased fertiliser, pesticides, and food stock inputs; and conversion to more intensive forms of agriculture, such as dairying (MacLeod & Moller 2006). In the West Coast region pastoral agriculture was the most consistently encountered and dominant form of anthropogenic activity occurring among sites that had significant trends for both improving and declining water quality. This is logical as exotic grassland is by far the main form of anthropogenic land cover in the West Coast region. Those sites with no indigenous vegetation were typically streams on alluvial river plains with a significant spring fed flow component.

Tracking precise changes in exotic forestry was difficult because of the crop rotation cycle (~28 years), and the range of interim land cover types that can exist over this period. An increase in exotic forestry was apparent, but it seems unlikely that this will have had a significant role in changing water quality trends across the region. Land used for mining/dumps increased by 126%, (2290 ha), drawing land primarily covered with indigenous forest.

With the exception of forestry, source land covers that were converted to exotic grassland came primarily from types with low loss of nutrients, sediment and pathogens. We would anticipate that a meaningful proportion of land would need to be changed into pasture in order to have a measurable effect on water quality, although it is hard to know what exactly constitutes 'meaningful'. The majority of sites did not experience major land cover changes. Sites with the most change were typically in the order of 1% to 5% change. Among these sites most had significant deteriorating trends for a range of water quality attributes, examples included: Molloy Ck

@ Rail Line, Vickers Ck @ Whataroa N Base, Bradshaws Ck @ Martins Rd, Deep Ck @ Blair Rd Br, and Hohonu Rv @ Mouth.

Sites with significant agricultural activity, that had *improving* water quality attributes, did not have any decrease in exotic pasture cover (other than one). So why might they improve? There were two sites with significant amounts of agricultural land cover where three or more water quality attributes improved. The first was the Crooked River @ Te Kinga. This catchment has been the focus of efforts by Council to reduce farm run-off into Lake Brunner since 2001, including three environmental farm planning projects and the addition of specific catchment specific legislation. These initiatives may have led to better management of farm run-off in the catchment. The other was L. Haupiri Trib @ Gloriavale. This site showed a number of improvements yet the amount of pasture in this catchment increased substantially. Further investigation determined that the bulk of this development occurred early, prior to the start of water sampling. With initial land development complete, involving major land disturbance and fertiliser input, water monitoring has probably captured a transition to lower nutrient additions and soil stabilization.

Several factors may be part of wider trends driving improving water quality in catchments with significant agriculture. Fertiliser use (assumed to be comparable to national patterns), showed no clear linear trend from 2009-2024, but there was a drop in consumption from 2020-2024. Additionally, there has been improved management of nutrients on many dairy farms (2013–2022), (Macintosh et al. 2025). Some key changes in the agricultural sector have been a drop in stocking rates, increased farm consolidation, and smarter fertiliser use/nutrient management. In each catchment, there will be competing influences that push water quality trends in different directions, like those mentioned, but will also include how effectively stock, soil and effluent are managed.

Introduction of irrigation can coincide with farm intensification, leading to increases in pathogens and nutrients - in particular, nitrates (McDowell et al. 2023, NIWA 2026). Depletion of flows associated with water takes can reduce instream habitat (MfE 2020). By national standards, irrigation is not currently substantial in the West Coast region, but at 2543 ha, it is not insignificant. With increasing weather extremes associated with climate change, there will be an increasing need to mitigate short dry spells and maintain pasture consistency. Therefore, it is worth tracking irrigation practices in future reporting.

On the West Coast, mining is the second largest employer among the primary industries, following agriculture. Over the timeframe used for evaluating trends, mining employment dropped but it is difficult to know if this relates to changes among a few large hard rock mines or a wider, more diverse selection of operations. Changes in the LCDB indicate an increase in mined land, much of which may be the legacy of the mining boom that declined sharply after 2012, with the land not yet transformed into a different vegetated land cover type. Fewer catchments monitored by Council have mining in comparison to agriculture. Sites with notable increases in dump/mining land cover did show increases in suspended sediment (e.g. Burkes Ck @ SH69).

4.2. Trends among water quality attributes

Nitrate is a highly soluble, inorganic component of TN and is readily used by plants and algae to help them grow. It leaches easily through soils, particularly when soil is sandy or porous, or after heavy rainfall (McDowell et al. 2008). Nitrate-nitrogen generally comes from nitrogen fertiliser and livestock urine in catchments containing substantial agriculture. Thirteen percent of monitoring sites displayed increasing trends in nitrate, all of which had significant pastoral agriculture in their catchments.

Increases in TN are often attributed to increasing nitrate from agriculture and other human activities (MfE 2015). Anthropogenic activity could still be driving TN increases at sites that had weaker nitrate trends. Other nitrogen forms, like organic and particulate nitrogen that aren't analysed, could be a significant component of the TN measured. The mechanisms driving increased TN are likely to be more diverse, with more scope for non-anthropogenic influences like climate variability. Of the sites with increasing TN but not nitrate, many displayed decreasing clarity trends, hence an increase in particulates might be driving TN increases. Dissolved organic nitrogen is often the dominant form of nitrogen in West Coast rivers and lakes that have moderate to high levels of dissolved organic carbon; examples being Lake Brunner and Okutua Stream in Okarito Forest. In both these catchments the majority of dissolved organic carbon comes from indigenous land cover.

Ammonia⁵ (also a component of TN), is often a waste product from industrial processes, humans, and animals. In the environment, ammonia typically comes from point-source discharges (rather than widespread run-off), such as those from sewerage treatment plants, dairy shed washdown, and industrial operations. Improving ammonia is likely to be due to improvements in the way discharges from sewage treatment plants, dairy sheds, and industrial operations are treated (MfE 2015). Ammonia was a small component of overall nitrogen load on the West Coast, which has been the case elsewhere in Aotearoa (MfE 2015). A small but significant increase in ammonia was detected at Okutua Creek, which is a forested reference site with no current anthropogenic activity. This high rainfall catchment (~3 m/yr) has a low gradient with poorly draining, acidic, gley podzol soils. Such conditions can leach ammonia directly to waterways as well as nitrate (Daniels et al. 2012). Logging was widespread in the catchment until 1981, in which time native forest slowly regenerated. Changes in forest composition maybe leading to subsequent changes in ammonification and nitrification (Xiao et al. 2022).

Phosphorus mostly enters waterways as part of eroded sediment and from phosphorus-based fertilizer (MfE 2015). Increasing trends in DRP (17% of sites), were the likely result of increased agricultural land cover and intensification. Improvement in DRP (7%), may be the result of better nutrient and effluent management, as well as changes to stocking rates. There have been widespread improvements in phosphorus around Aotearoa for waterbodies influenced by agriculture (MfE 2017).

One site showed deterioration in TP. A large slip occurred in the Orowaiti River catchment, although the drop in clarity was not statistically significant. Improving trends for TP (26% of sites), often matched improvements in clarity, suggesting that improving TP trends were commonly linked to particulate sources. However, as for TN, the range of factors driving nutrient concentrations among sites, particularly for the total fractions, were

⁵ Ammonia is used as a shorthand reference to total ammonia or ammoniacal nitrogen.

likely to be varied and complicated. We can use clarity and turbidity as a surrogate for suspended particulate matter. Several sites had dual TP and turbidity relationships involving improvement. This supports the theory that in some instances changes in TP could be related to corresponding trends in suspended particulate material.

Water clarity is a measure of underwater visibility and a surrogate measure for suspended sediment. Fine particles like silt and dissolved substances can reduce water clarity. Some West Coast water bodies have naturally reduced water clarity, despite a lack of suspended particulate material, due to dissolved organic carbon (brown colouration). Beyond this natural colouration, suspended material, e.g. fine sediment, is the cause of reduced clarity and elevated turbidity. Approximately one quarter of sites showed deteriorating trends for clarity with a fewer number improving (13%). Significant changes are likely to be caused by suspended material derived from land disturbance associated with primary industries. Rivers that arise from lakes may additionally have suspended phytoplankton (e.g. Arnold River).

The bacteria *Escherichia coli*, in rivers or lakes, comes from the faeces of warm-blooded animals, including humans. Higher levels of *E. coli* indicate a higher risk of infection from pathogens like *Campylobacter* while swimming, wading, or boating. Pathogens can also affect people and stock if the water is consumed. *E. coli* deteriorated at 17% of sites and improved at 13% of them. Point source pollution (e.g. dairy effluent ponds and wastewater treatment facilities), and sources that are more diffuse (e.g. stock access to waterways), can contribute faecal contamination to waterways.

The addition of treated wastewater led to an increase in *E. coli* at one site, and a decrease at another in response to improved wastewater treatment efficacy. A reference site, dominated by indigenous forest and with no anthropogenic activity upstream, showed an increase in *E. coli*. These *E. coli* concentrations were not high and the absolute increase relatively small compared to farmed catchments, with an increase in feral mammals may have been responsible. Additionally, this catchment was small, steep and was dominated by limestone geology. Limestone fractures may be more conducive to rapid supply of *E. coli* to surface waterways (Mathes, 2000), while providing less attenuation. Improvements in point source management, like dairy effluent ponds and wastewater treatment facilities, can be offset by an increase in more diffuse sources associated with agricultural intensification, with trends in each catchment probably reflecting that balance. It should be noted that sources, transport and survival of *E. coli* can be complex, and determining the drivers of change difficult, as demonstrated by a large study in the Waikato (Woodward et al. 2022).

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Appendix 1: Monitoring site locations



Figure 8. Location of monitoring sites used for trend analysis. Kawatiri Freshwater Management Unit (FMU), including Karamaea, Seddonville, and Charleston.



Figure 9. Location of monitoring sites used for trend analysis. Kawatiri FMU, Westport/Cape Foulwind.



Figure 10. Location of monitoring sites used for trend analysis. Grey FMU, except for Burkes Creek, which is in the Kawatiri FMU.



Figure 11. Location of monitoring sites used for trend analysis. Grey FMU, Seven Mile Creek.



Figure 12. Location of monitoring sites used for trend analysis. Grey FMU, Sawyers and Arnold River (lower).

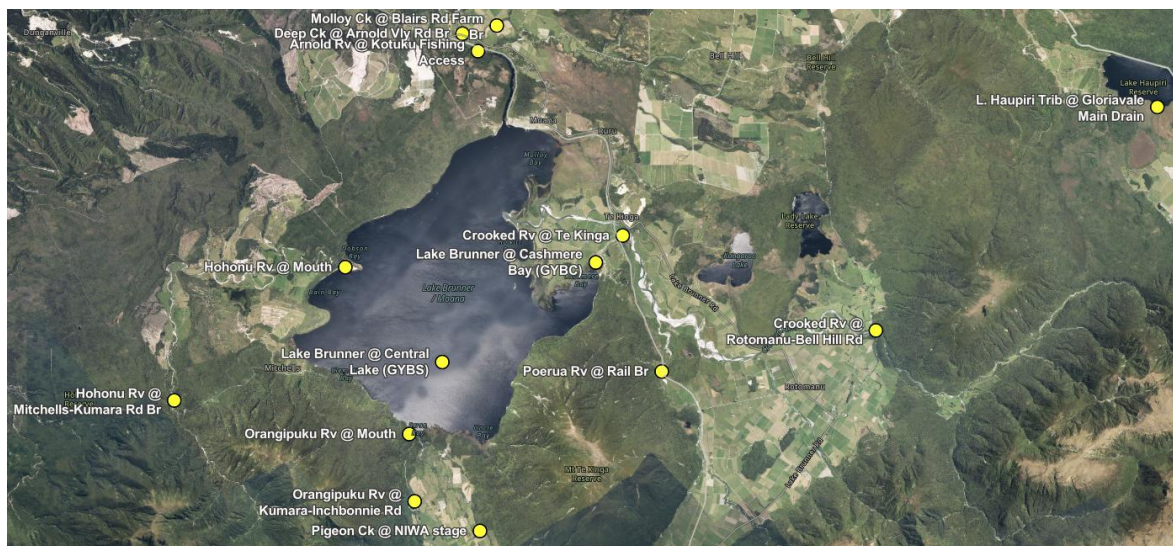


Figure 13. Location of monitoring sites used for trend analysis. Grey FMU, Lakes Brunner and Haupiri catchments, and Arnold River (lower).

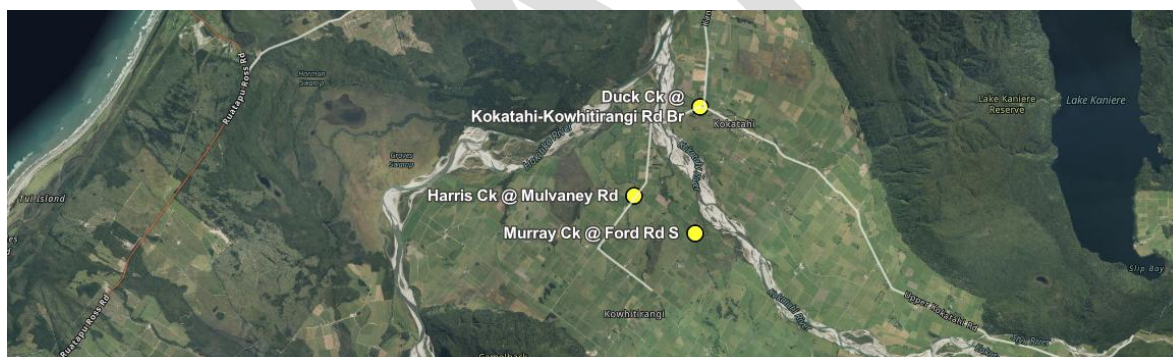


Figure 14. Location of monitoring sites used for trend analysis. Hokitika FMU, Hokitika Valley.



Figure 15. Location of monitoring sites used for trend analysis. Hokitika FMU, Waitaha Valley to Whanganui Valley.



Figure 16. Location of monitoring sites used for trend analysis. Hokitika FMU, Whataroa Valley to Okarito Forest.

Appendix 2: Changes in land cover at sites monitored by WCRC

Changes in land cover of more than 1% of their catchment area, at sites with long term monitoring, have been listed below. Shading is included to help differentiate sites.

Site	Land cover	Total catchment area Ha	1996 Ha	2023 Ha	% change of catchment
Arnold Rv @ Blairs Rd No. 2 Br	Exotic Forest	58789	2092	639	-2.5%
Arnold Rv @ Blairs Rd No. 2 Br	Low Producing Grassland	58789	1405	1971	1.0%
Arnold Rv @ Blairs Rd No. 2 Br	High Producing Exotic Grassland	58789	11513	12637	1.9%
Baker Ck @ Baker Ck Rd	Low Producing Grassland	1014	29	10	-1.8%
Blackwater Ck @ Farm 846	Herbaceous Freshwater Vegetation	1160	20	3	-1.4%
Blackwater Ck @ Farm 846	Flaxland	1160	27	11	-1.4%
Blackwater Ck @ Farm 846	High Producing Exotic Grassland	1160	213	246	2.9%
Bradshaws Ck @ Martins Rd	Manuka and/or Kanuka	3041	306	236	-2.3%
Bradshaws Ck @ Martins Rd	High Producing Exotic Grassland	3041	2064	2142	2.6%
Burkes Ck @ SH69	Gorse and/or Broom	1652	129	48	-4.9%
Burkes Ck @ SH69	High Producing Exotic Grassland	1652	519	485	-2.1%
Burkes Ck @ SH69	Surface Mine or Dump	1652	7	67	3.6%
Burkes Ck @ SH69	Exotic Forest	1652	1	91	5.5%
Deep Ck @ Arnold Vly Rd Br	Forest- Harvested	6153	119	26	-1.5%
Deep Ck @ Arnold Vly Rd Br	High Producing Exotic Grassland	6153	2151	2264	1.8%
Deep Ck @ Arnold Vly Rd Br	Low Producing Grassland	6153	129	262	2.2%
Ford Ck @ Blackball-Taylorville Rd	Indigenous Forest	2137	1811	1754	-2.7%
Ford Ck @ Blackball-Taylorville Rd	Surface Mine or Dump	2137	13	70	2.7%
Grey Rv @ Dobson	High Producing Exotic Grassland	381339	43157	48315	1.4%
Hohonu Rv @ Mouth	Exotic Forest	4675	587	72	-11.0%
Hohonu Rv @ Mouth	Fernland	4675	1	75	1.6%
Hohonu Rv @ Mouth	Forest- Harvested	4675	29	176	3.1%
Hohonu Rv @ Mouth	Low Producing Grassland	4675	48	332	6.1%
L. Haupiri Trib @ Gloriavale Main Drain	Herbaceous Freshwater Vegetation	386	131	109	-5.8%
L. Haupiri Trib @ Gloriavale Main Drain	Indigenous Forest	386	26	7	-4.8%
L. Haupiri Trib @ Gloriavale Main Drain	High Producing Exotic Grassland	386	217	259	10.9%
Mawheraiti Rv @ Atarau Br	Exotic Forest	48654	1688	962	-1.5%
Mawheraiti Rv @ Atarau Br	Gorse and/or Broom	48654	1690	1106	-1.2%

Mawheraiti Rv @ Atarau Br	High Producing Exotic Grassland	48654	8096	8833	1.5%
Molloy Ck @ Rail Line	Forest- Harvested	4113	149	0	-3.6%
Molloy Ck @ Rail Line	Manuka and/or Kanuka	4113	449	329	-2.9%
Molloy Ck @ Rail Line	Gorse and/or Broom	4113	277	344	1.6%
Molloy Ck @ Rail Line	Low Producing Grassland	4113	61	290	5.6%
Nelson Ck @ Swimming Hole Reserve	Indigenous Forest	11740	7726	7590	-1.2%
Nelson Ck @ Swimming Hole Reserve	Gorse and/or Broom	11740	206	86	-1.0%
Nelson Ck @ Swimming Hole Reserve	Forest- Harvested	11740	180	298	1.0%
Nelson Ck @ Swimming Hole Reserve	High Producing Exotic Grassland	11740	1537	1702	1.4%
Orowaiti Rv @ Keoghans Rd	Indigenous Forest	875	720	704	-1.7%
Page Stm @ Chasm Ck Walkway	High Producing Exotic Grassland	321	127	68	-18.2%
Page Stm @ Chasm Ck Walkway	Exotic Forest	321	19	5	-4.5%
Page Stm @ Chasm Ck Walkway	Gorse and/or Broom	321	19	7	-4.0%
Page Stm @ Chasm Ck Walkway	Manuka and/or Kanuka	321	66	98	9.9%
Sawyers Ck @ Dixon Pk	High Producing Exotic Grassland	1651	82	55	-1.7%
Sawyers Ck @ Dixon Pk	Exotic Forest	1651	41	60	1.1%
Seven Mile Ck @ SH6 Rapahoe	Gorse and/or Broom	3696	186	149	-1.0%
Vickers Ck @ Whataroa N Base	Indigenous Forest	960	27	14	-1.3%
Vickers Ck @ Whataroa N Base	High Producing Exotic Grassland	960	932	945	1.3%
Vickers Ck @ Whataroa N Base	Indigenous Forest	960	27	14	-1.3%