Waituna **catchment**

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Te Taiao Tonga

Waituna catchment

This document summarises science information for freshwater and estuarine areas, opportunities for action and the socioeconomic context for the Waituna catchment. This includes the land and waterways that contribute to the Waituna Lagoon.

It is one of twelve catchment summaries prepared for the Muruhiku Southland region.

We have collated and presented scientific data at the catchment scale to provide an understanding of freshwater quality and quantity challenges and their underlying factors. We have included an evaluation of the current state of freshwater within the catchment and highlighted the magnitude of change necessary to meet freshwater aspirations.

The information in this document should be considered alongside other information sources, including mātauranga Māori.

Main features

Land area: 20,500ha

Major rivers and streams:
Waituna Creek, Moffat Creek, Carran Creek

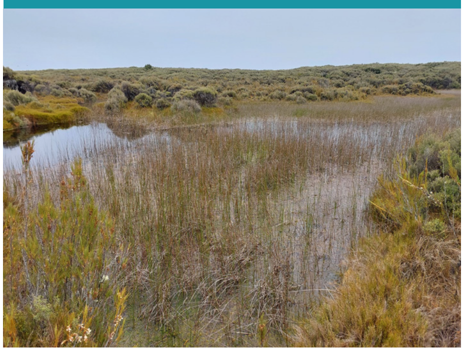
Aquifers:
Awarua

Lakes/Lagoons:
Waituna Lagoon

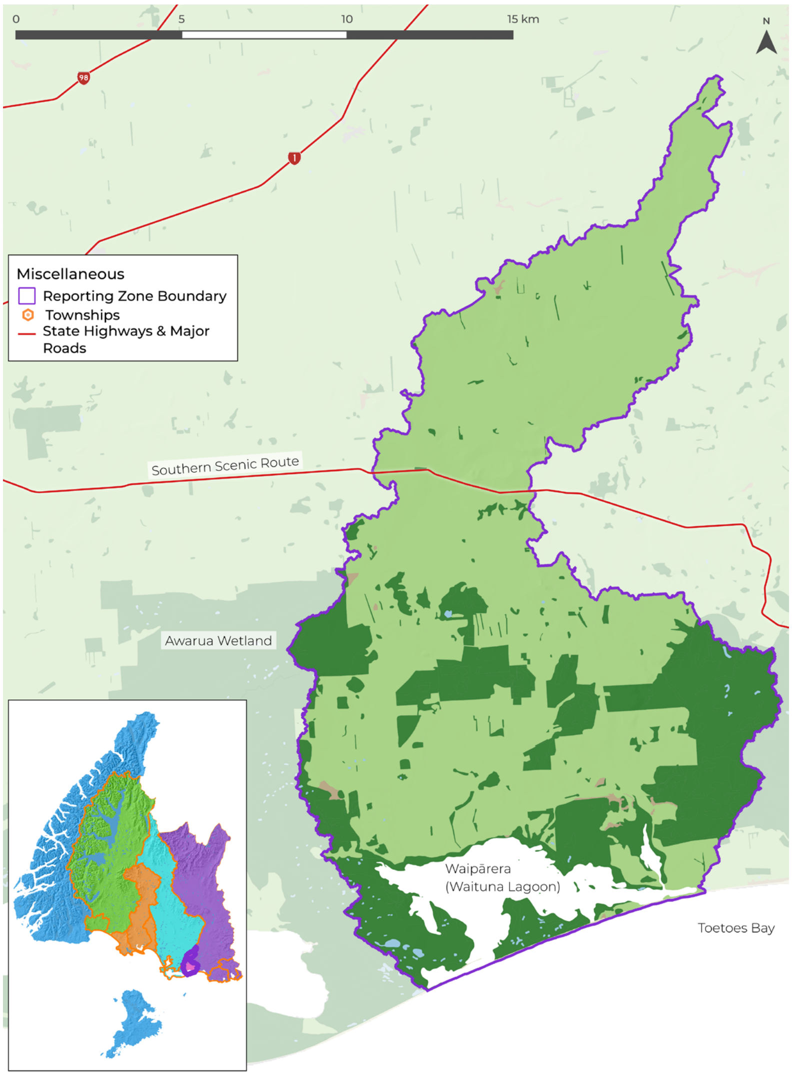
Estuaries:
None

Townships:
None

Population:
Approximately 450



Catchment outline



For most attributes, current state is assessed using data from the 2018 – 2022 period.

Key messages

Issues

- Monitoring indicates that freshwater ecosystem health is poor in many parts of the Waituna catchment. Nine of the 12 (75%) attributes presented here do not meet hauora targets, and five of the 12 (42%) attributes are graded as poor or very poor.
- Waituna Lagoon does not currently meet the hauora targets for any nutrient and phytoplankton attributes. High nutrient loads delivered to the lagoon make it susceptible to eutrophication, particularly during periods of prolonged lagoon closure. Conversely a sustained opening can result in significant stress to vegetation habitat.
- Modelling indicates large contaminant load reductions are required to achieve desired freshwater and lagoon outcomes. Reductions are required for nitrogen (77%), phosphorus (61%), sediment (84%) and *E. coli* (78%).
- Approximately 931ha of wetland has been lost since 1996 in the Waituna catchment. A large proportion of remaining wetlands on non-conservation land are at moderate to moderately-high risk of being lost.

Opportunities for action

- Large-scale land use change and de-intensification. This may be achieved through the development of long-term catchment plans, promotion of alternative land use options and diversification, or implementation of regulation that provides clear mechanisms and outcomes regarding contaminant loss reductions.
- Implementation of property-scale mitigations that are tailored to the physiographic characteristics of the land, the sensitivities of the receiving environments, and the outcomes sought in the catchment. In particular, this would include a focus on reducing nitrogen loss from high-risk parts of the landscape to help reduce load to the lagoon.
- Adoption of an opening and closing management regime that is targeted specifically at improving ecological outcomes and resilience in Waituna Lagoon. It is important to note that implementation of active lagoon restoration techniques may only result in long-term condition improvements if nutrient inputs are reduced.

Socioeconomic context for action

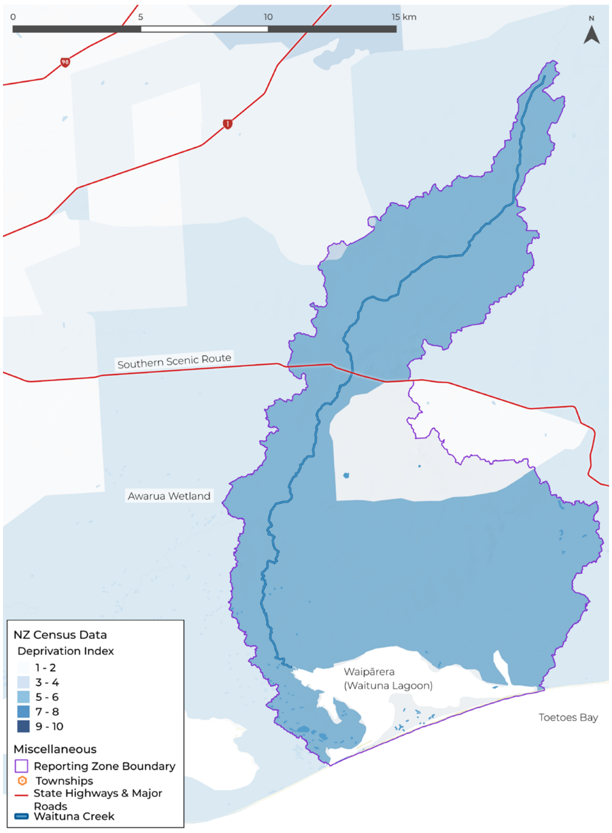
The Waituna catchment and the broader Awarua Plains area have been shaped by historic socioeconomic shifts in the late 20th century. In particular, the impacts of deregulation from the 1980s removed agricultural subsidies and export assistance, creating a period of austerity for many farming communities in the area.

However, the rise of dairy farming in the 1990s began to reverse these conditions, particularly in the Waituna catchment. This industry drove significant land use changes, such as converting wetlands to pasture. It also brought many new residents from the North Island and overseas, leading to notable demographic differences compared to the rest of Murihiku Southland. Around a third of the total population is directly involved in this industry.

The Waituna catchment experienced a general population decline during this period; however, since the mid-2000s, there has been a steady increase. The current catchment population is estimated to be around 450 people. There is a higher percentage of younger people (0-39), and fewer older people (55-85+). The population tends to be more highly qualified and growing increasingly ethnically diverse, especially among ethnically Asian populations.

Unemployment is low in the area. Although housing statistics are unreliable at this scale, historical records suggest that the Waituna catchment is reasonably affordable. However, home ownership has generally declined, in line with trends across the Southland district from 2013-2018. This is possibly due to the transient nature of dairy farm workers, where renting is more common.

Social Deprivation Index

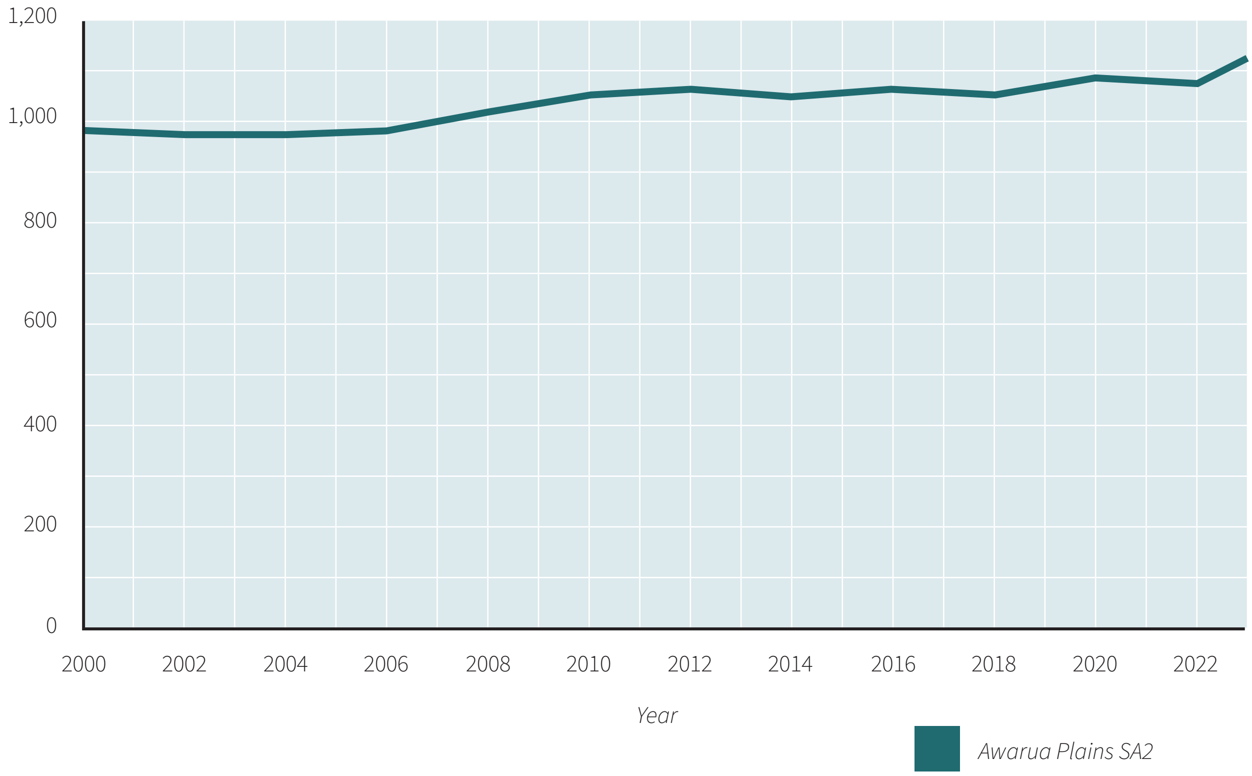


Social Deprivation Index

The Deprivation Index measures socioeconomic deprivation based on census information. It considers income, income benefits, communication access, employment, educational qualifications, home ownership, care support, living space and living conditions.

Although Southland district is among the least socioeconomically deprived areas in New Zealand, the Waituna catchment falls within an area of moderate deprivation. Deprivation levels around Waituna fluctuated between lower and moderate from 2014 to 2023, suggesting the community may not have the same vulnerabilities as those at higher deprivation levels. However, the demographic changes and increases in migration could indicate a need for additional support.

Estimated population trends (Dot Loves Data, 2024)



The Waituna catchment comprises only a portion of the Awarua Plains SA2, so this graph only indicates general population trends in the area.

Summary

- The local rural economy relies heavily on intensive lowland agriculture, increasing risks from industry or regulatory changes.
- Established catchment groups, such as the Waituna Catchment Group, provide a support system for members and community projects and may facilitate adaptation to external pressures and challenges.

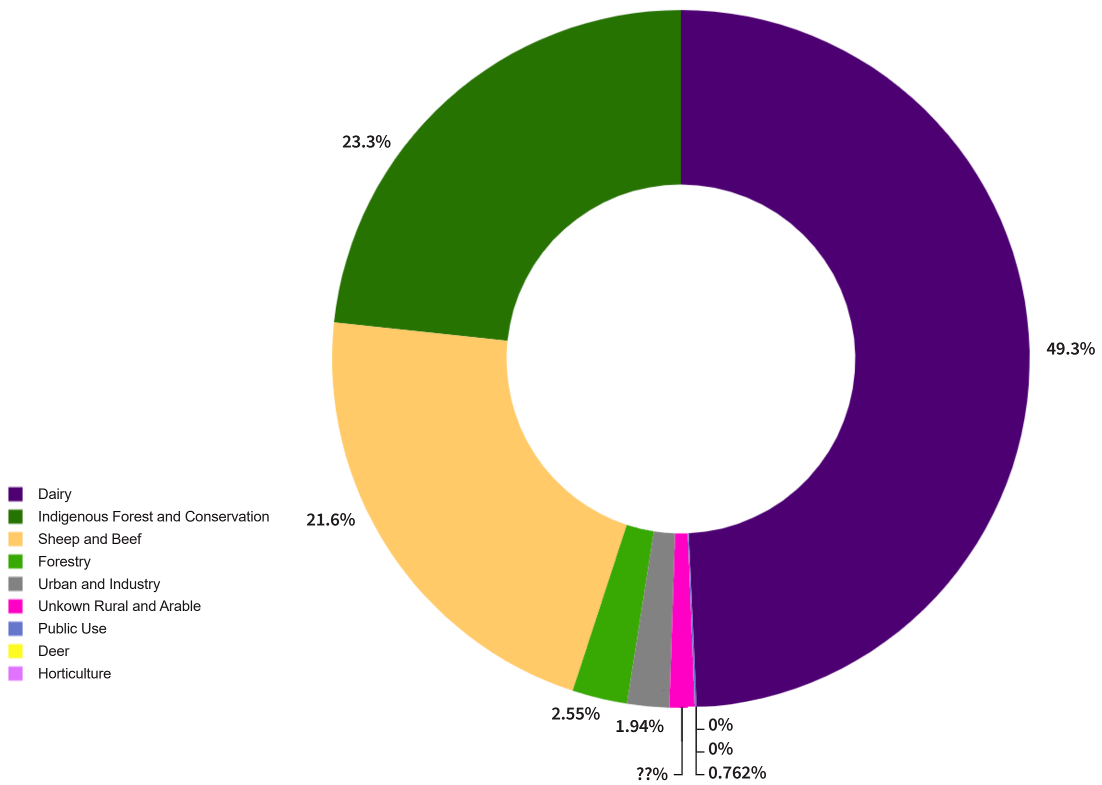
Catchment overview

The Waituna catchment is a small, coastal catchment located east of Invercargill. The catchment begins near the western extent of Tramway Road West. From here, it extends and expands southward across lowland plains, incorporating the districts of Waituna, Oteramika, Mokotua and Kapuka South. The catchment encompasses parts of the Awarua Wetlands and ends at the Waituna Lagoon which discharges into Toetoes Bay.

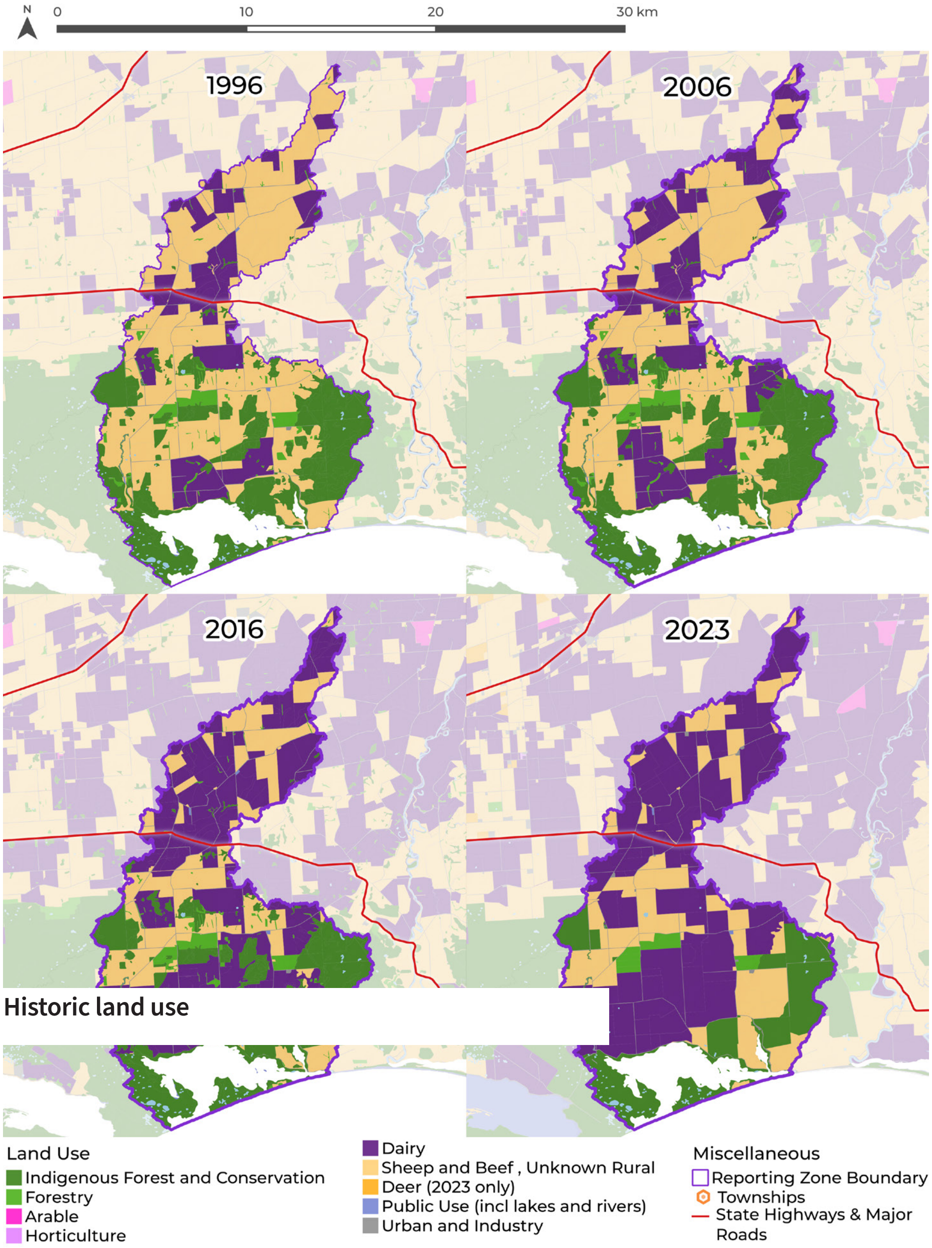
Land use

The Waituna catchment is approximately 20,500ha in size. Land use in Waituna is dominated by farming activities with 75% or 14,760ha of the catchment utilised for these purposes. Conservation estate and indigenous forrest cover most of the remaining area (23% or 4,715 ha), with a small component of Forestry (3% or 615ha) and Urban and Industry (2% or 410ha) making up the rest.

There have been large changes in land use in the last 25 years. In particular, the map sequence below shows the growth of dairy farming in the catchment. There have been some increases in total pastoral land due to land conversion. The growth of dairy farming represents a large increase in agricultural land use intensity over this time, which has resulted in a large increase in contaminant loss and increased pressure on natural resources.The development of dairy farming represents an increase in agricultural land use intensity. This has resulted in an increase in contaminant loss and pressure on natural resources.



Historic land use



Historic land use

Please note that these maps and figures are indicative only due to land use class aggregation and differences in mapping methods.

	1996 to 2006	2006 to 2016	2016 to 2023	Overall 1996 to 2023
Pastoral land	No change	↑ 2%	↑ 15%	↓ 17%
Dairy	↑ 37%	↑ 87%	↑ 18%	↑ 204%
Drystock	↓ 13%	↓ 47%	↑ 8%	↓ 50%

Climate

Understanding climate at a catchment scale helps to explain spatial and temporal variation in land use, water quality and quantity.

Current climate

The Waituna catchment is a cool, wet, coastal climate with consistent annual rainfall (1,000-2,000mm) and small variations in seasonal temperatures (3-12°C mean).

Future climate

The impacts of a changing climate on the Waituna catchment have been examined in a regional study exploring scenarios based on the representative concentration pathways of 4.5 and 8.5. The potential changes are summarised in the following table.

Precipitation

		RCP 4.5		RCP 8.5	
		Mid 21st century	End of 21st century	Mid 21st century	End of 21st century
Temperature	Daily mean (°C)	↑ 0.5-0.75	↑ 0.5-1	↑ 0.5-0.75	↑ 1.75-2
	Mean minimum (°C)	↑ 0-0.5	↑ 0.5-0.75	↑ 0.25-0.5	↑ 1.25-1.5
	Number of hot days	↑ 0-5	↑ 5-10	↑ 0-5	↑ 10-20
	Number of frosty nights	↓ 0-5	↓ 5-10	↓ 5-10	↓ 15-20
Rainfall	Annual rainfall change (%)	↑ 0-5	↑ 5-10	↑ 0-5	↑15-20
	Number of wet days	168-174	170-176	169-175	170-176
	5-Day maximum rainfall (mm)	↑ 0-15mm	↑ 0-15mm	↑ 0-15mm	↑ 15-30mm
	Heavy rainfall days	31-32	31-33	30-32	35-37
	Seasonal changes	Much wetter springs	Consistent change across year	Concentrated to winter/spring	Concentrated to winter and spring

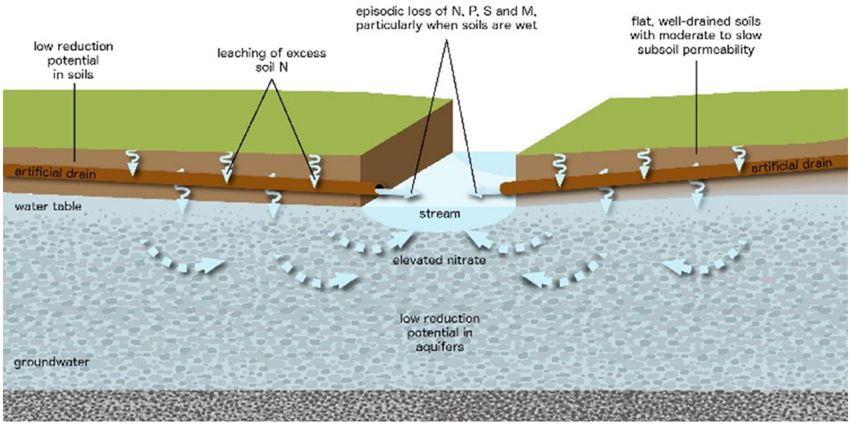
Catchment landscapes and hydrology

Water quality variations within a catchment are influenced by biogeochemical and physical processes. Understanding hydrology, geology and soil types within a catchment helps explain variations in catchment yields, water chemistry and water quality outcomes independent of land use.

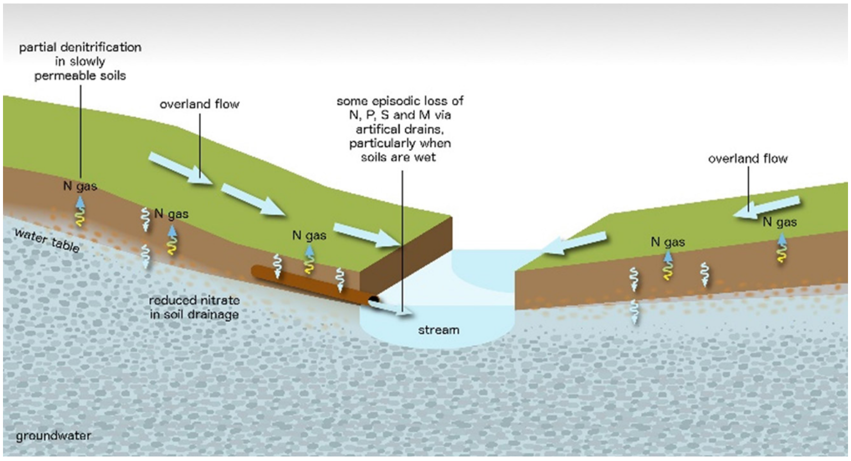
Upper and mid catchment

Rain falling in the upper Waituna catchment interacts with the intensively farmed agricultural landscape. These upper and middle areas of the catchment have gentle topography and are characterised by interspersed areas of brown soils (deep Waikiwi and Woodlands silts) and more poorly drained gley soils (deep Mokotua and Eureka silts). These soils are formed over Middle Pleistocene (Quaternary 8 - Quaternary 10) quartz rich river gravel deposits underlain by the Tertiary Gore Lignite Measures.

The areas of brown soils have higher risk of nitrogen loss to streams and groundwater via soil and deep drainage pathways. This makes these areas of brown soils high risk with regard to catchment nitrogen load. Areas of gley soils have more capacity to attenuate nitrogen in the soil profile, but are susceptible to contaminant loss via artificial drains and overland flow pathways.



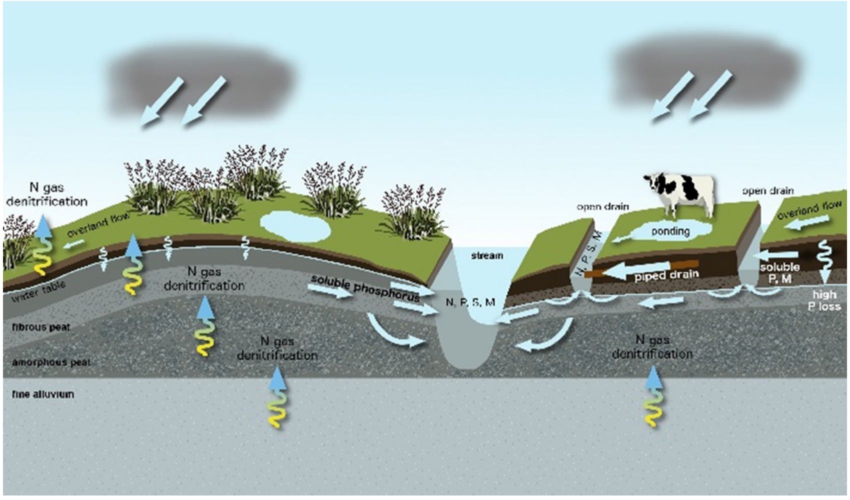
▲ *Conceptual illustration of the typical hydrological and landscape setting in the areas of brown soils in the upper and mid catchment.*



▲ *Conceptual illustration of the typical hydrological and landscape setting in the areas of gley soils in the upper and mid catchment.*

Lower catchment

The areas of the catchment are characterised by larger areas of gley and poorly drained organic peat soils. Soils and peat are underlain by younger Pleistocene – Holocene river, shoreline, and swamp deposits. These areas are generally extensively drained to improve agricultural production. As a result, water typically reaches streams via artificial drainage, overland flow, and soil lateral flow pathways. These flow pathways and the nature of the soils poses an increased risk of phosphorus, sediment and microbial transport.



Conceptual depiction of the typical hydrological and landscape setting in the areas of organic and peat soils in the lower catchment.

Each of the major streams in the catchment discharge into Waituna Lagoon. Estimates of flow lag times for surface water in the catchment ranges from very short (days – for water derived through overland and artificial drainage pathways) to longer (several months – for water derived from groundwater flow). When compared with other parts of Murihiku Southland, lag times are short and as a result, contaminant loads delivered to the lagoon are generally reflective of annual, rather than multi-year cycles and processes.

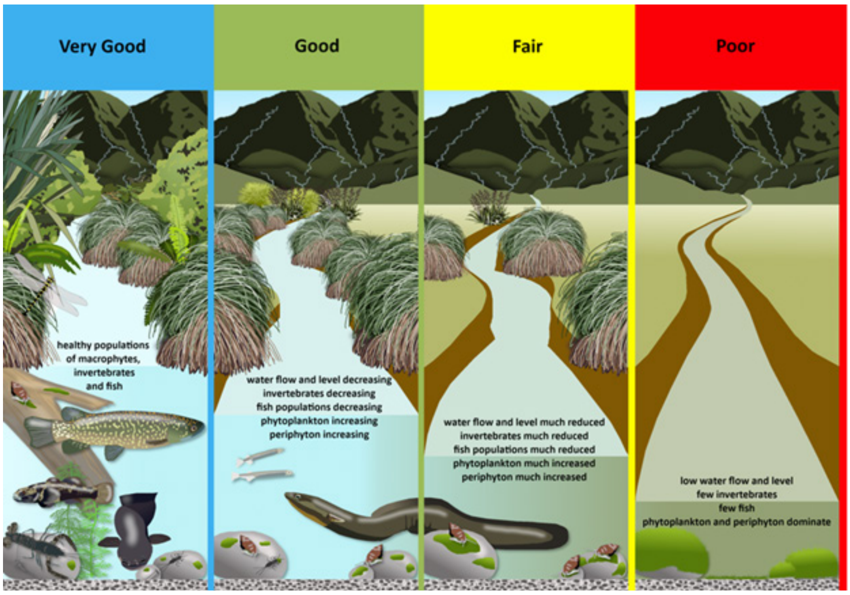
The lagoon itself is intermittently closed and discharges directly to the ocean, when open.

What are the water issues for this catchment?

Freshwater outcomes and how we measure them

Freshwater outcomes can be described from ‘very good’ to ‘poor’. This spectrum helps us understand the current state of the freshwater environment and what we might be trying to achieve in the future. The image below depicts this concept for rivers and streams.

Although many factors contribute to freshwater outcomes, we can only measure some of them to get an understanding of ecosystem health. We measure the aspects of the freshwater environment that can help us define and determine freshwater outcomes. These aspects are called ‘attributes’.



Attributes (the things we measure)

Attributes can relate to the ecosystem's physical or chemical environment or biological communities, such as periphyton, macroinvertebrates and fish. The measured state of an attribute tells us about some aspects of the environmental state, and together, they build a picture of the ecosystem's overall health. The more attributes we monitor, the more precise the picture can become.

Attributes may relate to ecosystem health or human health outcomes (e.g. *E. coli* or cyanobacteria concentrations). Some attributes are graded using ‘ABCD’ categories: A (very good), B (good), C (fair) and D (poor). In some cases, *E. coli* has an additional E (very poor) grade. Other attributes have simple ‘pass’ or ‘fail’ grades.

The more attributes with a higher grade, the better the overall ecosystem health. Conversely, when many attributes have poorer grades, the overall ecosystem health is poorer.

Hauora target attribute states

In 2020, Environment Southland and Te Ao Mārama Inc (TAMI) approved in principle the use of hauora as a freshwater target to be achieved within a generation. These targets provided the basis for the Regional Forum recommendations, on how freshwater aspirations may be achieved.

The concept of hauora encompasses far more than the numeric attributes and targets described here. For simplicity, a reduced number of attribute states are presented in this document as they relate to ecosystem and human health. Hauora is a state of healthy resilience and is generally associated with the A 'very good' and B 'good' attribute states. However, attribute states that support hauora can be anywhere on the scale from A 'very good' to C 'fair', depending on the natural characteristics of that freshwater environment.

The natural characteristics have been differentiated through the use of classes.

We use monitoring results to compare current attribute state with the hauora target state for different classes in the Waituna catchment.

Streams and rivers

River classes

“River classes’ group rivers (or parts of rivers) with similar characteristics. Similarities can include natural characteristics of the rivers, such as climate, gradient and flow. River classes can also group environments that are subject to similar pressures, such as land use.

The river classes used in Muruhiku Southland are: Mountain, Hill, Lowland, Spring-fed, Lake-fed and Natural State.

About 95% of the rivers in the Waituna catchment is classified as Lowland. The rest are Natural State.

Target states can differ between attributes and between different river classes, which may have different target states for the same attribute.

Periphyton is an example of an attribute with different target states for different river classes.

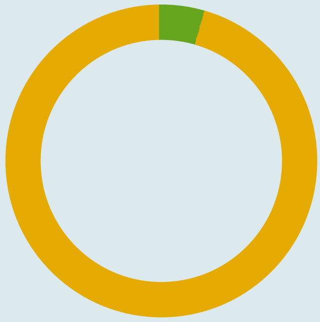
The different target states reflect the differences in natural characteristics for each river class.

- C target state: Lowland class
- B target state: Hill class
- A target state: Mountain, Spring-fed and Lake-fed classes.

Natural State waterbodies can be identified for management purposes but are assigned attribute targets according to their underlying river classification (displayed here).

The map below shows the distribution of periphyton targets for each river class within the Waituna Catchment. In this case, targets are the same for all waterways in the catchment.

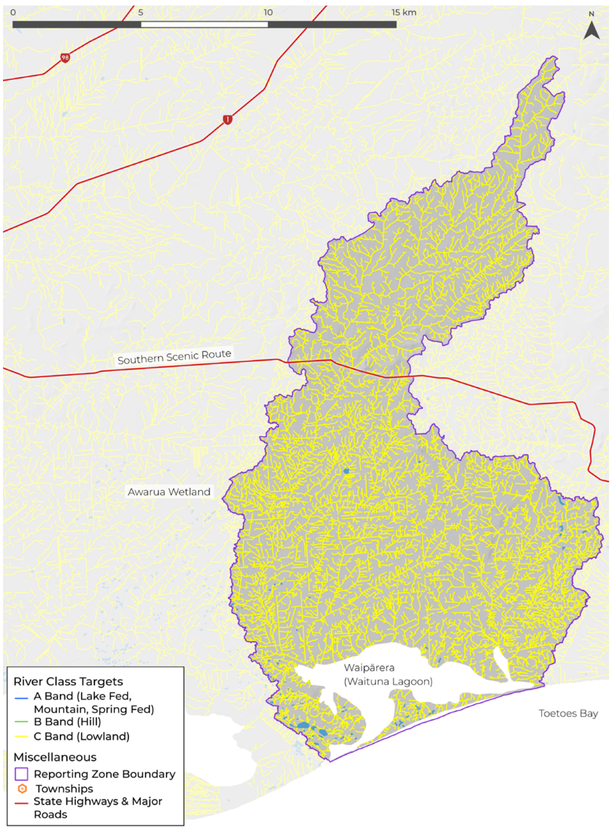
Length of river network in each class



Lowland = 271,707m

Natural State = 12,936m

River class hauora targets



Comparison of current state to targets for river classes

Hauora targets and current states for ecosystem and human health attributes are summarised in the table below for the catchment's Lowland river classes. Table colours correspond to the 'ABCDE' grading for attributes described previously. Results show that many of the monitored attributes do not achieve hauora targets.

Current state is assessed using data from the 2018-2022 period.

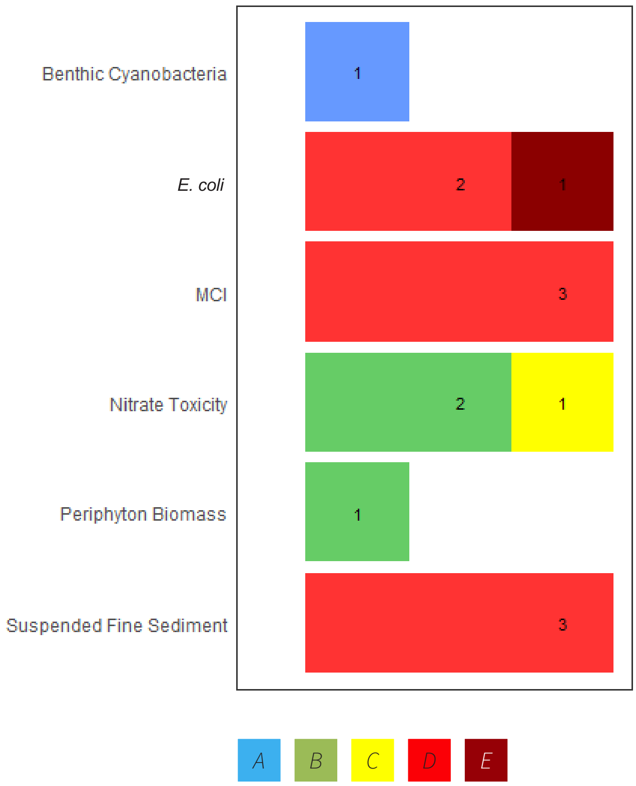
	Lowland	
Ecosystem health attributes	Hauora target	Current state
Periphyton	C	B
Nitrate toxicity	A	C
Ammonia toxicity	A	B
Suspended fine sediment	C	D
Macroinvertebrates	C	D
Deposited fine sediment	A	A
Dissolved reactive phosphorus	B	D
Water temperature (summer)	C	C
Human contact attributes		
E. coli	A	E
Benthic cyanobacteria	A	A
Visual clarity	B	D

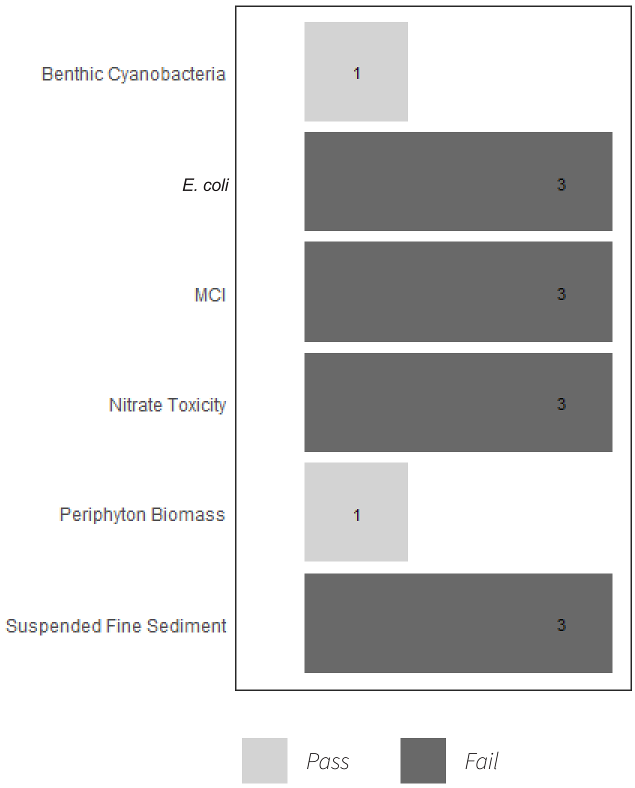
Results for streams and rivers monitoring sites

Ecosystem health

Results for the monitoring sites in the Waituna catchment are presented for nitrate toxicity, suspended fine sediment, macroinvertebrate community index (MCI), and periphyton biomass. The number of sites that meet hauora targets is also provided.

MCI and suspended fine sediment have a current state of poor throughout the Waituna catchment and require improvement to reach hauora targets. Nitrate toxicity has a current state ranging from good to fair and would require improvement to reach the hauora target of very good





Human health/contact

Sites in the Waituna catchment have poor or very poor states for *E. coli*. Substantial improvement would be required to achieve the hauora target of very good. Benthic cyanobacteria is monitored at one site which achieves the hauora target of very good.

Case study

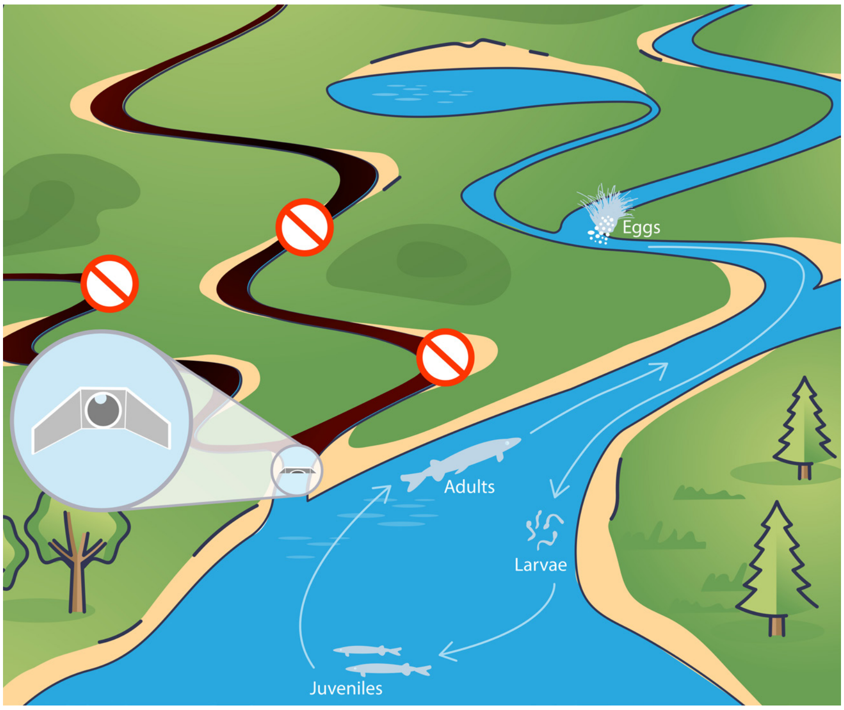
In-stream plant growth is found in the form of periphyton (algae) or macrophytes (plants with structures like leaves, stems and roots). Periphyton is an attribute that we measure and have hauora targets set for. While we monitor periphyton in Waituna Creek, the plant growth is dominated by macrophytes, and therefore the periphyton attribute is less useful as an indicator of ecosystem health compared to most Southland's rivers.

The larger size of macrophytes makes them effective at causing sediment suspended in the water column to become deposited on the streambed. This gives them more sediment to grow roots into and can make it even more suited to macrophytes growth instead of periphyton growth over time. The macrophytes also hinder assessment of the amount of sediment on the streambed and make the information that we use to assess the deposited fine sediment attribute less accurate.

Fish passage

Fish passage barriers obstruct the passage of fish species. This particularly impacts migratory fish species that complete their lifecycles in both freshwater and the ocean, such as tuna/eels, kanakana/pouched lamprey and migratory galaxiids/whitebait. Generally, the closer a barrier is to the coast, the larger the area of habitat that becomes inaccessible to migratory fish, making it a higher priority for restoring passage. Common examples of fish passage barriers include structures like culverts, weirs and dams, while natural features such as waterfalls can also form barriers. Different fish species and life stages have varying climbing and swimming abilities, so a barrier for one species or life stage may not be a barrier for another.

Whitebait lifecycle



In some cases, fish barriers may be desirable to protect populations of non-migratory galaxiids that struggle to co-exist with trout. In these cases, a barrier could be installed or maintained in a specific location to prevent trout from reaching the population of non-migratory fish.

Culverts are the most common fish passage barrier in the Waituna catchment. When culverts are designed and installed, consideration of fish passage and regular maintenance of structures will help improve fish passage.

The mainstream of both rivers is relatively free of barriers, with most occuring in the smaller tributaries and waterways of the catchment.

Groundwater

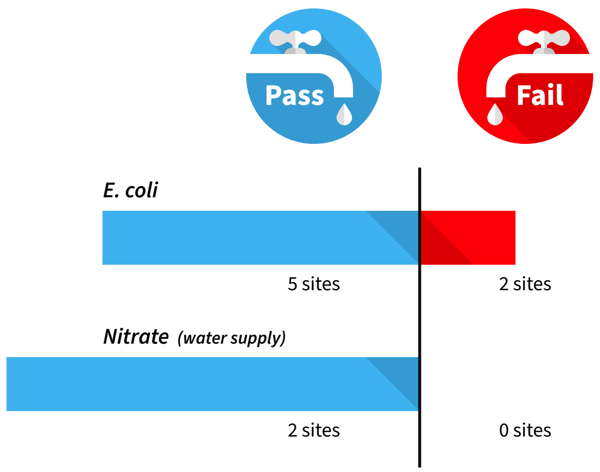
Human consumption – is it safe to drink?

Shallow groundwater is hosted in Quaternary alluvial deposits and is generally accessible across the catchment area. The depth to groundwater decreases from north to south. Along the coastal margin and around Waituna Lagoon, groundwater levels become so shallow that major wetlands have formed. The median well depth is 30m.

The main contaminants affecting the suitability of potable groundwater for drinking are pathogens (*E. coli*) and nitrate.

Target states for groundwater are based on the New Zealand drinking water standards and use a pass/fail assessment system.

Waituna groundwater assesment

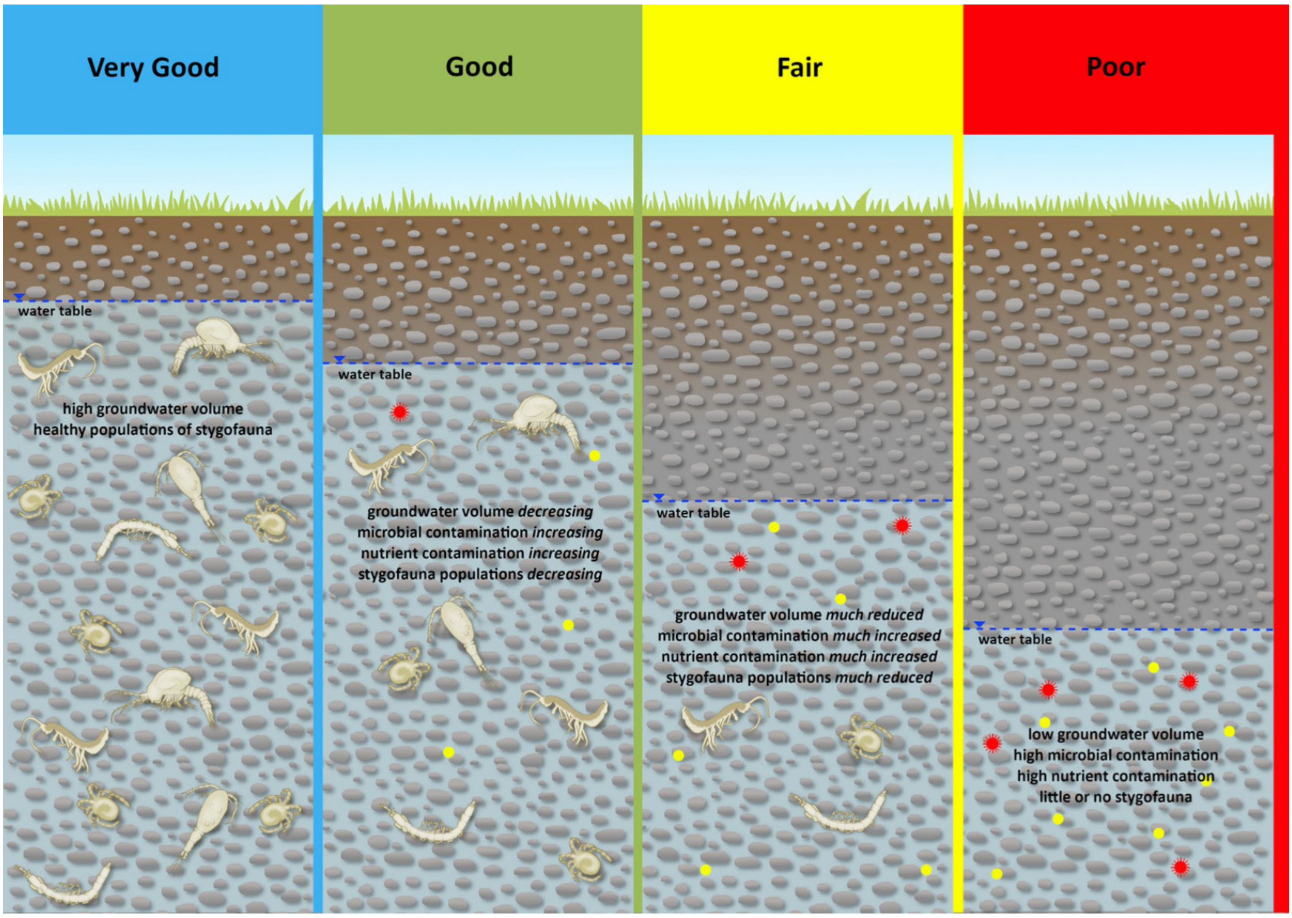


Results show that a small proportion of monitored sites in the Waituna catchment fail drinking water standards for *E. coli*. All monitored sites pass the drinking water standards for nitrate.

Ecosystem health

Nitrate concentrations are also used to monitor ecosystem health – for both groundwater ecosystems and connected surface waterways. Groundwater ecosystem health outcomes are represented conceptually in the figure. Nitrate concentrations are one factor that contributes to overall ecosystem health. Nitrate concentrations that relate to groundwater and surface water ecosystem health outcomes are different to those used in relation to drinking water mentioned above.

We have limited data to assess nitrate concentrations in the Waituna catchment. Where we do have data, nitrate concentrations achieve the hauora target of very good. The chemical conditions in the aquifers contribute to the low nitrate concentrations in this area.



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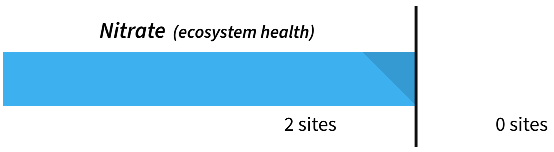
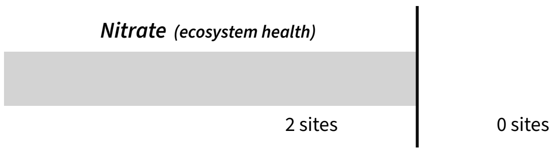




A *B* *C* *D* *E*

Pass *Fail*

Wetlands – how many do we have left?

Wetlands and water quality

Wetlands are increasingly being recognised for their functional values within the landscape. For example, their ability to intercept and attenuate agricultural runoff is now recognised as an important contribution to farm nutrient management.

Wetlands purify water through sediment capture and storing nutrients in their soils and vegetation. This is particularly important for the agricultural nutrients nitrogen and phosphorus, which contribute to the eutrophication of receiving environments such as rivers, lakes and estuaries.

For the purposes of this document wetlands are generally defined as per the Southland Water and Land Plan definition.

The following areas were not included as wetlands in this classification:

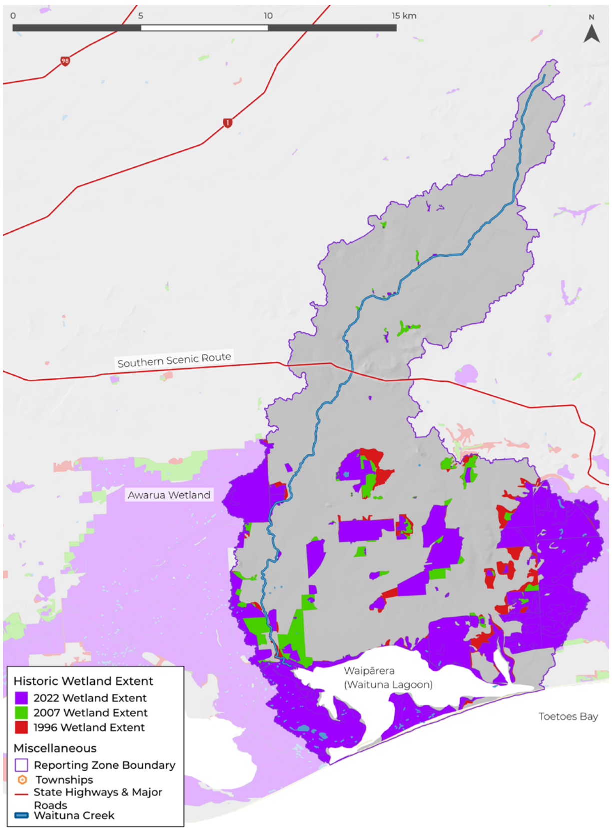
- Wet pasture or where water ponds after rain
- Pasture containing patches of rushes less than 50% total cover
- Ponds of any kind unless associated with 0.5 or more hectares of terrestrial wetland.
- Areas of forest unless previoulsy identified as wetland.
- Areas associated with the main active flood channels of rivers.

Current state

The current wetland extent for the Waituna catchment is 4525 ha. Most wetlands lost were bogs, which are the most common wetland type in Murihiku Southland. These have been mainly converted to pasture farmland with small areas of exotic forestry.

This map shows the wetland extent over three time periods. Wetland areas that have been lost since 1996 and 2007 are shown as red and green areas, respectively

Historic wetland extent



	1996 to 2007	2007 to 2022	Overall 1996 to 2022
Change in wetland area	↓ 8% 439 ha	↓ 10% 492 ha	↓ 17% 931 ha

Remaining wetlands

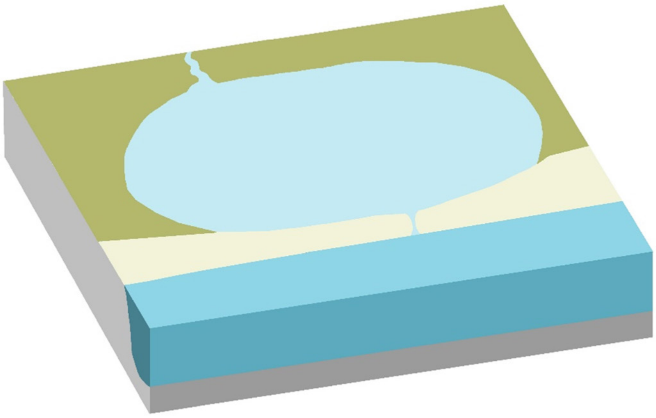
Waituna Lagoon is New Zealand's first Ramsar site, a regionally significant wetland, and one of the country's most important wetlands. Initially, it only included the Waituna Lagoon and the area immediately adjacent to the lagoon before it was expanded to incorporate the greater Awarua wetland complex. The wetland supports a diverse and abundant range of plants and animals, including native birds, lizards and fish and is culturally important. The wetland surrounding the lagoon is mostly bog with extensive oioi (wire rush) and mānuka. A second regionally significant wetland, Toetoes Flat, forms part of the expanded Awarua wetland complex but also includes fragmented bogs on private land not part of the Ramsar wetland but would have formed part of the original historic Awarua wetland complex. The upper catchment has several small bog and fen wetlands surrounded by farmland.

Of the remaining wetlands on non-conservation land, 70% are at moderate or moderately-high risk of loss.

	1	2	3	4	5
Risk of Loss (1 = low, 5 = high)	4%	13%	40%	36%	8%

Waituna Lagoon

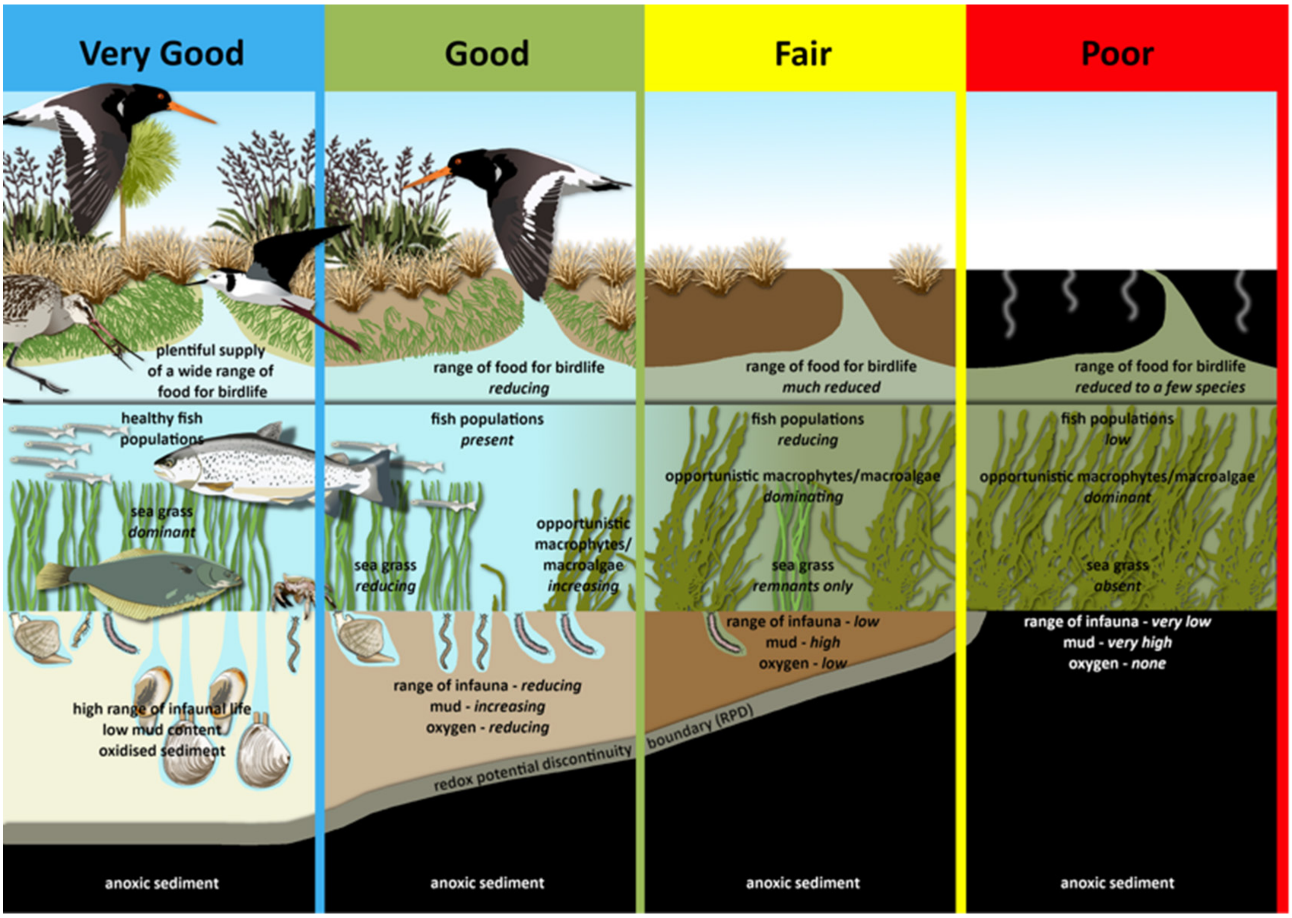
Waituna Lagoon is classified as a brackish Lagoon. The opening and closing of this lagoon refer to the connection of the waterbody to the ocean. For the past 100+ years, this has predominantly, if not exclusively, been facilitated by human actions for the purpose of land drainage at several locations along the sand barrier.



There are few examples of natural ICOLLs in Aotearoa New Zealand, and those that are present tend to be in hypertrophic or highly degraded states (e.g. Te Waihora/ Lake Ellesmere). This is due to their location at the bottom of typically highly modified catchments and a lack of continual ocean interaction to facilitate flushing of land-based contaminants (including fine sediment).

Lakes and lagoon outcomes can be described on a scale from ‘very good’ to ‘poor’. Using this scale helps us to understand the current freshwater environment state, and what we might be trying to achieve in the future. This concept is depicted in the image below.

We measure the aspects of the freshwater environment that can help us define and determine outcomes for lakes and lagoons.



	Brackish lakes and lagoons (Waituna Lagoon)		
Ecosystem health attributes	Hauora target	Current state (closed)	Current state (open)
Phytoplankton	B	D	C
Total phosphorus	B	C	C
Total nitrogen	C	D	C
Ammonia toxicity	A	B	B
Nitrate toxicity	A	B	B
Macrophytes	B	B	-
Trophic state	B	D	C
Human contact attributes			
E. coli	A	A	A
Cyanobacteria (planktonic)	A	C	A

"-" data not available.

Waituna Lagoon does not currently meet the hauora target for either of the two nutrient attributes. Both nutrient attributes (TN and TP) are required to improve by one band to reach the target.

Of the two nutrient-affected attributes (phytoplankton and macrophytes) phytoplankton is currently in poor state and would require improvement to achieve the hauora target of good. Macrophytes have a current state of good and are the only ecosystem health attribute to achieve the hauora target.

E. coli achieves the hauora target of very good, indicating that the *E. coli* concentrations do not usually present a risk to recreational users. In contrast, planktonic cyanobacteria has a current state of fair and would require improvement to very good to achieve the hauora target.

Water quantity – how much do we have, and how much are we using?

Surface water allocation

Surface water takes are managed through two types of allocation blocks. A primary allocation block restricts the amount of water that can be taken during low flows (allocation available is 30% of Q95). A secondary allocation block restricts the amount of water that can be taken when flows are above mean or median levels, depending on the time of year (10% of mean flow from December to March and 10% of median flow from April to November).

Stream depletion occurs when groundwater is abstracted in an area hydraulically connected to nearby surface waterways, reducing stream flow. As a result, it must be accounted for in surface water and groundwater allocation management. Under the Southland Water and Land Plan, we are required to manage surface water allocation at any point of a surface water network, so allocation totals change along rivers to reflect the balance between the natural addition of water and the abstraction of water.

The following allocation figures do not include permitted take estimates.

2% of the Waituna Creek primary allocation block has been allocated, when analysed at the Marshall Road monitoring site. This represents a sole consented take for dairying.

Site	Primary allocation (l/s)		Secondary allocation – Summer - 1 Dec - 31 Mar (l/s)			Secondary allocation – Remainder of year - 1 Apr - 31 Nov (l/s)		
	Minimum flow (Q95, l/s)	Most consecutive days below Q95	Mean (l/s)	Average days below mean (Summer period)	Most consecutive days below mean (Summer period)	Median (l/s)	Average days below median (remainder of year period)	Most consecutive days below median (remainder of year period)
Waituna Creek at Marshall Road	103	44 (2022)	1,517	90	121 (2022)	798	69	55 (2012)

	Primary allocated (l/s)	Primary allocation (% of limit)
Waituna Creek at Marshall Road	2	7

Groundwater allocation

Most groundwater allocation thresholds are set using a proportion of annual rainfall recharge to aquifers, varying depending on the aquifer type. In the Waituna catchment, there is one Groundwater Management Zone (GMZ); the Awarua GMZ which is 3.7% allocated. This GMZ covers almost all the Waituna catchment and extends to cover a considerable area to the west where it underlies part of the Ōreti catchment. Because GMZ are delineated management zones under the Southland Water and Land Plan, the Awarua zone has been included in its entirety in the Waituna catchment instead of being split between multiple catchments.

Most of the allocated groundwater is consented for dairy (94%) with the other use being commercial (6%).

Monitoring data provided by consent holders indicates that groundwater use for consented dairy takes is approximately half of the total volume allocated for the 2022/2023 season. There is no data to give an indication of the use for the consented commercial abstraction.

How much do we need to reduce contaminants to achieve a state of hauora?

Regional contaminant modelling

We have undertaken contaminant modelling to help us better understand water quality across Muruhiku Southland. This modelling utilises monitoring data to estimate water quality in all waterbodies (excluding Fiordland and Islands). This expanded view of water quality allows us to estimate the reductions in contaminant load and concentrations required to achieve the identified target attribute states and to test the impact of different land use scenarios.

For this work, we focus on four main contaminants of concern: nitrogen, phosphorus, sediment, and *E. coli*. Actions taken to reduce the impact of these contaminants on our freshwater systems will have benefits for ecological and human health outcomes.

How much do contaminant loads need to be reduced?

Load is a measure of the total mass of a contaminant (in kg or tonnes) coming from a given area past a given point over time. For example, the total amount of nitrogen delivered to the sea by a river in one year.

We use loads to quantify contaminants here because they describe the amount of contaminants lost over a whole catchment area. It is the land that consequently needs to be managed to reduce those loads. It is important to remember that concentrations (e.g., the mass of the contaminant per litre of water in the waterbody in kg/L) must also be considered. Concentrations in waterbodies are affected by the size of the contaminant load lost from land and the amount of water available to dilute that load. Hence, water takes and climate can affect concentrations too.

Concentrations are the relative amount of contaminant present in a given volume of water at that time. Concentrations are important because they have direct relevance to toxicity attributes as well as ecological processes.

This modelling considers draft targets for the following attributes:

Rivers
Periphyton biomass, nitrate toxicity, dissolved reactive phosphorus, visual clarity, suspended sediment, *E. coli*.

Lakes
Total nitrogen, total phosphorus, phytoplankton.

Estuaries
Macroalgae.

This modelling accounts for loads and concentrations required to achieve target states everywhere for all the above attributes.

Estimated load reductions for the Waituna catchment are presented in the table. Load estimates were calculated using sites with ten years of data and relates to 2017.

It is worth noting that several previous studies have also estimated the nutrient load reductions required to achieve lagoon water quality objectives. These studies also indicate that reductions required are large (≥50% for nitrogen).

Contaminant	Total Load (2017 - Best estimate*)	Percentage load reduction required to achieve hauora (Best estimate*)
Total Nitrogen	249 Tonnes/Year	↓ 77% (58-90)
Total Phosphorus	8 Tonnes/Year	↓ 61% (12-85)
Sediment	460Tonnes/Year	↓ 84%
E. coli	5 peta *E.coli*/Year	↓ 78% (50-93)

These values represent our best estimate. Levels of uncertainty are indicated by the 90% confidence interval shown in brackets where available.

What options do we have to reduce nutrient and sediment loads?

We have modelled different scenarios to indicate how far each may go toward achieving the estimated load reductions required. We have also bundled multiple scenarios to test the effect of combining multiple strategies.

This work is not intended to assess individual properties or activities. Rather, it generalises land use so that we can make some broad catchment scale assessments of the impact of different actions. This can also help give information about the differences between possible allocation approaches.

The results for each of the scenarios modelled are presented below. Explanations of each scenario can be found in our published reports. The coloured table cells indicate how far each scenario achieves the required load reductions.

None of the tested scenarios would likely achieve the nitrogen reductions required. This is because the reductions are very large and will likely require more widespread changes to how land is used rather than maintaining the status quo and relying on the implementation of mitigations.

We have also modelled phosphorus and suspended sediment load reductions under different mitigation options. These results are not presented here for simplicity, but broadly show:

- Implementation of scenarios 5 and 15 (over page) are estimated to achieve the phosphorus reductions required. Furthermore, scenarios 2, 3, 4, 9, 11, 12, 13, and 14 were estimated to achieve reductions within the uncertainty of the required estimate. The range of reductions across all scenarios was between 0 – 71%.
- Implementation of the existing rules and regulations relating to sediment was estimated to achieve a 50% reduction in suspended sediment load. This is large but still less than the 84% reduction required to support hauora.

ID	Scenario	Reduction in nitrogen load (%)	Remaining deficit from target (%)
Individual methods			
1	100% adoption of established farm Good Management Practice (GMP) mitigations	19	58
2	Adoption of all established and developing farm mitigations	49	28
3	Wetlands returned to the same area as existed in 1996	13	64
4	Establishment of wetlands in a way that treats all surface runoff from agricultural land	37	40
5	Establishment of large community wetlands in inherently suitable areas	60	17
6	All wastewater point sources are discharged to land rather than directly to water	0	77
7	Reducing land use intensity on flood prone land	0	77
8	Reducing land use intensity on public land	1	76
9	Destocking (10% reduction drystock, 20% reduction dairy)	29	48
10	Riparian planting (full shading of streams <7m wide)	1 (indirect effect on periphyton)	76
Bundled methods			
11	1996 wetlands returned, wastewater discharged to land (3 + 6)	12	65
12	Established and developing farm mitigations, 1996 wetlands, wastewater to land (2 + 3 + 6)	55	22
13	Established and developing farm mitigations, 1996 wetlands, wastewater to land, repurposing public land (2 + 3 + 6 + 8)	56	21
14	Established and developing farm mitigations, 5% wetlands, wastewater to land, repurposing public land (2 + 4 + 6 + 8)	68	9
15	Established and developing farm mitigations, community wetlands, wastewater to land (2 + 5 + 6)	79	-2
16	Established farm mitigations, wastewater to land, plantain on dairy farms, 1996 wetlands, repurposing of ES land, forestry expansion (1 + 6 + 3 + new individual methods)	27	50

Required reductions likely achieved (green) — *Within uncertainty range* (orange) — *Deficit remaining* (red)

Reducing load from pastoral land across the catchment

We also examined the effect of different nitrogen load reduction scenarios for dairy and drystock farms on the overall catchment load. The purpose of this work was to help show the load reductions that could be achieved by reducing contaminant losses from drystock and dairy land.

The table shows the catchment load reduction achieved (coloured cells) for each combination of simulated reductions. For example, we can see that a 40% reduction in loss from dairy farms combined with a 20% reduction from drystock farms will result in approximately a 29% reduction in the instream TN load across the catchment.

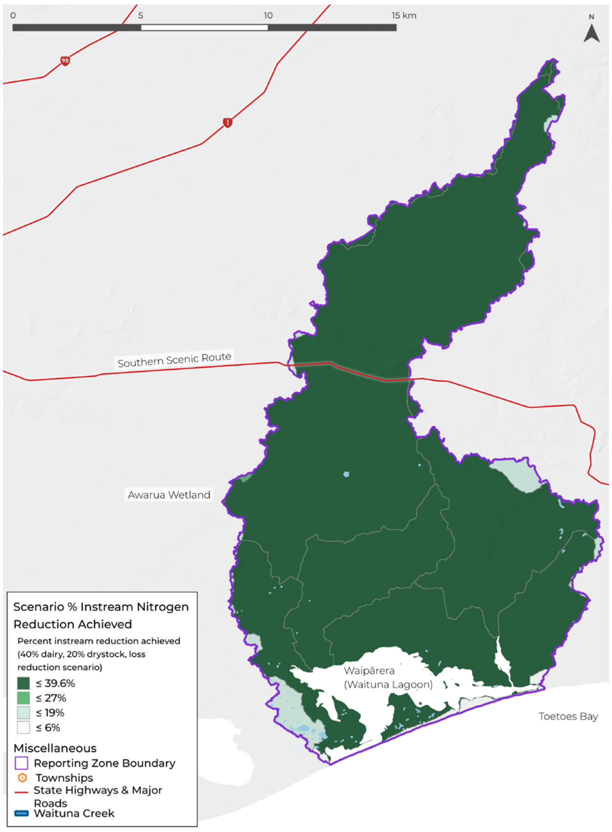
Basin-wide mean % TN reduction, relative to baseline

Drystock loss rate reduction (%)					
80%	24%	35%	47%	59%	70%
60%	18%	29%	41%	53%	65%
40%	12%	24%	35%	47%	59%
20%	6%	18%	29%	41%	53%
0%	0%	13%	13%	27%	40%
	0%	20%	40%	60%	80%

Dairy loss rate reduction (%)

- *Required reductions likely achieved* (green)
- *Within uncertainty range* (orange)
- *Deficit remaining* (red)

Instream nitrogen reduction achieved (%)



The map shows how the modelled nitrogen reductions achieved vary spatially across the sub-catchments. It highlights that we might expect reductions to be relatively similar across the catchment under that scenario. This is largely due to the widespread nature of dairy farming in the catchment.

Opportunities for action

We've put together opportunities for action in the Waituna catchment to reduce contaminant loads and improve the state of freshwater.

The catchment

Scale of the problem

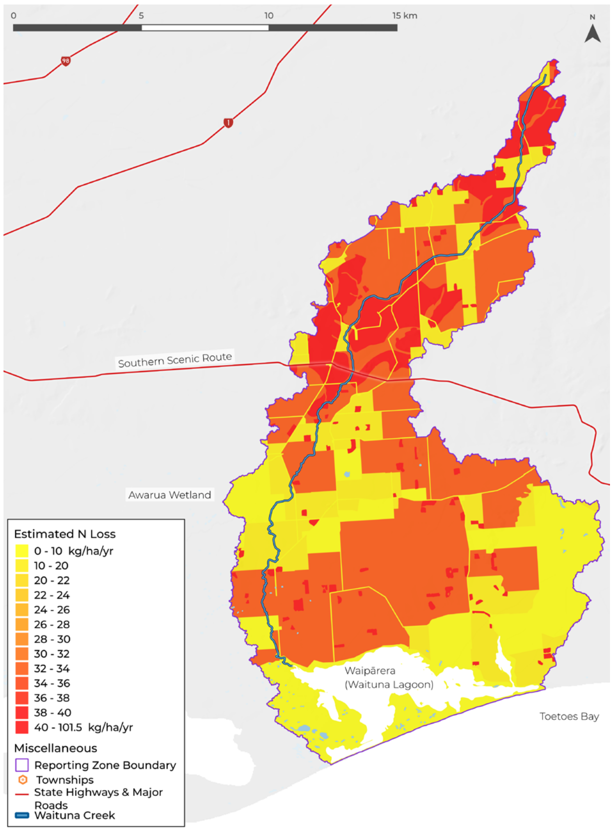
There are extensive areas of land contributing high contaminant loads in this catchment.

The following map set shows the spatial distribution of intensive land use and the associated estimated nitrogen loss, the modelled in-stream nitrogen concentrations (using monitoring data), and the modelled excess nitrogen load patterns across the catchment. These maps help to demonstrate the spatial scale of the reductions required. Excess loads depend on the modelled concentrations as well as all the defined targets both local and downstream. This map indicates the magnitude of nitrogen load reductions needed to achieve all river and estuary targets for the entire catchment area.

High nitrogen loads may be difficult to mitigate, and the implementation of improved management practices alone is unlikely to achieve the desired outcomes for freshwater and the estuary. Consideration should be given to the potential for large-scale catchment mitigations and changes to the way land is used.

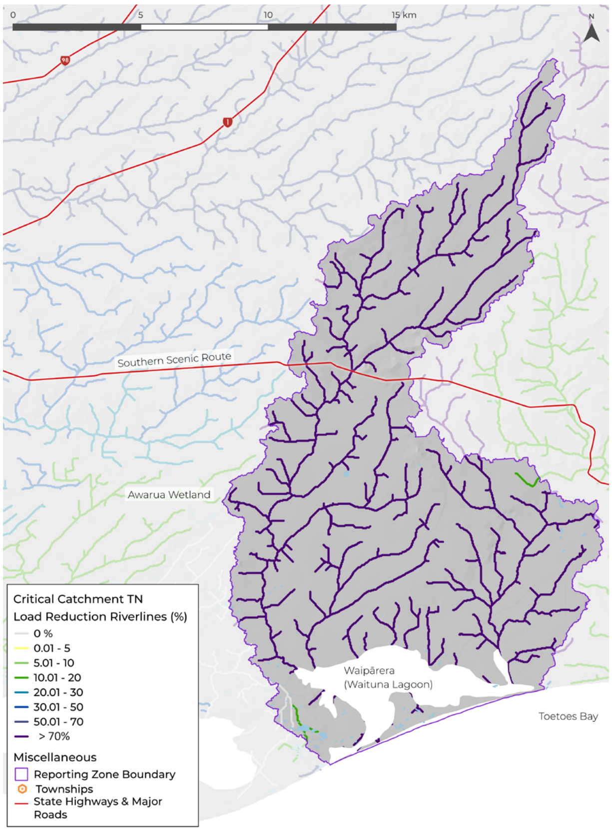
Large nitrogen reductions over large areas will likely require changes to land use over a long period of time. This might be through exploration and adoption of different land uses or via technological advances in farm systems and management. In addition, because the hydrology of the catchment has been extensively modified through stream channel straightening and artificial drainage, efforts to implement nature-based solutions and slow water flow are likely to have multiple benefits for water quality, biodiversity, flood mitigation, and catchment resilience.

Estimated nitrogen loss

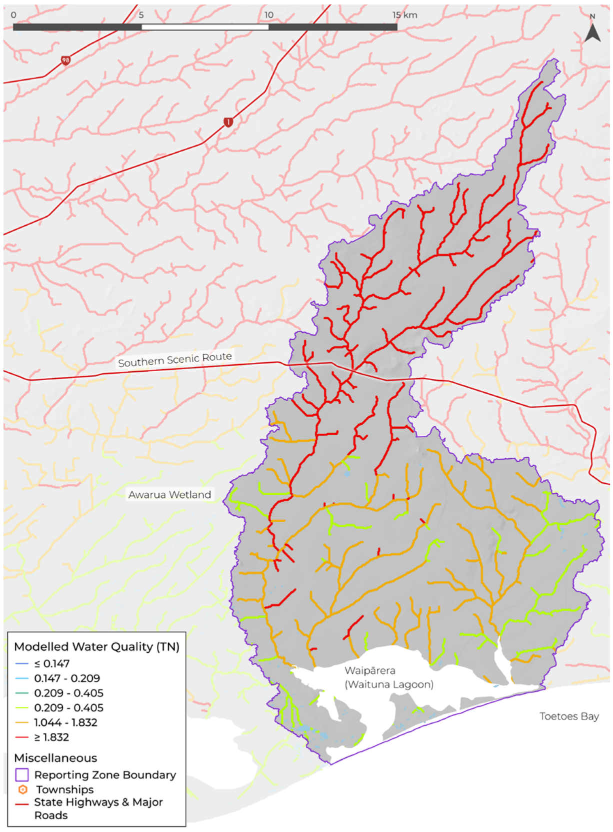


Nitrogen loss depicted here is an approximation and only differentiated by land use, soil drainage, rainfall/irrigation and slope.

Critical catchment TN load reduction (%) riverlines



Modelled water quality (Total Nitrogen)



Farm scale opportunities for action

Farm-scale actions should be tailored to the physiographic setting and catchment priorities. In the Waituna catchment, load reductions are required for all major contaminants (nitrogen, phosphorus, sediment, and *E. coli*).

We can use farm-scale observations, physiographic information, and our understanding of water quality to help refine the most relevant actions for a given location or landscape.

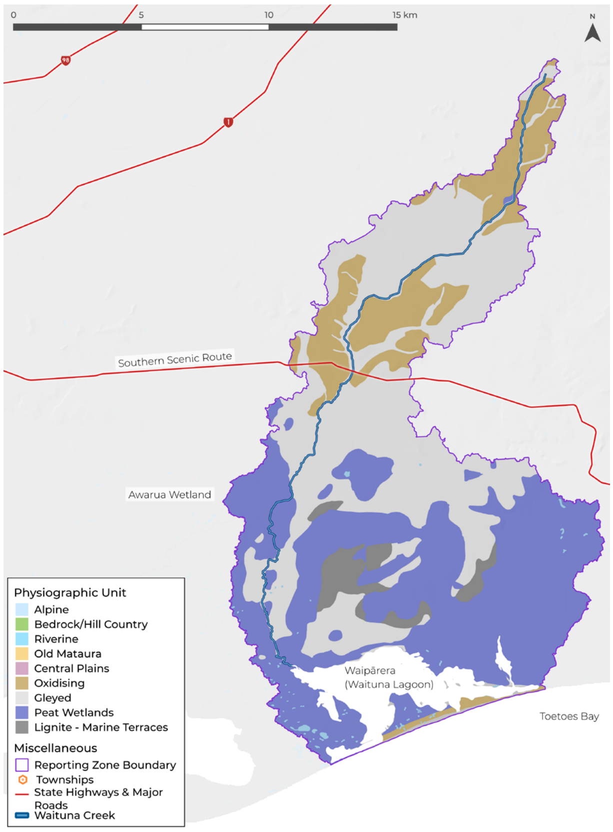
Physiographic information helps us to better understand how contaminants move through the landscape. Each zone has common attributes that influence water quality, such as climate, topography, geology and soil type.

Physiographic zones differ in how contaminants build up and move through the soil, through areas of groundwater and into rivers and streams.

Contaminants can move from the land to waterways via:

- overland flow (or surface runoff)
- artificial drainage - e.g. tile drains and mole pipe drainage
- deep drainage (or leaching) - of either nitrogen or phosphorus to groundwater
- lateral drainage (or horizontal movement through the soil) - of phosphorus and microbes

Physiographic zones



These key transport pathways for contaminants differ for each physiographic zone. Understanding differences between zones allows for targeted land use and management strategies to be developed to reduce impacts on water quality.

Widespread implementation of property actions to improve water quality can have significant co-benefits for catchment hydrology (flood risk and climate change resilience) as well as biodiversity outcomes.

The Waituna catchment is predominantly made up of gleyed and oxidising zones in the Northern areas, and peat wetlands, gleyed and lignite/marine terraces zones in the Southern areas.

Farm scale or more resolute physiographic information may be available in some locations. We promote the use of the best information available to identify farm specific risks and solutions.

The maps help to identify the most important actions to focus on in different parts of the catchment.

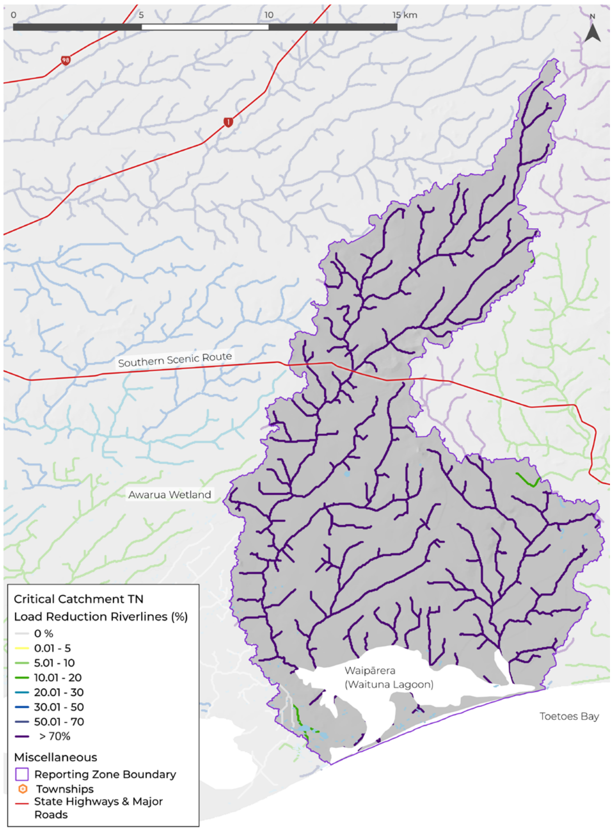
Nitrogen

Over time, widespread load reductions will be required to achieve hauora targets.

This means reducing nitrogen loss should be a priority in all farm-scale mitigation planning.

Physiographic zones can help to identify what contaminant loss pathways likely need attention in different locations. The excess load map shown here indicates parts of the catchment where nitrogen loss mitigation should be a particular focus on farm. This map indicates the magnitude of nitrogen load reductions needed to achieve all river and estuary targets for the entire catchment area.

Critical catchment TN load reduction (%) riverlines



Phosphorus

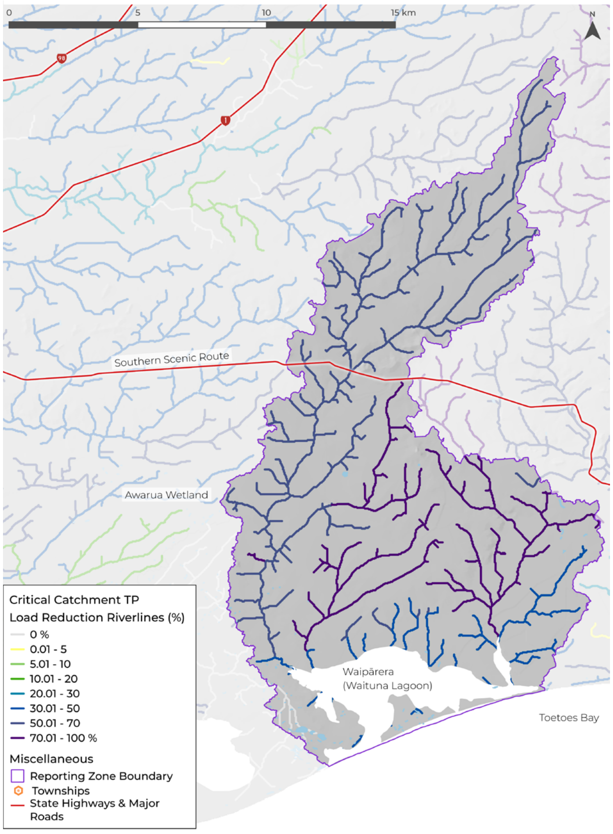
Over time, widespread load reductions will be required to achieve hauora targets.

This means reducing phosphorus loss should be a priority in all farm-scale mitigation planning.

Physiographic zones can help to identify what contaminant loss pathways likely need attention in different locations. In particular, organic rich soils can be prone to high rates of phosphorus loss and likely contribute disproportionately to the catchment load.

The excess load map indicates areas where phosphorus loss mitigation should be a particular focus in farm planning. In this case large reductions are right across the catchment.

Critical excess TP load reduction (%) riverlines

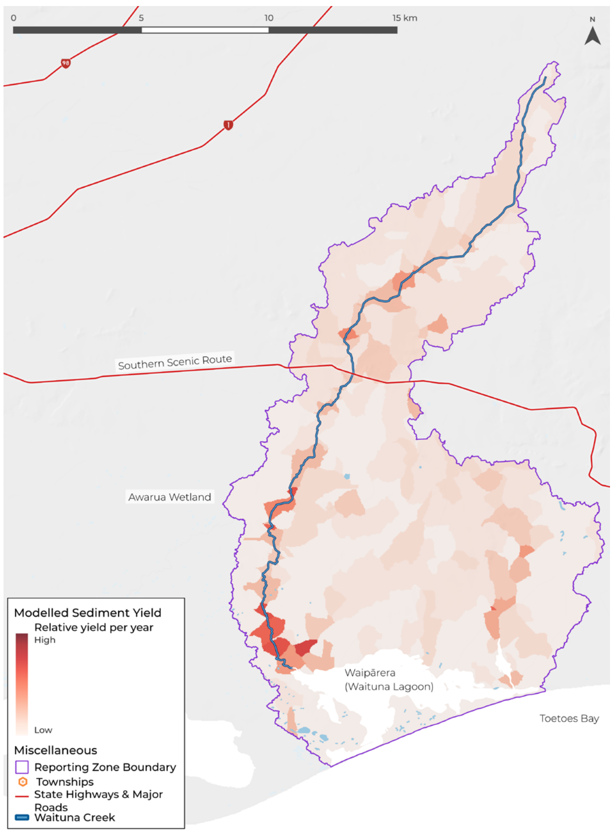


Sediment

The map (right) shows how we expect sediment loss to vary throughout the catchment. There are places in the agricultural landscape that have higher rates of sediment loss. These are primarily areas with more sloping land, soils susceptible to erosion, and where stream bank erosion is likely an issue.

Sediment from agricultural land generally poses a greater threat to rivers and the estuary, as it is often fine-grained and carries higher concentrations of nutrients. Properties within the areas shaded darker red should specifically look for opportunities and mitigations to reduce sediment loss. Because of the landscape features in this catchment, actions should focus on minimising stream bank erosion, losses from critical source areas, and episodic losses from high-risk activities such as winter grazing and cultivation.

Modelled sediment yield



E. coli

The risk of *E. coli* loss to water depends on landscape type, slope, stock and vegetation. Property scale assessments should be used to mitigate the highest risk loss pathways on farms.

Waituna Lagoon – opportunities for action

Active restoration may include:

- Reducing contaminant loads to support ecosystem health and function.
- Introducing an opening and closing regime that is targeted specifically at improving ecological outcomes and resilience in Waituna Lagoon.
- Retiring and restoring marginal land around Waituna Lagoon.

Nitrogen loss to groundwater in areas of the oxidising physiographic zone (well-drained soils) is likely contributing disproportionately to the nitrogen load in the catchment. In these locations, landowners should implement management plans that focus on key pathways and the stockpile of property scale actions that target nitrogen loss via deep drainage.

Groundwater contamination

Actions to reduce *E. coli* in groundwater

E. coli contamination of groundwater and groundwater drinking supplies is a widespread issue across Waituna and Muruhiku Southland.

Actions to reduce *E. coli* to groundwater:

- Ensure good well-head protection is in place for all bores, especially bores used for drinking water.
- Carefully consider the proximity of contamination point sources to bores. These can be things like septic tanks, stock sheds and effluent storage.
- Carefully consider effluent application on freely draining soils or soils with a high likelihood of bypass flow (cracks or conduits that may allow effluent to flow directly to groundwater).
- Ensure wastewater and stormwater are not cross-connected in industrial and municipal systems.
- Target improvements to on-site wastewater disposal systems to reduce the risk on human faecal contamination of freshwater.
- Urban development incorporates best practice stormwater management methods.

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