Our Ecosystems

Southland Water 2010: Part 2

Te Ao Marama Inc.

environment SOUTHLAND Te Taiao Tonga

Whakatauaki

Hutia te rito o te harakeke	*If you pluck out the centre shoot of the flax*
Kei whea to kōmako e ko?	*Where will the bellbird sing?*
Ka rere ki uta, ka rere ki tai	*It will fly inland, it will fly seawards*
Ki mai koe ki ahau	*If you ask me*
He aha te mea nui	*What is the greatest thing*
O tēnei ao	*On Earth*
Maku e ki atu	*Then I shall reply*
He tangata, he tangata, he tangata.	*It is people, it is people, it is people.*

Our Ecosystems: How healthy is the life in our water and our freshwater ecosystems?

Southland Water 2010: Part 2

Bibliographic reference:
Environment Southland and Te Ao Marama Inc. 2011.
Our Ecosystems: How healthy is the life in our water and our freshwater ecosystems?
Part 2 of Southland Water 2010: Report on the State of Southland's Freshwater Environment.
Environment Southland. Invercargill. Publication number 2011/7 ISBN 0-909043-45-0

Cover photo credit: Z. Moss.
Other photos as mentioned.

Designed by **SRA Media Ltd**.

Printed by **Craigs Design and Print Ltd**.

Printed on **Forest Stewardship Certified** paper.

Full reference list and supporting materials on www.es.govt.nz.

Kowhaiwhai design featured illustrates patiki (flounder and symbol of hospitality).

Foreword

The health of Southland's freshwater resources has been a popular topic of conversation for some time, gaining publicity locally and nationally through the issues like those facing the Waituna Lagoon.

The lagoon has become synonymous with degraded water quality through the impacts of intensive land use. But the sorry truth is that it's just one of many waterways in Southland and around the country that are suffering in the same way.

Our Ecosystems, one in a series of four reports, represents a significant amount of work, and we are pleased to have been able to partner with Te Ao Marama Incorporated in writing this series, Southland Water 2010.

This comprehensive report sets a baseline from which we can measure our performance in meeting the targets set in the Regional Water Plan. Those targets are to reduce the levels of nitrogen, phosphorus and faecal coliforms, and improve water clarity by at least 10% over the next 10 years.

We already recognise the need to address the causes of poor water quality, and we intend to lead the way by working with all the groups whose activities are contributing to the problem.

There is no easy way round this and no one simple answer. The solution will only be found if the whole community accepts responsibility for water quality and every single one of us makes changes.

This means people living in towns will have to improve the quality of the water in their drains and farmers will have to accept that the way they operate their business has a direct impact on the environment.

Ali Timms
Environment Southland Chairman

Whāia te iti kahurangi, Ki te tūohu koe, me he maunga teitei

Pursue excellence – should you stumble, let it be to a lofty mountain

Water is the lifeblood of Papatūānuku (mother earth); it sustains her, our life, and our cultural identity.

Mahinga kai (the gathering of resources and food) is at the heart of Ngāi Tahu culture. It creates and maintains our whanau and hapu ties through the activities of fishing, eeling and gathering cultural materials. It also provides the link from one generation to the next – passing with it the knowledge of managing, preparing and consuming kai.

The health of the lower reaches of catchments particularly concerns us – as it is here that we use the water closest to our settlements and where we have the easiest access to mahinga kai. It is where many of our food baskets, such as Watiuna Lagoon and estuaries are showing the most stress from the pressures of upstream intensive production and development. The degradation of these sites not only harms the life sustained by them, it harms our people – our cultural health and wellbeing, and indeed our cultural survival.

Ngāi Tahu ki Murihiku have been concerned for some about the state of this taonga (treasure). Compiling the Southland Water 2010 report series is an important first step in the collaborative journey – using Māori monitoring tools and frameworks to inform our resource management mahi (work).

Water is a taonga and it is the responsibility of this generation as kaitiaki (guardians) to ensure this is available for future generations – in as good as, if not better quality as now. This may seem an insurmountable task, but it is one we must all work together to achieve.

Donald Mowat
Te Ao Mārama Incorporated Chairman

At a glance

Our Ecosystems is one of four reports which together make up *Southland Water 2010: Report on the State of Southland's Freshwater Environment*. Here we report on the health, and changes in health, of the following freshwater ecosystems.

Our rivers and streams — Ngā awa

Nutrients: We report on the dissolved inorganic forms of nitrogen and phosphorus, as these are the forms that are easily taken up by the life in our waters and can produce nuisance growths of algae. High concentrations of ammonia and nitrate–nitrite–nitrogen can be toxic to freshwater fish and invertebrates.

- **Dissolved reactive phosphorous (DRP):** Just over 50% of the sites we monitor have very poor and poor compliance with national guidelines. Since 1 July 2000, the majority of sites (67%) have shown no change in condition (ie no trend), 26% have been improving, and 7% have shown deterioration.
- **Nitrate–nitrite–nitrogen (NNN):** The majority of sites (63%) showed very good compliance with NNN guidelines for chronic toxicity. However 12% of our sites have very poor to poor compliance, indicating that the NNN levels are likely to be increasing the health risk to aquatic animals. Since 1 July 2000, 48% of sites have shown deterioration in condition, 46% have shown no change, and 6% are improving.
- **Ammonia (NH_3):** All sites complied with the NH_3 guidelines, and 65% of those sites show no change in concentrations over time. A quarter of the sites show an increasing trend (deterioration) and 10% show an improvement.

Visual clarity: Visual clarity is the measurement of how far you can see through the water. It provides an indication of the level of suspended sediment or algae in the water. The majority of the monitored sites (54%) showed only fair compliance with visual clarity standards. Since 1 July 2000, 86% of sites have shown no change in condition (ie no trend), 10% have shown improving visual clarity and 4% have deteriorated.

Faecal bacteria: Faecal bacteria indicate human or animal faecal matter and the possible presence of disease-causing organisms. When broken down in water, faecal bacteria consumes dissolved oxygen and releases nutrients. The majority of monitored sites (61%) showed good or very good compliance with faecal bacteria standards. Since 1 July 2000, 87% have shown no change in condition (ie no trend), 12% have shown decreasing bacteria levels and only 1% have shown increasing levels.

Within this section we also report on the variables: temperature, dissolved oxygen, and the indices for cultural health and water quality.

National comparison: In a national report from the Ministry for the Environment (MfE), Southland was ranked the worst out of all regions for NNN concentrations, third worst for visual clarity, and sixth worst for faecal bacteria and DRP concentrations (2003 to 2007).

The life in our waters – Koiora wai

This section reports on the life that we monitor within our ecosystems - macroinvertebrates, periphyton and fish. These organisms are slower to show the effects of changes in their habitat and water quality; however when effects are shown on these organisms this should signal real concern.

- **Macroinvertebrates:** Based on their Macroinvertebrate Community Index scores, 23% of our monitored sites were classified as 'excellent', 39% as 'good', 32% as 'fair' and 6% as 'poor'. Overall, 71% of sites fell into the 'good' or 'fair' quality classes, indicating mild to moderate pollution at these sites.
- **Periphyton:** The majority (75% and 48%) of the monitored sites for the two measures of algae biomass, chlorophyll *a* and Ash Free Dry Mass, showed very good compliance with periphyton guidelines.
- **Fish:** The Southland records in the New Zealand Freshwater database (1970 to 2010) were used to calculate the Southland Index of Biotic Integrity (IBI). The majority of records were spread evenly between the 'good', 'fair' and 'poor' IBI categories, while 10% were classed as 'excellent' and 5% as

having no fish. Southland sites, within both the 'high productivity pastoral' and 'tussock' land cover classes, showed a significant decline in IBI scores between the periods 1970–1999 and 2000–2010. However, Southland has significantly higher IBI scores in the 'high productivity pastoral' and 'tussock' land cover classes than the New Zealand average.

Our lakes and lagoons — Ngā roto waimāori

Natural state lakes: Lakes Manapouri and Te Anau are within the oligotrophic category of the Trophic Level Index, ie have good water quality. Total nitrogen levels are improving in Lake Te Anau, while clarity has been deteriorating in Lake Manapouri, and this requires further investigation.

Lowland coastal lakes: Waituna Lagoon is part of the internationally recognised Awarua Wetlands, which became a Ramsar site in 1976. The lagoon is eutrophic, ie has poor water quality with high concentrations of nutrients. Data from Waituna Lagoon indicates an increasing trend for total nitrogen and total phosphorus at some sites.

Recent monitoring has shown that Waituna Lagoon is at risk of a shift in lake water quality that is called 'flipping', which would change the lagoon into a highly degraded murky water state and harm the highly valued fishery, birdlife, and wetlands, as well as the cultural and recreational values of the lagoon.

Our wetlands — Ngā repo

There is currently no regular monitoring of wetlands in Southland. This means very little is known about the general health of Southland's wetlands. However, we do know that we have lost 90% of our wetlands since circa 1840 (excluding Fiordland and Rakiura National Park areas).

Our estuaries — Ngā wahapu

The condition ratings of our ten monitored estuaries range from 'poor' to 'very good', with three estuaries in each of the 'poor', 'moderate' and 'very good' categories. The best estuarine ecosystems in Southland are in undeveloped catchments, around Awarua Bay and Freshwater Estuary on Stewart Island.

Tidal dominated systems with highly developed catchments like New River, Jacobs River and Waikawa, are in the worst condition.

Since 2000, none of the Southland estuaries have shown improvement in their condition ratings. Overall, the majority of indicators are showing no change (60%), while the rest are deteriorating over time.

How do we affect and what we are doing about the health of our ecosystems?

The majority of our monitoring occurs within the developed parts of Southland/Murihiku (excluding Fiordland and Rakiura National Parks). Therefore, this report focuses on the areas of Southland where we interact, work in and have the most influence on our freshwater environment.

Southland's main economic contributor is agriculture and primary production. Land-use has intensified significantly over the past two decades, especially dairying and dairying support. This has great economic advantages for Southland, but the rapid intensification of agriculture is, in part, reflected in the health of our waterways. NNN concentrations in our rivers, streams and groundwater (See *'Our Health'*) reflect this intensification, through contributions from animal urine to increased stocking rates and winter fodder crop grazing. There can also be a lagged effect, whereby groundwater, currently contributing to our surface waters, is decades old.

We are tackling issues such as effluent disposal, stock access and winter grazing, and educating our community on how to look after our freshwater environment. The delay of measuring changes in our environment from particular responses is probably the reason why we have not yet seen any large improvements in the health of our freshwater environment.

There is no doubt that it is the cumulative effects of intensification of land-use, seen in the effects of NNN increases, the rapid deterioration of Waituna Lagoon and the deterioration of our estuaries and loss of wetlands that requires further action. This will require hard work, a more focussed approach, and a willingness to change our current practices where necessary – Southland's social, cultural, economic and environmental wellbeing depends on this.

Mō tātou, ā, mō ngā uri, ā muri ake nei
For us and our children after us
— Ngāi Tahu whakataukī

Figure 1: Southland Region

Introduction to Southland Water 2010

> *He taura whiri kotahi mai ano te kopunga tai no i te Pū au*
>
> *From the source to the mouth of the river all things are joined together as one*[1]

In our natural environment, water can be categorised as rainfall, surface water (eg rivers, lakes and wetlands), groundwater and coastal marine waters.[2] These forms of water are all connected in the hydrological cycle: rainwater supplies our rivers and groundwater aquifers, groundwater supplies some of our surface waters, surface waters contribute to some of our aquifers, and rivers and some aquifers discharge water to the sea.

For Māori, water or wai also has categories according to its spiritual and geographical features. These categories include: waiora (pure water used for healing), waimāori (ordinary water), waitohi (pure water used to remove tapu), waimate (dead water), wai whakaheke tūpāpaku (burial waters), waipuna (springs) and waimātaitai (brackish/estuarine waters).

Southland's social, cultural, economic and environmental wellbeing is supported by and interwoven with the quality and quantity of these waters.

Our quality of life depends on a constant and clean supply of water to our homes and businesses, and the ability to flush or drain away unwanted liquid wastes.

Our cultural and regional identity, our recreational pursuits and development rely on the health of waters and the life they support.

The value Southlanders place on their environment is the basis of the *Regional Water Plan for Southland* and our *Regional Policy Statement*. *Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008: Te Tangi a Tauira - the Cry of the People* consolidates the Māori values for the freshwater environment.

The management outcomes for the freshwater environment within these documents, in turn provide the framework for *Southland Water 2010: Report on the State of Southland's Freshwater Environment*. This framework enables our monitoring and reporting to inform future management of Southland's freshwater resources, and helps determine the planning for the work programmes (including identifying gaps in our monitoring) within the next Long-term Council Plan 2012–2022.

Southland Water 2010 builds and expands upon Environment Southland's first *Southland's State of the Environment Report for Water* published in October 2000, and provides a baseline to measure the success of the Water Plan that became operative in January 2010.

Southland Water 2010 will consist of a series of four reports:

- Our Health
- Our Ecosystems
- Our Uses
- Our Threats.

This second part, *Our Ecosystems*, reports on the health of freshwater ecosystems and the life they support. We report on the current state of our freshwater ecosystems and also the changes that have occurred over time.

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[1] Te Taumutu Rūnanga 2003
[2] MfE 1997

Southland / Murihiku: Our place and our people

Southland is the most southerly part of New Zealand and the country's second largest region. It supports a wide variety of ecosystems, including those of the coast, lakes and rivers, wetlands, forests, grasslands, alpine and urban. All of these ecosystems contain indigenous and introduced species.

When we talk about an ecosystem, we are focusing on the way particular zones combine landscape, soil types, vegetation, climate, water and air to support a community of living organisms. They are fundamentally set by landform and plant coverage, but also depend on complex interactions of natural features, and perhaps now most of all, on human uses of the area – in freshwater ecosystems, water quality is a crucial factor in overall ecological health.

Prior to European settlement, Southland's plains were covered by forest, scrub, tussock and wetlands. Forest densely covered the mountains of Fiordland as it does today.

Early southern Māori were hunter-gatherers and relied heavily on the local habitats for their survival. They did not practice farming to the extent of their northern counterparts. Their pre-European culture did not have the use of metal and all their tools were made of stone, bone, shell, flax and wood. These iwi moved with the seasons around the southern region to exploit various food resources, and waterways were central to those journeys.

In the 1840s and 1850s farmers settled around Invercargill, with the first wool shipped from Invercargill in 1857. By the end of 1859 nearly all the suitable areas of the region were occupied by European farmers, with most development occurring alongside the region's major waterways – see 'Southland/Murihiku: Our place and our people' section in the 'Our Threats' report.

Surface water

The region's three main lakes, Hauroko, Manapouri and Te Anau, are also the deepest in the country, while the four major river catchments (the Waiau, Aparima, Oreti and Matuara) cover more than 18,000 square kilometres. Southland also has a number of coastal lakes including Lake George/Uruwera and Waituna Lagoon, which is part of the internationally recognised Awarua wetland system.

The large rivers provide a diverse range of habitats for fish, birds, algae, invertebrates and plants.

River flows, such as those in the Waiau and Monowai Rivers, have been altered for hydroelectric power generation. Many other waterways have been diverted or had their natural courses changed through channelling and flood protection schemes. These works can impede the free movement of indigenous fish, many of which travel to and from the sea as part of their life cycle in Southland.

Groundwater

Groundwater (the freshwater found beneath the surface) forms an integral part of the hydrological cycle and therefore has a significant influence on the health of our surface waters and our ecosystems.

Estuaries

Estuaries are highly complex systems found at the bottom of catchments where they are influenced by both freshwater and saltwater. Their health can be used as an overall indicator of the health of the freshwaters draining into them.

Southland has several estuaries including the Waiau Lagoon, Jacobs River Estuary, New River Estuary, Bluff Harbour and Awarua Bay, Waituna Lagoon, Haldane Estuary, Fortrose Estuary, Toetoes Harbour and Waikawa Harbour. Together they form a complex that is the single most important bird habitat in Southland, and one of the most important wading bird habitats in New Zealand.

Wetlands

Wetlands are one of the most valuable, yet vulnerable ecosystems in the world. They are so valuable because they act as a buffer for the rivers and lakes that drain into them.

Wetlands come in many shapes and sizes, and can occur in a variety of environments, such as coastal lagoons and estuaries, flood plains, valley floors and alpine areas. Once considered wastelands, wetlands are becoming more valued for the vital role they play in our environment. Many of these areas provide important fish-spawning habitat and contain threatened fish species.

Southland has many significant wetland areas, some of which are internationally important; however, the extent of wetland overall in Southland has been heavily reduced due to drainage for land development.

The people

There are 90,873 Southlanders (2006 Census) and we make up 2.3% of New Zealand's population. In terms of ethnicity, 78.6% of Southlanders identify themselves as of European descent, 16.5% as New Zealanders, 11.8% as Māori, 1.7% as Pacific people, 1.3% as Asian and 0.2% as another ethnicity (you can identify with more than one ethnicity).

Manawhenua refers to the iwi or hapū that holds the traditional/customary authority over resources within a particular area. In Southland/ Murihiku there are four Ngāi Tahu papatipu rūnanga (traditional local Māori councils) that hold manawhenua status within the region.

Since the Ngāi Tahu Claims Settlement Act 1998, particular rivers and lakes have been given special significance to Ngāi Tahu ki Murihiku, as their identity is inextricably linked to these locations. The Act sets out areas that are to be recognised when dealing with issues under the Resource Management Act and Regional Water Plan. These areas are known as Statutory Acknowledgement areas, and include tōpuni features, nohoanga (campsites alongside specified rivers and lakes), and taonga (treasured or valued) species of plants and animals – they include coastal marine areas that can be significantly affected by inland freshwater quality.

Agriculture and primary production are the main contributors to our economy, and nearly 19% of Southlanders are employed in agriculture, forestry and fishing industries.

Southlanders generally have a significant personal relationship with their landscapes and its ecosystems. Most inhabitants would consider their individual and community identity as closely tied to their natural surroundings. Freshwater ecosystems matter in Southland/ Murihiku: they host the base of life, they nourish the community, they provide recreation and relaxation opportunities. In the Māori world view, everything is connected 'ki uta ki tai – from the mountains to the sea', and this applies equally to a high country farmer as someone working in a shop in Invercargill.


M. Poole

How this report works

This report has been written to:

- Raise awareness and understanding of issues that affect our shared environment
- Tell us how effective our decisions and actions have been
- Help us set priorities for future action
- Help people and organisations to make informed decisions to protect what they value in the environment
- Inspire community action.

State of the environment reporting

State of the environment (SOE) reporting is the equivalent of a report card on the environment. Within this SOE report we look at the current conditions and trends of Southland's freshwater, identify pressures and discuss our response.

SOE reports are not technical documents although they are based on large amounts of technical information. They set out to show the health and other specific environmental qualities of a particular aspect of our environment, against an agreed set of measures, and to identify how things can be improved when they fall short of the agreed standard. SOE reports therefore give an overview of the complex and interwoven relationships that make up environmental systems.

Approach taken in this report

Southland Water 2010 focuses on the freshwater environment but also includes estuaries.

Nationwide, a network of regional authorities work collaboratively to ensure or improve national consistency and robustness of the environmental information collected. As such, Environment Southland's monitoring programmes encompass aspects that are traditionally monitored by regional authorities in New Zealand, and are consistent with current national best practices.

The vast majority of our monitoring occurs within the developed parts of the Southland excluding Fiordland and Rakiura National Parks. Therefore this report focuses on the area of Southland where we interact and have the most influence on our freshwater environment.

By reporting collaboratively, Environment Southland and Te Ao Mārama Incorporated seek to strengthen monitoring and reporting to encompass a more holistic picture of environmental and cultural health.

Report structure

The report's structure is based on the *Regional Water Plan for Southland* (the Water Plan) and *Ngāi Tahu ki Murihiku Natural Resource and Environmental Iwi Management Plan 2008: Te Tangi a Tauira – the Cry of the People*. We present the results of monitoring programmes conducted by Environment Southland and Te Ao Mārama Incorporated (Table 1).

The first part of this report on Our Ecosystems is based around the overall question: 'How healthy is the life in our water and our freshwater ecosystems?' This looks at the health, and changes in health, of the following aspects of freshwater ecosystems:

- Our rivers and streams - Ngā awa
- The life in our waters - Koiora wai
- Our lakes and lagoons - Ngā roto waimāori
- Our wetlands - Ngā repo
- Our estuaries - Ngā wahapu

The later parts of this report address two other questions:

- How do we affect the health of our ecosystems?
- What are we doing about the health of our freshwater ecosystems?

As the purpose of SOE reporting is also to determine future management actions, and inform the wider community about how they can help directly, we also report on:

- 'What we don't know and could do better'
- 'What you can do'.

Table 1: Summary of the monitoring results presented

Section	Monitoring	Indicator/measure reported	Page
Rivers and streams	Water quality – Nutrient enrichment	Dissolved Reactive Phosphorous (DRP)	20
	Water quality – Nutrient enrichment and toxicity	Nitrate–nitrite–nitrogen (NNN)	21
	Water quality – Nutrient enrichment and toxicity	Ammonia (NH_3)	21
	Water quality – Life-supporting capacity	Temperature	23
	Water quality – Life-supporting capacity and sedimentation	Visual clarity	24
	Water quality – Life-supporting capacity	Dissolved oxygen	25
	Water quality – Life-supporting capacity	Faecal coliforms and *E. coli*	*26*
	Water quality compliance against our water quality standards and guidelines for NNN, DRP, faecal bacteria, and visual clarity.	Water Quality Index (WQI)	27
	Mauri, mahinga kai and life-supporting capacity of river and stream sites	Cultural Health Index	29
Life in our waters	Stream invertebrates – amount and types	Macroinvertebrate Community Index (MCI)	41
	Periphyton – amount of algae and slime found on river beds	Periphyton biomass: chlorophyll *a*	43
		Periphyton biomass: Ash Free Dry Mass (AFDM)	43
	Fish	Index of Biotic Integrity (IBI)	44
Lakes and lagoons	Water quality and degree of nutrient enrichment	Trophic Level Index (TLI)	52
	Ecological condition – aquatic plants	Lake Submerged Plant Indicators (LakeSPI)	55
Wetlands	Wetland extent	Changes from historic to current wetland extent and wetland type	63
Estuaries	Sedimentation	Condition ratings for: Area of soft mud Sedimentation rate Sediment grain size	72
	Nutrient enrichment	Condition ratings for: • Nuisance macroalgae extent • Sediment nutrient concentrations • Depth of sediment oxygen level • River water nutrient inputs • Estuary water nutrient concentrations [ICC data, only available for New River Estuary]	72
	Toxicity	Condition rating for sediment heavy metals	72
	Habitat quality	Condition ratings for: • Seagrass meadows • Saltmarsh cover • Estuary invertebrates	72
	Overall ecosystem health of estuary	Overall Estuary Health Grade	72
	Mauri, mahinga kai and life-supporting capacity	State of the Takiwā scores	72

State of the Takiwā monitoring

The State of the Takiwā programme is an environmental monitoring approach developed by Te Rūnanga o Ngāi Tahu.

It is aimed at assisting tangata whenua to gather information, assess and report on the cultural health of significant sites, natural resources and environment within their particular takiwā (region). This monitoring uses Māori environmental measures such as a Cultural Health Index[3], cultural indicators for wetlands[4], western science measures such as *E. Coli*, and components of the Stream Health Monitoring Assessment Kit[5].

At each designated monitoring site, teams of tangata whenua use the State of the Takiwā programme to measure and evaluate the following:

- the amount of external pressures
- level of modification
- suitability for harvesting mahinga kai
- accessibility
- willingness to return to the site
- abundance and diversity counts of native birds, plants and fish species, and other resources (such as stone, bone or driftwood), as well as introduced plant and animal species.

The scores from the above are then incorporated into an overall site-health score. This score is then assigned a State of the Takiwā rank from 'very good' to 'very poor'.

Cultural Health Index

The Cultural Health Index used in this report focuses on the cultural health of a river or stream at a particular site. It forms an integral part of the State of the Takiwā monitoring, but can also be used as a reporting tool on its own.

The Cultural Health Index includes three components that incorporates instream and riparian margins – traditional association, mahinga kai, and stream health. All three components contribute to an overall Cultural Health Index rating.

Ngāi Tahu ki Murihiku site assessments and reporting

Ngāi Tahu ki Murihiku conducted State of the Takiwā assessments on the Waiau River in 2005[6] and the Mataura and Waikawa catchments in 2007[7].

The Cultural Health Index ratings from these studies are reported in the 'Rivers and streams' section, while the 'Estuaries' section uses overall State of the Takiwā scores. By incorporating cultural monitoring within this report we hope to gain a more holistic picture of the health of the environment.

Reporting on our water quality standards

Each section of Our Ecosystems compares monitoring results against the relevant water quality standards stated within the Water Plan; where there is no standard that applies we report against the relevant national guideline.

The Water Plan divides all of Southland's rivers and lakes into different water body classes: natural state, lowland hard bed, lowland soft bed, hill, mountain, lake-fed, spring-fed, lowland/coastal lakes and wetlands, hill lakes and wetlands, mountain lakes and wetlands, and Mataura 1, 2 and 3. These categories are based on water source and existing water quality (Figure 2).

'Mataura water bodies', have Water Plan standards but these are older, mainly narrative standards from the Mataura Water Conservation Order 1997. To report on the quality of the water in those areas, we have used the standards or guidelines that apply to the nearest equivalent water body classification, ie 'Lowland hard bed' for Mataura 3 (lowland), and 'Hill' for Mataura 3 (upland) and Mataura 2.

Water quality standards have been identified for each class and standards for certain water quality measures can vary between classes. For example, water quality standards for upland water bodies, which are less likely to be affected by human activities, tend to have more stringent standards than lowland water bodies, which are more affected.

'Natural state' waters are within public conservation land and/or are largely unmodified or unaffected by human activities. These waters have no numerical standards, but instead have a desired standard of 'no change to the natural water quality'.

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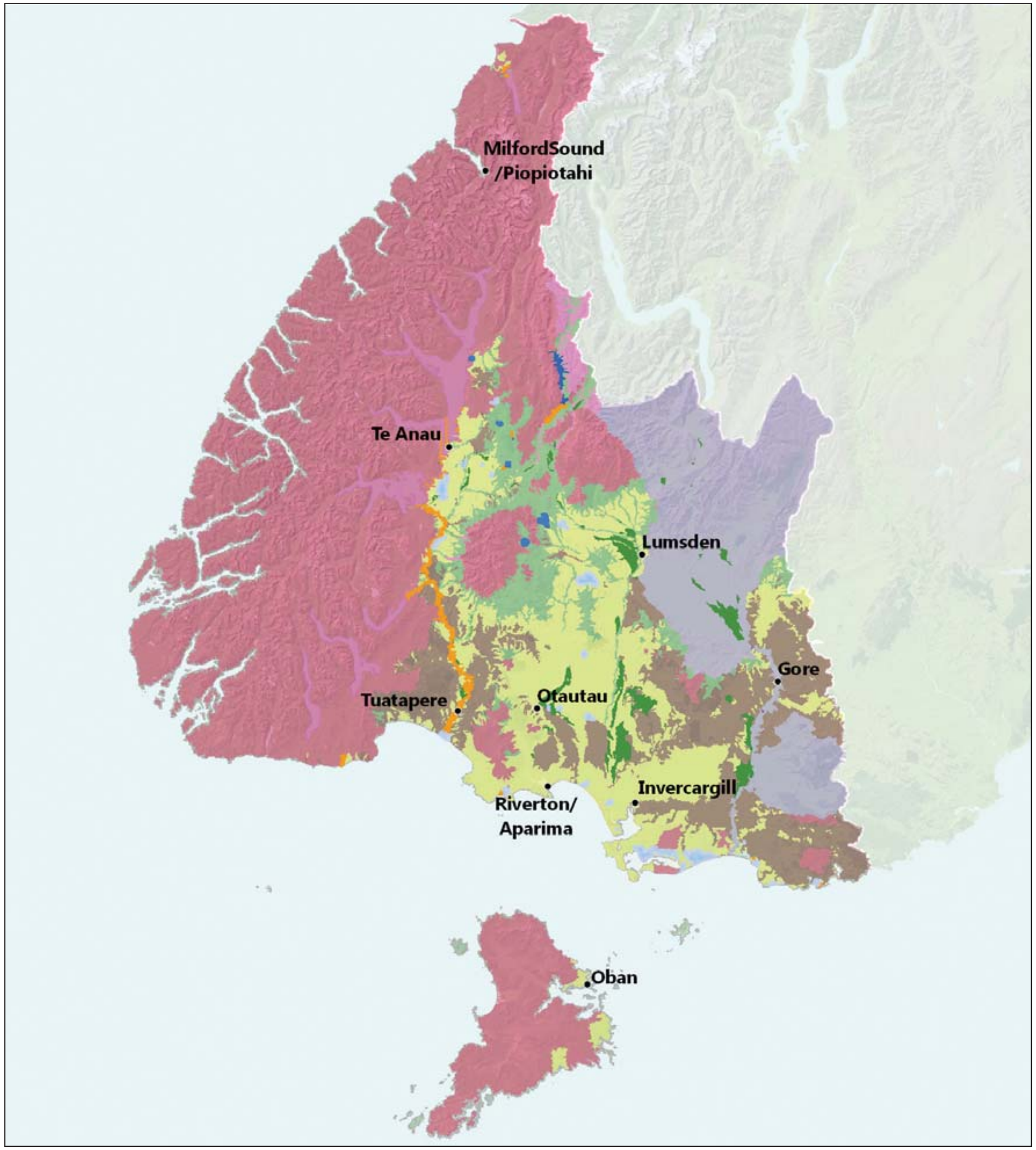
[3] Tipa and Tierney 2003, 2006
[4] Harmsworth 2002
[5] Biggs *et al.* 2002
[6] Pauling *et al.* 2005
[7] Pauling 2008

Figure 2: The water body classes used in Southland's regional Water Plan



Water quality

- Hill
- Hilly Lakes
- Lake Fed
- Lowland/Coastal Lakes
- Lowland Hard Bed
- Lowland Soft Bed
- Mataura 1
- Mataura 2
- Mataura 3
- Mountain
- Mountain Lakes
- Natural State
- Spring Fed

Framework for reporting water quality

When we report against water quality standards, we use a common framework to show the results, in terms of the values set in each standard (see 'The life in our waters - Koiora wai', pg 35 and 'Our rivers and streams - Ngā awa', pg 17). The range of measures used is:

- *Median* – median (middle value) of monthly data from sites within each Water Plan classification over the last 5 years (2005–2010).
- *Number of breaching sites* – the number of sites within each Water Plan classification which have breached (exceeded) the relevant standard at least once over the last 5 years (2005–2010).
- *Percent samples breaching* – percentage of samples for each site within each Water Plan classification which breached (exceeded) the relevant standard over the last 5 years (2005–2010).
- *Magnitude of breaches* – the amount by which the sites breached the relevant standard over the last 5 years (2005–2010). This is based on the collective amount by which individual samples taken at each site breach the standard and is scaled to be between 0 and 100. The lower the index the better.[8]
- *Percentage compliance with standards/ guidelines* – the percentage of sites which have breached the relevant standard/ guideline over the last 5 years (2005–2010) and grouped into different compliance categories: Very Good (>90% compliance), Good (75–90%), Fair (50–74%), Poor (25–49%) and Very Poor (<25%).

Note that site-specific information and a full reference list is available on our website: www.es.govt.nz.

Water quality changes over time or 'trends'

In order to be able to tell if something is changing over time, we require a number of samples to obtain enough 'data' to conduct statistical tests. Therefore, when we become interested in a new site, there is a delay before we have enough data to determine trends.

All water quality trends reported are statistically 'significant' and based on a minimum of 60 samples. The trends have been determined using national best practice and advice from water quality experts.

In water quality trend analysis, it is common practice to adjust for the effects of flow[9]. Water quality variables, in particular nutrients, increase with river flow. We have used flow adjustments in the analysis of water quality trends in our ecosystems, so we can determine changes in the amounts of a particular contaminant coming into a particular area. In the Our Health report we did not incorporate this flow adjustment in our analysis because we were primarily interested in water quality in relation to human health and the concentrations of pollutants. These variations in our analysis for different subject areas are consistent with national reporting for these kinds of measures.[10]

Technical detail about trend analysis for the Macroinvertebrate Community Index and the Index of Biotic Integrity (see 'The life in our waters – Koiora wai', pg 35 and 'Our lakes and lagoons – Ngā roto', pg 49), can be found in the technical reports available on www.es.govt.nz.

Differences between Maori standards and Water Plan standards

There are some differences between the standards Maori use to assess stream health when compared to those identified by the Water Plan. This illustrates that there are some fundamental differences between Maori and science perspectives.

One example of this is the definition of water pollution. Maori cultural and spiritual values with respect to water include perceptions of pollution that often conflict with scientific measures. For example "drinkable" or "fit for recreation" water quality may be scientifically defined as carrying contaminants, but at a level that is not toxic to humans. In other words some contaminants may be present. In contrast, Maori require water to be protected from pollution, which prohibits certain discharge activities, especially the discharge of faecal coliforms, regardless of the level of physical contamination.

[8] CCME 2001
[9] Scarsbrook & McBride, 2007
[10] Scarsbrook, 2006 and Ballantine *et al.*, 2010

Managing for Southland's freshwater ecosystems

Environment Southland

Environment Southland is responsible for the governance and management of Southland's natural and physical resources: air, land, water and coast.

The 'outcomes' we aim for in our management of freshwater resources are the community expectations set out within the Regional Policy Statement and The Water Plan. The Water Plan further sets out in detail the community's standards and targets for water management within the Southland region.

Environment Southland is responsible, under the Resource Management Act 1991, to monitor the overall state of the region's environment. As part of this we monitor and report on water quality and quantity measures that relate to the health of our ecosystems. We recognise that many other agencies and groups are working to ensure the health of our ecosystems and we work closely with many of them, including the Department of Conservation and Fish and Game. These partnerships ensure integrated management and shared knowledge of the complex ecosystems in Southland.

Te Ao Mārama Incorporated

Te Ao Mārama Incorporated looks after manawhenua interests in resource management and other aspects related to local government in Southland. It represents the four Ngāi Tahu papatipu rūnanga in Murihiku/Southland:

- Te Rūnaka o Waihopai
- Te Rūnanga o Awarua
- Te Rūnanga o Oraka/Aparima
- Te Rūnanga o Hokonui

It is involved in the protection of the spiritual and cultural values of the region, including wāhi tapu (sacred places), mahinga kai (gathering of food and resources) and other natural resources.

The central traditional principle behind Ngāi Tahu management of the environment is Kaitiakitanga (guardianship).

The planning document Te Tangi a Tauira, consolidates these values and perspectives on natural resource and management issues. The document assists Ngāi Tahu ki Murihiku in carrying out kaitiaki roles and responsibilities. The role of communities in achieving good environmental outcomes and healthy environments is recognised in Te Tangi a Tauira, and thus is designed to assist others in understanding manawhenua values and policy.

Toitū te marae o Tane, toitū te marae o Tangaroa, toitū te Iwi.

Protect and strengthen the realms of the land and sea and they will protect and strengthen the people.

Our rivers and streams — Ngā awa

Ki ngā korero o ngā Tūpuna ko ngā awaawa ngā uaua a Papatūānuku

In the words of our ancestors, the rivers are the veins of the Earth

The health of Southland's rivers and streams is very much dependent on the quality and quantity of the water that flows in them, and the quality of their physical habitat. In this section we focus on water quality. Water quantity and its effects on ecosystem health are covered in the *'Our Uses'* report.

Rivers flow from the mountains to the sea (ki uta ki tai). They connect numerous tributaries, wetlands, springs, lakes and estuaries, as well as the groundwater that nourishes the catchment from below. Because they are fed by, and in turn feed all these interlinked environments, the water quality of rivers affects the health and life of all within these ecosystems.

This section reports how well the water quality of Southland's rivers and streams complies with regional standards and national guidelines. These are the measures of the water's capacity to support ecological health, rather than its direct effect on human and stock health.

In addition, we use two indices to help present the bigger picture. The Water Quality Index combines a range of measures to illustrate the overall situation in relation to the relevant water quality standards/guidelines. The Cultural Health Index similarly illustrates how well current water quality meets our cultural standards.

We also report on changes over time in Southland's river water quality, with the aim of assessing whether we will meet the targets specified in the Water Plan based on current trends. The section concludes with comments on Southland's river water quality in a national context.

Monitoring our rivers and streams

Our management targets

The Water Plan objectives state that water quality of all surface water bodies in the region will be suitable for fish, contact recreation, stock drinking water and Ngāi Tahu cultural values, including mahinga kai. Natural state water quality is also to be maintained – these 'natural state' waters are within public conservation land and/or are largely unmodified or unaffected by human activities.

The water quality issues that affect human and animal health – in terms of swimming and playing in water, drinking water supply, and gathering and eating kai from our waters – are addressed in the *'Our Health'* report. This section of 'Our Ecosystems' describes how we monitor the suitability of the water in our rivers and streams for fish and mahinga kai, and for supporting cultural values overall.

The Water Plan also has a specific target to reduce nitrate, phosphorus and microbiological contaminants and to improve water clarity in hill, lowland and spring-fed surface water bodies by a minimum of 10% by 2020. To be able to measure against this target, we collect data on levels of nitrate–nitrite–nitrogen (NNN), dissolved reactive phosphorus (DRP), faecal coliforms, and visual clarity (see 'Progress towards our management targets', pg 31).

The management targets for Ngāi Tahu ki Murihiku are illustrated by the following text from Te Tangi a Tauira:

> *Water is a taonga, or treasure of the people. It is the kaitiaki responsibility of tangata whenua to ensure that this taonga is available for future generations in as good as, if not better quality.*
>
> *Water has the spiritual qualities of mauri and wairua. The continued well-being of these qualities is dependent on the physical health of the water. Water is the lifeblood of Papatūānuku, and must be protected. We need to understand that we cannot live without water and that the effects on water quality have a cumulative effect on mahinga kai and other resources."*

The standards and guidelines we use

The water quality standards and guidelines we report against are from the Water Plan and the ANZECC[11] guidelines (Table 2).

It is important to recognise that undesirable ecological effects can occur below the levels set in these standards and guidelines. For example, we report nitrate–nitrite–nitrogen (NNN) against guidelines for chronic NNN toxicity; however, accelerated periphyton growth will occur below these concentrations if phosphorus is also available, which will affect how the waterway looks, its dissolved oxygen concentration, pH and the health of aquatic life within it.

For a description of the range of measures we use to report against these standards and guidelines, see 'How this report works', pg 11.

Table 2: Water body classifications and relevant water quality standards and guidelines

Water body classification	**DRP*** (mg per L)	**NNN**** (mg per L)	**NH_3*Δ** (ppb)	**Temp#** (°C)	**Temp#** (°C) *May to Sept only*	**Visual clarity#** (m) *Below median flow*	**Faecal coliforms#** (per 100 ml)	***E. coli*#** (per 100 ml)
Natural state	No change	No change	No change	No change	No change	No change	No change	No change
Lowland soft bed	<0.010	<1.7	<34.4	<23	N/a	>1.3	<1,000	N/a
Lowland hard bed	<0.010	<1.7	<34.4	<23	<11	>1.6	<1,000	N/a
Hill	<0.009	<1.7	<34.4	<23	<11	>1.6	<1,000	N/a
Mountain	<0.009	<1.0	<12.2	<21	<11	>3.0	N/a	<130
Lake fed (upland)	<0.009	<1.0	<12.2	<21	<11	>3.0	N/a	<130
Lake fed (lowland)	<0.010	<1.0	<12.2	<21	<11	>3.0	N/a	<130
Spring fed	<0.010	<1.0	<12.2	<21	<11	>3.0	<1,000	N/a
Mataura 2	<0.009	<1.7	<34.4	<23	<11	>1.6	<200	N/a
Mataura 3 (upland)	<0.009	<1.7	<34.4	<23	<11	>1.6	<1,000	N/a
Mataura 3 (lowland)	<0.010	<1.7	<34.4	<23	<11	>1.6	<1,000	N/a

* ANZECC guideline (2000)

** Proposed nitrate toxicity guideline (Hickey & Martin 2009)

Δ Toxicity guideline

Environment Southland Water Plan Standard

[11] Australian and New Zealand Environment and Conservation Council

Other measures we use

As well as reporting on the eight standards and guidelines outlined in Table 2, we also use a Water Quality Index and Cultural Health Index as indicators of the ecological health of water quality in Southland's rivers and streams.

Water Quality Index (WQI)

The Water Quality Index[12] is based on a formula developed in Canada by the Ministry of Environment, Lands and Parks in the state of British Columbia, and modified by Alberta Environment. NIWA has recently suggested this index could be adopted as a New Zealand national reporting tool.[13]

The index incorporates three elements: *scope* – the number of variables not meeting water quality standards or guidelines; *frequency* – the number of times these standards or guidelines are not met; and *amplitude* – the magnitude by which the standards are not met. The resulting index value has a range between 0 and 100, where 0 represents the 'worst' water quality and 100 represents the 'best' water quality.

In Southland, we calculate the WQI based on four variables: nitrate–nitrite–nitrogen (NNN), dissolved reactive phosphorus (DRP), faecal coliforms (including *E. coli*), and visual clarity.

The Water Quality Index scores are graded into these categories:

Very good (WQI value 95–100): water quality is protected with a virtual absence of threat or impairment; conditions very close to natural or pristine levels.

Good (WQI value 80–94): water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from natural or desirable levels.

Average (WQI value 65–79): water quality is usually protected but occasionally threatened or impaired; conditions sometimes depart from natural or desirable levels.

Poor (WQI value 45–64): water quality is frequently threatened or impaired; conditions often depart from natural or desirable levels.

Very poor (WQI value 0–44): water quality is almost always threatened or impaired; conditions usually depart from natural or desirable levels.

Cultural Health Index

The Cultural Health Index (CHI)[14] is a monitoring method used to assess the health of a particular site on a river or stream in cultural terms.

It is derived from three components: traditional association, mahinga kai (abundance and access) and stream health. In the State of the Takiwā monitoring, the mahinga kai and stream health scores are averaged for an overall site health score, which is then assigned a grade from 'very good' to 'very poor'.[15]

(For more information on the State of the Takiwā monitoring and Cultural Health Index see 'How this report works', pg 11).

Where we monitor

Environment Southland monitors water quality on a monthly basis at 71 sites, in 41 rivers and streams in Southland. Water quality monitoring began in some rivers as early as 1975, but most of our regular water quality monitoring began between 1995 and 1999.

Te Rūnanga o Ngāi Tahu State of the Takiwā monitoring has been conducted within the Waiau catchment in 2005, and the Mataura and Waikawa catchments in 2007[16]. This monitoring was conducted over different environment types (ie rivers, lakes and estuaries.) See 'How this report works', pg 11.

How the water quality measures up

This section presents results of water quality monitoring in Southland's surface water bodies, in terms of their ability to support life in our waters and our cultural practices dependent on that. All of the results reported here are for a five-year period, from 2005–2010.

[12] Canadian Council of Ministers of the Environment (CCME), 2001
[13] Hudson *et al* 2011
[14] Tipa and Tierney 2003, 2006
[15] Pauling 2007
[16] Pauling 2005 (Waiau), 2008 (Mataura and Waikawa)

Nutrients

Dissolved inorganic forms of nitrogen and phosphorus, such as dissolved reactive phosphorous (DRP), nitrate–nitrite–nitrogen (NNN), and ammonia (NH_3) are the nutrients of most concern in water bodies, as these are the forms that are easily taken up and used by plants.[17]

High concentrations of ammonia can be toxic to aquatic insects, fish and animals. The toxicity is dependent on the pH and temperature of the water.[18]

Nitrate–nitrite–nitrogen can also be toxic to freshwater fish and invertebrates, and toxicity increases with increased concentration and exposure time.[19]

Monitoring results: dissolved reactive phosphorous (DRP)

Out of 69 sites, 40% have very poor compliance with the guidelines, while 23% have very good compliance (Figure 3). The results are not reported for the other two sites of the 71 monitored, as these are natural state sites, where the standard is 'no change' over time, rather than a specific level.

In terms of water body classes, the lowland soft and hard bed, lowland Mataura 3 and spring fed classes have the highest DRP medians and are above the relevant guideline (Table 3). Of these, the single spring-fed site (Waimatuku Stream downstream of Bayswater Bog) had the highest percentage of samples that breached the guideline (98%) and the largest magnitude of breaches (80).

Figure 3: Compliance of sites with the DRP guidelines (2005-2010)

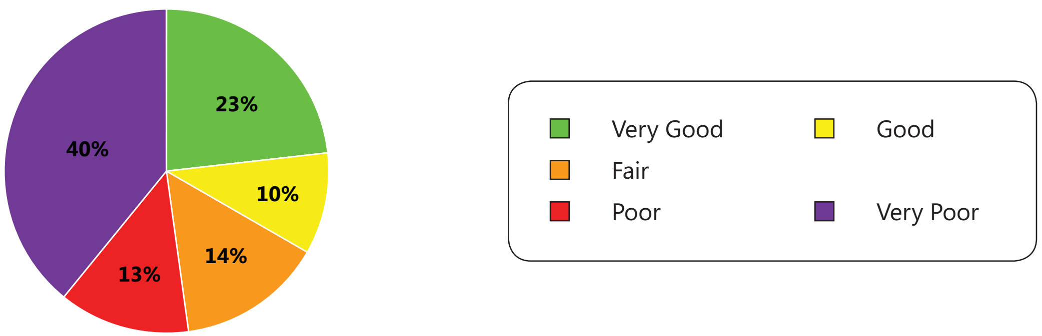


Table 3: DRP concentrations by Southland surface water body class (2005–2010)

Water body classification (number of sites)	**DRP (mg per L)**				
	Guideline*	**Median**	**Percentage samples breached**	**Magnitude of breaches**	**Number of breaching sites**
Natural state (2)	No change	0.011	–	–	–
Lowland soft bed (13)	<0.010	0.014	72	50	13 of 13
Lowland hard bed (18)	<0.010	0.015	61	62	17 of 18
Hill (10)	<0.009	0.003	5	3	10 of 10
Lake fed (upland) (3)	<0.009	0.002	0	0	0 of 3
Lake fed (lowland) (1)	<0.010	0.002	2	1	1 of 1
Spring fed (1)	<0.010	0.047	98	80	1 of 1
Mataura 2 (1)	<0.009	0.009	44	20	1 of 1
Mataura 3 (upland) (8)	<0.009	0.008	39	27	8 of 8
Mataura 3 (lowland) (14)	<0.010	0.015	70	51	14 of 14

* See Table 2 for an explanation of the guideline

Note: we have no sites in the mountain water body class

Lake fed and hill classes had the lowest DRP medians, lower than the natural state sites over the 2005–2010 period.

All lowland sites (soft bed, hard bed and Mataura 3 lowland) have a high percentage of samples that breached the guideline (61–72%) with all but one of the sites in these classes having breached over the 2005–2010 period. The magnitude of breaches was also large (50–62%).

[17] Harding *et al.* 2004
[18] Meijer 2010
[19] Camargo *et al.* 1995

Monitoring results: nitrate–nitrite–nitrogen (NNN) and ammonia (NH3)

Out of 69 sites, the majority (64%) showed very good compliance with nitrate–nitrite–nitrogen (NNN) guidelines for chronic toxicity (Figure 4).

Two-thirds of NNN samples taken from Waimatuku Stream downstream of the Bayswater Bog breached the guideline with a magnitude of breach of 32 (Table 4). Sites in the natural state class have the lowest NNN median of 0.03 mg/L.

The level of breaches at the spring fed site, lowland Mataura 3 sites, lowland soft bed sites and lowland hard bed sites, indicate that the NNN levels may impact on the ability of aquatic life to use oxygen at least some of the time, putting those organisms under stress. At most lowland sites, NNN is the highest in winter when most soil leaching (through tile drains) and runoff occurs; however, there are a few sites that are groundwater dominated at low flows and experience higher NNN concentrations in summer due to elevated levels of NNN in the groundwater.

Sites in the hill, lake fed, Mataura 2, and upland Mataura 3 water body classes had no or very low breaches of the guidelines (1–2%), indicating that NNN is not adversely affecting aquatic life at these sites.

All 69 sites complied with the NH3 guidelines (Table 4). (The two natural state sites have a different standard, ie 'no change').

Figure 4: Compliance of sites with NNN toxicity guidelines (2005-2010)

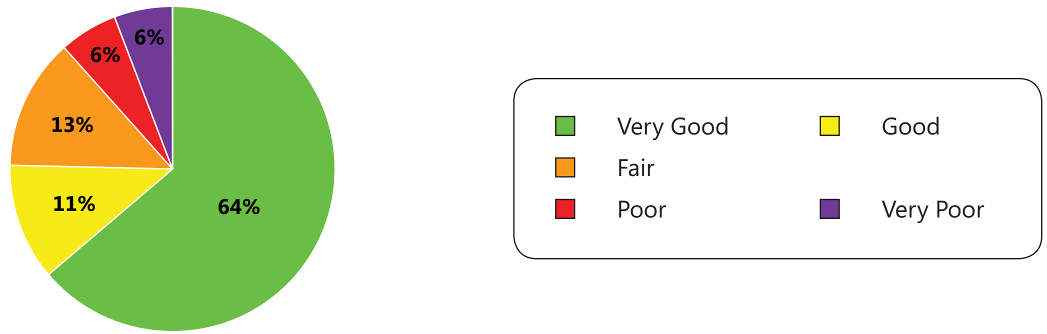


Table 4: NNN and NH$_3$ concentrations by Southland surface water body class (2005–2010)

Water body classification (number of sites)	NNN (mg per L)					NH$_3$ (ppb)				
	Guideline*	Median	Percentage samples breached	Magnitude of breaches	Number of sites breached	Guideline*	Median	Percentage samples breached	Magnitude of breaches	Number of sites breached
Natural state (2)	No change	0.03	–	–	–	No change	0.017	–	–	–
Lowland soft bed (13)	<1.7	0.90	21	10	9 of 13	<34.4	0.104	0	0	0 of 13
Lowland hard bed (18)	<1.7	0.55	19	12	14 of 18	<34.4	0.060	0	0	0 of 18
Hill (10)	<1.7	0.17	2	1	3 of 10	<34.4	0.037	0	0	0 of 10
Lake fed (4)	<1.0	0.15	<1	1	1 of 4	<12.2	0.047	0	0	0 of 4
Spring fed (1)	<1.0	1.30	66	32	1 of 1	<12.2	0.089	0	0	0 of 1
Mataura 2 (1)	<1.7	0.67	0	0	0 of 1	<34.4	0.047	0	0	0 of 1
Mataura 3 (22)	<1.7	0.72	20	16	16 of 22	<34.4	0.060	0	0	0 of 22

* See Table 9 for explanation of guidelines

See "How this report works' for an explanation of the measures

Note: we have no sites in the mountain water body class

Case Study: Nutrient limitation in Southland rivers and streams

Nutrients can be problematic in streams, as increased levels, even below toxicity guideline values, can lead to excessive algae growth. However, algae growth depends on a number of favourable conditions – light, temperature and sufficient nutrients (both nitrogen and phosphorus). If the supply of one nutrient becomes depleted relative to the other, it can become a key factor controlling algae growth. Rivers and streams in this state are referred to as phosphorus (P) or nitrogen (N) limited. For example, being P limited means that the supply of P for algae growth is depleted compared to the supply of nitrogen. Even if all other factors which control algal growth are favourable, the lack of phosphorus is likely to limit the growth of algae at these sites. Or alternatively, it can also mean that the level of N in relation to P is high, and require an investigation into why N has increased in relation to P (eg from nitrate leaching).

Environment Southland has analysed the water quality data to determine which limiting conditions apply to our rivers and streams and found 54 out of 71 water quality monitoring sites (76%) appear to be P-limited (Figure 5).

Nutrient ratios can vary depending on factors such as the time of year or river flow. As a result, some river systems may be P-limited for most of the year but 'switch' to N-limited during periods of low river flows.[20] While 76% of sites are dominated by P-limited conditions, about a quarter of these sites appear to be switching to either co-limited (where both nutrients are low), or are switching between P and N limitation at low river flows, which are critical times for algae growth (Figure 6).

With 32% of sites being either N-limited or co-limited, at least during the periods of low river flows (Figure 6), management of N and P inputs remains essential in a number of river systems.

This is consistent with previous recommendations by expert panels[21] and recent findings in North Island river systems.[22]

Figure 5: Nutrient limitation of Southland river monitoring sites

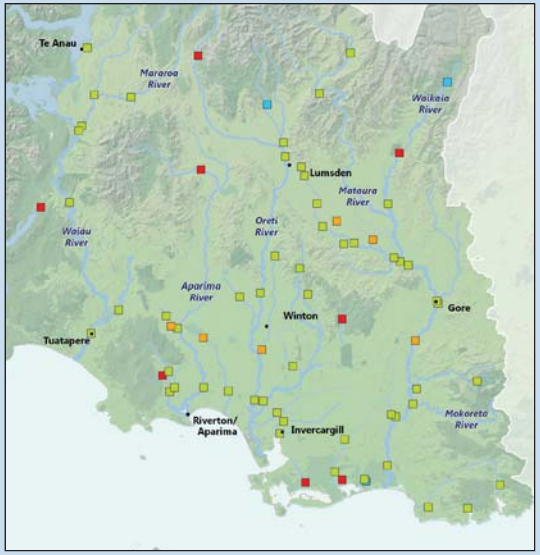
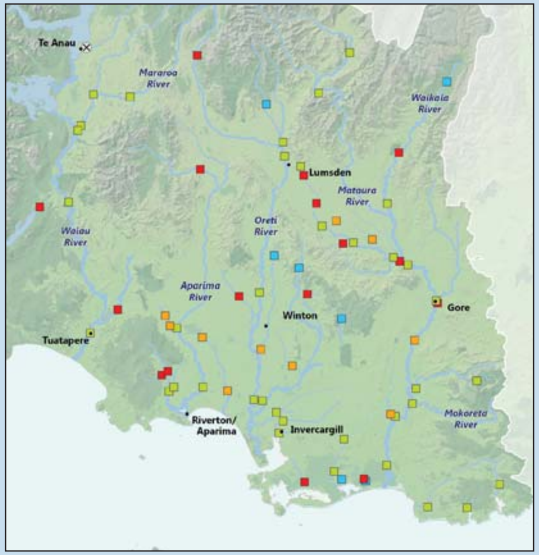


Figure 6: Nutrient limitation of Southland river monitoring sites during low river flows



Co-limited
Nitrogen limited
Phosphorus limited
Unlimited
N/A - no flow data

[20] Ausseil 2008

[21] Wilcock *et al.* 2007

[22] Ausseil, 2008, 2009a and 2009b, as well as McArthur *et al.* 2009

Temperature

Water temperature affects plants and animals living in a river or stream. Changes in temperature can be caused by climate or human activities. Removing riparian vegetation, discharging heated or cooled water after it has been used in industrial processes, or taking too much water from a river or stream can alter the temperature. If temperatures increase beyond their usual ranges for too long, plants and animals in waterways can become stressed and die.[23]

In Southland waterways, temperature is particularly important for mayflies (trout food) and trout spawning rates: adult trout have a narrow ideal temperature range and die when water goes above 24°C, while their eggs and young die at temperatures above 11°C.[24] Mayflies are also very sensitive to temperature, and half will die at temperatures above 22.6°C.

In areas enriched by nutrients, increased temperature can also increase the growth of periphyton (see 'The life in our waters', pg 35). Oxygen is more soluble as temperature decreases, so cooler water can hold more oxygen than warmer water.[25]

Monitoring results

All river and stream sites had very good compliance (ie more than 90% of the time) with the temperature standard.

Sites in the lowland soft bed, hard bed, Mataura 3 and lake fed water body classes have all breached the temperature standards at least once between 2005–2010; however, the percentage of breaching samples was less than 1% (Table 5). Sites in the hill, Mataura 2 and spring fed classes did not breach the standards.

Five water body classes (lowland soft bed, hard bed, Mataura 3, lake fed and hill) breached the trout spawning temperature standard of 11^{0}C at least once during May to September. The magnitude of the breaches was low, at less than 1. Although low, the lake fed sites (Waiau and Monowai Rivers) showed the highest percentage of breached samples (4%).

Table 5: Temperature of Southland Surface Water Classes (2005-2010)

Water Body Classifications (number of sites)	**Temperature (°C)**						**Temperature Trout spawning areas (May to Sept only) (°C)**					
	Standard	**Median**	**Range**	**Percent samples breached**	**Magnitude of breaches**	**Number of breaching sites**	**Standard**	**Median**	**Range**	**Percent samples breached**	**Magnitude of breaches**	**Number of breaching sites**
Natural State (2)	No change	8.9	1.6 – 17.8	-	-	-	No change	5.6	1.6-9.7	-	-	-
Lowland soft bed (13)	<23	10.0	1.4-25.0	0.1	0.011	1 of 13	-	6.8	1.4-11.7	0.4	0.039	3 of 13
Lowland hard bed (18)	<23	9.8	1.0-23.7	0.2	0.005	1 of 18	<11	6.3	1-12.4	0.7	0.119	6 of 18
Hill (10)	<23	9.3	0.25-18.9	0	0	0 of 10	<11	5.7	0.25-11.4	0.2	0.013	1 of 10
Lake fed (4)	<21	11.3	3.5-22.9	0.7	0.003	1 of 4	<11	7.6	3.5-12.5	4	0.7	4 of 4
Spring fed (1)	<21	10.2	4.8-19.2	0	0	0 of 1	<11	6.6	4.8-11	0	0	0 of 1
*Mataura 2 (1)	<23	10.2	3.4-19.8	0	0	0 of 1	<11	6.4	3.4-10.6	0	0	0 of 1
*Mataura 3 (22)	<23	9.5	0.7-24.2	0.1	0.038	1 of 22	<11	6	0.7-12.9	0.2	0.1	3 of 22

See Table 2 for explanation of standards

See 'How this report works' for an explanation of the measures

Note: we have no sites in the mountain water body class

[23] Mfe Website - http://www.mfe.govt.nz/environmental-reporting/freshwater/river/temperature-oxygen/

[24] Bjorn and Reiser 1991 cited in Ryder 2004

[25] Harding *et al.* 2004

Visual clarity

Visual clarity is how far you can see through the water. It provides an indication of the level of suspended sediment or algae in the water.[26] Visual clarity is important for photosynthesis in river ecosystems and lower visual clarity may reduce light penetration and also influence the efficiency for fish to find prey.[27]

Visual clarity can be influenced by both natural and human factors. Sandstones, mudstones and gravels are easily eroded, resulting in high suspended sediment levels. Visual clarity can decrease as a result of land use and other human activities, including erosion, sediment runoff from paddocks, urban development, and harvesting of forestry.[28]

Suspended sediments can affect aquatic communities directly. For example, high sediment concentration can result in abrasion injuries to animals and stream beds being smothered by fine sediment as it settles out of the water column. Sediment can also degrade feeding and spawning habitats of fish.[29]

Monitoring results

Three sites are excluded from these visual clarity results, as the data from those river and stream sites does not have a corresponding water flow.[30] Of the other 66 sites monitored, 36 (54%) showed only fair compliance with visual clarity standards (Figure 7). Fifteen sites (23%) showed very good compliance with clarity standards.

Sites in the hill class and the one Mataura 2 site have the best water clarity, with maximums of 11.1m and 11.5m (Table 6).

The spring fed site (Waimatuku Stream downstream of Bayswater Bog) has the highest percentage of samples breaching the clarity standard (56%), with a breach magnitude of 68.

Other water body classes with high breaches of the standard include lowland soft bed (41% non-compliance with the standard), lowland hard bed (39%) and Mataura 3 (31%). The magnitude of the breaches in these classes ranged from 19 to 33.

The hill class had the best compliance with the clarity standard, with just 6% of samples breaching, and a magnitude of 1.

Figure 7: Compliance of sites with visual clarity standards (2005-2010)

Table 6: Visual clarity by Southland surface water body class (2005–2010)

Water body classification (number of sites)	**Visual clarity (m)**					
	Standard**	**Median (m)**	**Clarity range (m)**	**Percentage samples breached**	**Magnitude of breaches**	**Number of breaching sites**
Natural state (2)	No change	0.70	0.14– 4.95	-	-	-
Lowland soft bed (13)	>1.3	0.82	0.05 - 3.0	41	26	13 of 13
Lowland hard bed (18)	>1.6	0.92	0.06 - 7.7	39	33	17 of 18
Hill (10)*	>1.6	3.25	0.03 - 11.1	6	1	8 of 9
Lake fed (4)*	>3.0	2.65	0.07-8.71	15	17	3 of 3
Spring fed (1)	>3.0	0.56	0.10 - 1.55	56	68	1 of 1
Mataura 2 (1)	>1.6	1.61	0.11 - 11.5	12	11	1 of 1
Mataura 3 (22)*	>1.6	1.21	0.04-10.2	31	19	20 of 21

*For each of these classes there is one site that does not have a median flow, and therefore exceedences could not be calculated for that site. However, all other statistics have been calculated using all sites within the class.

** See Table 2 for explanation of standard.

- Not applicable

See "How this report works' for an explanation of the measures

Note: we have no sites in the mountain water body class

[26, 28, 29] Mfe Website - http://www.mfe.govt.nz/environmental-reporting/freshwater/river/clarity/

[27] Rowe and Dean, 1998

[30] These sites are the Upukeroa River at Milford/Te Anau Rd Bridge (Hill); Monowai River d/s Gates (Lake fed), and Mimihau tributary at Venlaw Forest (Mataura 3)

Dissolved oxygen

Dissolved oxygen is the amount of oxygen in the water, and is an important indicator of stream health as it allows fish and other aquatic life to 'breathe'.[31] Photosynthesis in plants and changes in water temperature cause variations in dissolved oxygen. Dissolved oxygen is usually highest at midday due to plant photosynthesis, and lowest in the early hours of the morning due to respiration and little photosynthetic activity. Dissolved oxygen also exhibits a seasonal pattern where it is lower in summer, when water temperatures are higher.

Monitoring results

Dissolved oxygen samples were collected at all 71 sites; however, as dissolved oxygen can vary throughout the day, these spot measurements are of little use for comparisons between sites.

Two sites (Mataura River at Gore and Mataura River at Wyndham) have dissolved oxygen monitored continuously. While these sites are not representative of all Southland rivers and streams, the data can be used to compare levels to the standard for the Mataura 3 water body classification.

Continuous dissolved oxygen has been monitored in the Mataura River at Gore reliably since April 2008. Between 2008 and 2010, dissolved oxygen levels reached a minimum of 7.9mg per L in January 2009 (Figure 8) and therefore did not breach the standard of 5mg per L for the Mataura 3 water body classification.

Continuous dissolved oxygen has been monitored in the Mataura River at Wyndham since August 2006. Dissolved oxygen levels reached a minimum of 5.5mg/l in February 2009 (Figure 9) approaching, but not breaching the standard.

Figure 8: Dissolved Oxygen concentration (mg per L) Mataura River at Gore (April 2008 – June 2010)

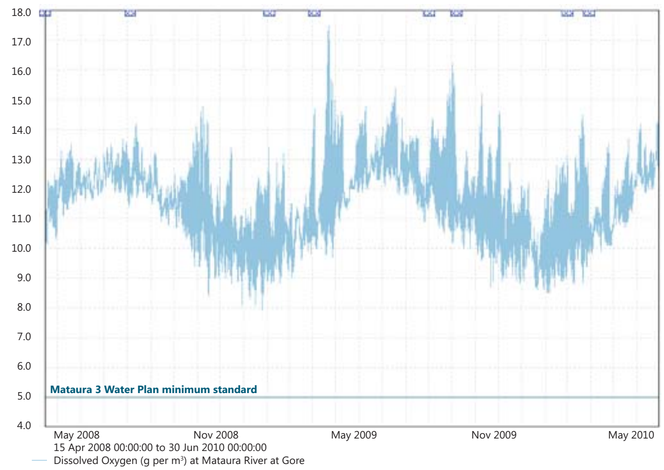
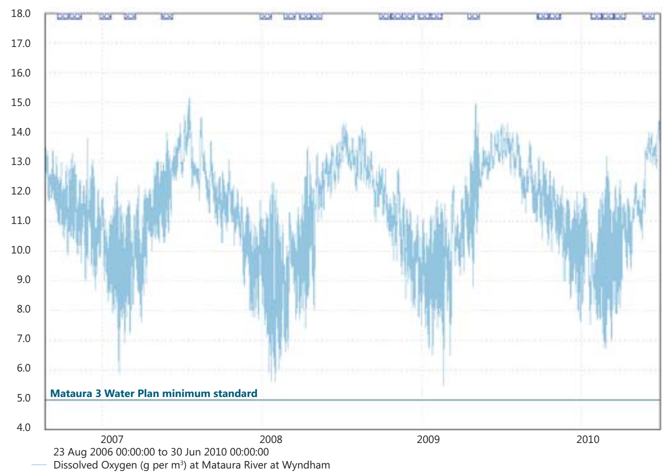


Figure 9: Dissolved Oxygen concentration (mg per L) Mataura Rver at Wyndham (August 2006 – June 2010)



[31] Harding *et al.* 2004

Faecal bacteria

The 'faecal coliforms' we measure are six species of bacteria found in human and animal faeces. One of those species, Escherichia coli (*E. coli*) has an important 'indicator' function, due to its ability to survive for 4–6 weeks in freshwater.[32] The presence of faecal coliforms and *E. coli* in water indicates the possible presence of disease-causing bacteria, as well as viruses and protozoans that also live in human and animal digestive systems. We currently do not distinguish between faecal coliforms that come from humans or animals in our monitoring programmes.[33]

The issues that faecal contamination raises for human and stock health are covered in the 'Our Health' report. The issue for ecological health that is examined in this report is the effect faecal material has when it breaks down in water – consuming dissolved oxygen and releasing nutrients. These nutrients can stimulate the growth of organisms, particularly bacteria, which in turn use more dissolved oxygen. The presence of faecal bacteria can therefore be associated with a decline in dissolved oxygen levels, and as a result, a decline in the life-supporting capacity of aquatic ecosystems.

Faecal coliforms reach our rivers and streams from a variety of sources. These include surface or subsurface drains and outfalls, farm waste discharges, septic tanks, irrigation water, dairy pond effluent, and urban stormwater. Agricultural runoff and riparian grazing (livestock in channels, and faecal contamination of riverbank sediment) can also contribute to faecal coliform levels in water bodies.[34]

Monitoring results

Out of 69 sites, the majority of sites (61%) showed good or very good compliance with faecal bacteria standards, and no sites had very poor compliance (Figure 10).

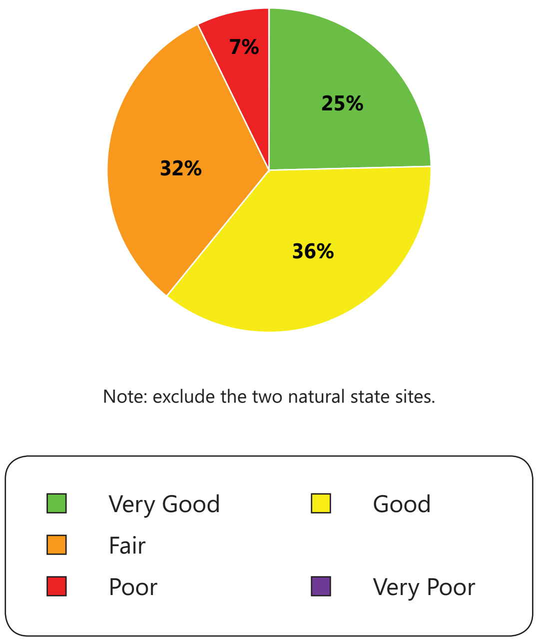
Lowland soft bed and hard bed water body classes breached their faecal coliform standard (1000 faecal bacteria per 100ml) a third of the time. The magnitude of these breaches was relatively high, ranging from 63 to 71. In addition, all sites within these two water body classes have breached the standard at least once between 2005 and 2010 (Table 7).

Lowland sites have the highest median faecal bacteria concentrations, closely followed by the one spring fed site.

Samples from Mataura 3, spring fed and lake fed sites breached faecal bacteria standards 21–25% of the time, while samples from hill sites breached only 5% of the time.

The Mataura 2 classification site (Mataura River at Otamita) has a more stringent faecal coliform standard of 200 faecal coliforms/100ml in the Water Plan; 42% of samples breached this standard, with a high breach magnitude of 75.

Figure 10: Compliance of sites with faecal coliform standards (2001-2010)



Note: exclude the two natural state sites.

[32, 33] MfE and MoH 2003

[34] Harding *et al.* 2004

Table 7: Faecal coliform levels by Southland surface water body class (2005–2010)

Water body classification (number of sites)	**Standards *** (faecal bacteria per 100ml)		**Median**	**Percentage samples breached**	**Magnitude of breaches**	**Number of breaching sites**
	Faecal coliforms	*E. coli*				
Natural state (2)	No change	No change	38	–	–	–
Lowland soft bed (13)	<1,000	–	535	33	71	13 of 13
Lowland hard bed (18)	<1,000	–	430	30	63	18 of 18
Hill (10)	<1,000	–	50	5	7	8 of 10
Lake fed (4)	–	<130	35	21	65	4 of 4
Spring fed (1)	<1,000	–	405	25	16	1 of 1
Mataura 2 (1)	<200	–	165	42	75	1 of 1
Mataura 3 (22)	<1,000	–	290	23	55	21 of 22

*See Table 2 for explanation of standards.

Note: we have no sites in the mountain water body class

See "How this report works' for an explanation of the measures

Want more detail on the results of a particular site?

Visit: http://www.es.govt.nz/environment/monitoring-and-reporting/state-of-the-environment/water-2010/

Figure 11: Percentage of sites in each WQI category class

Water Quality Index (WQI)

Southland's Water Quality Index is calculated from the four water quality variables (NNN, DRP, faecal coliforms, and clarity). Of the 69[35] sites on rivers and streams, 89% are in the poor or very poor categories (Figure 11). Only one site (Monowai River below gates) is in the good category.[36]

It is important to note that indices such as the Water Quality Index do have limitations, including the loss of information on individual variables and on the interactions between variables.[37]

Hill, lowland hard bed and Mataura 3 sites had WQI values ranging from the very poor to average (Figure 12). The lake fed sites have WQI values ranging from poor to good water quality. Lowland soft bed sites have WQI values ranging between 24 and 55, indicating they are in very poor to poor condition.

Out of the 69 sites, Winton Stream at Lochiel (Lowland hard bed) has the worst WQI value (18 out of 100); while Monowai River (Lake fed) has the best (81) (Figure 13).

[35] excludes the two natural state sites

[36] WQI value calculated using CCME with the following four parameters NNN, DRP, faecal coliforms (or *E.coli* if Lake Fed) and visual clarity. Visual clarity data has not been included for a total of 3 sites (See previous 'Visual Clarity' section for explanation) The WQI User Guide recommends a minimum of 4 parameters should be used to calculate a WQI score, so results for those 3 sites should be treated with caution.

[37] CCME 2001

Figure 12: Water Quality Index categories for Southland surface water body class

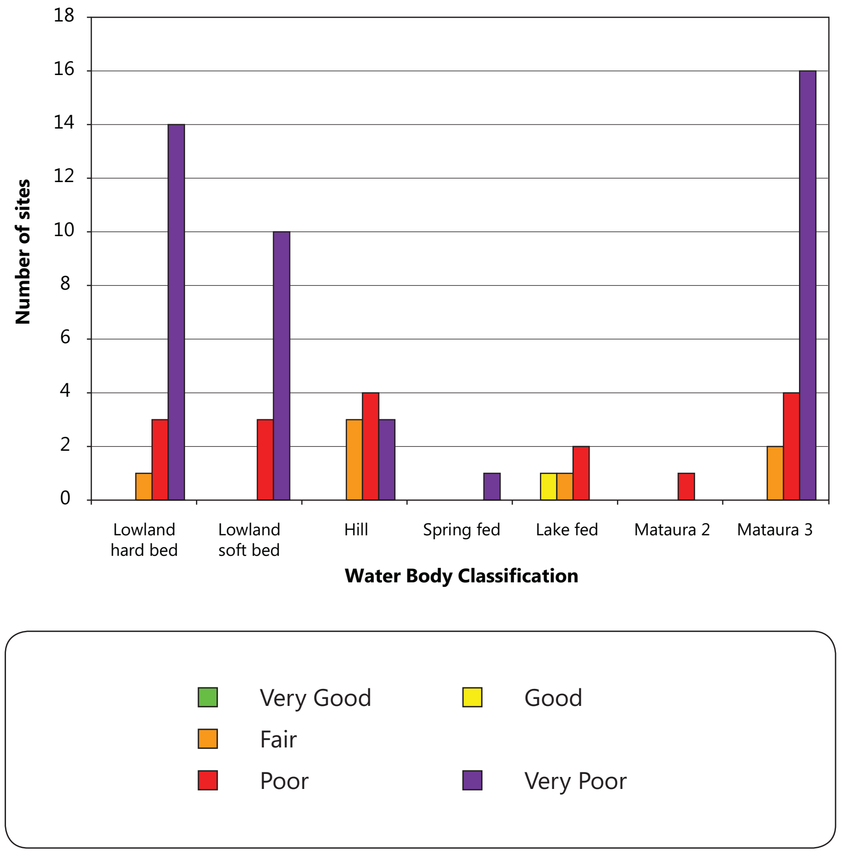
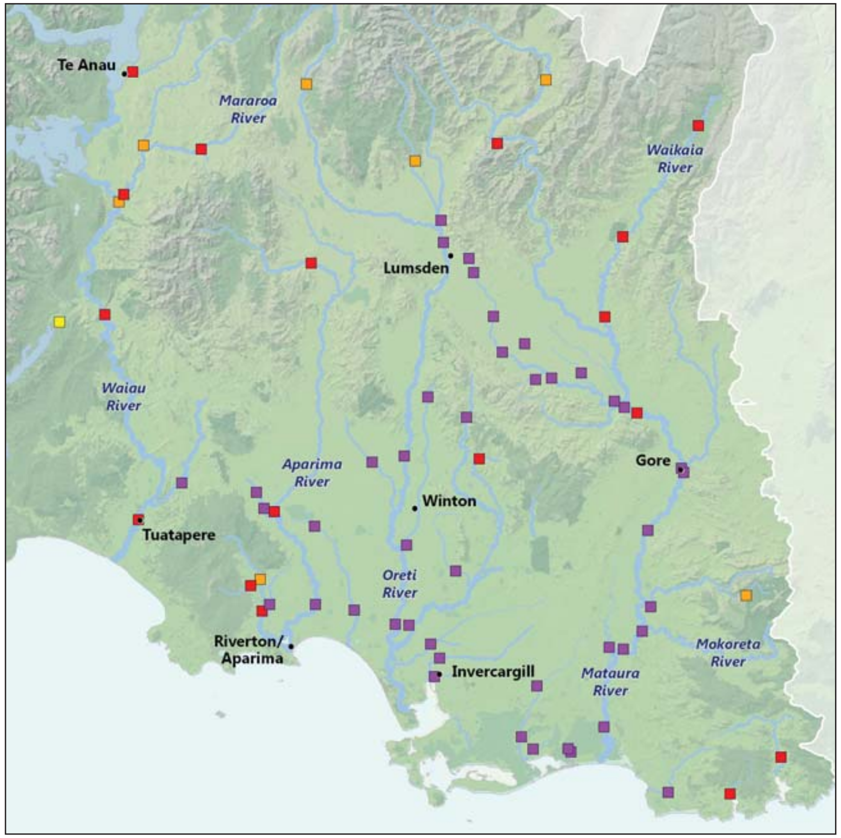


Figure 13: Water Quality Index categories for Southland river monitoring sites



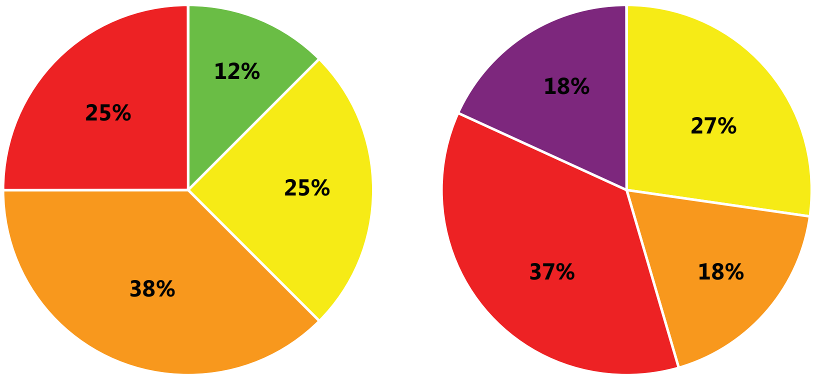
More site specific information is available on our website, www.es.govt.nz

Cultural Health Index

The Cultural Health Index is calculated on the scores given to two aspects of sites assessed during the State of the Takiwā monitoring (in the Waiau in 2005, and in the Mataura and Waikawa catchments in 2007). These are the abundance of and access to mahinga kai, and stream health.

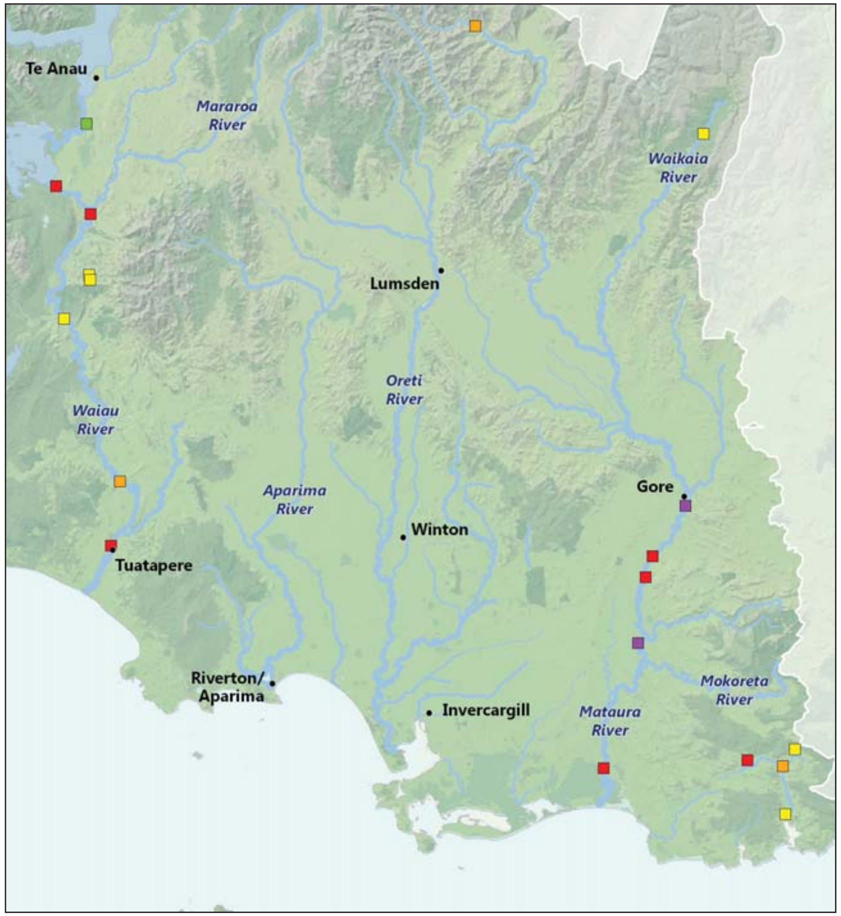
The monitoring shows that the Mataura and Waikawa catchments have broadly similar cultural health, but the health of the Waiau catchment is quite different (Figures 14, 15). The Waiau has higher overall CHI ratings, with 38% of sites scoring good or very good cultural health and no very poor sites. In contrast, the majority of sites within the Mataura and Waikawa catchments have poor or very poor cultural health (55%), with no very good sites.

Figure 15: Percentage of State of the Takiwā sites in each cultural health category class



A) Waiau **B) Mataura & Waikawa**

Figure 14: Cultural Health Index ratings from State of the Takiwā monitoring



Very Good | Good | Fair | Poor | Very Poor

Figure 16: Nutrient trends over 5-10 years (as at 30 June 2010)

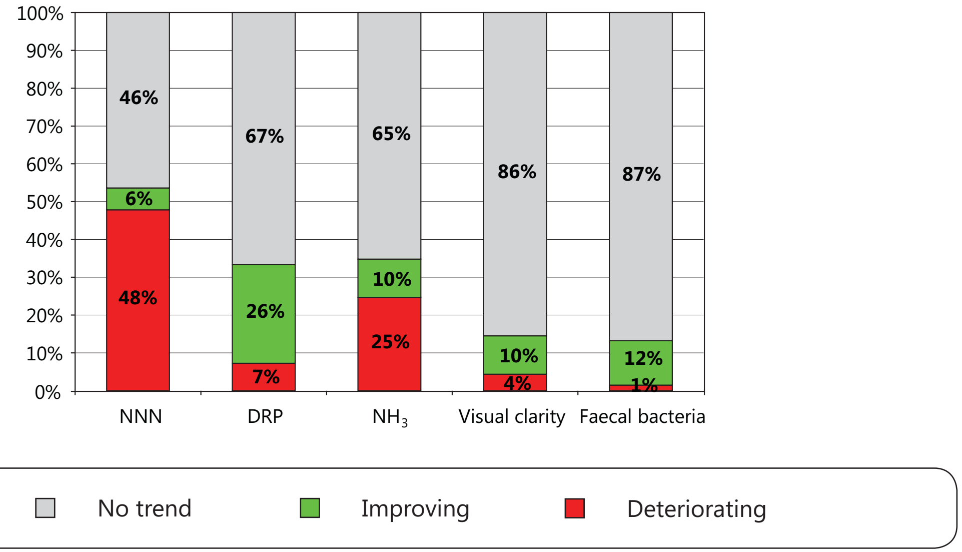


Table 8: Nutrient trends by water body class over 5-10 years (as at 30 June 2010)

		Water body classification							
		Hill	Lake fed	Lowland hard bed	Lowland soft bed	Mataura 2*	Mataura 3	Natural state**	Spring fed*
DRP	Deteriorating			6%	15%			50%	100%
	Improving	67%		17%	38%		19%		
	No trend	33%	100%	78%	46%	100%	81%	50%	
NNN	Deteriorating	67%	25%	39%	31%		71%		
	Improving			11%	8%			50%	
	No trend	33%	75%	50%	62%	100%	29%	50%	100%
NH_3	Deteriorating	33%	25%	28%		100%	24%	50%	100%
	Improving		25%	11%	8%		14%		
	No trend	67%	50%	61%	92%		62%	50%	
Visual clarity	Deteriorating	11%		6%			5%		
	Improving				23%		19%		
	No trend	89%	100%	94%	77%	100%	76%	100%	100%
Faecal coliforms	Deteriorating							50%	
	Improving	11%		11%		100%	19%		
	No trend	89%	100%	89%	100%		81%	50%	100%

* only one site monitored in this class

** only two sites monitored in this class

How river and stream water quality is changing over time

To assess this change over time, we measure trends in five variables: dissolved reactive phosphorous (DRP), nitrate–nitrite–nitrogen (NNN), ammonia (NH_3), visual clarity, and faecal coliforms including *E. coli*. The period over which we measure these trends is 10 years where possible; otherwise we use a minimum of 60 monthly data points collected over 5–10 years, to establish a water quality trend.

Water quality variables increase with river flow, particularly nutrients and sediment. This analysis of water quality trends is flow adjusted in order to determine the amount of a particular contaminant coming into an area. There are, however, gaps in this information for two sites which do not have river flow information (Upukerora River at Te Anau Milford Highway and Mimihau Stream tributary at Venlaw Forest), and there are no trend reports for those sites.

The standard in the Water Plan for natural state waters is to have 'no change', so if a site shows an improving or deteriorating trend it will not meet the standard.

Want more detail on the results of a particular site?

Visit: www.es.govt.nz/environment/monitoring-and-reporting/state-of-the-environment/water-2010/

Significant trends in the indicators we measure

Nutrients

Water quality trend results for all 69[38] sites are shown in Figure 16.

Dissolved reactive phosphorus (DRP)

The majority of sites (67%) show no significant change in DRP concentrations.

Across all water body classes, 26% of sites show an improvement in DRP concentrations (the rate of change across those 18 sites is between 2.3 and 15.0% per year).

Seven percent of sites are deteriorating for DRP concentrations. The Carran Creek tributary at Waituna Lagoon Road (Lowland hard bed) shows the highest rate of change, deteriorating at 16.5% per year.

In the hill classification, the majority of sites show improving DRP trends (Table 8).

Nitrate–nitrite–nitrogen (NNN)

Nearly half of the sites (48%) show deteriorating trends for NNN concentrations. In the hill and Mataura 3 classifications the majority of sites are deteriorating. The mid and lower Mataura River sites show deteriorating NNN trends, while the Waimea Stream at Murphy Rd site shows the highest rate of deterioration – 34% per year.

Across all water body classes, while 46% show no significant change over time in NNN concentrations, four sites show an improvement.

Ammonia (NH_3)

The majority of sites (65%) show no change in ammonia concentrations.

A quarter of sites show deteriorating trends in ammonia concentrations. Those 17 sites are predominantly in the hill water body class, in the middle and upper parts of the Mataura and Aparima rivers.

Ten percent of sites show an improvement. They are in a variety of locations, with the Sandstone Stream at Kingston Crossing Road (Mataura 3 class) showing the biggest rate of improvement – 145% per year.

Visual clarity

No detectable change in visual clarity was shown at 86% of the sites we monitor.

Seven sites (10%) show an improving trend in visual clarity. All these improving sites occur in lowland rivers and streams, with the Sandstone Stream at Kingston Crossing Road (Mataura 3 class) showing the highest rate of improvement – 11% per year.

Three sites (4%) show a deteriorating trend in visual clarity. These sites are the Oreti River at Centre Bush, Otapiri Stream at Otapiri Gorge and the Mataura River at Garston (Hill, Lowland hard bed, and Mataura 3 classes, respectively).

Faecal coliforms

The majority of sites (87%) show no detectable change in faecal coliform concentrations.

Twelve percent of sites are decreasing in faecal coliform concentrations. Six of these eight sites are lowland hard bed rivers and streams, largely in the mid and lower Mataura River. The Waimea Stream at Murphy Road shows the highest rate of improvement (78% per year).

Of concern is the natural state site, Mokotua Stream at Awarua, which is increasing in faecal coliform concentrations by 58% per year.

Natural state waters – compliance with the standards

Water quality data for the last 10 years has been analysed for four key variables (NNN, DRP, faecal coliforms, clarity) at the two natural state sites that we monitor: Dunsdale Stream at Dunsdale Reserve, and Mokotua Stream at Awarua. The Dunsdale Stream at Dunsdale Reserve shows no significant change over the 10-year period. It therefore meets the ‘no change’ target.

The Mokotua Stream at Awarua meets the target for water clarity (no up or down trend observed), but there are deteriorating trends for DRP, faecal coliforms and ammonia, while nitrate at this site shows an improving trend over the last nine years.

Progress towards our management targets

Environment Southland’s Water Plan has a target to reduce nitrate, phosphorus and microbiological contaminants and to improve water clarity in hill, lowland and spring-fed surface water bodies by at least 10% by 2020.

[38] There is no river flow data and therefore no trend analysis for two sites.

In order to determine whether a monitored site was likely to meet this target, current trend direction for each parameter at a site was used. If a site shows an improving trend over the last 5 to 10 years and we assume this pattern continues for the next 10 years (to 2020), then the site is likely to meet the 10% target. However, if a site shows no trend or a deteriorating trend over the last 5 to 10 years, it is unlikely that the site will meet the 10% target if the current trend direction remains the same.

Currently, it appears that the Water Plan target is unlikely to be met. However, this approach is conservative and may not necessarily represent what will occur at a site over the next 10 years. The community and our management responses could still generate water quality improvements (or deteriorations) in Southland over the next 10 years.

How do Southlands rivers and streams compare nationally?

This section compares the water quality of Southland's rivers and streams with overall New Zealand statistics. The comparison is with data from a 2010 Ministry for the Environment (MfE) report on national river water quality.[39] The report compares 16 regional and territorial authorities, with Southland performing the worst for NNN concentrations, third worst for visual clarity, and sixth worst for faecal bacteria and DRP concentrations (2003 to 2007).

The MfE report uses different water quality guidelines for some measures. In terms of NNN, the conservative ANZECC upland and lowland guidelines are used (upland national guideline is 0.167 mg per L compared to 1 mg per L while lowland is 0.444 mg per L, compared to 1.7 mg per L).[40] The national report also uses clarity and faecal bacteria guidelines differently; faecal contamination was reported using E. coli as an indicator rather than faecal coliforms. Hoever, the DRP guideline is the same and ammonia (NH_3) is not recorded at all in the MfE report.

Despite some variance in the use of guidelines, for the purposes of determining trends, units used aren't particularly significant. Therefore, differences in the trends reported by MfE and in this report are likely to be due to the lower number of Southland sites analysed in the MfE study[41] and the different trend periods analysed (this report covers 5–10 years to 30 June 2010 and MfE covers 1998–2007). Both sets of trends were determined using the same methodology.

Dissolved reactive phosphorus (DRP)

Median DRP concentrations in Northland, Auckland, Waikato, Bay of Plenty, Taranaki and Southland regions exceeded the ANZECC (2000) trigger value at more than 50% of sites. The Southland region ranks sixth worst and median DRP concentrations exceeded the guidelines at 54% of sites over 2003-2007.

Nationally, there was approximately the same number of sites with deteriorating and improving trends for DRP. Most significant decreases were observed in the Southland and Wellington regions (50% and 29% of sites respectively). Southland is therefore the best region in New

Groundwater and water quality interactions

Groundwater (the freshwater found beneath the ground) is often a major component of a stream or river's flow, water level, and physical and chemical properties. Throughout Southland, groundwater is a significant component of our rivers, streams, freshwater lakes, lagoons and estuaries.

As ground and surface waters are inextricably linked, any changes in groundwater quality and quantity can exert a major influence over the health of our waterways. Unlike surface waters, groundwater reservoirs (aquifers) often respond slowly to changes, and once polluted, the legacy of contamination may persist for generations. Consequently, surface waters may receive contaminated groundwater long after the pollution source has been removed or the water body has been protected by riparian planting, fencing or reclamation. Restricting the degradation of groundwater is therefore critical to the health of Southland surface waters.

For more detail on groundwater and river water quality interactions go to the groundwater case study on the Environment Southland website www.es.govt.nz/environment/monitoring-and-reporting/state-of-the-environment/water-2010

[39] Ballantine *et al* 2010. Note that this reports water quality results from 2003 to 2007

[40] Hickey and Martin, 2009

[41] The MfE report analysed trends at between 23 and 36 sites for Southland (34 sites NNN, 32 sites DRP, 23 sites faecal coliforms and 36 sites for clarity)

Zealand for improving DRP trends in our rivers between 1998 and 2007 (50% of sites). The most significant increases were in the Otago and Waikato regions (59 and 21% of sites respectively).

However, more recent DRP trends analysed for Southland in this report show that just 26% of sites have an improving trend compared to 50% of sites stated in the MfE report.

Nitrate–nitrite–nitrogen (NNN)

Median NNN concentrations in Southland and Canterbury regions exceeded the ANZECC (2000) trigger value at more than 50% of sites. The Southland region ranks worst for NNN, with median NNN concentrations exceeding ANZECC (2000) guidelines at 56% of sites over 2003-2007.

Nationally there were a similar number of sites with increasing and decreasing trends for NNN. The largest deteriorating trends were in the Waikato region (38% of sites), while the most improving trends were in the Northland, Auckland, and Wellington regions (75, 56, 46% of sites respectively).

Southland was not specifically mentioned in the report as it was found to have just 12% of sites with a deteriorating NNN trend. However, if we take the most recent trend analysis results for this report, Southland has a deteriorating NNN trend at 48% sites. This puts Southland as worse than Waikato for nitrate in our rivers.

Faecal bacteria

E. coli was used rather than faecal coliforms in the MfE report. Throughout New Zealand the *E. coli* guidelines[42] were exceeded over the period 2003-07. The Southland region exceeded the *E. coli* guideline at 82% of sites over this period, ranking sixth worst nationally.

While very few significant national trends exist for faecal contamination, the most significant improvements were observed in the Hawke's Bay, Southland, Wellington and Otago regions. Southland ranks second best nationally in terms of improvements over this period, with 26% of sites improving, better than the national average of 16%.

Visual clarity

Median visual clarity in Northland, Auckland, Waikato, Manawatu-Wanganui and Southland regions was below the MfE guideline value at more than 50% of sites. The Southland region ranks third worst, with 71% of sites exceeding median clarity over 2003–2007.

The Waikato region has the greatest proportion of deteriorating trends for clarity (44% of sites). In comparison, Southland has just 8% of sites with deteriorating trends. Southland also showed significant improving trends at 8% of sites over 1998-2007, just below the national average of 8.5%.

K. Yardena

[42] The 95th percentiles for the *E. coli* 'action' guideline (550 E. coli/100ml) (MfE and MoH, 2003)

Case study: Trout and salmon in Southland

Trout and salmon fishing in Southland is a popular pastime, with an estimated 155,000 angler visits[43] made to Southland's rivers and lakes each year. Approximately 113,000 of these were made by locals, around 17,000 by overseas anglers and the remainder by people from other places in New Zealand.

Since the 1990s, overall angler use in the region has remained relatively constant, but a survey conducted in 2006/07 revealed a reduction in the use of lowland rivers and an increase in the use of headwater rivers and large lakes. It is possible that perceptions of reduced fish numbers, increased pollution or reduced access opportunities have contributed to this shift, but there has been no research completed to quantify the effects of each of these factors.

Trout are an important indicator to the health of our freshwater environment. They are the 'canary in the mine' species. As trout are more sensitive to poor water quality than native species, we know if the number of adults, juveniles or even preferred food decline at a particular site, it is a good indication of a reduction in water quality there. Many of the Water Plan water quality standards are based on their habitat requirements.

Adult trout numbers have mainly been monitored in the upper reaches where good water clarity makes counting by divers feasible. This shows that populations have remained relatively steady or increased, with the exception of the Waiau and Mararoa rivers, where trout numbers declined after didymo became established. The practice of 'catch and release' has become more widespread since the 1990s and this, as well as reduced bag limits and prohibition on use of natural bait, has resulted in reduced harvest of larger trout in popular fisheries such as the upper Mataura and upper Oreti rivers. It is surmised that these changes in fishing behaviour have resulted in increased trout numbers in upper reaches, rather than any environmental change.

Brown trout

Brown trout were first introduced into Southland in the late 1860s from Great Britain via Tasmania. Brown trout occur in most fresh and estuarine waters of the region, with the exception of Stewart Island/Rakiura.

Adult brown trout prefer habitats where the water is over 50cm deep, with large trout requiring deep water refuges. Still water areas, such as estuaries and lakes, do provide good trout habitat, provided water quality is good.

Brown trout survive in water temperatures from close to 0^{o}C to about 24^{o}C. They thrive where summer temperatures are between 12^{o}C and 19^{o}C. Water quality also needs to be good for brown trout to survive. High water clarity, low nutrients and high concentrations of dissolved oxygen contribute to the health of brown trout habitats.

Trout are mainly invertebrate feeders and are most abundant where stream insects, especially mayflies, stoneflies and caddisflies, are also abundant. Streams with cobbles and gravels made of hard rock (eg greywacke, quartz and shist) provide the best physical habitat, whereas those with a high proportion of bedrock, silt or sand have low populations of trout regardless of the water quality.

Peak spawning time for brown trout is between late May and July. Low temperatures and high concentrations of dissolved oxygen are required for the eggs to survive through to hatching, which normally occurs September/October. Habitats with fine sediment and high dissolved nitrate concentrations can reduce the chance of survival. Ammonia concentrations found in lowland stream beds may also reduce survival.

In Southland waters, trout normally grow to about 15cm in their first year, 25cm in their second and then 35–40cm in their third year, by which time they spawn. The brown trout of about 50cm will generally only feed on macro invertebrates, while larger fish will have done some feeding on small fish, which are most abundant in estuaries. This implies that large trout in upper reaches of the main rivers, such as in the Oreti, have spent some time in the lower reaches where they were able to grow to such a size.

Rainbow trout

Rainbow trout, native to the west coast of North America, are only found in the Waiau catchment. They were introduced into other Southland rivers, mainly in the early part of the twentieth century, but did not survive. Rainbows have similar habitat requirements to brown trout in terms of water quality, flows and physical space.

Chinook salmon

Adult Chinook salmon migrate into the Waiau, Oreti, Aparima, Mataura and Hollyford Rivers in the late summer and autumn to spawn. Numbers vary between years and between rivers, from several dozen to several hundred. There is also a small 'land-locked' population in Lake Manapouri.

These fish were also introduced to New Zealand from North America and liberated into the Waitaki river system in the early 1900s. Numbers remained low in Southland rivers, although they have increased since the 1990s when releases into Bluff Harbour and escapees from salmon farms on Stewart Island/Rakiura occurred. Salmon have similar freshwater habitat requirements to trout.

[43] Unwin 2009

The life in our waters — Koiora wai

Ngā Ponong a Tāne a Tangaroa – Biodiversity

Tāne created trees and all
living things that breathe air.
Manu, ngata, ngārara, rākau, tohorā,
kekeno, aihe, tuna, tangata, kararehe
Birds, snails, insects and lizards, trees,
whales, seals, dolphins, people, animals
Tangaroa is responsible for all fish
Ikanui, ikaroa, ikaiti, tuna
Big fish, long fish, small fish, eels

— Ngāi Tahu ki Murihiku, Te Tangi a Tauira, 2008

We have a diverse range of life in our waterways – including algae, aquatic plants, invertebrates, fish and birds, many of which are taonga. This is referred to as biodiversity, and includes variety within a species and between species, as well as the ecosystems and processes that maintain them. Biodiversity is fundamentally important in maintaining healthy, functioning ecosystems.

Culturally important mahinga kai species found in Southland rivers range from tuna (eels), kanakana (lamprey) and inanga (whitebait) to waikōura (freshwater crayfish), waikākahi (freshwater mussels) and wātakirihi (watercress).

When we talk about 'waterways' we need to include the water's edge – the riparian areas that are transition zones between water and land. These are often the places that people and animals interact with the water and the life it supports. Such areas are often associated with mahinga kai and other customary use activities using preferred techniques that have been passed down from one generation to the next. Riparian areas contain a range of important plant species some of which are used for wāhi rāranga (sources of weaving materials), or rongoā (traditional medicines).

Healthy riparian areas also play a role in maintaining or improving the ecological function of streams. They reduce bank erosion, provide habitat, regulate temperature, provide shade, and enhance water quality by filtering contaminants and sediment, thus reducing nutrient and bacteria entering a waterway. Healthy riparian areas can also reduce weed growth along a waterway or drain.

Southland has traditionally been a popular region for sports fishing, whitebaiting and game bird hunting. These sports, as well as mahinga kai traditions, depend heavily on the health of their habitats. The presence/absence and health of the creatures in our waterways can tell us a lot about the health of the habitat they depend on to survive.

This section reports on the aquatic freshwater flora and fauna in our river and streams, however this monitoring doesn't currently extend to other freshwater environments. These monitoring programmes cover:

- fish species
- the macroinvertebrates and algae growing on the beds of rivers and streams (periphyton) that form the base of the food chain
- some limited information on mahinga kai – the species that are culturally important to Māori.

Trout are one of the most sensitive fish found in our waters therefore the majority of the Water Plan water quality standards are based on their habitat requirements.

Our reporting also highlights which animals and plants in freshwater ecosystems are considered 'under threat'. The different pressures on freshwater ecosystems, and what we are doing in response to those pressures, are covered in later sections of the report.

The fish in our waters

The Southland region has a rich range of native freshwater fish. At least 20 of New Zealand's 50[44] native fish species are found here. In Southland, as with most of New Zealand, the bulk of our freshwater fish are found relatively close to the coast. This reflects the need for the majority of New Zealand's native fish to spend time in both fresh and saltwater to complete their life cycle.

Fish are of great cultural, social and economic significance to Ngāi Tahu ki Murihiku. Fish from Southland/Murihiku rivers traditionally formed an essential part of the Ngāi Tahu economy prior to the Treaty of Waitangi. The importance of such fisheries remains today. However, issues such as poor waterway health, barriers to fish movement (ie dams, culverts and weirs) and private land ownership, often impede the ability of tangata whenua to access and use customary fisheries.

Commercial freshwater fisheries such as eels, also provide economic value to the overall Southland community. In Southland, we also have introduced sports fish, namely brown and rainbow trout, which support internationally significant recreational fisheries. Other introduced species include Chinook salmon and perch.

Freshwater fish survey records collected in New Zealand are held in the New Zealand Freshwater Fish Database (NZFFD). This database contains more than 30,000 records across the country. Between 1970 and 2010, 1135 sites were surveyed in Southland (Table 9).

For more information and images of Southland's important fish species check out the 'Freshwater Fish in Southland' poster inserted in this report and also available for download from www.es.govt.nz.

[44, 45] Allibone *et al* 2010

Table 9: Freshwater fish species found in Southland and frequency of occurrence (1970–2010)

Common name	Scientific name	Number of sites	Frequency of occurrence (% of sites)	Geographical distribution	National threat classification 2010[45]
Longfin eel[Φ•]	*Anguilla dieffenbachii*	493	43	Widespread	Declining
Brown trout	*Salmo trutta*	487	42	Widespread	Introduced and naturalised
Koaro[wb]	*Galaxias brevipinnis*	319	28	Frequent	Declining
Common bully	*Gobiomorphus cotidianus*	218	19	Frequent	Not threatened
Upland bully	*Gobiomorphus breviceps*	197	17	Frequent	Not threatened
Unidentified galaxias (including Southern flathead)	*Galaxias spp.*	170	15	NA	NA
Redfin bully	*Gobiomorphus huttoni*	169	15	Frequent	Declining
Gollum galaxias	*Galaxias gollumoides*	120	11	Frequent	Declining
Inanga[wb]	*Galaxias maculatus*	117	10	Frequent	Declining
Giant kōkopu (Taiwharu)*[wb]	*Galaxias argenteus*	109	10	Frequent	Declining
Banded kōkopu[wb]	*Galaxias fasciatus*	102	9	Sparse	Not threatened
Shortfin eel[Φ•]	*Anguilla australis*	99	9	Sparse	Not threatened
Rainbow trout	*Oncorhynchus mykiss*	63	5	Sparse	Introduced and naturalised
Unidentified bully	*Gobiomorphus spp.*	62	5	Sparse	NA
Lamprey (Kanakana)[•]	*Geotria australis*	46	4	Sparse	Declining
Torrentfish (Piripiripōhatu)*	*Cheimarrichthys fosteri*	44	4	Sparse	Declining
Unidentified eel[Φ•]	*Anguilla spp.*	42	4	Sparse	NA
Common smelt (Paraki/ Ngaiore)*	*Retropinna retropinna*	33	3	Sparse	Not threatened
Alpine galaxias	*Galaxias paucispondylus*	27	2	Sparse	Not threatened
Black flounder	*Rhombosolea retiaria*	24	2	Sparse	Not threatened
Bluegill bully	*Gobiomorphus hubbsi*	22	2	Sparse	Declining
Yellow-eye mullet	*Aldrichetta forsteri*	16	1	Marine wander	Not threatened
Perch	*Perca fluviatilis*	12	1	Rare	Introduced and naturalised
Shortjaw kokopuwb	*Galaxias postvectis*	6	<1	Rare	Declining
Giant bully (Kōkopu/Hawai)*	*Gobiomorphus gobioides*	2	<1	Rare	Not threatened

[Φ] Commercially harvested species
* Taonga species – NTCA 1998 (and important customary fishery)
[•] Important customary fishery
[wb] Whitebait species (and important customary fishery)
NA = not applicable

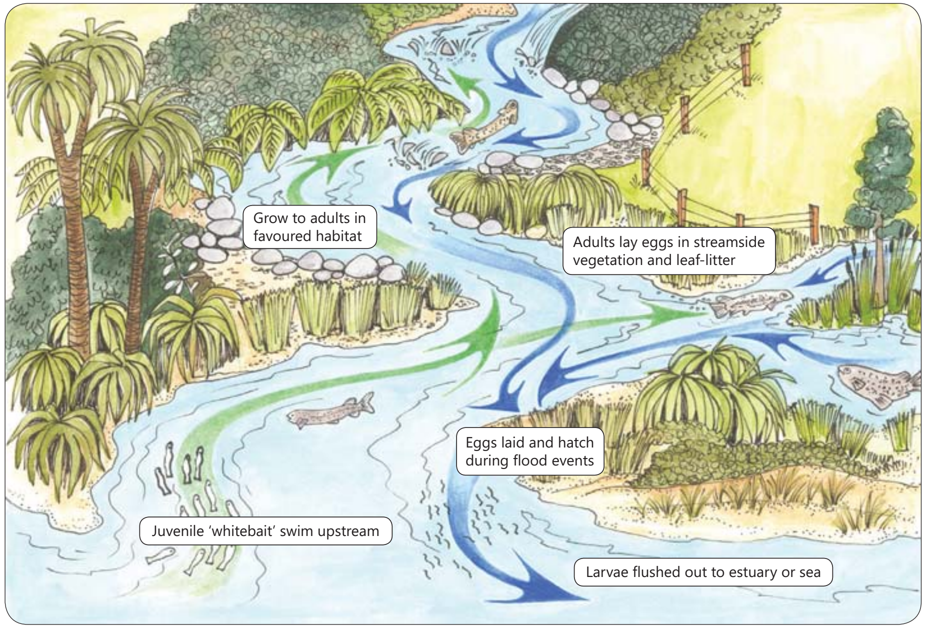
Our 'whitebait' fish species

Next time you fry a whitebait patty, you could be about to get a taste of up to five different native fish. Whitebait is the collective term given to the juveniles of inanga, koaro, banded kōkopu, giant kōkopu and shortjaw kōkopu[46].

All whitebait species are diadromous. This means they spend different parts of their lifecycle in fresh and saltwater (Figure 17). However, there are also some landlocked populations that use lakes for the 'marine phase' of their life cycle, before returning to lake tributaries. In Southland, examples of this include a giant kōkopu population in Lake Monowai, while koaro occur in Lakes Te Anau and Manapouri and their tributaries.

The most significant threat to the survival of our iconic whitebait fishery is the loss and degradation of suitable habitat[47]. Whitebait generally require clean, shallow waterways with native vegetation nearby, such as those provided by swamps and wetlands. Modification of waterways, such as the draining of wetlands and removal of native plant cover, has reduced the quantity and quality of readily available habitat for whitebait. An added pressure is the trampling of banks and grazing of streamside vegetation by stock, which can damage spawning grounds for whitebait species.

Figure 17: Lifecycle of our whitebait species



Monitoring the life in our waters

This section outlines the monitoring programme that allows us to report how well plant and animal life is supported in our freshwater environments. It sets out *how* we monitor – in terms of the management targets we work towards and the standards and guidelines used for those targets. It then describes *what* we monitor, and how we measure those things.

How we monitor

Our management targets

The Water Plan sets targets for the water quality in our freshwater environment in terms of its ability to support life in the water. A target for ecological health is that the water quality of all surface water bodies will be suitable for trout and native fish (including all life stages the water body naturally contains habitat for).

An additional Water Plan target states that water quantity, flow and level regimes, and the quality and quantity of aquatic habitat, are maintained at levels that protect aquatic ecosystem health and the life-supporting capacity of surface water bodies.

The protection of indigenous biodiversity is important for Ngāi Tahu ki Murihiku. Indigenous species, and the habitats that support them, must be protected for future generations. In many parts of the takiwā, where land use is dominated by agriculture and forestry, the impact

[46, 47] McDowall 1984

of human activity on indigenous species has been significant.

An important focus for Ngāi Tahu ki Murihiku is finding ways to protect, maintain and improve habitat for all biodiversity, be it in water, riparian margins, native bush or wetlands.

The standards we use

The Water Plan sets standards for water quality in Southland rivers based on analysis of macroinvertebrates (eg insects, worms and snails) and benthic periphyton (algae on the riverbed) – see Table 10 and 11, and 'The measures we use', pg 39. These standards do not apply, however, to the areas of water classified as 'Mataura water bodies', which do not currently have Water Plan standards of this type. They have older, mainly narrative standards from the Mataura Water Conservation Order 1997. To report on the 'life-supporting' quality of the water in those areas, we have used the standards or guidelines that apply to the nearest equivalent water body classification, ie 'Lowland hard bed' for Mataura 3 (lowland), and 'Hill' for Mataura 3 (upland) and Mataura 2.

The Water Plan also sets water quality standards that specify plants and animals need to have suitable habitat in our freshwater ecosystems. By ensuring water quality is suitable to sustain the most water quality sensitive species like trout, then other species will also be sustained. These water quality standards are detailed in the 'Rivers and Streams', 'Wetlands' and 'Lakes and Lagoons' sections.

This need for high quality habitat also shapes the minimum limits we set on water quantity (see *'Our Uses'* report in the Southland Water 2010 series) and our management of wetlands and estuaries.

What we monitor

Macroinvertebrates and periphyton

Environment Southland monitors the amount and type of macroinvertebrates (eg insects, worms and snails) and benthic periphyton (algae on the river bed) as a measure of the ecological health of our waterways. We currently monitor 79 sites each summer, which has increased significantly from the 51 sites initially monitored in 1996. By monitoring these plants and animals we can determine how 'healthy' the river or stream is, as macroinvertebrates and periphyton can be adversely affected by things like industrial and stormwater discharges and changes to stream habitat (eg removal of shady vegetation, straightening of stream channels).

Fish

Since 2007/08, we have monitored fish populations at 14 sites as part of our state of the environment monitoring programme (Figure 18).

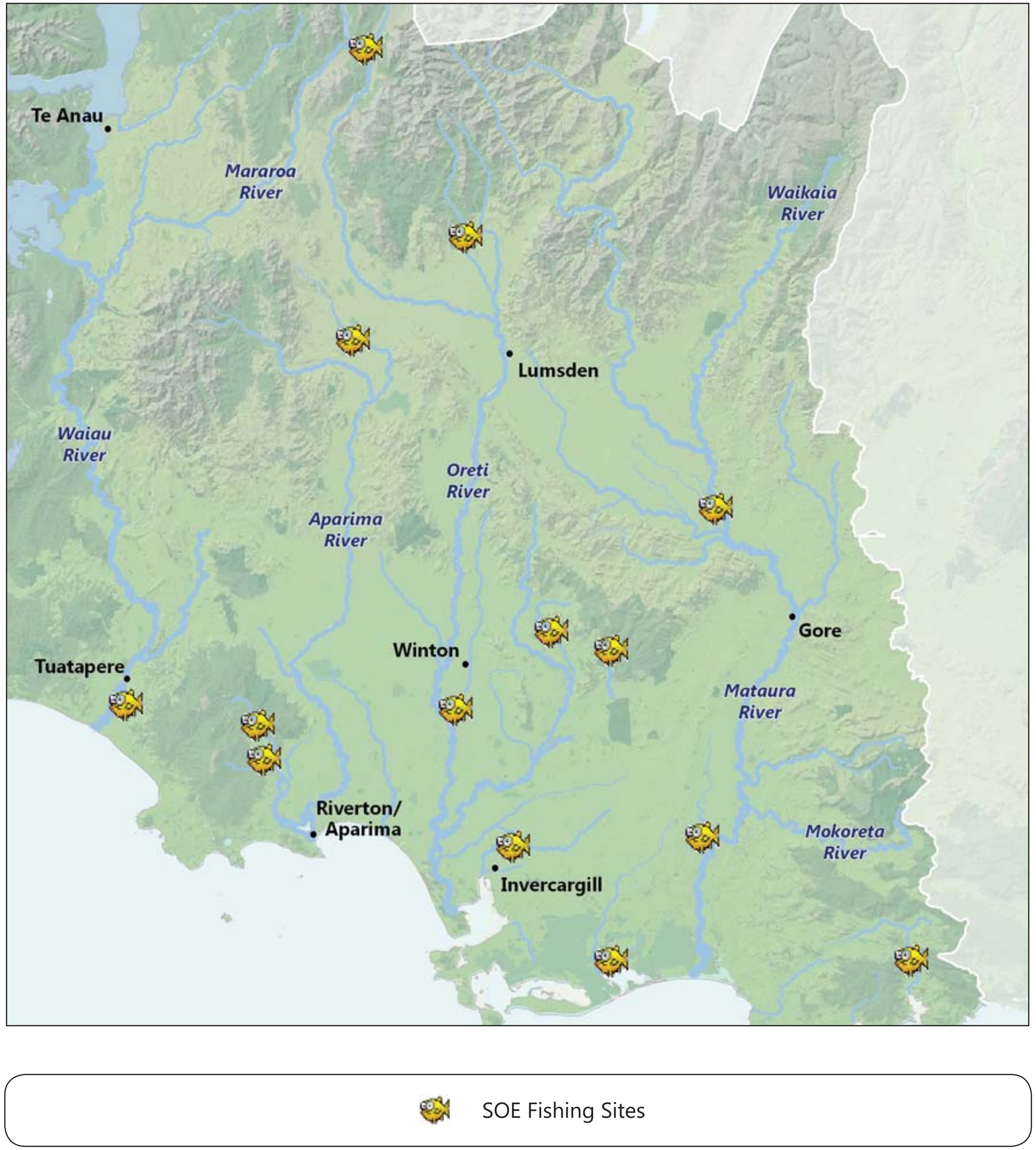
Monitoring our diverse fish species and their populations is a useful way of assessing ecosystem health. This is based on fish species' usual position at the top of the food chain in aquatic ecosystems – any changes to water quality and resulting impacts on macroinvertebrates can be expected to affect fish populations. Detrimental effects can show up as either a decline in fish population numbers and/or as a decline in fish species diversity.

Fish populations generally experience short-term fluctuations due to natural factors such as flooding, drought, migration and the success of each year's spawning effort. Therefore, annual fish monitoring is not very sensitive at detecting short-term changes arising from changes in water quality. Instead, fish monitoring is more useful for detecting the longer-term effects of poor water quality, or the loss of habitat. Because fish are at the top of the aquatic ecosystem food chain, they are generally slower to respond to deteriorating conditions than the food items they prey on (macroinvertebrates). However, when these impacts are detected in fish species, the affects can be dramatic – such as the loss of a species from a river site.

Monitoring information alone is not yet sufficient to determine trends in fish populations nor in fish species distribution across the Southland region. However, the data gathered to date does give us a useful 'status report' for the native fish species found in Southland's rivers and streams.

This information is also added to the New Zealand Freshwater Fish Database (NZFFD).

Figure 18: State of the environment fish monitoring sites



Mahinga kai species

The presence and abundance of mahinga kai species was documented in the State of the Takiwā monitoring (see 'How this report works', pg 11). Those results are included as part of the overall assessment of each site in our freshwater monitoring programme – as such it is reported in the following sections on specific ecosystem types, eg 'Estuaries'.

Te Ao Mārama Incorporated, in conjunction with the Cawthron Institute and Environment Southland, is investigating ways of monitoring kanakana (lamprey) because the abundance of this species is poorly understood. Cultural monitoring was initiated at a traditional harvesting site on the Waikawa River in 2008. It is too early to use this information to describe the state of this fishery, but some details of this monitoring can be found in the case study on Vincent Leith, pg 90.

The measures we use

Macroinvertebrate Community Index (MCI)

Macroinvertebrates are an important part of the aquatic food chain, feeding on algae and dead organic matter (eg leaf litter), and are eaten by fish.

Some macroinvertebrates are known to be less tolerant of pollution than others. Organic pollution of a waterway, either directly or through excessive algae growth, reduces the number of pollution-sensitive species, for example mayflies, caddisflies and stoneflies. At the same time, there is an increase in pollution-tolerant species such as midge larvae and snails.

Assessing the amount and type of macroinvertebrates at a site gives a good indication of the health of the ecosystem.

The Macroinvertebrate Community Index (MCI) is an index based on combining the pollution-tolerance scores of all species found at a site to determine the health of the ecosystem. Species that are very sensitive to pollution score highly, whereas species that are more pollution tolerant receive a lower MCI score (Table 10).[48]

Table 10: Macroinvertebrate Community Index water quality categories[49]

Water quality category	MCI score	Description
Excellent	> 119	Clean water
Good	100–119	Doubtful quality or possible mild pollution
Fair	80–99	Probable moderate pollution
Poor	< 80	Probable severe pollution

As well as reporting the latest MCI scores, this report also presents 10-year trends in the MCI (2000–2010) but only for sites that had eight or more annual samples collected. For more information about trend analysis in our reporting, see 'How this report works', pg 11.

Periphyton measures

Periphyton serves as an important food source for bacteria, invertebrates, and some fish. It can also absorb contaminants, removing them from the water and limiting their movement through the environment.[50]

High levels of nutrients can result in excessive growths of algae. This growth can reduce habitat for invertebrates and fish, increase suspended dead organic matter, deplete oxygen, increase fluctuations in pH and thereby increase ammonia toxicity.[51]

Periphyton is an important indicator of water quality, specifically nutrient enrichment, and is measured annually by Environment Southland using two measures of algal biomass (the weight of living material): chlorophyll a and Ash Free Dry Mass (AFDM). Chlorophyll a is the green-coloured photosynthetic pigment found in living plant cells and therefore indicates the amount of live algae present. AFDM is a measure of the total organic material present.

Periphyton is an important indicator for Māori and is included in the Cultural Health Index.

Trend analysis was not performed using annual periphyton data due to the highly variable nature of periphyton in rivers and streams.[52] Periphyton biomass varies depending on the accrual period (time since last flushing river flow), and therefore samples collected annually in summer may not represent peak biomass. To be able to determine long-term trends, we would need to take monthly periphyton samples, to capture periods of peak biomass.[53]

Fish Index of Biotic Integrity (IBI)

The Index of Biotic Integrity (IBI) compares the native fish species found at a site, with those that would normally be expected there, taking into account the natural changes in species numbers due to distance inland and elevation above sea level.[54] Trout are also included in the Southland fish IBI, as they are found in many areas and are considered indicator fish for good water quality.

IBI scores can range between 0 (no native fish) to 60 (when all expected species are found) and can be assigned an 'integrity class' (Table 11). The IBI allows for the comparison of fish communities at sites in different land-use types. It allows for comparisons of land-use effects and changes in fish communities over time, reflecting the ecological health of rivers[55].

Table 11: Index of biotic integrity score classes

IBI score	Integrity class	Attributes
49–60	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for site are present.
36–48	Good	Species richness and habitat, or migratory access is reduced; site shows some signs of stress.
24–35	Fair	Some stressors present; biotic integrity is impaired.
6–23	Poor	Species richness is drastically reduced; biotic integrity is impacted.
0*	No native fish	Site is grossly impacted or access for fish is non existent.

* The IBI calculations do not compute scores between 1-5.

[48] Stark and Maxted, 2007a
[49] Stark and Maxted, 2007b
[50, 51, 52] Biggs, 2000
[53] Kilroy *et al.* 2008
[54] Joy 2010a
[55] Joy 2010b

The Southland fish IBI has been developed from fishery records from a large variety of Southland sites, collected by numerous field staff, using an array of different sampling methods at different times of the year and at various flow conditions. These variations mean that only presence/absence data met our requirements for validity. Fish population health at each site has not been analysed due to the above data limitations.

Another limitation is that while the IBI model provides scores for each site, it cannot differentiate between possible causes, such as poor water quality, a man-made barrier such as a tidal gate, or naturally occurring barriers such as waterfalls.

IBI analysis is used in four ways in this report:

- IBI scores for 14 'state of the environment' fish monitoring sites provide us with a 'status report' for those sites, in terms of native species present.
- The Southland data from New Zealand Freshwater Fish Database (NZFFD) records is reported in the IBI framework, showing how Southland sites compare generally. Note that while NZFFD records date back to the 1900s they were generally sporadic in frequency until the 1970s, so we have only used records from 1970 to 2010 in this analysis.
- Changes over time in the NZFFD records are shown over two periods: 1970–1999 to provide a long-term context, and 2000–2010 to highlight changes since the last round of state of the environment reporting. Note that the comparisons are not between the exact same sites, and this could be the cause for some of the variation.
- These NZFFD records are also reported on by three land cover classes (high productivity pasture land, tussock, and indigenous forest) and by major catchment.

How the life in our waters measures up

Macroinvertebrates

Compliance with the Water Plan standards

The median MCI scores for all water body classes (other than Mataura 2 for which we have no data) was better than the relevant standard over the 2005–2010 period, except for the mountain and spring fed classes. The mountain class had a median score of 113 (compared to its standard of 120), while the spring fed class had a median of 88 (standard is 90) – see Table 12. Breaches occurred in 67% of mountain samples and 70% of spring fed samples; however, the magnitude of those breaches was relatively low.

MCI water quality categories

When we examine sites by water body classes, the majority of the natural state sites (83%) are in the 'excellent' or 'good' water quality categories for over the 2005–2010 period (Table 12). No natural state sites are in the 'poor' category. Similarly, 100% of sites in the hill and mountain classifications were in the 'excellent' or 'good' water quality categories in terms of median MCI scores. The lowland soft bed and hard bed classes had the only sites within the 'poor' category.

Of the 71 sites, 16 were classified as 'excellent' on the basis of their MCI scores, 28 as 'good', 23 as 'fair' and 4 as 'poor' (Figure 19). Overall, 71% of sites fell into the 'good' or 'fair' quality classes, indicating mild to moderate pollution at these sites.

Table 12: MCI scores for Southland surface water body classes (2005–2010)

Water body classifications (number of sites)	MCI Water Plan standard#[56]	Median*	Percentage samples breached	Magnitude of breaches*	Number of breaching sites	Percentage sites in MCI water quality category (2005–2010 median)			
						Excellent	Good	Fair	Poor
Natural state (6)	No change	118	–	–	–	50	33	17	0
Lowland soft bed (15)	>80	95	13	1.2	4 of 15	7	40	47	7
Lowland hard bed (17)	>90	96	38	5.2	8 of 17	18	24	41	18
Hill (12)	>100	117	6	0.1	3 of 12	42	58	0	0
Mountain (1)	>120	113	67	5.3	1 of 1	0	100	0	0
Lake fed (2)	>90	108	14	0.3	1 of 2	0	50	50	0
Spring fed (5)	>90	88	70	5.8	5 of 5	0	20	80	0
Mataura 2 (0)	>100	nd	–	–	–	–	–	–	–
Mataura 3 (upland) (8)	>100	121	15	1.5	2 of 8	50	38	13	0
Mataura 3 (lowland) (5)	>90	98	24	1.3	2 of 5	0	60	40	0

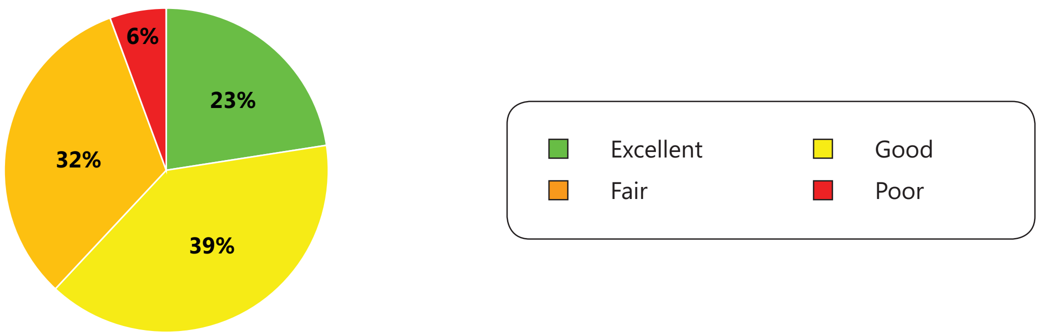
See 'The measures we use' for an explanation on the Macroinvertebrate Community Index.

* See "How this report works' for an explanation of this term

– not applicable

nd = no data

Figure 19: Percentage of sites (including natural state sites) in the MCI quality classes (2005–2010)



[56] The Water Plan also uses the Semi-Quantitative Community Index (SQMCI) as a standard. Here we report on the MCI because it is recognised as potentially a more sensitive index than the SQMCI (Quinn and Hickey 1990).

Periphyton

Compliance with the standards/guidelines

Chlorophyll a

All Southland water body classes[57] had chlorophyll *a* medians lower than the standard over the 2005–2010 period (Table 13).

The lake fed class had the highest median chlorophyll a and a high percentage of breached samples (30%), although the magnitude of breaches was low (2.2). Lowland soft bed and lowland hard bed classes also had high chlorophyll a medians (72.3 and 55.5mg per m^2 respectively), and they had the highest magnitude of breaches.

Ash Free Dry Mass (AFDM)

All Southland water body classes had median AFDM levels lower than the guidelines over the 2005–2010 period (Table 13). Sites in the lake fed class had the highest AFDM median (33.5g per m^2). Half of the samples in this class breached the guideline, by a magnitude of 53. Lake fed sites appeared to have greater periphyton biomass (AFDM) due to the incursion of Didymosphenia geminata (didymo) in 2004 and because their flow is restricted by dams. All other classifications have very few breaches of the AFDM guideline in comparison (ranging from 0% to 12% of samples breaching).

Hill and natural state classes had the lowest AFDM medians of 6.6g per m^2.

Table 13: Periphyton levels in Southland surface water body classes (2005–2010)

Water body classifications (number of sites)	**Chlorophyll *a*** (mg per m^2)					**AFDM** (g per m^2)				
	Guideline$^\Delta$	**Median***	**Percentage samples breached**	**Magnitude of breaches***	**Number of breaching sites**	**Guideline**$^\Delta$	**Median**	**Percentage samples breached**	**Magnitude of breaches**	**Number of breaching sites**
Natural state (5)	No change	12.1	–	–	–	No change	6.6	–	–	–
Lowland soft bed (14)	<120	72.3	34	16.3	10 of 14	<35	17.3	12	2.4	7 of 14
Lowland hard bed (14)	<120	55.5	28	14.9	9 of 14	<35	13.2	2	1.4	1 of 14
Hill (12)	<120	10.9	5	2.7	3 of 12	<35	6.6	4	7.2	1 of 12
Mountain (1)	<120	16.3	0	0	0 of 1	<35	7.2	0	0	0 of 1
Lake fed (3)	<120	83.4	30	2.2	2 of 3	<35	33.5	50	53.3	3 of 3
Spring fed (5)	<120	21.7	5	0.6	1 of 5	<35	7.8	0	0	0 of 5
Mataura 2 (0)	<120	nd	-	-	-	<35	nd	-	-	-
Mataura 3 (13)	<120	32.6	25	10.3	8 of 13	<35	10.9	4.9	0.7	3 of 13

* See "How this report works' for an explanation of this term

$^\Delta$ Ministry for the Environment guideline.[58] Periphyton guidelines distinguish between two different types of periphyton (diatoms/cyanobacteria and filamentous algae), whereas our state of the environment monitoring does not. Here we report on the combined samples for both chlorophyll a and Ash Free Dry Mass (AFDM).

– not applicable

nd = no data

[57] Mataura 2 water body class has no data

[58] Biggs 2000

Fish species

Southland fish Index of Biotic Integrity (IBI)

State of the environment fish monitoring sites

Between the summers of 2007/08 and 2009/10 the majority of our fish monitoring sites had relatively similar IBI scores each year (Table 14). At some sites, particularly in 2008/09, our fish monitoring was impeded by high flows, which limited our ability to thoroughly fish the site. Accordingly, this led to some lower IBI scores at these sites. Scores for the Oteramika Stream at Seaward Downs have varied considerably, including no fish being caught in 2007/08.

Southland NZFFD records (1970–2010)

IBI-based analysis of the Southland records in the New Zealand Freshwater Fish Database (NZFFD) shows we have a small percentage of sites which have no native fish present (5%) and a relatively even dispersal of 'poor', 'fair' and 'good' quality sites (Figure 20). Ten percent of our sites fall into the 'excellent' quality integrity class.

Figure 20: Percentage of Southland NZFFD records (1970–2010) in IBI integrity classes

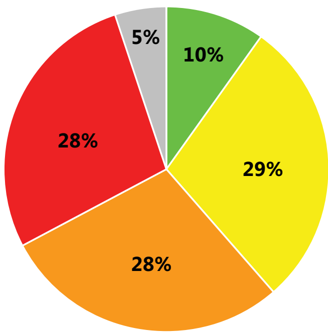
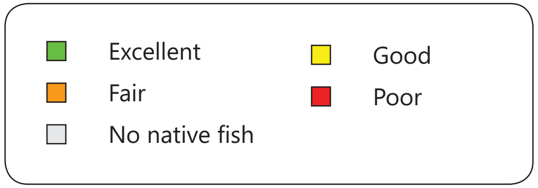


Table 14: State of the environment fish monitoring sites IBI scores

Site	IBI Score		
	2007/08	2008/09	2009/10
Cascade Creek at Pourakino Valley Road	38	48	38
Pourakino River at Pourakino Valley	42	20*	34
Winton Stream at Winton Substation Road	32	28	46
Dunsdale Stream at Dunsdale Reserve	40	20*	40
Waihopai Stream u/s Waihopai Dam	38	38	40*
Waikawa River at Biggar Road	32	22*	40
Meadow Burn at Round Hill Road	16*	36	nd
Moffat Creek at Moffat Road	42	54	48
Makarewa River at King Road	30	24*	24
Oteramika Stream at Seaward Downs	0	32	22
Cromel Stream at Selby Road	34	34	nd
Hamilton Burn at Goodall Road	42	42	42
Oreti River at McKellars Flat	48	nd	42
Camp Creek at State Highway 99	nd	32	32

* Monitoring limited by high flows

nd = no data



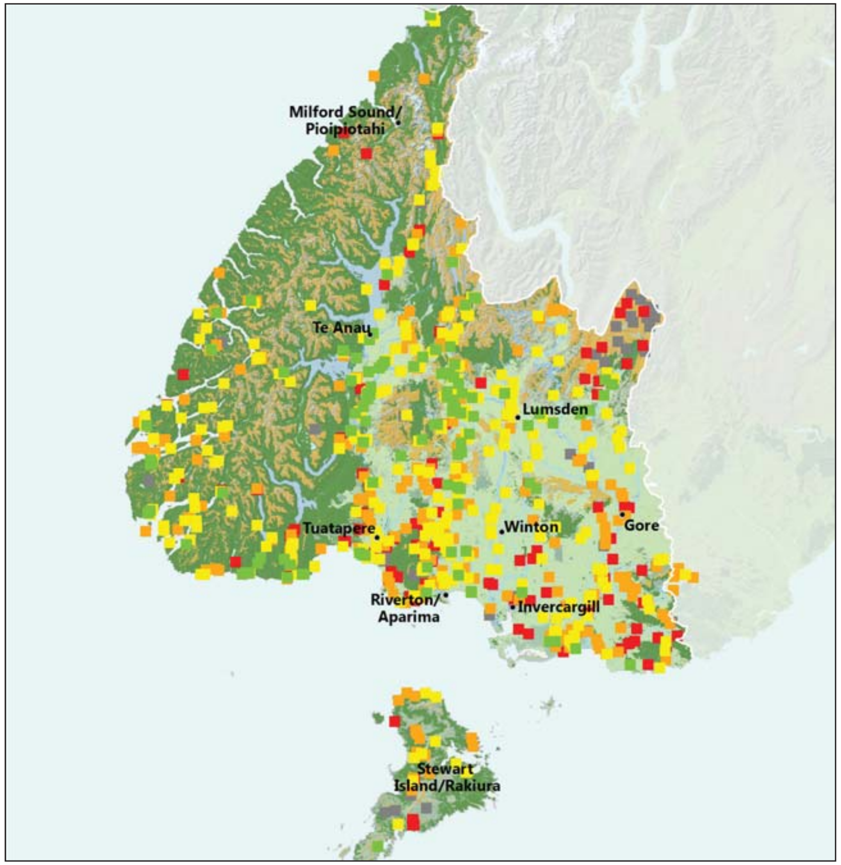
By catchment

The Southland NZFFD records and their associated IBI scores (Figure 21), show a zone of excellent and good quality sites in the areas around the upper Aparima and Oreti catchments, whereas there appears to be a zone of fair and poor quality sites around the middle and lower Mataura catchment. The upper Waikaia catchment in the north-east of the region has a large proportion of sites with limited native fish species. This is most likely due to natural fish barriers, such as waterfalls, in this catchment.

IBI scores at Stewart Island/Rakiura sites show several sites classed as poor and fair. This highlights the fact that we need to be careful in our interpretation of results where a solitary site visit has occurred. It is possible the method used to capture fish or the time of year sampled could have led to a number of fish species not being caught when they may otherwise have been recorded.

The Waiau, Oreti and Aparima River catchments all have similar average IBI scores (32.7–33.4; Figure 22). The Mataura River has a lower average IBI score of 25 for the same data period, but this increases to 28.3 if the upper Waikaia sites surveyed in 2003 are excluded, which have naturally low fish diversity due to the presence of natural fish barriers.

Figure 21: Distribution of IBI scores across the Southland region (based on NZFFD records 1970–2010)



IBI score

Excellent	Good	Fair
Poor	No native fish	

Landcover

High productivity pastoral	Tussock
Indigenous forest	

Figure 22: Average catchment IBI scores

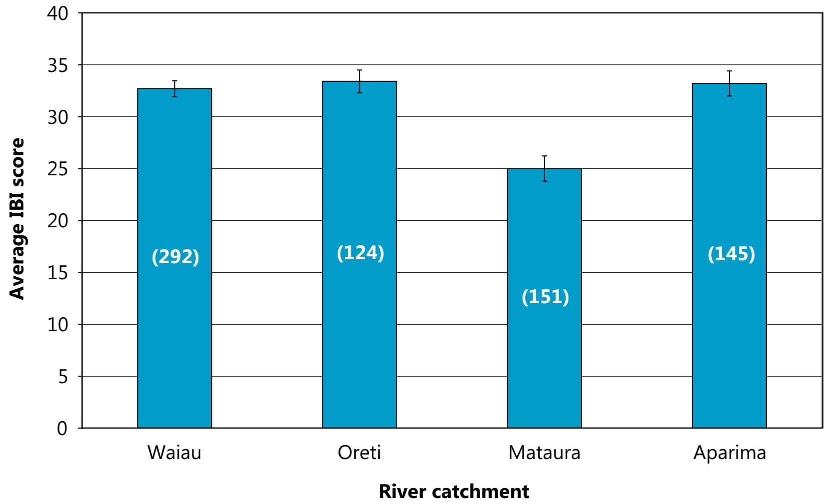
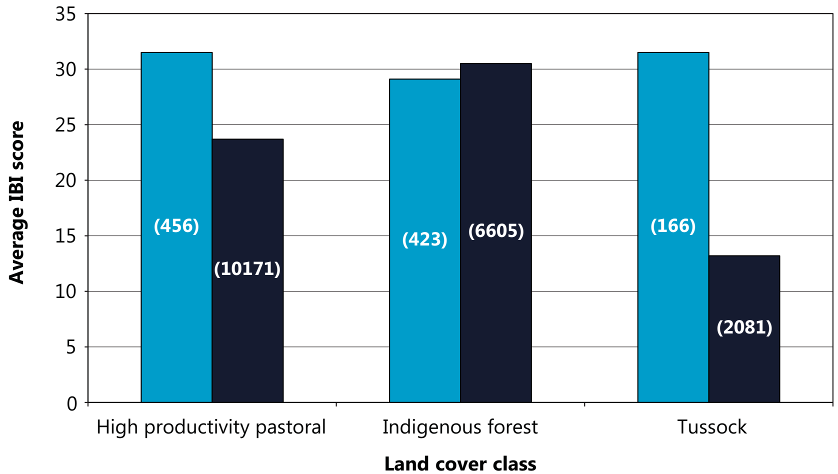


Figure 23: Southland and national IBI scores for various land cover classes (1970–2010)



Total number of sites are shown in brackets

Southland | New Zealand

By land cover class and national comparison

The Southland region has significantly higher IBI scores in the 'high productivity pastoral' and 'tussock' land cover classes than the New Zealand average.[59] Average IBI scores for Southland indigenous forest sites are not significantly different to the national average (Figure 23).

The average IBI scores for Southland sites within the 'high productivity pastoral' and 'tussock' classes are higher than Southland sites in indigenous forest for the 1970-2010 period. This is contrary to what has been found nationally.[60]

Z. Moss

Why the difference?

We do not know why high productivity pastoral and tussock land appear more suitable to native fish in Southland than indigenous forest. The reverse is found in all other regions where this comparison has been made. Many of the small, lowland Southland streams with high productivity pastoral catchments often have extensive macrophyte (aquatic plant) growths, which can provide excellent cover for native fish from predators. With our generally lower ambient air temperatures, surface water temperatures in small, macrophyte-dominated streams may not reach the critical levels that impede fish survival. Also in Southland, many of our lowland streams have a high percentage of groundwater baseflow (input) in summer time, which may further help retain lower water temperatures and limit dissolved oxygen reaching critically low levels. Over summer, Southland experiences very long daylight hours (5am–10pm), which would shorten the length of time when dissolved oxygen levels are at their lowest.

It is not a coincidence that high productivity pastoral land occurs where it does in Southland. This land has naturally always been highly productive; it is the land cover which has changed. Historically, the rich floodplain soils sustained highly productive forests and wetlands and would have provided very good habitat for our native fish.

It is possible that Southland's indigenous forest sites score lower than high productivity pastoral lands as the majority of these sites have been located in Fiordland's low productivity beech forests. These low productivity systems often have lower fish species diversity compared to high productivity forest systems such as podocarp–broadleaf forests. The rugged nature of the terrain in Fiordland is more likely to limit fish access to streams and rivers, when compared to sites on the high productivity pastoral lands of the Southland plains.

It is therefore very likely that in their natural state, the lowland Southland plains with their gently flowing rivers and ease of access to the coast would have supported a more diverse number of fish species than observed in our indigenous beech forests.

Research is required to determine whether the above (and other factors) are the reason that high productivity pasture and tussock lands in Southland performs so well compared to the national average. The above results highlight the significance of all of our waterways as native fish nurseries, whether they are pristine streams in the heart of Fiordland or small, straightened, weedy streams near Invercargill.

[59, 60] Joy 2010b

What's changing for life in our waters?

The life in our waters is showing some changes. When we analysed trends in Southland fish IBI scores for the land cover classes; sites within the 'high productivity pastoral' and 'tussock' land cover classes showed a significant decline between the periods 1970–1999 and 2000–2010.

The macroinvertebrate community index scores show only occasional small levels of change.

Macroinvertebrates

Only 6 of the 71 sites monitored displayed statistically significant trends in terms of their Macroinvertebrate Community Index scores between 2000 and 2010 (Figure 24). Four of these sites displayed moderate deterioration (1% to 2% per year in the hill, lowland hard bed and lowland soft bed classes), while two showed improvements of the same magnitude (both sites are in the lowland soft bed class).

Fish

As a whole, there is no significant difference in average IBI scores from Southland sites surveyed between 1970 and 1999, and those surveyed between 2000 and 2010.[61]

However, when we analysed trends in IBI scores over time for each of the land cover classes, Southland sites within both the 'high productivity pastoral' and 'tussock' land cover classes showed a significant decline in IBI scores between 1970–1999 and 2000–2010 (Figure 25).[62]

[61, 62] Joy 2010b

Figure 24: Macroinvertebrate MCI trends (2000–2010)

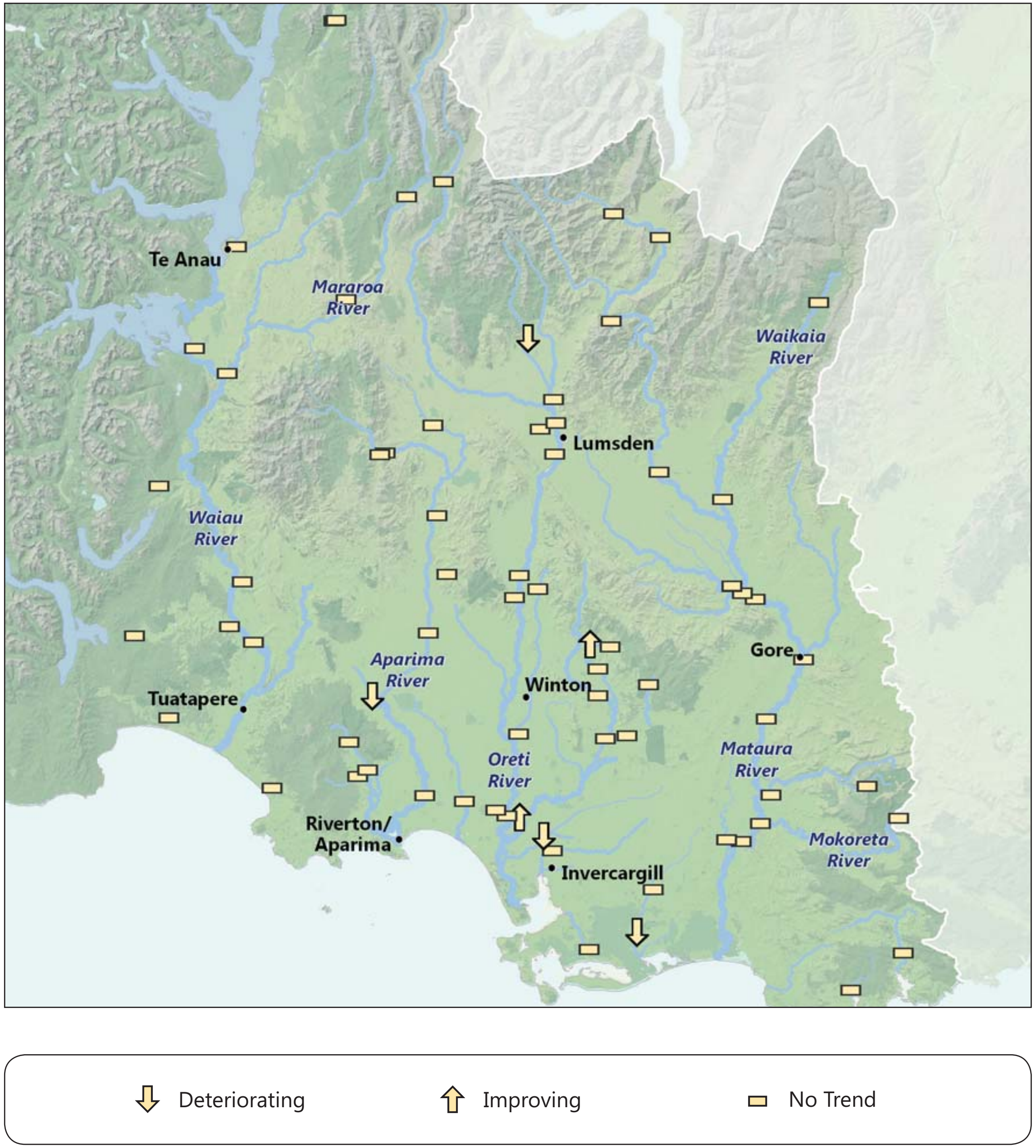
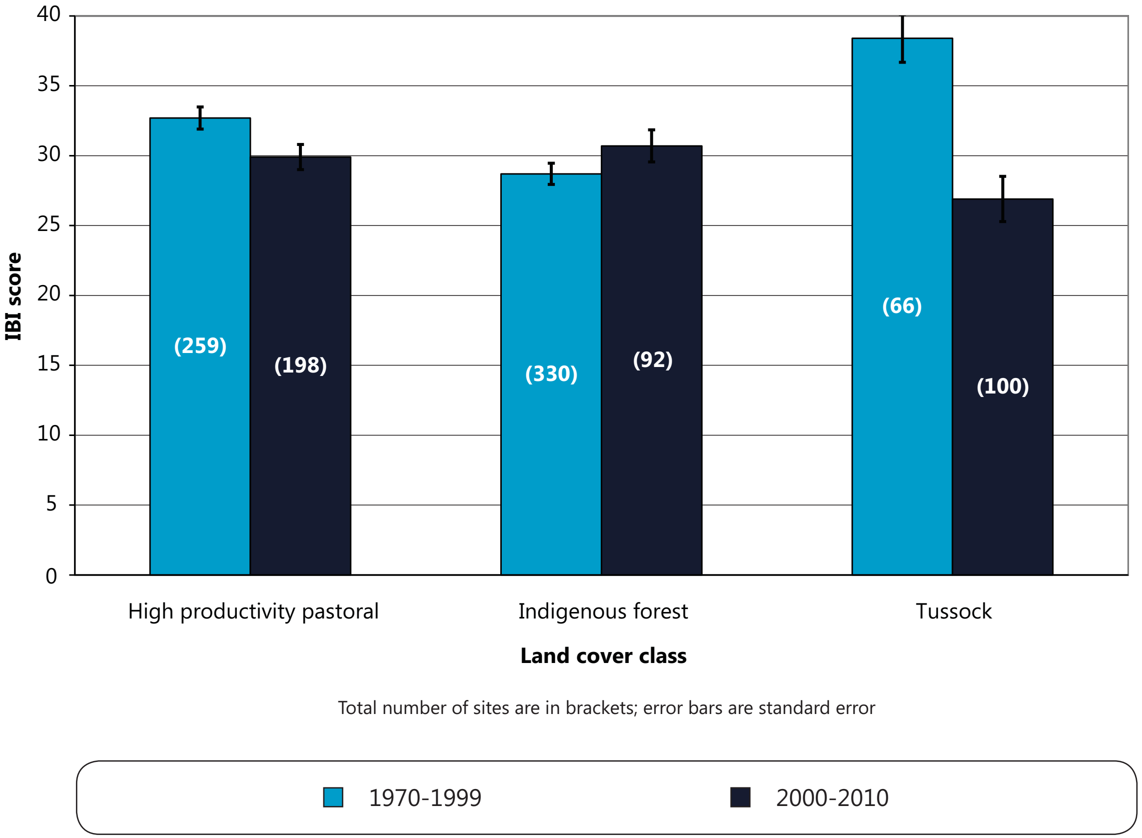


Figure 25: Comparison between average IBI scores across all Southland sites in 1970–1999 and 2000–2010 for different land cover types



Further research is required to determine why there is a deteriorating trend in fish IBI scores in our high productivity and tussock lands. It must be noted that the samples do not come from exactly the same sites for the two time periods and this may influence some of the results.

The IBI is limited in its ability to show declines in fish population health. For a decline to be observed over time at a given site, at least one less fish species needs to be recorded at the time of a second survey. A species absence could be due to a number of factors such as the time of year, flow conditions or the fishing technique used. However, it could also represent a localised extinction of the species. The fact that we have seen a significant decline in IBI scores across all sites in 1970–1999 and 2000–2010 for 'high productivity pastoral' and 'tussock' land covers is a cause for concern. In contrast, IBI scores within the indigenous forest land cover class have shown a small increase over time.

Our lakes and lagoons — Ngā roto waimāori

> *"...the principal lakes of Fiordland, including Moturau (or Motu-ua Lake Manapōuri), Hauroko and Te Ana-Au (Lake Te Anau) were dug by the rangitira (chief) Rakaihautu on his inland journey south with his famous ko (digging stick)."*
>
> *— Ngāi Tahu ki Murihiku, Te Tangi a Taiura, pg 98*

The Southland region abounds with lakes, many of them remarkable. The lakes in the Fiordland area are mostly glacially formed, and so are deep and steep-sided – they include lakes Te Anau and Manapouri, and Lake Hauroko, which at 462 metres is the deepest in the country.

There are also smaller coastal lakes, such as Lake Vincent, Lake George/Uruwera, Forest Lake, The Reservoir, and Waituna Lagoon – the last of which is part of the internationally recognised Awarua wetland system.

Lakes are intimately linked to their catchments. Land-use activities in a catchment affect the amount of water, nutrients, sediment and other contaminants that enter a lake. These inputs affect the water quality and the functioning of the lake's ecosystem. Unlike rivers, lakes are not continually replenished; this means the water quality and ecological health is more vulnerable, and can take longer to respond following catchment changes.

Factors affecting lake water quality can be very complex. Some of the key factors that interact to affect lake water quality are: stratification, sediment re-suspension and release of nutrients, grazing of phytoplankton, phytoplankton community composition, macrophytes and fish.

Typically, an increase in nutrients to a lake stimulates growth of phytoplankton which reduces water clarity. This is called eutrophication. At high nutrient levels algae blooms may occur, often of potentially toxic cyanobacteria species, causing surface scums and a decline in dissolved oxygen as the bloom decomposes. In very bad situations, fish may die from the low dissolved oxygen levels.

This section reports on water quality in our lakes and how they rate against the Water Plan standards and against the Trophic Level Index (nationally recognised indicator for lake water quality). It also describes how our lake water quality is changing over time. We present results from Submerged Plant Indicator monitoring – a system for assessing ecological conditioning, which is increasingly used in New Zealand lake monitoring programmes.

The case study focuses on Waituna Lagoon, and its risk of 'flipping' from a high quality state to an extremely degraded state. Waituna Lagoon is known for internationally important birdlife, large areas of relatively unmodified wetland, and the terrestrial vegetation. It is also highly valued for its aesthetic qualities, rich native biodiversity, cultural significance, and recreational activities.

Monitoring our lakes

Our management targets

The key reference for our monitoring of lake water quality is the core management target for freshwater quality in the Water Plan – that water quality of all surface water bodies in the region will be suitable for fish, contact recreation, stock drinking water and Ngāi Tahu cultural values, including mahinga kai. The Water Plan also requires that natural state water quality is maintained – these 'natural state' waters are within public conservation land, and are largely unmodified or unaffected by human activities.

The management targets for Ngāi Tahu ki Murihiku are illustrated by the following text from Te Tangi a Tauira:

> *Water is a taonga, or treasure of the people. It is the kaitiaki responsibility of tangata whenua to ensure that this taonga is available for future generations in as good as, if not better quality.*

Water has the spiritual qualities of mauri and wairua. The continued well-being of these qualities is dependent on the physical health of the water. Water is the lifeblood of Papatūānuku, and must be protected. We need to understand that we cannot live without water and that the effects on water quality have a cumulative effect on mahinga kai and other resources."

The standards we use

The Water Plan sets different water quality standards for lakes according to their water body classification.

The lakes monitored by Environment Southland fall within two classes:

- Natural state: Lakes Te Anau and Manapouri
- Lowland coastal lakes: Waituna Lagoon (and 'spot' sampled lakes: Lake Vincent, Lake George, Forest Lake, and The Reservoir).

We do not currently monitor lakes within the mountain and hill classes.

The target for natural state waters is that their high water quality is maintained, ie that there is 'no change'. There are no numerical standards set; rather we consider those water bodies comply if there is no measurable trend (up or down) in their monitoring results. See 'How lake water quality is changing over time', pg 55.

For lowland coastal lakes, the Water Plan has set targets for a variety of water quality parameters, including chlorophyll a and visual clarity. Table 15 also shows measures in terms of their 'equivalent TLI' or Trophic Level Index.

Table 15: Lake water body classifications, relevant Water Plan standards and equivalent TLI

Water Plan classes	pH	Chl *a* (mg per L)	Visual clarity (Secchi depth m)*	Equivalent TLI4
Natural state (2)	Standards aren't applicable	Standards aren't applicable	Standards aren't applicable	Standards aren't applicable
Lowland coastal lakes (1)	6.5 – 9	<0.005mg per L	>1.5	4.0 (in between mesotrophic and eutrophic)

* When lake inflows are below their median values, except where the water is naturally low in clarity as a result of high concentrations of tannins. In this case the natural colour and clarity shall not be altered.

Note: standards do apply to Mountain and Hill Lake classes; however we do not monitor any lakes within these classes.

TLI4 - TLI using TN, TP, Chl *a* and Secchi depth.

Trophic Level Index

The state of water quality and degree of nutrient enrichment in lakes is described as trophic state. There are New Zealand protocols for monitoring lake trophic levels and assessing trends in trophic state.[63]

The Trophic Level Index (TLI) is used to report on lake water quality and to measure changes in the nutrient (trophic) status of lakes. This index considers:

- total phosphorus (TP)
- total nitrogen (TN)
- visual clarity (Secchi depth)
- algal biomass (chlorophyll *a*).

The overall TLI score for a lake is the average of individual TLI scores for each variable. The score corresponds to one of seven trophic states. A high TLI indicates more nutrient enrichment, more algal productivity and reduced water clarity (Table 16).

Table 16: Trophic Level Index categories

Trophic state	TLI score	Interpretation
ultra-microtrophic	<1	**Good water quality** Low nutrients and algae and high clarity.
microtrophic	1–2	
oligotrophic	2–3	
mesotrophic	3–4	
eutrophic	4–5	**Poor water quality** High nutrients and algae and poor clarity.
supertrophic	5–6	
hypertrophic	>6	

While the Water Plan does not set specific TLI standards for lakes, it is useful to compare our results with the TLI because it is an overall assessment of a lake's water quality. The chlorophyll *a* targets were converted to an equivalent TLI[64], which showed that the Water Plan target for lowland coastal lakes is equivalent to a TLI score of 4.0 (in between mesotrophic and eutrophic).

[63] Burns *et al.* 2000

[64] This is the same approach as used by Burns *et al.* (2000), i.e. they defined the trophic level index using Chlorophyll *a* data and normalised the other variables against the trophic state index for Chlorophyll *a*. Full details in Hamill 2011.

Other measures we use

Lake Submerged Plant Indicators (LakeSPI)

The Lake Submerged Plant Indicators (LakeSPI) index is being increasingly used in New Zealand lake monitoring programmes to assess ecological condition. Features of aquatic plant structure and composition are used to assess the character of native and pest aquatic plants in a lake.[65]

NIWA has used LakeSPI to assess the ecological condition of six lakes in Southland as part of a largerr research project. The data used was collected between 2001 and 2007 and all lakes assessed had catchments dominated by native bush.

The LakeSPI results in this report are expressed as a percentage of a lake's maximum scoring potential and correspond to the depth of each lake. The highest possible score is 100%. The LakeSPI ecological condition classes are shown in Table 17.

Where we monitor

Environment Southland regularly monitors water quality in three lakes: Lake Te Anau (two sites), Lake Manapouri (three sites) and Waituna Lagoon (four sites). Spot sampling of water quality has also occurred in several small coastal lakes (Lake Vincent, Lake George/Uruwera, Forest Lake and The Reservoir). Sampling of Lake Te Anau and Lake Manapouri occurs at two depths (top and bottom), while only the surface water of Waituna Lagoon is sampled, due to its shallow, well-mixed nature.

Ecological condition has been assessed by NIWA using LakeSPI at Lake Te Anau, Lake Manapouri, Lake Hauroko, Mavora Lake North, Mavora Lake South and Lake Gunn. A description of monitored lakes is provided in Table 18 and the location of these lakes is shown in Figure 26.

Table 17: LakeSPI ecological condition classes

LakeSPI Index (%)	Ecological condition score
> 75 %	Excellent
>50–75 %	High
>20–50 %	Moderate
>0–20 %	Poor
0	Non-vegetated (defined as having a macrophyte cover of <10 %)

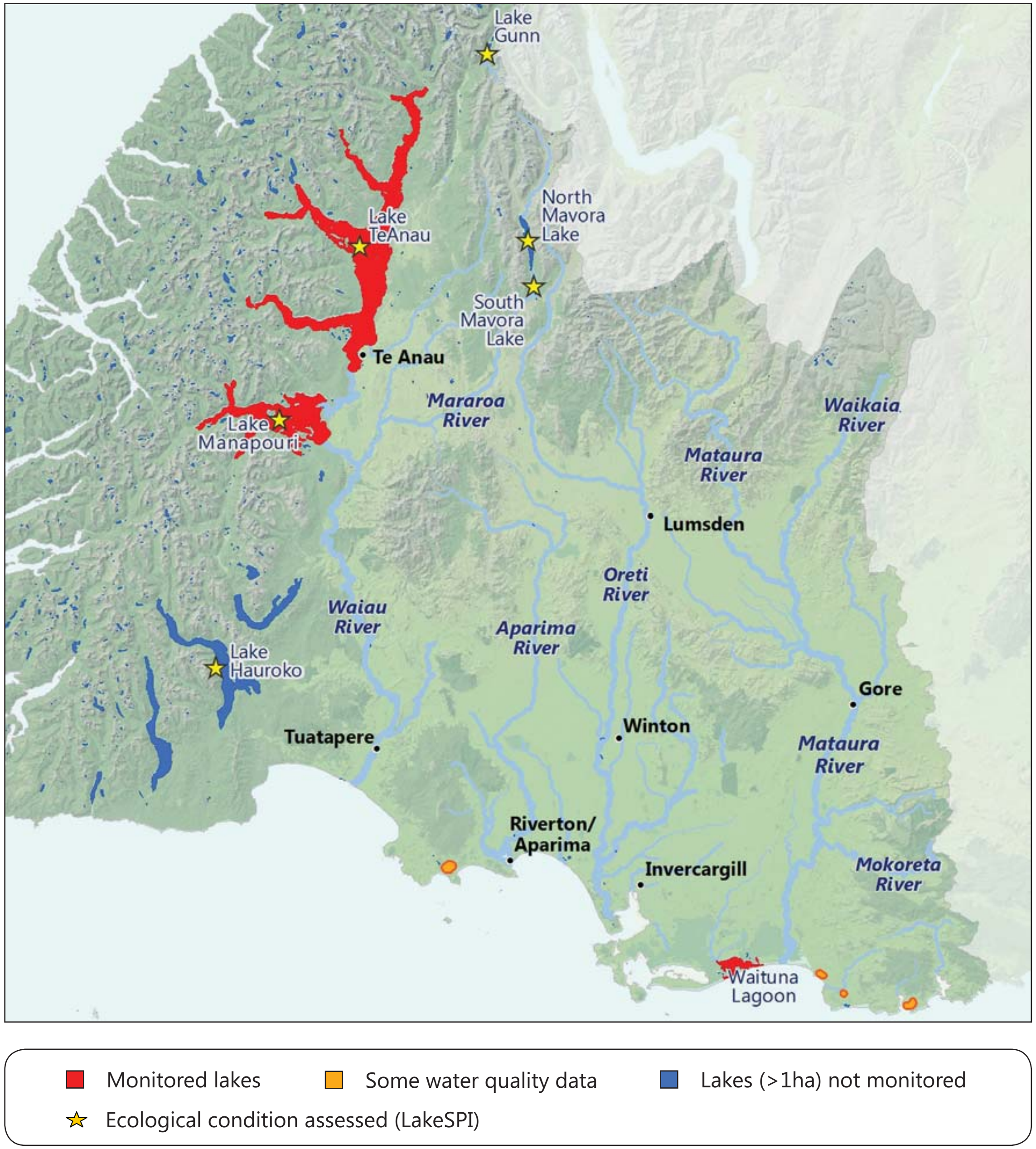
Table 18: Description of monitored lakes in Southland

Lake	Water Plan classification	Maximum depth (m)	Catchment area (km²)	Lake area (km²)	Dominant catchment land use
Lake Te Anau	Natural state	417	2998	343	Native
Lake Manapouri	Natural state	444	1428	142	Native
Waituna Lagoon	Coastal lakes and wetlands	3.3 (1.6 if open)	210	16.34 (7.21 if open)	Pasture
Lake Hauroko	Natural state	462	554	68	Native
Mavora Lake North	Natural state	77		10.2	Native
Mavora Lake South	Natural state	40		1.6	Native
Lake Gunn	Natural state	60	22	1.7	Native

Sources: Waters of National Significance (WONI) lake classification (DoC); Livingston *et al.* 1986; Waituna Lagoon data from Schallenberg *et al.* 2010; Mavora Lake depth from NZOI 1981.

[65] Clayton and Edwards 2006a, 2006b

Figure 26: Location of lakes in Southland where water quality and/or LakeSPI is monitored



The water quality of our lakes

Compliance with our standards

Water quality results for surface samples from sites on Lake Te Anau, Lake Manapouri and Waituna Lagoon are shown in Table 19 –median values are reported.

Reviewing this data against the Trophic Level Index provides a reading of overall water quality for the two 'natural state' lakes that we monitor (as their actual compliance with the Water Plan standards is reported in the later section 'How lake water quality is changing over time', pg 55). Lakes Te Anau and Manapouri are shown to be in the mid-range of the TLI index, in the oligotrophic category (Figure 27).

Clarity monitoring in Waituna Lagoon began in 2009, which means there is not enough data to get a reliable estimate for the lagoon. Instead, a statistical relationship between turbidity (the cloudiness of the water) and Secchi depth[66] was used to calculate a synthetic Secchi depth record. This method estimated the median Secchi depth to be 1.1 – 1.2 m for Waituna Lagoon, which breaches the standard set by the Water Plan for lowland coastal lakes (Table 20).

Median chlorophyll *a* concentrations in Waituna Lagoon are within standards set by the Water Plan for lowland coastal lakes. However, the margin of error (shown by error bars on the figure) indicates there may be times when the standards are breached (Figure 28).

[66] $y = -0.11x + 1.91$ ($R^2 = 0.53$)

An examination of individual components of the TLI in Waituna Lagoon shows that concentration of chlorophyll a is relatively low compared to the nutrient concentrations. This suggests that some factors (eg flushing, and competition for available nutrients) may be reducing the growth of phytoplankton in the lagoon – see Waituna lagoon case study, pg 57.

Reviewing this data against the Trophic Level Index shows that Waituna Lagoon is eutrophic (low water quality) and exceeds the TLI equivalent for the target set for coastal lakes in the Water Plan. Water quality is slightly worse when the lagoon is closed (Figure 27).

Opening Waituna Lagoon to the sea does result in improved water quality; however, it could negatively affect wetland vegetation that grows on the lagoon fringes, macrophyte communities, and other plants and animals sensitive to high salinities.[67] We do not fully understand the ideal opening regime that will support growth of seagrass (*Ruppia*) in Waituna Lagoon, and care is needed to ensure that any change in the opening regime to improve water quality does not adversely affect germination of *Ruppia* there.

Spot sample data from Forest Lake, Lake George/ Uruwera, Lake Vincent and The Reservoir indicate that these small coastal lakes are in a eutrophic condition (poor quality), with high concentrations of nutrients (Table 19). However, the limited amount of monitoring on these lakes means this data should be viewed with caution. More monitoring is required to fully assess the condition of all of Southland's coastal lakes.

Table 19: Median surface water quality for Southland lake monitoring sites July 2005 – June 2010

Site		n	Water temp (oC)	pH	TN (mg per L)	TP (mg per L)	Chl *a* (mg per L)	Clarity Secchi (m)	TLI4	TLI3
Manapouri at Frazers Beach		37	11.0	7.1	<0.11	<0.01	0.0015	11.2	2.0	
Manapouri at Stony Point		35	10.9	7.2	<0.11	<0.01	0.0015	11.7	2.0	
Manapouri at Pomona Island		36	10.5	7.1	0.084	<0.01	0.0015	11.9	2.0	
Te Anau Blue Gum Point		37	9.8	7.2	<0.11	<0.01	0.0011	11.6	2.0	
Te Anau South Fiord		38	10.1	7.2	0.090	<0.01	0.0009	12.1	1.9	
Waituna Lagoon East	All data	45	12.7	7.8	0.750	0.036	0.0021			**4.3**
Waituna Lagoon South	All data	54	12.2	7.8	0.745	0.035	0.0022			**4.4**
Waituna Lagoon Centre	All data	49	11.9	7.7	0.760	0.041	0.0032			**4.6**
Waituna Lagoon West	All data	54	11.9	7.8	0.800	0.040	0.0024			**4.5**
Waituna Lagoon East	Closed	37	12.9	7.8	0.780	0.038	0.0020			**4.3**
Waituna Lagoon South	Closed	39	12.8	7.8	0.800	0.036	0.0022			**4.6**
Waituna Lagoon Centre	Closed	35	12.7	7.6	0.930	0.042	0.0037			**4.7**
Waituna Lagoon West	Closed	39	12.5	7.7	1.000	0.040	0.0024			**4.7**
Forest Lake		1		4.9	2.000	0.710				
Lake George		1	13.2	7.7	1.100	0.074				
Lake Vincent East		2	12.8	8.3	0.780	0.030	**0.0081**	**1.5**		**4.7**
Lake Vincent West		2	12.5	7.8	0.625	0.124		1.8		**5.0**
The Reservoir South		3	10.1	7.7	0.670	0.040	**0.0076**	**0.8**		**5.0**
The Reservoir North		3	10.0	7.6	0.680	0.040	**0.0051**	**0.8**		**4.9**

Bolded values are above the Water Plan standards set for coastal lakes. Data for Forest Lake, Lake George, Lake Vincent and The Reservoir should be treated with caution as it is based on a few spot samples in 2000 and 2007. There are insufficient measurements to provide reliable Secchi data for Waituna Lagoon.

TLI4 = TLI using TN, TP, Chl *a* and Secchi depth.

TLI3 = TLI using TN, TP and Chl *a*.

[67] Schallenberg *et al.* 2010

Table 20: Percentage of Waituna Lagoon samples breaching Water Plan standards and equivalent TLI.

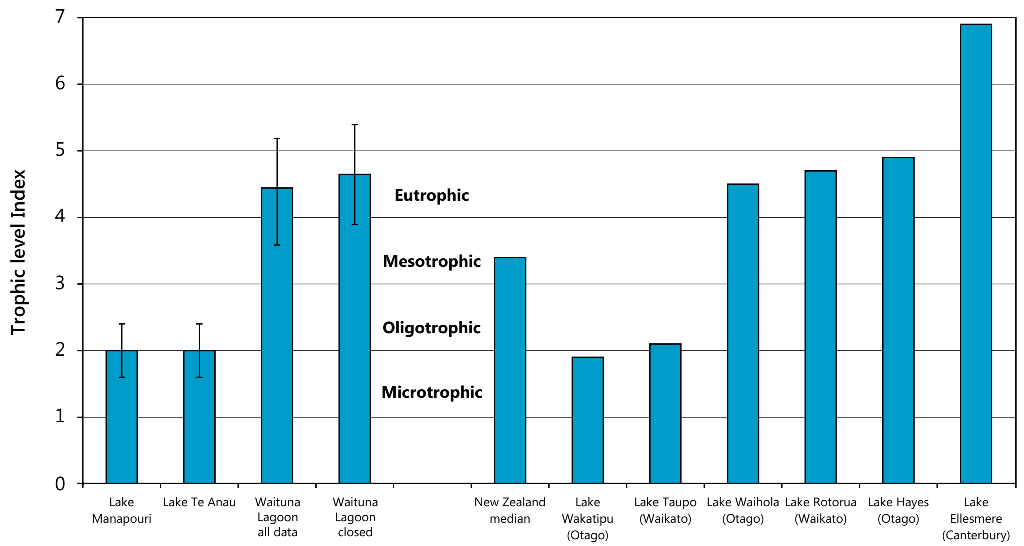
Sites	Frequency target exceeded (% exceeding target)		
	Chl *a*	Secchi	TLI
Waituna Lagoon centre	36%	2.8%	68%
Waituna Lagoon east	31%	4.9%	75%
Waituna Lagoon south	27%	1.4%	67%
Waituna Lagoon west	38%	1.4%	78%

Targets applied to Waituna Lagoon were respectively 0.005 mg per l, 1.5 and 4 for for Chl *a*, Secchi depth and TLI.

Lakes Te Anau and Manapouri are defined as natural state waters with the Water Plan standard of 'no change', therefore numerical water quality standards do not apply.

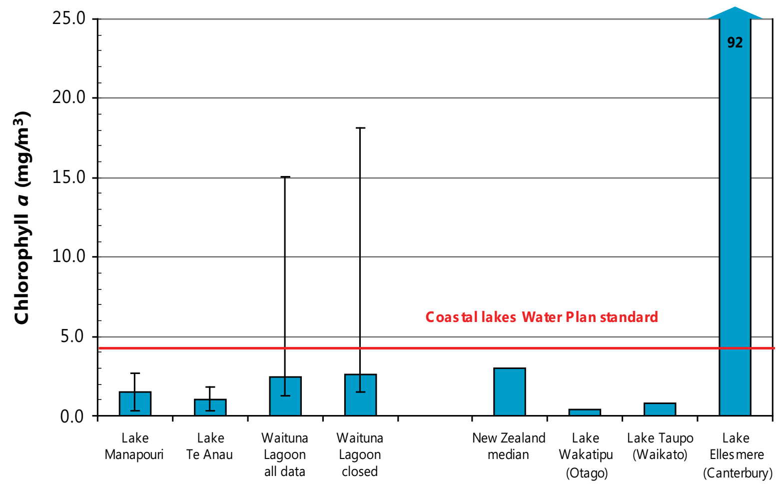
Further detail on Southland's lake water quality can be found in Southland Water 2010: Our Ecosystems Technical Report for lakes and lagoons which can be accessed on www.es.govt.nz/environment/monitoring-and-reporting/state-of-the-environment/water-2010/

Figure 27: Median Trophic Level Index of Southland lakes



Error bars show 10th and 90th Percentile values. Comparison given with the national median and lakes in other regions.

Figure 28: Median chlorophyll *a* concentration in Southland lakes



Error bars show 10th and 90th percentile values. The red line shows the Water Plan standard for coastal lakes. Comparison given with the national median and lakes in other regions.

Lake Submerged Plant Indicators (LakeSPI)

The lakes assessed under this system in Southland (as part of the NIWA study) were natural state lakes in Fiordland – see 'Other measures we use', pg 51. All had 'high' LakeSPI scores, ie 50–75% (Table 21).

The lakes in the best ecological condition (Lake Hauroko, and the Mavora Lakes) had the smallest proportion of invasive plants and the highest proportion of native plants.

Table 21: Ecological condition of Southland lakes using LakeSPI

Site	% LakeSPI	% native	% invasive
Lake Hauroko	70.3	54.8	5.8
Mavora Lake North	70	71.7	27.8
Mavora Lake South	69	73.3	31.5
Lake Te Anau	56.7	26.7	62
Lake Gunn	53	50	40.7
Lake Manapouri	50.7	53.9	48.1

How lake water quality is changing over time

The monitoring programme enables us to review the trends in lake water quality.

This is particularly important for assessing the quality of our 'natural state' lakes, as the target set for that class of water bodies in the Water Plan is no change, ie that there will be no significant shift over time in their high water quality levels.

We also examine trends in Waituna Lagoon.

We use the full length of monitoring record available for each lake:

- Lake Te Anau: July 2000 – June 2010
- Lake Manapouri, Stony Point and Pomona Island: April 2002 – June 2010
- Lake Manapouri near Frazers Beach: September 2004 – June 2010
- Waituna Lagoon: July 2003 – June 2010.

For detail on how the trends are determined, see Southland Water 2010: Our Ecosystems Technical Report for lakes and lagoons which can be accessed on www.es.govt.nz

Our natural state lakes: Manapouri and Te Anau

In Lake Manapouri, trends were observed for two variables: deterioration in water clarity at Frazers Beach since 2004, and an improvement in turbidity at Pomona Island Bottom water site (Table 22).

In Lake Te Anau improving trends were observed in total nitrogen (TN) and turbidity.

The reasons for the deteriorating clarity trend in Lake Manapouri at Frazers Beach should be investigated – including whether it is a water quality issue or a systemic error due to a change in measurement method.

Unreliable data and laboratory changes

The improvement in turbidity found at some sites in Lakes Manapouri and Te Anau, is probably the indirect result of changes in the detection limit of some variables (Table 22).

A large number of data values lower than the detection limit make trend analysis of water quality from these lakes unreliable; it is possible that trends may be occurring without being detected.

Waituna Lagoon

Data from Waituna Lagoon indicated deteriorating trends at some sites for total nitrogen (TN), total phosphorus (TP) and the TLI scores. A substantial part of the variation in TN (and therefore in the TLI) can be explained by opening and closing of the lagoon (Table 22).

A deteriorating trend in TP at the Waituna Lagoon Centre site is particularly concerning because the lagoon has been suggested to be predominantly P-limited (see case study: Nutrient limitation in Southland rivers and streams', pg 22). This trend should be carefully monitored.

An improving trend in chlorophyll a at the Waituna Lagoon sites South and West was apparent after adjusting data for a closed regime. Blooms of macroalgae (attached to sediments and plants) have been recorded in 2009 and 2010 and this may have suppressed the growth of planktonic algae (measured by chlorophyll a concentrations) by competing for nutrients.

Concentrations of nitrate-nitrite-nitrogen (NNN) during winter have increased at some sites, independent of whether the lagoon is open or closed. Summer nitrate concentrations are still often low, probably due to plant and algae uptake.

Table 22: Summary of water quality trends in Southland lakes

Site		TLI	TN	TP	Chl *a*	Clarity	Turbidity
Manapouri at Frazers Beach Top		ns	ns	*	ns	-5.5%	ns
Manapouri at Frazers Beach Bottom		–	ns	*	–	–	ns
Manapouri at Stony Point Top		ns	ns	*	ns	ns	ns
Manapouri at Stony Point Bottom		–	ns	*	–	–	ns
Manapouri at Pomona Island Top		ns	ns	*	ns	ns	ns
Manapouri at Pomona Island Bottom		–	ns	*	–	–	-6.3%
Te Anau Blue Gum Point Top		ns	-6.3%	ns	ns	ns	ns
Te Anau Blue Gum Point Bottom		–	ns	ns	–	–	ns
Te Anau South Fiord Top		**	-7.1%	ns	ns	ns	-6.3%
Te Anau South Fiord Bottom		ns	ns	*	–	–	-8.3%
Waituna Lagoon East	All data	ns	6.7%	ns	ns	–	ns
Waituna Lagoon South	All data	ns	11.5%	ns	ns	–	ns
Waituna Lagoon Centre	All data	2.4%	12.7%	10.1%	ns	–	ns
Waituna Lagoon West	All data	–	12.7%	ns	ns	–	ns
Waituna Lagoon East	Closed	ns	ns	ns	ns	–	ns
Waituna Lagoon South	Closed	ns	ns	ns	-12.5%	–	ns
Waituna Lagoon Centre	Closed	ns	ns	ns	ns	–	ns
Waituna Lagoon West	Closed	ns	ns	ns	-15.2%	–	ns

Red indicates a deteriorating trend, blue indicates an improving trend ($p<0.05$). Numbers refer to percent annual change.

Period Te Anau July 2000 – June 2010; Manapouri April 2002–2010, Manapouri Frazers Beach Sept 2004–2010; Waituna Lagoon July 2003–2010.

There were no significant trends when Waituna Lagoon TLI and TN data was adjusted for EC as a covariate.

* Statistically significant improving trends were detected for TP at all Lake Manapouri sites and one Lake Te Anau site; however, these are not reliable due to the large number of non-detects and changes in the detection limit.

** TLI trend for Te Anau South Fiord Top is unreliable due to change in Chl a detection limit since mid 2008.

Adjusting Waituna Lagoon TP data for turbidity identified a deteriorating trend at Centre and West sites.

– = not enough data

ns = no significant trend

How do Southland's lakes compare nationally

To see Southland lake water quality (ecologically) in national terms, we can compare our data with median values for all New Zealand lakes from a report prepared for the Ministry for the Environment[68] (see Figure 27 and 28).

Lakes Manapouri and Te Anau are in the top 10% of the 112 lakes monitored in New Zealand, with similar water quality to other large lakes such as Lake Wakatipu and Lake Taupo.[69]

Waituna Lagoon is in the lower third of lakes monitored in New Zealand, with water quality similar to Lakes Waihola and Hayes in Otago and Lake Rotorua in Bay of Plenty. Lake Ellesmere in Canterbury has the worst water quality (TLI) of the lakes monitored in New Zealand (see Figure 27).

The Southland LakeSPI results put our six assessed 'natural state' lakes in the top third of New Zealand lakes. Of the New Zealand lakes assessed by LakeSPI, 33% have 'high' or 'excellent' scores.

[68, 69] Verburg *et al.* 2010

Case study: How likely is Waituna lagoon to 'flip'?

Waituna Lagoon is a highly valued, large, brackish, shallow coastal lagoon that is fed by three watercourses, and periodically drains to the sea through a managed, artificial opening. Historically the lagoon was surrounded by peat bog wetland, the drainage of which gave the lagoon its characteristic clear, brown humic stain, low nutrient status, and low pH. It is a system that has very high ecological habitat diversity, including a community dominated by the seagrass *Ruppia*. The lagoon is contained within the Awarua Wetlands, which was listed under the Ramsar convention in 1976 as a wetland of international significance for its bird habitat, its large areas of relatively unmodified wetland, and terrestrial vegetation. Waituna Lagoon is also highly valued for its aesthetic qualities, its rich native biodiversity, cultural significance, and the recreational activities it supports.

Recent monitoring has shown that Waituna Lagoon is at risk of a shift in lake water quality that is called 'flipping'.

Lake flipping

Lake flipping refers to a phenomenon where lakes shift between a clear water state dominated by macrophytes (aquatic plants) and a devegetated, turbid water state. There are at least 37 lakes in New Zealand that have undergone this shift; they occur from Northland to Otago, but the phenomenon is more common in shallow lakes in the North Island.[70]

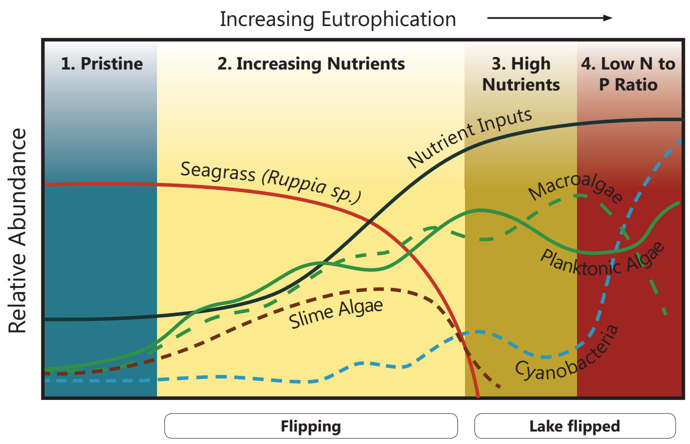
Increased nutrients (eutrophic conditions) can lead to aquatic plants (macrophytes) becoming stressed and subsequently dying. A collapse of macrophyte populations in shallow lakes is typically followed by deterioration in water quality. For example, in Lake Ellesmere (Canterbury) macrophyte beds collapsed in 1968 following a severe storm, and since this event turbidity and phytoplankton biomass have remained high.[71] If macrophytes establish again then water quality can improve, but often macrophytes do not re-establish.[72]

A diagram of how lakes respond to increasing nutrients (eutrophication) is shown in Figure 29. Lakes in phase 2 'increasing nutrients', like Waituna Lagoon, are particularly vulnerable to 'flipping'.

Will Waituna Lagoon flip?

Waituna Lagoon is dominated by the native aquatic seagrasses, *Ruppia polycarpa* and *Ruppia megacarpa*, and to a lesser extent water milfoil

Figure 29: Generalised lake response to increasing eutrophication/nutrients



From de Wit *et al.* 2001, Viaroli *et al.* 2004, Zaldivar *et al.* 2008. Modified by Wriggle Coastal Management 2009.

[70] Schallenberg and Sorrell 2009

[71] Schallenberg *et al.* 2010

(*Myriophyllum triphyllum*). In 2007, one-third of the lagoon had moderate-to-high vegetative cover (>20% cover), and about two-thirds had some (>1%) cover. Most *Ruppia* cover was in the eastern part of the lagoon and in other areas that were sheltered from wave and wind disturbance.

One particular macrophyte species, *Ruppia megacarpa*, is a keystone species in Waituna Lagoon, because of its importance as a habitat for invertebrates and fish, as a food source for invertebrates and waterfowl, and because of its role in regulating water quality.

Ruppia growth in Waituna Lagoon is probably limited by the availability of light.[73]

In 2008 the Department of Conservation commissioned annual monitoring of macrophytes in Waituna Lagoon. Since 2007 there has been a decline in the condition of the *Ruppia* beds, decreased levels of oxygen in the lake bed sediments and the build up of rotting organic matter on the lake bed. The monitoring also found much greater abundance of the nuisance macroalgae *Enteromorpha* and *Bachelotia* in March 2009 and February 2010, compared to March 2007.[74]

These monitoring results, combined with high nutrient and sediment levels and increasing nutrient trends, has created a high level of concern about Waituna Lagoon. Current expert opinion is that unless urgent intervention occurs, the lagoon will continue to deteriorate and will 'flip' to an even more degraded phytoplankton-dominated, *Ruppia*-absent, turbid state.[75] Such a shift would degrade the highly valued fishery, birdlife, wetlands, as well as cultural and recreational values of the lagoon.

Considerable effort is being undertaken to minimise the risk of Waituna Lagoon from flipping – see www.es.govt.nz for more information on monitoring and research in Waituna and the response underway.

[72] Hamill 2006
[73] Schallenberg and Tyrrell 2006
[74] Stevens and Robertson 2010
[75] LTG 2010

P. Hoffmann

Our wetlands — Ngā repo

Ka nui te Harakeke, ka ua te ua.

When the harakeke plants are plentiful, it is a sign of much rain.

Wetlands provide a vital link between water and land. While rivers, lakes, underground water and wetlands are all closely connected, wetlands occupy a unique place in the freshwater system – being neither fully terrestrial nor fully aquatic. They have been referred to as 'biological supermarkets' and they play an integral role in ecosystem health.

Wetlands are important areas for Ngāi Tahu. They are frequently venues for the preservation and teaching of traditional *matauranga* (knowledge), and were often the scene of significant historical events. They are traditional places for Ngāi Tahu food gathering (see 'Life in our waters', pg 35). Plants from wetlands were used for a variety of purposes including clothing, houses, and making rafts (out of reeds). Wetlands are also important sources of muds, dyes and rongoa (medicines) valued by Ngāi Tahu.

A wetland is a place where the ground is always, or regularly, wet and supports a natural ecosystem of plants and animals. Wetlands are generally found in flat vegetated areas, in depressions in the landscape, and between areas of dry land along the edges of streams, rivers, lakes and coastlines. There are several types of wetlands that can be classified depending on soil type, topography, climate, hydrology, water chemistry and vegetation (Table 23).

Wetlands naturally regulate water flow and absorb nutrients, while also providing other services vital to maintaining healthy ecosystems (Table 24). Generally associated with areas of shallow water, wetlands are a transitional zone that provides habitat for both land-dwelling and aquatic plants and animals. As a terrestrial habitat, wetlands support a high proportion of endangered species, they are an important 'genetic reservoir' for certain species of plants, and their contribution to biodiversity is essential to the natural functioning of our environment.

Like rivers, streams and lakes, wetlands can receive groundwater inflow, help recharge groundwater or both.

Southland is home to numerous wetland systems, ranging from those still in their natural state, to those that have been highly modified or affected by the development of surrounding landscapes. They are found across the region, from alpine areas through lowland plains and across to the coastal margins. Many of the wetland systems in the region are defined by the thick layer of layer of peat they are based upon; wetlands found on the Awarua Plains and in the Te Anau basin are excellent examples. Other significant wetland types in our region are the alpine ribbon and cushion bogs found in the high country, as well as the last remaining swamps of central Southland.

Currently we do not regularly monitor the ecological health of wetlands in Southland. In this section we present the initial results from one-off Wetland Condition Index (WCI) surveys carried out as part of our High Value Areas programme. Māori environmental indicators of wetland health have also been developed, but are yet to be implemented in Southland/Murihiku (Table 25).[76]

As a precursor to further investigation of wetlands in the region, baseline information has been gathered that illustrates the type and extent of Southland's wetlands and how this has changed over time (excluding the areas of public conservation lands of Fiordland National Park and Stewart Island/Rakiura). We also comment on how Southland's wetlands compare nationally.

[76] Harmsworth 2002

Table 23: Wetland types in Southland adapted from 'Wetland Types in New Zealand' (Johnson and Gerbeaux, 2004)

Wetland Class	Water origin (predominant)	Water flow	Drainage	Water table position	Periodicity	Substrate	Nutrient status	Predominant landforms
Bog	rain only	Almost nil	poor	near surface	wetness permanent	peat	low or very low	usually almost level ground, including hill crests, basins, terraces
Fen	rain + groundwater	slow to moderate	poor	near surface	wetness near-permanent	mainly peat	low to moderate	slight slopes of bog margins, swamp perimeters, hillside toe slopes, alluvial fans
Swamp	mainly surface water + groundwater	moderate	poor	usually above surface in places	wetness permanent	peat and/or mineral	moderate to high	mainly on valley floors, plains, deltas
Marsh	groundwater + surface water	slow to moderate	moderate to good	usually below surface	may have temporary wetness or dryness	usually mineral	moderate to high	slight to moderate slopes, valley margins, edges of water bodies
Seepage	surface water and/or groundwater	moderate to fast	moderate to good	slightly above to below surface	permanent wetness to temporary dryness	peat, mineral, or rock	low to high	moderate to steep hill slopes, scarps, heads and sides of water courses
Shallow water	lake, river etc, or adjacent groundwater	nil to fast	nil to good	well above surface: inundated	wetness almost permanent	usually mineral	moderate	ponds, pools, streams, margins of lakes, lagoons, rivers
Ephemeral wetland	groundwater + rain	nil to slow	moderate to good	well above to well below surface	seasonal, sometimes temporary wetness/dryness	mineral	moderate	closed depressions especially on moraines, bedrock, dunes, tephra
Saltmarsh	seawater, brackish water, salt spray, groundwater from land	moderate to slow	good	closely below surface between tides	mainly tidal	mainly mineral	moderate	margins of estuaries, wet coastal platforms

Table 24: Benefits of and threats to wetlands

Benefits of wetlands	
Buffer	Nutrients Sediment Toxins, microbes
Regulate	Water flow in dry conditions and floods
Capture	Carbon
Sustain	Plants Animals Birds Fish
Values	Cultural values (mahinga kai) Recreational values (hunting and fishing) Aesthetic values

Threats to wetlands
Surface runoff Vegetation clearance Erosion Toxic sprays Untreated effluent Fertilisers Diversion of water Channelisation Drainage and groundwater takes Development of wetland margins Irrigation Stock grazing, including margins Introduced plants, particularly grey willow Introduced animals Peat mining Fire Lack of knowledge and statutory protection

Table 25: Examples of Māori Indicators that provide an assessment of wetland ecosystem health (Subsample of indicators from Te Rūnanga o Kaikoura 2005[77])

Indicator	Examples	Measures
Te mauri	Mauri (life force) of the wetland, degree of naturalness, degree of modification	• Presence and absence of culturally important species • Spiritual association with wetland • Access to wetland for tangata whenua • Contamination levels and contamination sources • Closeness to natural water levels • How far has the wetland system moved away from original Māori values? • Odour and water temperature • Are there problems eating kai from the wetland? • Nearness of industrial sites and landfills • Degree of livestock access • Ratio of exotic species vs native species • Land use activities in the catchment • Land use practices adjacent to the wetland
Water quality	Clarity, feel, taste	• Māori water quality classifications • Observations of water clarity and water colour • Observed or measured sediment load • Observed or measured pollution/contaminants • Water taste and feel of water • Frequency of floods • Is there mixing of waters? • Use tangata whenua indicator species associated with water quality
Mahinga kai	Plant species used for weaving Plant species used for food Plant species used for medicine Customary fish species	• Area of the wetland that is considered healthy for mahinga kai • Number of people with access to the area for mahinga kai purpose • Number of people using the area for mahinga kai • Amount of kai and other resources collected from the wetland in a given time frame • Observation and collection of quality fish and plants
Community wellbeing / human health	Health illnesses Psychological illnesses	• Number of people from the marae who collect kai or other resources from the wetland • Reported sicknesses • Number of people with concerns about the health of mahinga kai • Number of culturally significant species at risk from pollution or contaminants

[77] Based on Harmsworth 2002

Monitoring our wetlands

Our management targets

The Water Plan states that all surface water bodies are to be maintained and enhanced so they are suitable for fish, contact recreation, stock drinking water and Ngāi Tahu cultural values, including mahinga kai.

There are no specific targets set for the management of wetlands as a whole – rather, each wetland is allocated to the Water Plan's different water body classes for assessment of water quality (see 'The standards and guidelines we use' in 'Our rivers and streams', pg 17 and 'Our lakes and lagoons', pg 49). Natural state water quality is also to be maintained. Wetlands are included in the Water Plan targets for water quantity (reported on in *'Our Uses'* report because of the complex interaction between surface water and groundwater).

Environment Southland does, however, highlight the importance of wetlands in the Regional Policy Statement, so too Te Ao Mārama Incorporated through Te Tangi a Tauira. These documents include objectives for wetlands and are to be considered during resource consent and planning processes.

The Water Plan also highlights the need for *integrated management of wetlands*. Currently there are no rules adopted across all agencies that direct the consistent administration of wetlands. The formation of the Southland Wetlands Working Party, a group of land owners, local authorities and other interested parties, has begun to address this.

The Water Plan states that draining any naturally occurring wetland in Southland (including the 46 'regionally significant wetlands') is discretionary and required to go through a resource consent process.

The standards we use

The standards in the Water Plan that apply to wetlands are for water quality in the water body class that each wetland is in. Currently there are no standards in the Water Plan or other Southland regional plans for the evaluation of wetland ecological health, ie that would take plants, animals, hydrology, and size of a wetland into consideration. These concerns are being considered.

How we monitor wetlands

Without regular monitoring of wetlands, little is known about their general health in Southland. However we do use the 'Wetland Condition Index' to conduct one-off surveys for the High Value Areas (HVA) programme. The results of the HVA survey illustrate how this could be utilised in the 'state of the environment' wetland monitoring programme.

Baseline information on the extent and the type of wetlands remaining has been gathered. This work classified and mapped current and historic wetlands in Southland, excluding the areas of public conservation lands of Fiordland National Park and Stewart Island/Rakiura.[78]

[78] Fitzgerald *et al.* 2010, Clarkson *et al.* 2011

Other forms of wetland protection

Southland's territorial authorities' management of wetland systems in Southland is largely carried out through rules and policies for the protection of indigenous flora and fauna. However, these polices were developed independently, and do not represent an overall regional approach, but there is crossover between the different management systems.

The Southland District Council's District Plan includes a schedule that lists 153 significant wetland or wildlife habitat sites where resource consent must be obtained before 'any activity which may impact on their quality' can be carried out (Policy HER.2). Outside these areas, resource consent may still be required before anyone can clear, drain or modify wetlands – depending on the nature and scale of the activity.

All wetlands on public conservation land are protected by the laws that govern activities there. In Southland, the Awarua Wetlands complex of approximately 20,000 ha is within public conservation land, and administered by the Department of Conservation. This wetland is of particular significance – internationally recognised under the Ramsar Convention in 1976.

Landowners can also voluntarily protect wetlands on their properties through the legally binding QII open space covenant. The agreement binds the current and all subsequent landowners. Each covenant is unique and can apply to the whole property or just part of the property. Conditions of the agreement can be stringent where rare or vulnerable natural features or habitats are being protected. In mid 2011, 82 QEII covenants (with a total area of 2,799.78 ha) were registered in the Southland region, or were in the process of becoming registered.

Are our wetlands changing?

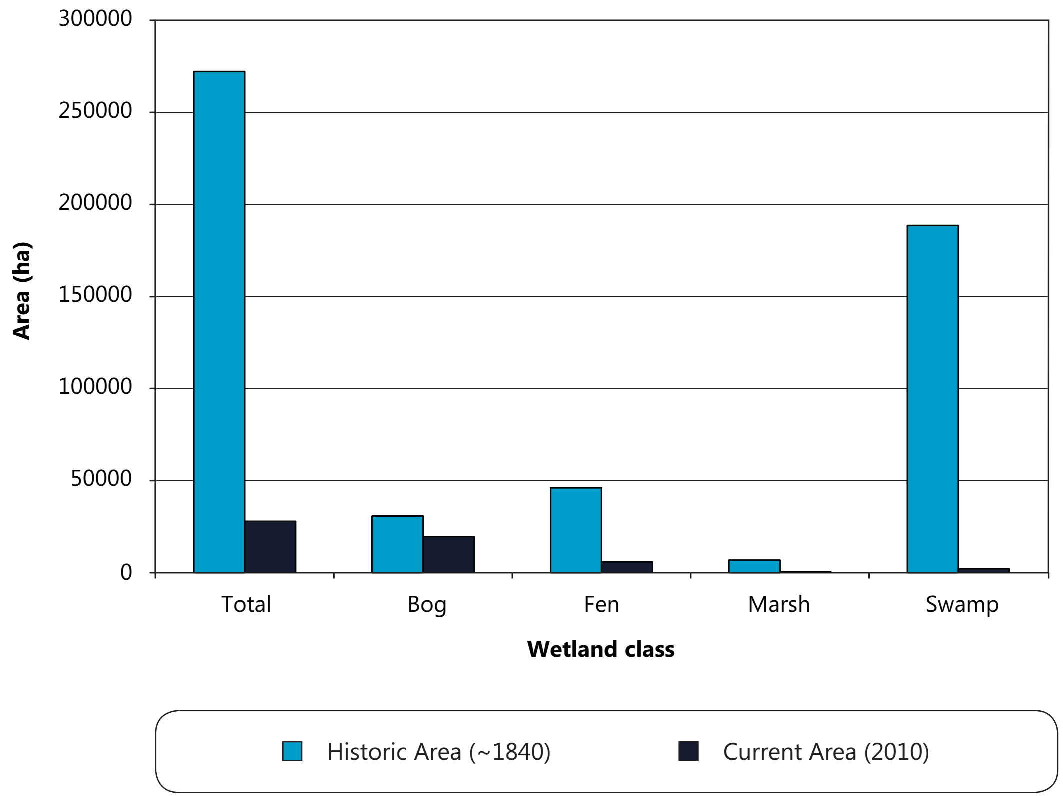
This report aims to identify how our freshwater environment is changing over time, as well as presenting a 'snapshot' of current condition. This is not possible for wetlands at this stage without baseline data for the ecological health of our wetlands.

Historic (circa 1840) and current wetlands (2010) within Southland (excluding the areas of public conservation lands of Fiordland National Park and Stewart Island/Rakiura) have been mapped and classed.[79] These wetlands were classified in four classes: bog, fen, swamp and marsh (see Table 23).

From the historic and current data, we can report that 90% of wetlands in Southland have been lost and the extent of loss varies according to wetland class. Of the remaining wetlands, bogs are the majority at 64%, whereas fens (13%), marshes (4%) and swamps (1%) are poorly represented (Figure 32).

The pressures to accommodate a growing population have led to a steady decline in the extent and condition of wetlands nationwide. Urban and rural landscape development has resulted in the destruction of more than 90% of New Zealand's original wetlands – one of the highest losses recorded in the world. Southland/Murihiku has some large, protected wetland areas that maintain their natural state such as those found on Stewart Island/Rakiura (Rakiura National Park), Awarua Wetlands, and also areas of Fiordland National Park. When combined with other wetlands in the region, around 37% of original wetland areas remain (compared with 1% in other regions in New Zealand).[80]

Figure 32: Changes in Southland wetland areas from ~1840 to 2010



[79] Fitzgerald *et al.* 2010, and Clarkson *et al.* 2011

[80] Cromarty and Scott 1995

Case study: Example of wetland condition monitoring - High Value Areas Programme

Environment Southland has developed the High Value Areas (HVA) programme to undertake surveys of the natural values and remnants of native biodiversity on private land in the Southland region. The programme is funded by Environment Southland with help from the Southland District Council and Landcare Trust New Zealand.

Landowners volunteer to have their land surveyed and the costs are met by the programme. The programme offers landowners the chance to have their land evaluated in terms of native flora and fauna, and to have management options identified, while providing valuable data on remaining natural areas to the organisations involved.

HVA sites undergo a rapid ecological survey by ecologists. If a wetland is found, the wetlands part of the survey is completed, generating the Wetland Condition Index (WCI). The WCI is the sum of the five parameters listed below, which are each scored from 1–5 (1=worst, 5=best). WCI scores can be used to evaluate the condition of individual wetlands or results can be grouped together and averaged to show the condition of a whole wetland class. WCI scores reflect the characteristics that would be in each environment if it had been left in an unmodified state.

- *Change in hydrological integrity* - focuses on changes to groundwater and surface water levels, and the recharge/discharge capacity of a system. The score for this is based on the impacts of man-made features that alter the hydrological state, changes in water table depth, and the invasion of dryland plant species.
- *Change in physiochemical parameters* - relates to vegetation growth, storage of nutrients, and water quality within a wetland system. This is scored by looking at fire damage, levels of sedimentation/erosion, nutrient levels, and for peat dominated wetlands – the level of relative peat health or decomposition using the Von Post Index (intact peat bogs present low levels of peat decomposition while degrading peatlands present high levels of decomposition).
- *Change in ecosystem intactness* - relates to species diversity, abundance, and reproduction patterns of flora and fauna in an area. The score for this is determined by loss of original wetland cover, and also connectivity barriers. Connectivity barriers may be hydrological features (such as stop banks, artificial weirs, ring drains or box culverts), or they may be terrestrial barriers (such as loss of riparian vegetation and buffer vegetation that links wetland environments to native forests, lakes and rivers).
- *Change in browsing, predation and harvesting regimes* - relates to vegetation composition and structure, along with species abundance and diversity of native fauna. This score is found by considering the extent of damage caused by domestic and feral animals, the impacts of introduced predators, and the harvesting of plants and animals.
- *Change in dominance of native plants* - links vegetation composition with habitat for native fauna, and whether the natural character of the area is being maintained. This score is based on the abundance and diversity of exotic species in the canopy and understory of plant cover.

HVA results

In mid 2011, we could report that, of the land already assessed through the HVA programme:

- 448 ha of wetlands had been found on 17 sites across Southland
- the 17 sites were made up of seven bogs, five swamps, two marshes, and one each of the wetland class: seepage, ephemeral wetland and saltmarsh.

Figures 30 and 31 show some results for Wetland Condition Index (WCI) scores to date. These results are based on a very small sample and are not representative of wetlands in the wider Southland region. However, the sample still provides useful early signals about how we could monitor and report on the state of the remaining wetlands in Southland.

Interpreting results within each wetland class on a site-by-site basis is a useful way to present WCI data, as it allows the ranking of wetland sites and provides insight as to which wetlands may be in the most need of attention. Figure 30 compares the two bog sites with the best and worst WCI scores. Bog 1 shows poorer results across all categories compared to Bog 2. 'Ecosystem intactness' and 'hydrological integrity' are of particular concern at Bog 1.

Figure 30 shows the average score for three wetland types, plotted against one another. This uses the data from the seven bog, five swamp and two marsh sites assessed in the HVA programme. The classes with only one site surveyed to date, seepage, ephemeral wetland and saltmarsh, are not represented. Figure 31 shows that the bogs and swamps surveyed are in much better condition than the marshes surveyed.

Figure 30: A comparison of 'best' and 'worst' bog sites assessed in the HVA programme

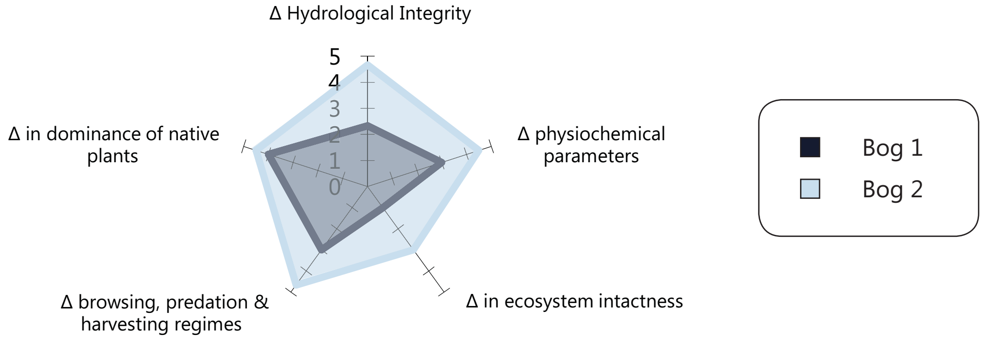
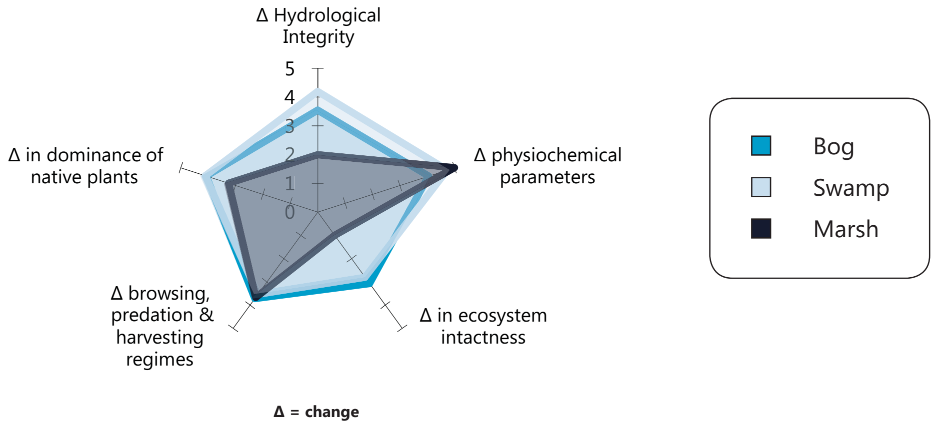


Figure 31: A comparison of all bog, swamp and marsh sites assessed in the HVA programme



Our estuaries — Ngā wahapu

"O Te Wai (Water) not only includes freshwater elements of water but extends to include O Te Moana – the sea, and the inherent connections between these two waters. Upstream effects in our river catchments influence the life-supporting capacity of our estuarine systems and waters of our seaward coastal environments. From the mountains to the sea, the ocean waters are the end of the line and the cumulative effects of upstream activity is reflected in the health of the waterway when it reaches the sea."

— Ngāi Tahu ki Murihiku, Te Tangi a Tauira, 2008

Located at the bottom of river catchments, estuaries are the meeting place for land and water, freshwater and salt water. This makes estuaries special in ecological terms, but also makes them highly vulnerable. Their health acts as an overall 'indicator' of the health of the freshwater catchment draining into them.

Estuaries are dynamic ecosystems that undergo rapid changes in water chemistry, such as shifts in water temperature, salinity (saltiness) and turbidity (cloudiness). These shifts are largely to do with the fluctuating influences of tide, freshwater inflows and wind, as well as the influence of the estuary's overall shape.

Estuaries are productive ecosystems and have a wide range of habitats within them, from subtidal reefs, intertidal mud flats and seagrass beds, to vegetation on their landward margins, such as herbfields, rush-land and sedge-land. Due to this high level of productivity, many fish species use estuaries for part or all of their lifecycle (Table 26).

Southland boasts a number of estuaries considered to be of national and international significance. The Waituna Lagoon (as part of the Awarua wetlands) is listed under the Ramsar Convention and together with Jacobs River Estuary, New River Estuary, Bluff Harbour, Awarua Bay, Haldane Estuary, Waikawa Harbour and Toetoes Estuary forms a complex that is the single most important bird habitat in Southland, and one of the most important wading bird habitats in New Zealand.

Estuaries are a natural buffer between the land and ocean, absorbing floodwaters and storm surges. Estuaries also have high value for humans as a place for harvesting food, for recreation and for aesthetic and biodiversity values. Ngāi Tahu ki Murihiku value wahapu as a source of mahinga kai including shellfish, patiki/flounder and waterfowl – and these resources supported settlements on the estuary edges. The historic settlements of Omaui, Oue,

Table 26: Fish that use our estuaries

Mostly freshwater species:
• Common smelt (Paraki/Ngaiore) • Inanga • Banded kōkopu • Giant kōkopu (Taiwharu) • Torrentfish (Piripiripōhatu) • Koaro • Black flounder • Lamprey (Kanakana) • Shortfin eel • Longfin eel • Redfin bully • Common bully • Bluegill bully • Giant bully (Kōkopu/Hawai) • Brown trout • Rainbow trout • Salmon

Mostly coastal species:
• Yellow-eye mullet • Yellowbelly flounder • New Zealand globe fish • Stargazers • Perch • Kahawai • Spotties • Triplefins • Red cod • Blue moki • Leatherjackets • Cockabully • Shark • Rig • Skate • Rays

and Mokomoko adjacent to New River Estuary/ Koreti are considered some of the oldest sites of Māori settlement in New Zealand, dating back to 800AD.[81]

Estuaries act as natural 'sinks' for sediments and for contaminants that runoff from land. This gives them an important role in maintaining coastal water quality. However, these sinks can also fill up, and it is the rate and the way they fill up that threaten ecosystems in or near the estuary, and the human uses and values placed on each habitat.

Sedimentation, excessive nutrients, toxic contaminants, and habitat loss are all major issues facing estuaries throughout Southland and New Zealand.

This section reports on the condition of our estuaries, using a locally developed Overall Estuary Health Grade which is based on the New Zealand Estuary Monitoring Protocol developed in 2001. We also report on the Overall Cultural Environmental Health of our estuaries, using State of the Takiwā scores. There is in-depth reporting on our largest and longest monitored estuary – New River Estuary.

This section also features a case study on stormwater impacts on rivers and estuaries.

Monitoring our estuaries

Our management targets

Estuaries are where salt and freshwater meet and they are also the meeting ground for our planning documents. The Coastal Plan set most targets that apply to estuaries, while there is also one relevant target in the Water Plan.

The Coastal Plan states that the natural values of estuaries will be maintained and enhanced, and it places particular emphasis on New River Estuary. It also requires that the life-supporting capacity of ecosystems is safeguarded, and spiritual and cultural values are protected.

The Water Plan target is that the quality of our freshwater will not have an adverse effect on the quality of our coastal waters – and therefore there will be no adverse effects on the health of our estuaries.

The targets for Ngāi Tahu ki Murihiku are reflected in the natural resource management plan Te Tangi a Tauira – the policies strive for the protection and enhancement of the productivity and life-supporting capacity of mahinga kai, indigenous biodiversity, air, water, land, natural habitats and ecosystems.

The water quality standards and guidelines we use

There are few standards and guidelines available for measuring the health of our estuary ecosystems.

The water quality standards in our Water Plan for the freshwater bodies that flow into our estuaries provide us with one set of measures, for the water itself. However, there are no standards for the *overall health* of estuaries set in the Water Plan or the Coastal Plan, nor are there national guidelines for estuarine health.

There is a recommendation in the Australian and New Zealand water quality guidelines (known as ANZECC 2000) to use the south-east Australia water quality guidelines for estuarine ecological health. However, these are of limited value, as they are for low-nutrient coastal waters and are unsuitable for comparisons in New Zealand's nutrient-rich coastal waters[82]. Instead, we have created our own Overall Estuary Health Grade – see 'Other measures we use' following.

In terms of measuring the quality of the water that flows into estuaries, and calculating the likely effects this has on ecosystems, we use these values set in the ANZECC 2000[83] guidelines:

- Ammonia toxicity trigger value, which provides a level of ammonia content that could cause harm to water-based estuarine species.
- Freshwater Total Nitrogen (TN), Total Phosphorus (TP) and dissolved reactive phosphorous (DRP) values, as reference points for a comparison of the incoming water to each estuary and likely drivers of estuary health.

As the ANZECC 2000 guidelines are not 'effect-based' guidelines for estuarine ecosystems, we have been cautious in our interpretation of the results.

It is also important to recognise that guideline breaches do not necessarily mean nuisance

[81] Ngai Tahu ki Murihiku 2008

[82] Bolton-Richie 2007

[83] Australian and New Zealand Environment and Conservation Council

growths of algae will occur (see Case study: Nutrient limitation in Southland rivers and streams pg 22). The ratio of different nutrients is as important as their quantity; this is why we note if a system is 'nitrogen limited', as this can be key to the control of algal or phytoplankton growth.

Manawhenua standards require the protection of the mauri and wairua of our waters, and the ability to access and safely eat mahinga kai.

Other measures we use

To provide a way of monitoring and reporting the ecological health of our estuaries, Environment Southland has developed an Overall Estuary Health Grade. This grade is an 'overall' average of all the condition ratings from each indicator gathered under our Estuary State of the Environment Monitoring Programme (ESEMP). The grade combines 12 condition measures, which are used to assess four main issues: *sedimentation, nutrient enrichment, toxicity* and *habitat quality*.

We also report on the Overall Cultural Environmental Health of our estuaries, using State of the Takiwā scores. Fewer sites have been assessed in the State of the Takiwā programme – see 'Where we monitor'. The cultural environmental health scores are based on seven indicators – see 'How this report works', pg 11.

Sedimentation

The current rate of sedimentation in New Zealand estuaries is about ten times greater than before Europeans arrived.[84] The clearance of large areas of native vegetation (bush and wetland) for agricultural development has increased the amount of fine suspended sediments carried in water to estuaries.

Finer grained sediments such as muds and clay reduce light available for photosynthesis, while an excess of sediment also smothers estuarine animals and can result in native species being replaced with animals that are more tolerant of mud and pollutants.

We use three measures to track the physical impact and effect of estuary sedimentation:

- area of soft mud
- rate of sediment increase or decrease
- sediment grain size.

Nutrient enrichment

Nutrient enrichment, or eutrophication, is when a water body receives too many nutrients, resulting in excessive plant growth, such as phytoplankton or algal blooms. These nutrients (nitrogen and phosphorus) occur naturally, but in many New Zealand estuaries they are in excess. They come from agricultural activities, wastewater treatment plants and industrial discharges.

Within Southland estuaries, excessive nutrients allow macroalgal blooms to grow on the sediment surface. Macroalgae are non-rooted, aquatic vegetation with multiple cells that can be seen with the naked eye. Macroalgal blooms of *Enteromorpha, Gracilaria* and *Ulva* species sometimes reach nuisance levels of cover, typically in late summer, where the mats may drift and accumulate on shorelines and slowly decompose. They are often associated with the 'rotten egg' smell of sulphide released from the sediment.

If these mats are thick enough, they reduce the estuary sediment quality, by decreasing oxygen levels through their decomposition and smothering. This can create a 'dead zone' where nothing survives due to the lack of oxygen in the sulphide-rich sediment – for example pipi, which were once abundant in upper New River Estuary, are now absent.

Estuary sediments dominated by sand and gravel are often well oxygenated (have a deeper Redox Potential Discontinuity (RPD) profile) as opposed to muddier sediments which tend to be deoxygenated (have a shallower RPD). The RPD layer can also be influenced by other indicator measures such as the sediment grain size, sediment nutrient concentrations and nuisance macroalgal cover.

We use the following to report the effect of nutrient enrichment:

- nuisance macroalgal cover
- sediment nutrient concentrations
- the depth of the oxidation level in the sediments (the RPD layer)
- estuary water nutrient concentrations
- contributing rivers' water nutrient concentrations – this information comes from

[84] Robertson and Stevens 2007, 2009 & 2010

our river water quality monitoring, not from the estuary monitoring programme itself.

Toxicity

Estuaries are natural collection points and toxic contaminants can accumulate in sediments. These contaminants include heavy metals from road and roofing runoff, pesticide residues from farm runoff, industrial discharges and wastewater. Often the levels of toxic contaminants are not high enough to kill estuarine organisms immediately, but they accumulate over time by moving up the food chain, where they present a greater risk of chronic poisoning. An example of this is in shellfish such as cockles, which accumulate copper when they grow adjacent to stormwater outfalls.[85]

In well-flushed parts of estuaries where stormwater sediments can't accumulate, toxicity is reduced. However, in areas close to and immediately downstream of stormwater drains in urban areas or below industrial discharges, some animals in the sediments can have elevated toxicity and are unsafe to consume.

Environment Southland measures heavy metals in the upper two centimetres of estuary sediments. The six heavy metals tested for are: *cadmium* and *chromium*, as they are found in alloys used in bearings, batteries, and sheet metal; *zinc* from roofing gutters and galvanising; *copper* from roofing and vehicle brake linings, and *nickel* and *lead* from many industrial uses and emissions.

Habitat quality

In Southland, most of our estuaries are shallow, well flushed and (apart from the upper parts) generally sandy. This means our estuaries have large intertidal flats that are dry at low tide. This results in a diverse range of organisms, which adapt to large changes in temperature, salinity and water flow. However, the margins of most of Southland's estuaries have undergone huge change since European settlement. Land reclamation, drainage, grazing pressure, dredging and introduced weeds and pests have all severely impacted upon the habitat quality of Southland's estuaries, particularly the areas of saltmarsh.

Saltmarshes are important because they have a diverse number of native species and are very productive ecosystems, critical for the breeding cycles of native fish such as the migrating whitebait species, and wading birds. Saltmarsh areas also provide a buffer between pastoral agricultural areas and estuary water by slowing and filtering contaminants that may be harmful to the estuarine environment.

Seagrass (*Zostera capriconi*) is another important habitat for many estuarine and coastal areas. Seagrass is a small flowering plant that stabilises and aerates sediments, and provides valuable habitat for many species of juvenile fish[86] – for example, studies of seagrass meadows on the North Island's west coast revealed most of the adult snapper population came from only one spawning area, in the Kaipara Harbour. Seagrass has very high value in ecosystem function, fish habitats and fish health. These habitats have been in decline in New Zealand since 1940 and are at risk from increased sedimentation. This results in poor water clarity, which hinders photosynthesis but also smothers the plant.

In Southland, extensive seagrass meadows are limited, but Awarua Bay and Freshwater Estuary still have moderately good areas of cover. Unfortunately, we have very limited data in Southland regarding their usage by Southland fish species and the role our estuaries play in their lifecycles.

To track the changes in estuary habitat (in terms of loss or recovery), every five years Environment Southland maps the areas of:

- margin habitats 200m round the estuary, such as saltmarsh
- intertidal seagrass meadows.

Estuaries are important habitats for invertebrates which live on and in the sediments. Invertebrates are good indicators of estuarine health and reflect impacts from the four indicators used in the Estuary State of the Environment Monitoring Programme (ESEMP): sedimentation, nutrient enrichment, toxicity and habitat quality. For example, if the estuary has lots of mud and excess nitrogen from its upstream catchment, this can result in algal blooms (nutrient enrichment). The species of invertebrates found are likely to be more pollution tolerant and there are likely to be large numbers of a few dominant species.

85 Townsend *et al.* 2009
86 Morrison 2009

Conversely, if the estuary has a lot of sand with little or no heavy metal toxicity, the species composition is more likely to be balanced, with lots of different species.

Environment Southland monitors the number and species composition of estuarine invertebrates for three consecutive years to attain a baseline and every five years thereafter in all the monitored estuaries.

Currently, our monitoring does not measure the suitability of each estuary for the health of native fish or *Salmonid* species.

Where we monitor

Environment Southland monitors[87] the health of intertidal and estuary margin habitats at eight estuaries, one harbour and one lagoon as part of the Estuary State of the Environment Monitoring Programme (Figure 33). The estuaries have been selected because of their biological and recreational values, combined with their 'risk' of environmental degradation from activities such as land-use intensification and freshwater abstraction. The monitoring programme aims to track long-term changes.

In 2000 monitoring started on the four largest Southland estuaries: New River, Jacobs River, Waikawa, and Toetoes (Fortrose) Estuaries. Over the following five years this was extended to Awarua Bay, Haldane Estuary and Bluff Harbour. In 2008, monitoring began on Waiau Lagoon, and Waimatuku and Freshwater Estuaries on Stewart Island. Freshwater Estuary was added as a 'control' or unmodified estuary, as a comparison for the other estuaries in the programme.

State of the Takiwā monitoring in Southland/Murihiku by Te Rūnanga o Ngāi Tahu has occurred in the following estuary sites:

- Papatotara – West Waiau Lagoon (2005)
- Matatarawae – East Waiau Lagoon (2005)
- Owi – Toetoes (Fortrose) Estuary (2007)
- Trypot Bay – Waikawa Estuary (2007).

The effect of change in the quality of freshwater entering estuarine environments is well known, through the impact of elevated contaminants such as sediments, nutrients and bacteria.[88] Data from our freshwater quality monitoring, which is used as a measure of the inputs to each estuary ecosystems, is taken from the closest state of the environment sampling site to each estuary.

The Invercargill City Council has monitored water quality in the New River Estuary since 1991. This is undertaken to determine background contaminant levels entering the estuary from catchment land use and other discharges to the estuary. The sampling is undertaken twice a month at high and low tide throughout the estuary and in the tidal reaches of incoming rivers.

[87] Environment Southland is one of eight regional councils in New Zealand which follows the Estuary Monitoring Protocol developed by the Cawthron Institute. Wriggle Coastal Management modified this protocol in 2008 to incorporate broad scale habitat mapping, fine scale sediment analysis, algal bloom mapping and vulnerability or risk assessments.

[88] Hewitt and Gibbs 2004, Jones 2008, Savage 2009

Case study: Stormwater

Stormwater is defined as surface water runoff following rainfall, snow melt or irrigation. Stormwater is collected from roofs, driveways, car parks, roads and other hard surfaces. Stormwater generally flows through kerbs, sumps, and drains directly to the river or coast without treatment. Stormwater is widely acknowledged as being of low quality and a source of contamination in the fresh and coastal water bodies that receive it. In Southland, stormwater drains are known to contribute a range of contaminants including bacteria, nutrients, sediment, heavy metals and hydrocarbons, depending on flow conditions.

The accumulation of heavy metals in river and estuarine sediments is the greatest risk to ecosystem health. Over time heavy metals can accumulate to levels that are toxic to animals living in the sediment and therefore to those fish and birds that feed on the animals.

In Southland, stormwater discharges to freshwater now require resource consent. As a result, monitoring data will provide a better understanding of the effect of stormwater on freshwater.

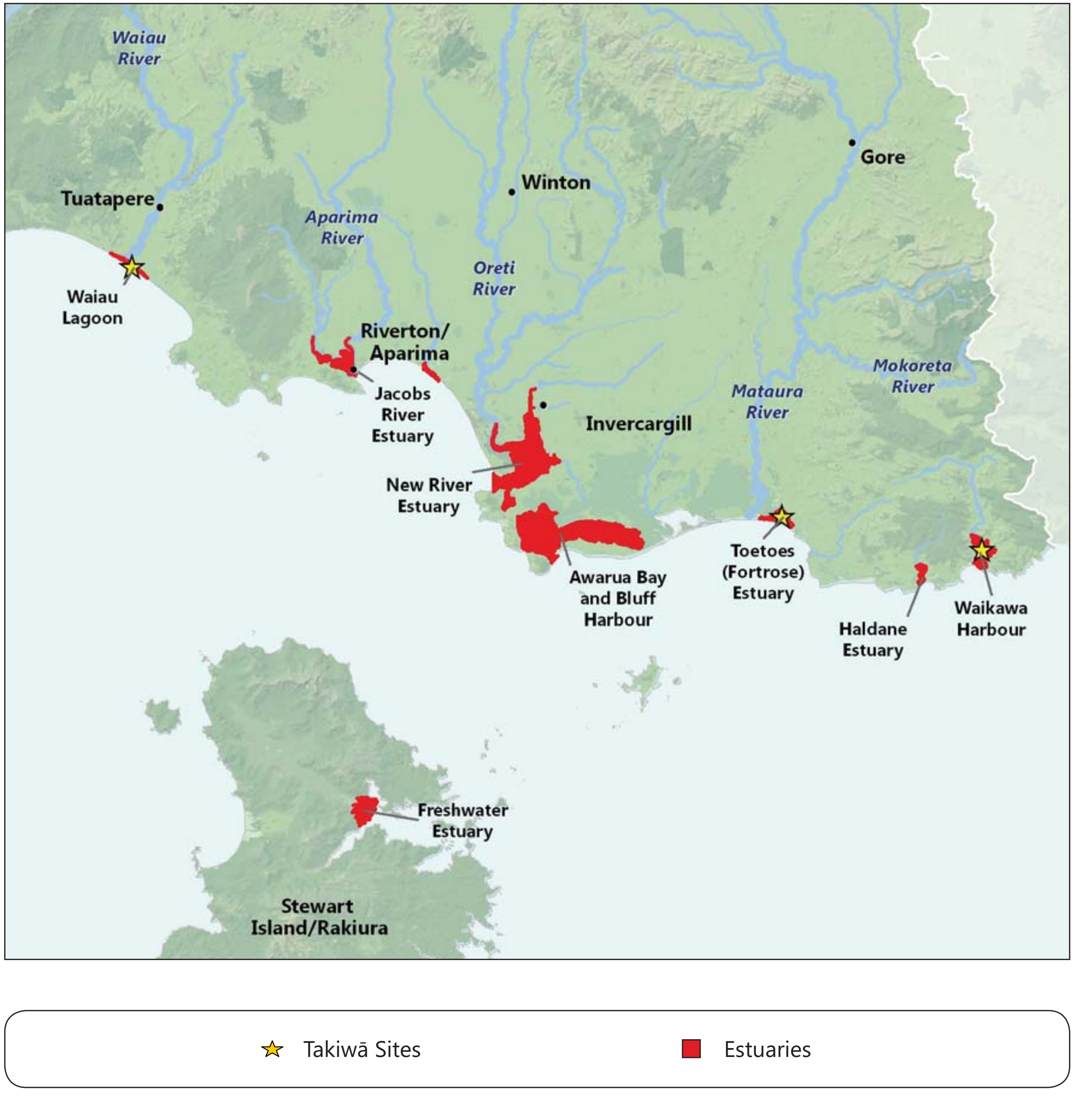
In the Southland Coastal Marine Area, discharges of stormwater are permitted providing they meet water quality guidelines. However, the current permitted status has resulted in the monitoring being limited to instances where complaints or elevated results from bathing beach or investigative sampling have been received.

The Water Plan has a target that stormwater discharges will meet water quality standards and current ANZECC sediment guidelines by 2010. However, the effect of stormwater on water and sediment quality is not currently known – it is the planned focus for the Environment Southland Waihopai Living Streams team in the next three years.

The Living Streams team is cooperating with the Invercargill City Council (ICC) in the Waihopai River area, to identify problem stormwater drains and to see them repaired. Investigations have revealed that numerous stormwater drains from the Avenal suburb are contributing faecal bacteria from human sources, resulting in particularly poor quality water discharging to the river. The ICC is now working to identify the individual properties with poor separation between sewerage and stormwater pipes and get it fixed. Ongoing monitoring will reveal whether the problem has been resolved.

Sediment samples collected in 1993 and 1995[89] showed elevated levels of metals in the Waihopai Arm of the New River Estuary. Zinc and nickel concentrations were higher than the current ANZECC 2000 ISQG-Low guidelines, suggesting that concentrations may be toxic and that further investigation is required to determine whether they pose a threat. A third survey of heavy metal concentrations in sediment of this area has recently been completed as part of our Living Streams programme. The investigation revealed elevated levels of nickel and zinc in several of the stormwater drains downstream of the North Road bridge on the Waihopai River.

Figure 33: Monitored Southland estuaries



[89] Robertson and Ryder 1993 & 1995

Table 27: Estuary health indicators and overall condition ratings

ISSUE	Indicators	New River Estuary	Jacobs River Estuary	Toetoes (Fortrose) Estuary	Waikawa Estuary	Haldane Estuary	Waiau Lagoon	Waimatuku Estuary	Bluff Harbour	Awarua Bay	Freshwater Estuary**
Sedimentation	Area of soft mud	↓	NC	–	–	–	–	–	–	–	–
	Sedimentation rate	↓	Not yet known	Not yet known	↓	Not yet known	Not yet known	Not yet known	Not yet known	Not yet known	–
	Sediment grain size	↓	NC	–	–	–	–	–	–	–	–
Toxicity	Sediment heavy metal levels	–	–	–	–	–	–	Not yet known	–	–	–
Nutrient enrichment	Nuisance macroalgae extent	↓	↓	↓	–	–	–	–	Not yet known	Not yet known	–
	Sediment nutrient concentrations	NC	NC	NC	NC	NC	–	–	–	–	–
	Depth of sediment oxygen level	↓	–	–	–	↓	↓	–	Not yet known	Not yet known	–
	Estuary water nutrient concentrations*	↓	No data	No data	No data	No data	No data	No data	Not yet known	Not yet known	No data
	River water nutrient input	↓	NC	↓	↓	NC	↓	↓	No data	No data	No data
Habitat quality	Seagrass meadows	↓	NC	Not present	–	–	Not present	Not present	–	–	–
	Saltmarsh cover	NC	–	–	–	–	–	Not yet known	–	–	–
	Estuary invertebrates	NC	NC	NC	NC	NC	Not yet known	Not yet known	–	–	–
	Estuary fish	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
Overall condition grade								Interim	Interim	Interim	
State of the Takiwā score		No data	No data			No data		No data	No data	No data	No data

* Invercargill City Council data

**Control site

Condition grades:	
	Very good
	Good
	Moderate/fair
	Poor
	Very poor
Not yet known	Monitoring has started but we have not enough data to determine condition grade
No data	Has not been monitored or there is an information gap

Changes in condition/trends:	
↑	Improving condition over time
NC	No change in condition over time
↓	Deteriorating condition over time
–	Insufficient data to assess

The health of our estuaries

The condition ratings of our 10 monitored estuaries range from 'poor' to 'very good', with three estuaries in each of the 'poor', 'moderate' and 'very good' ranges. One estuary is in the 'good' range and no estuary is in 'very poor' condition (Table 27). The best estuarine ecosystems in Southland are in undeveloped catchments, around Awarua Bay and Freshwater Estuary on Stewart Island/Rakiura.

Tidal dominated systems like New River, Jacobs River, and Waikawa, with highly developed catchments, are in the worst condition. However, Toetoes (Fortrose) Estuary, although draining a developed catchment, remains in good condition – this is because the river dominates the system, so contaminants, such as excessive sediments, are flushed through the estuary quickly.

There are differences between the State of the Takiwā scores and the Overall Estuary Health Grade based on the ESEMP and water quality parameters. This difference is likely because the Takiwā cultural environmental score includes assessment of species abundance and the potential opportunities for harvesting mahinga kai. For example, the 'moderate' Takiwā score (3.2 out of 5) for Owi – Toetoes (Fortrose) Estuary was the second highest recorded in the Mataura River State of the Takiwā study, with the upper catchment site of Piano Flat scoring the highest (3.9). The Owi – Toetoes score was lifted because of the bigger range of species to harvest in the estuary compared to other areas in the catchment (Table 27).

How estuary quality is changing over time

We do not have sufficient consecutive years of monitoring data to show long-term trends in our estuaries. This limits us in determining the year-to-year impacts of human activities and/or natural influences. However, we have enough data to describe measurable changes in our estuaries. Since 2000, none of the Southland estuaries have seen an improvement in their condition ratings. Overall, the majority of indicators are showing no change (60%) and the rest show a deteriorating condition over time (40%).

Worryingly, three estuaries (New River, Jacobs River, and Toetoes (Fortrose) Estuary) are showing a deteriorating condition in regard to nuisance macroalgal blooms. This change is being driven by degraded incoming water providing a constant nutrient supply for the macroalgae. When the sediments are excessively muddy and/or deoxygenated, more organic matter is released, further exacerbating the blooms. These blooms decrease the productivity and biodiversity of the sediments and decrease the habitat suitability for estuary invertebrates and fish.

Out of the four estuaries where we can determine changes in ecosystem health, New River Estuary with its 'moderate' overall condition rating is deteriorating the most.

New River Estuary

New River Estuary (Koreti) is Southland's largest estuary (4100 ha) and is adjacent to Invercargill City.

New River Estuary's health has been monitored as part of the ESEMP since 2000. The monitoring results indicate the estuary still has high biodiversity values, extensive areas of saltmarsh and sea-grass meadows. However, eight of the twelve measured parameters indicate the ecosystem health of the New River Estuary is in decline (Table 27). Three parameters, heavy metal toxicity, saltmarsh cover and sediment nutrients, were in the 'good' to 'very good' category.

The issue of eutrophication is currently the greatest threat facing the New River Estuary. The area covered by nuisance macroalgae (*Enteromorpha, Ulva* and *Gracilaria* spp) in the New River Estuary has increased from 26% to

40% in the last four years, along with declining sediment oxygenation. The Waihopai Arm has recorded the largest increase in macroalgae. The factors driving the macroalgal blooms are the degraded quality of incoming water from the Waihopai and Oreti Rivers and the favourable growing conditions, with lower wind speeds because of the reduced wind fetch. This is typical across the New River Estuary, where the more sheltered parts such as Daffodil Bay, offer better growing conditions.

In estuaries, dissolved inorganic nitrogen (DIN) can be the most important nutrient to limit algal growth. Research[90] shows concentrations below 0.25mg/l N are needed to limit macroalgal growth, while concentrations above this level will not help limit algal growth. In the monitoring sites in the Waihopai Arm and the Oreti River at Dunns Road, 95% and 100% of all samples in the last five years exceeded the level that limits algal growth. All the freshwater river and stream inputs to the estuary exceeded their respective ANZECC (2000) freshwater total nitrogen guidelines (Table 28). This highlights the poor condition of the incoming freshwater and suggests there is no limit to the supply of nutrients to fuel macroalgal blooms.

Freshwater total phosphorus and dissolved reactive phosphorus (DRP) concentrations are also elevated in the Waihopai Arm (Otepuni Creek and Waihopai River, Table 28). The DRP concentrations in the estuary sites are elevated at both low (freshwater dominated) and high tides, which suggests the high nutrient concentrations remain in the estuary and are not removed by tidal flushing or mixing. This means there is more time available for uptake of the nutrient by the macroalgae in the estuary.

Over the last 20 years there has been little change in the DIN:DRP ratios at the three estuary sites. The two incoming river sites (Dunns Road and Stead Street, Table 28) are predominantly phosphorus limited. However, the more estuarine Sandy Point site is split equally between being unlimited by any nutrient and co-limited between nitrogen and phosphorus. This supports the statement above that macroalgal species will bloom if nutrients are not limited and if stable growing substrate and reduced winds are present.

Often the greatest pool of nutrient supply in estuaries is in the sediments[91]. In the New River Estuary total nitrogen concentrations in the sediments have doubled in the last five years at all three monitoring sites in the estuary. This further drives the eutrophication process already evident in New River Estuary and is intensified by the continual input of nutrient-rich sediment and water.

Ammonia toxicity in the New River Estuary was not evident at any of the monitoring sites and in the last five years concentrations have been decreasing.

Sedimentation rates in the upper estuary are extremely high and are up to 30 times higher than currently recommended for estuaries like New River Estuary[92]. The fine muds entering the upper estuary are from both historical catchment development and current land-use intensification in the Waihopai, Makarewa and Oreti catchments.[93]

The area with the highest density of thick muds and nuisance algal conditions, the Waihopai Arm, also historically had the highest densities of the seagrass *Zostera capriconi*. Seagrass meadows are hugely important for many invertebrate and fish species, which use them as breeding and juvenile rearing grounds[94]. They are nationally in decline. In 2007, seagrass covered 5.6% of the New River Estuary, which gave the estuary a 'good' rating. However, by 2010 seagrass only covered 3.6% of the estuary ('fair'). This habitat deterioration in the Waihopai Arm is caused by the degraded incoming water, which results in muddy sediments, nuisance macroalgae blooms and reduced sediment oxygenation.

Compared to other estuaries in New Zealand, the New River Estuary has a moderate range of invertebrate species (between 4–16 per sample) but often low numbers of species, which indicate those species are slightly tolerant to pollution. There are low numbers of sand-dwelling species, with species such as the pipi (*Paphies australis*) now absent from all three of the monitoring sites, whereas in 2003 pipi were abundant. Conversely, a few mud-loving species are starting to dominate, such as the estuarine mud snail (*Potamopyrgus estuarinus*) and the sediment filtering bivalue (*Arthritica bifurca*).

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[90] Pederson and Borum 1997
[91, 92] Robertson and Stevens 2010
[93] Blakely 1973; Thoms 1981; Denton 2008; Gibbs and Cox 2009
[94] Morrison 2007

Table 28: Water quality trends in the New River Estuary and incoming freshwater river sites (2005–2010)

Upstream river sites	TP*	DRP	TN
Waihopai River u/s Queen Drive	0.04 NC	0.01 NC	2.6 ↑
Otepuni Creek at Nith St	0.01 NC	0.05 NC	2.4 NC
Oreti River at Wallacetown	0.014 NC	0.006 NC	1.0 ↑
Makarewa River at Wallacetown	0.054 NC	0.017 NC	1.7 ↑
Waikiwi River at North Road	0.04 NC	0.01 NC	3.1 ↑
Estuary sites			**DIN**
Sandy Point	0.0475 NC	0.024 NC	0.42 NC
Dunns Road Bridge	0.058 NC	0.0355 NC	1.21 NC
Stead Street Bridge	0.063 NC	0.024 NC	1.59 NC

Data presented as medians. Trends are flow adjusted and are meaningful significant.
*TP guidelines for New Zealand estuaries are still in development, ANZECC 2010 revision.

Condition grades:	
(green)	Very good
(yellow)	Good
(orange)	Moderate/fair
(red)	Poor
(purple)	Very poor

Changes in condition/trends:	
↑	Improving condition over time
NC	No change in condition over time
↓	Deteriorating condition over time

How Southland's estuaries compare nationally

The overall health of Southland's estuaries is similar to that of other estuaries in New Zealand of similar size, hydrology, shape, and catchment land-use. The number and abundance of invertebrates and the habitat quality in the 10 estuaries that Environment Southland monitors are typical of other tidal estuaries in the country. Invertebrate biodiversity shows a slight tolerance to pollution from organic matter and mud. The dominant habitat in Southland estuaries is intertidal mud and sand flats, which are still in a moderate condition overall, with lower concentrations of sediment nutrients and heavy metal concentrations compared to other New Zealand estuaries. However, incoming water quality is often degraded, resulting in more muddy estuaries where rates of sedimentation are higher than national averages.


B. Robertson

How do we affect the health of our ecosystems?

Many of the activities we undertake can affect the ecological health of our waterways. That includes things we do to make a living, as well as to have fun; and the activities may actually be on land, as well as in or near freshwater systems.

The key factor is the effect on water quality. Reduced water quality can have long-lasting effects on a freshwater ecosystem, including:

- increased growth of nuisance algae and plants associated with a high amount of nutrients in the water (eutrophication)
- impact on aquatic life by ammonia, nitrate-nitrite-nitrogen and faecal contamination
- change or loss of habitat or spawning areas due to sedimentation.

Contaminants directly affect the ecosystem downstream (eg sediment from land use activities accumulating in estuaries), and can impact on the mauri of surrounding air, plants, animals, freshwater, and coastal systems.

Sometimes the negative effects on ecosystems are not seen immediately, but are still significant. This is because there can be a time lag between the activity and a resultant change in the ecosystem; also the effect may not become apparent until it has accumulated over several seasons, or it may actually only show up further downstream—this is especially true in estuary areas.

The effect a particular land-based activity has on freshwater ecosystems depends a great deal on *where* and *when* the activity occurs. For example, land development in steep hill country can result in more soil erosion and sediment loss than development in lowland areas, and winter grazing when soils are saturated can cause more contaminants to enter the waterway when the ground is dry, as in the summer months.

It is not very useful to look at the different pressures on freshwater ecosystems in isolation. Rather, we need to examine the cumulative effect of all activities, across all sectors of our community.

We also need to recognise the effects of the accelerated rate of climate change, and also our community's growing disconnection from the environment. These overall factors can intensify the pressures put on our sensitive freshwater ecosystems by local activities.

Agricultural activities

Farming practice activities

Many day-to-day aspects of farm operations have the potential to put additional pressure on our ecosystems, such as:

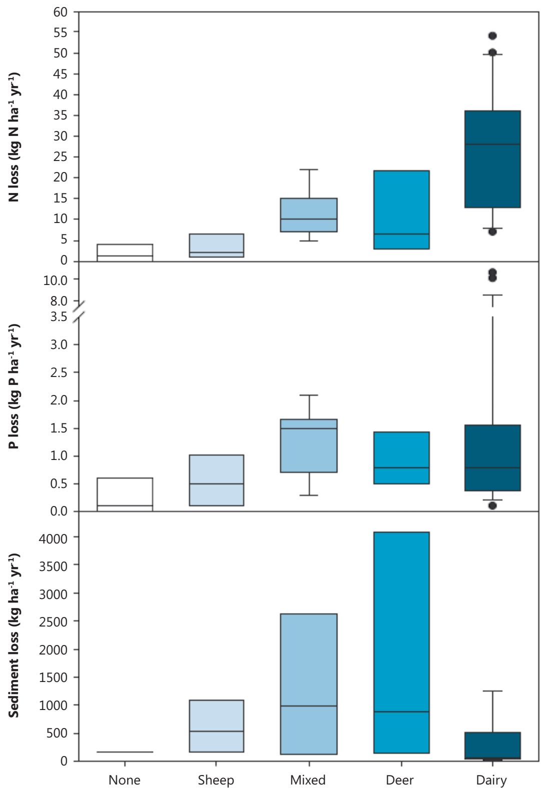
- Infrastructure – tracks, ford races and bridges can increase sediment in waterways, if built in unsuitable locations, or poorly designed and managed.
- Fertiliser – inappropriate use of fertilisers, including applying them at wrong times of the year (eg urea in winter), in high winds, near streams or over applying, can lead to nutrients either leaching or directly entering. Over 480,000 tonnes of fertiliser per year are applied to land in Southland[95].
- Silage – silage leachate that reaches waterways can produce an unsightly grey fungus, and deplete oxygen levels.
- Offal and farm dumps – offal pits and farm dumps can leach to groundwater and surface water if constructed in inappropriate areas. This can mean pathogens, toxins and faecal material can leach into surrounding ecosystems.
- Herbicide and pesticides – use of herbicides and pesticides can settle in the sediments on the stream beds.

Stock impacts

Animals including sheep, beef cattle, dairy cattle and deer can put pressures on ecosystems. Heavy stocking can compact soil, reducing its ability to retain moisture, and increase the overland flow of nutrients and sediments to waterways.

[95] Statistics NZ 2007

Figure 34: Annual load losses of nitrogen, phosphorous and sediment, by land use class.



'None' refers to non-agricultural rural land uses such as exotic plantation and native forest, while 'mixed' refers to a catchment with more than one type of land use class. From McDowell and Wilcock 2008.

Patches of urine and dung in paddocks from stock are a significant source of pathogens, nutrients and oxygen-depleting substances. Stock also contribute to sediment and nutrients (nitrogen and phosphorus) entering freshwater systems. The form of farming that has the highest losses of nitrogen is dairy; these levels are significantly higher than the next farming types, deer and mixed stocking, which are about equal (Figure 34).[96] For phosphorus, the greatest median losses come from mixed and then equal losses come from deer farming and dairy, with dairy having a larger range and more variation. Deer farming has the largest range and variation for sediment losses but mixed farming has a slightly higher median loss.[97]

Dairy farming

The pressures that dairy farming puts on Southland's freshwater ecosystems have increased markedly since 2001, in particular through:

- farm dairy effluent disposal
- the expansion and intensification of dairying.

Farm dairy effluent disposal

Farm dairy effluent contains ammonia, phosphorus, sediment and faecal material. Ponding of effluent, contamination of groundwater, surface runoff and contamination of mole and tile drains, can cause effluent to enter waterways. There can result from:

- poor maintenance and management of effluent systems;
- lack of knowledge about location of mole and tile drains;
- lack of fail-safe/automatic shut-off systems;
- over-application of effluent for soils and conditions;
- lack of available storage for effluent.

There were 838 consents to discharge farm dairy effluent over 785 farms across Southland as at June 2010. Each year, farm dairy effluent consents are inspected at least once and re-inspected if a significant non-compliance is found. The inspections check for system maintenance and operation issues, and aim to identify systems that are affecting or likely to affect waterways.

Over the past three dairy seasons the number of systems failing inspection has increased. There is a clear trend upwards in significant non-compliant grades, rising from 9.6% in 2007/08 to 14.6% in the 2009/10 dairy season. Twenty-eight infringement notices and 15 abatement notices were issued in the 2009/10 year for farm dairy effluent related issues.

Expansion and intensification

The dairy industry is expanding rapidly. Just over 10% of the total dairy cows in New Zealand are located in Southland.[98] At the end of 2009 there were 589,184 dairy cows in the region, compared with 114,378 in 1994. The herds are farmed on just over 169,000ha of land. This land area has increased, by more than 10,000 ha since the 2008/09 season. The average herd size has also increased, from 365 in 1998/99 to 539 in 2009/10[99].

[96, 97] McDowell and Wilcock 2008

[98] Livestock Improvement Corporation and DairyNZ 2010

[99] Statistics NZ 2010

The intensification and expansion of dairy has meant additional pressures have been put on our freshwater ecosystems through:

- *Spread into marginal land* – the topography, climate and soil types may be unsuitable for the intensity of farming, resulting in increased nutrients, faecal bacteria, sediment and oxygen-depleting substances entering waterways, and additional demand on groundwater for irrigation.
- *Water abstraction for irrigation* - groundwater abstraction leads to reduced groundwater levels, which can impact on other users of the aquifer (see 'Our Uses' report). Taking too much water from a river or stream has the effect of raising water temperatures, and altering the habitat for plants and animals within the stream.
- *Loss of vegetation* – trees and scrubland are lost and replaced by pastoral farming. This reduces the biodiversity, and increases the ability for nutrients and sediment to enter waterways if vegetation has been removed from riparian areas.
- *Drainage* – wet areas and wetlands are drained with surface cuts or installation of mole and tile drains. This decreases the natural water table of the area, reducing the land's ability to hold water, and creating direct pathways for nutrients, faecal material, sediment and oxygen-depleting substances to enter waterways. Subsurface mole and tile drainage is the main pathway of nitrogen transfer from agricultural land to water[100].
- *Requirement for dairy support* – Beef and Lamb New Zealand estimates that for every four farms converted from sheep to dairy, the equivalent of another farm is also required for dairy support, such as producing feed and grazing stock.[101] Intensive winter grazing, especially on sloping land or with no buffer zone to waterways, increases surface runoff of contaminants.

Discharges from industry and residential sources

Activities associated with industrial processing, manufacturing, and residential living, result in contaminants being discharged at point sources. As at 30 June 2010, there were 141 consented discharges to Southland freshwater and estuaries, including consents associated with power generation and mining activities. This is almost double the number of consented discharges to freshwater since 2000.

These discharges impact on waterways by contributing sediments, nutrients, bacteria and metals, and by removing oxygen from the receiving waters. Sediments can discolour the water, thereby reducing light and habitat for stream life. Nutrients promote nuisance weed and algal growth and, if excessive, can be toxic. High levels of bacteria and metals can make animals downstream unsafe for human consumption. Reduced oxygen levels can harm or even kill plants and animals living in our waterways.

Discharges from manufacturing and processing plants

Manufacturing and processing industries that discharge wastewater directly to our waterways include meat, fish and milk processing, timber and wood chip processing, and fertiliser production plants. Consents for these discharges are tailored to suit the nature of the industry and the main contaminants that are likely to be discharged to our waterways.

The plants responsible for these discharges are scattered throughout the region. However, the Mataura River is under the most pressure, as seven out of the sixteen consents for manufacturing and processing discharges are to the Mataura River.

Wastewater treatment

The purpose of treating wastewater is to reduce bacteria and nutrients to a level that will not harm the receiving environment and ensure that the amount of oxygen removed from a waterway will not stress aquatic organisms. In mid-2010, only 9 out of 24 of Southland's wastewater treatment systems were found to be fully compliant with their discharge consent conditions. While some of this non-compliance was due to not submitting data, the remainder was a result of discharges exceeding consent limits for sediment, nutrients and faecal bacteria. This is putting additional pressure on our river and estuarine ecosystems.

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[100] Monaghan *et al.* 2010

[101] Venture Southland

Stormwater

Stormwater is collected from hard surfaces like roads, and transported via pipes to our waterways. Stormwater can contain sediment, heavy metals (which in high concentrations can be toxic) and organic material that can deplete oxygen from our streams as it breaks down. A large volume of water can pass through the stormwater system. In Invercargill, a land area of 30ha is capable of generating a discharge of 1,050 litres per second. Stormwater pipes can also act as a pathway to carry sewage to our waterways if they are cross-connected. This is not only highly undesirable as it contains lots of faecal material, but can form an unsightly grey sewage fungus. Wastes containing heavy metals and organic poisons can have lasting negative effects on ecosystems.

High faecal bacteria concentrations have been found in stormwater draining on to Morrison's Beach in Bluff – see the 'Urban' section in 'What are we doing about the health of our ecosystems?' pg 84. This may be a sign of cross-connections between the stormwater and waste networks in this area. Invercargill City Council is working to identify points at which human waste may be entering the stormwater network.

Pollution incidents

For the year ending 30 June 2010, there were 981 incidents reported to Environment Southland's Pollution Hotline and this number is increasing over time. Of the 981 incidents, 375 were related to water; it is also possible some of the 286 incidents that were recorded as relating to land could impact on the freshwater environment.

Failing septic tanks

Household wastewater disposal systems can contribute to elevated levels of faecal coliforms in groundwater and surface water. Investigations through Environment Southland's Living Streams programme have revealed that some waterways have become contaminated with human faecal material from septic tanks that are connected to tile drains which discharge into streams. Groundwater can also be contaminated as a result of septic tanks leaking.[102]

Modification of aquatic habitats

The beds and margins of waterways, natural drainage, and how the stream is connected, are integral to the way ecosystems function. Beds of waterways and their margins provide habitat for plants and animals and are part of the natural processes in the ecosystem. This section discusses removal of riparian habitats, extraction of gravel, modification of rivers and catchment drainage, expansion and maintenance of drainage channels and structures in our waterways, and how these activities put additional pressures on our ecosystems.

Removal of vegetation

Vegetation clearance, including removal of riparian vegetation, can raise water temperatures; less stable banks may collapse resulting in deposition of sediment into waterways, which decreases water clarity; high temperatures (and high pH) can increase the ratio of some nutrients, which can be toxic to aquatic life.

Gravel Extraction

The development of Southland's infrastructure has been aided by people harvesting gravel from Southland's riverbeds. Historically this was through skimming and excavations of gravel beaches and bars, and in recent times, habitat pond construction. Extraction of this nature can put additional pressure on our river ecosystems, particularly habitats for our in-stream and riparian animals, although if carefully managed it can be beneficial.

In Southland the average annual gravel extraction from our river beds is 338,183 cubic metres. Altering rivers by removing gravel can result in increased sediment, bank degradation, erosion, and changes to river channels and characteristics such as width of stream and speed of water. Changes in river flow and the creation of new channels can have negative impacts on riparian margins and the birds that nest or roost on river margins. In-stream impacts include reducing the number and diversity of macroinvertebrates, which in turn can have a profound impact on fish.[103]

Disturbance and modification of river and stream beds

River and stream beds are home to a diverse community of aquatic plants and animals. In the 1980s and 1990s, the overriding desired outcome

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[102] Rekker 1996

[103] Kelly *et al.* 2005

was to protect our communities from flooding risks, and to get rid of any flood waters quickly. Tools of the time included channel manipulation, construction of stop banks, erosion control works and fairways cleared of pest vegetation. This has resulted in increased pressure on our freshwater ecosystems through altering and in some instances, removal of river and stream bed habitat.

Catchment Drainage and Maintenance

Successful farming in areas with high water tables, such as in Southland, depends on reliable and effective land drainage outfall. The total length of Southland's drainage network, which includes both natural and man-made drainage cuts, streams and artificial channels, is estimated at several thousand kilometres, but its full length is unknown. Both man-made drains and natural waterways are home to plants and animals, including the threatened giant kōkopu.

The extent of the mole and tile drainage networks on private properties is also unknown. Mole and tile drains are designed to transport water from paddocks to nearby watercourses. In doing so, they act as the primary pathway for nitrate runoff to freshwater. They can also deliver significant amounts of phosphorus (possibly even more in poorly drained soils), sediment and faecal bacteria from soil to our waterways[104].

Our waterways need to be maintained in a way that ensures that upstream landowners have sufficient drainage outfall, while the habitats they provide for plants and animals are sustained. Since 2001, Environment Southland has been responsible for maintaining a regional drainage network equating to some 10% of Southland's surface water drainage networks and has maintained on average 440km of drains per year across 890 properties.

The use of excavators to remove aquatic weeds from waterways is one of the tools used for some drainage maintenance, but that process also impacts on important habitat and cover for fish and macroinvertebrates. An unintended consequence of these operations can be that eels, fish and koura are sometimes removed from the waterway during this process.

Research in Southland on drainage impacts and methodologies is limited, however Environment Southland was a partner in the development of the Sustainable Drainage Management Field Guide published in 2005 by the New Zealand Water Environment Research Foundation and implements and promotes those best practices. This study drew on extensive international research and practices.

A 2011 pilot study conducted within the Waituna catchment, led by the Department of Conservation, investigated the effects of drain clearance on kōkopu and nutrient and sediment release.

Structures in waterways

Floodgates, dams, concrete bridge aprons, weirs and hanging culverts placed in streams can present a physical barrier to migrating fish, which can limit their choice of habitat. Structures can also change the dynamics of stream channels by reducing the depth of water in the stream during low flows. These additional pressures can reduce the number of fish that can migrate up or down stream to important breeding grounds.

Exotic plants and animals

The ecological, cultural and economic impacts of exotic pests are significant and ongoing. Pest plants, fish and algae put additional pressure on our freshwater ecosystems. Deliberate introductions of exotic fish species include trout, salmon and perch. These species were introduced more than a century ago by anglers and acclimatisation societies for sport and recreation, often with little knowledge or thought of the impact on native species. The total number of exotic species, their abundance and distribution is not well known. Some exotic species found in our freshwater and estuarine ecosystems are listed in Table 29.

Exotic plants and animals can spread into or within Southland in a number of ways, such as escape or release from aquariums and aquaculture, transfer from birds, infected fishing and hunting equipment, boats, kayaks, and gravel extraction machinery.

Exotic fish compete for prey with native fish, use native fish as a food source, and can severely alter habitat, increasing turbidity and decreasing water quality through stream bed and bank erosion. While most are regarded as pests, trout and salmon are highly valued recreationally and

[104] Monaghan *et al.* 2010

economically in Southland – and as such are protected by legislation.

In freshwater ecosystems, exotic plants are often aggressive colonisers and can crowd out native plants and animals. They can significantly alter habitat, cause significant shading and also encourage sediment buildup. Plant mass can also break off, causing blockages and increased flooding risk, while also impacting on recreational activities.

A large number of exotic plants are also found along Southland's river margins. Of these, Californian thistle, broom and gorse are the most numerous. Crack willow is also abundant, as this has been used extensively for river bank stabilisation.

Exotic plants cause a range of problems in wetlands. Of the plants already present in Southland, grey willow probably presents the greatest threat to our wetlands. Once established in a wetland, exotic plants can often grow more quickly and aggressively than our native plants. This reduces both the diversity and abundance of native wetland plants, and can impact upon the habitat and available food for birds, fish and insects in our wetlands.

One exotic algae dominates in Southland – *Didymosphenia geminata* (didymo), the microscopic pest that can be spread by a single drop of water and has the potential for substantial negative impacts on aquatic ecosystems. Didymo was first discovered in New Zealand in Southland's Waiau River in 2004. Didymo is now found in all of Southland's major river systems, even though it is not always visible. As at July 2010, didymo had been identified in at least 34 Southland waterways.

Fishing and traditional food gathering

Gathering of kai from freshwater is part of the history and tradition of Southland. The harvesting (whether it is commercial, recreational or traditional) of mahinga kai and other species during breeding season, or in juvenile stage, can put additional pressures on our freshwater species – particularly if over-harvested.

There has been a consistent rise in lake fishing since 2001/2002. Fishing in Lake Te Anau has more than doubled since 1994/1995. Usage figures for the larger Southland rivers show little or no change since 2001/2002. There was a strong decline in fishing on the Mataura River in 2007/2008.[105]

Throughout Southland there are 658 consented whitebait stands located on the banks of the Aparima, Mataura, Waikawa, Titiroa, Pourakino, Awarua and Hollyford Rivers. Approximately half of these (330) are on the Mataura River.

Mining

Mining involves digging under the surface to extract ores such as coal and gold. Resources in Southland are nationally significant and there is a long history of mining for coal, used in local industry and exported. Lignite ('young' coal usually softer with a higher moisture and lower carbon/energy content), lime, peat, rock and metal are also mined in Southland.

Only one coal mine is currently in operation in Southland; it produces about 250,000 tonnes per year; however, two other mines continue to hold consents and monitor their sites as they work towards remediation. Our freshwater ecosystems may be affected by active mining operations as well as by closed or disused mines.

During mining preparation, vegetation is cleared and bare ground is exposed, increasing the risk of erosion and dust and consequently sediment entering waterways. The use of heavy machinery in mines can compact the surface, reducing the soil's ability to hold water, therefore increasing the amount of runoff. Water used on site is generally treated before being discharged to streams to remove sediment and to ensure it is not too acidic or alkaline.

Future pressures from mining

As New Zealand's demand for energy continues to rise, an expansion of mining in Southland may occur. While the scale of mining is not currently large in Southland, the activity has the potential to have huge and long-lasting environmental impacts, including acid mine drainage, which lowers the pH to toxic levels in the ecosystem. Seventy-two percent of New Zealand's recoverable coal and lignite reserves (six billion megatonnes of lignite reserves) are located in Southland and this has created interest in the potential energy options available. Extracting other resources such as silica, natural gas, and oil reserves both on-shore and off-shore in the

[105] Unwin 2009

Table 29: Exotic plants, animals and alga known to occur in Southland's fresh and estuarine ecosystems.

	Common Name	Scientific name	Habitat	Abundance and distribution	Effect
Exotic plants	Spartina	*Spartina anglica*	Estuarine	Only New River Estuary (now). Was also previously in the Jacobs River and Haldane estuaries.	Forms dense grassy clumps and vast meadows in estuaries causing a build up of sediment. Can increase the risk of flooding and also alter the habitat for wading bird species and other estuarine plants and animals.
	Reed Sweet Grass	*Glyceria maxima*	Margins of Lakes, streams, wetlands, ditches	Widespread throughout Mataura Catchment. Present in Waiau River, Lora Stream and Makarewa River.	Forms dense mats on top of the water. Replaces nearly all other species where it establishes and degrades the habitat for other plants and animals in the area. Can cause a build up of silt, leading to increased flooding – and in wetland areas can attract cattle for grazing causing further degradation.
	Lagarosiphon	*Lagarosiphon major*	Ponds, lakes, slow moving streams	Widespread through Waihopai, Otepuni and Oreti catchments	Forms vast deep meadows that can shade out other species. Can increase the risk of flooding, cause blockages and restrict recreational activities.
	Starwort	*Callitriche stagnalis*		Kingswell Creek. Likely to be present in other areas but has not been recorded.	
	Water Forget-me-not	*Myosotis laxa*		Lakes Manapouri, Hauroko and Lochie	
	Oxygen Weed	*Elodea canadensis*		Widespread through all catchments	
	Water Buttercup	*Ranunculus tricophyllus*		Lake Lochie. Likely to be present in other areas but has not been recorded.	
	Bulbous Rush	*Juncus bulbosus*		Lake Hauroko, Lake Manapouri, Lake Orbell, Waitutu River mouth, and near Colac Bay	
	Grey Willow	*Salix cinerea*		Low abundance, wetland margins	Replaces native species in wetlands and forms dense stands. Causes blockages and flooding in waterways.
Exotic algae	Didymo	*Didymosphenia geminata*	Streams, rivers and lakes	Widespread	Forms massive blooms on the bottom and can form a thick brown layer that smothers rocks, submerged plants and other materials.
Exotic Fish	Brown Trout	*Salmo trutta*		Highly abundant, wide distribution	Outcompetes native fish for food and predates directly on threatened whitebait.
	Rainbow Trout	*Oncorhynchus mykiss*		Highly abundant, restricted distribution	As above
	Chinook Salmon	*Oncorhynchus tshawytscha*		Low abundance, restricted distribution	As above
	Atlantic Salmon	*Salmo salar*		Probably extinct	As above
	Brook Trout	*Salvelinus fontinalis*		Probably extinct	As above
	Goldfish	*Carassius auratus*		Isolated, Oreti Gravel pit	
	Perch	*Perca fluviatilis*		Highly abundant, restricted distribution	Juveniles predate on koura and invertebrates. Adults predate directly on other fish, including juvenile trout, salmon and native fish.

Great South Basin, is also being explored. A site has been selected near Mataura for a pilot plant to turn 150,000tonnes/yr of low grade coal into briquettes for heavy industry.

Forestry

Southland has a well-established forestry industry that involves mostly plantation forests and timber production. Compared to the rest of the country, trees in Southland forests are relatively young and there is significant potential for harvest volumes in the region to increase. Most wood is sourced from exotic forests, with only 1% coming from sustainably managed native forests in Southland.

There are many activities within forestry that have the potential to impact on the health of our freshwater ecosystems. The exposure of bare ground during burning (to clear felled wastage), land preparation and harvesting, increases the risk of erosion and of sediment entering waterways. Compaction of soil from repeated use of machinery can decrease the soil's ability to hold water and increase runoff. Cuts for drainage adjacent to roads can act as pathways for sediment to reach streams.

Z. Moss

What are we doing about the health of our ecosystems?

Introduction

The success or failure of efforts to protect our freshwater ecosystems depends on the collaborative actions and initiatives of individuals, landowners, industry groups, communities, recreational users, and central and local government.

This section focuses on the actions Environment Southland is taking to address the pressures on our freshwater ecosystems. Behind these programmes is the work of many other organisations, groups and individuals who make important contributions; some in partnership with Environment Southland, others independently. The actions Te Ao Mārama Incorporated is undertaking are also outlined in this section.

Currently, we are not able to match the scale of our response to the speed of change (or trend) in the state of the environment. Nor are we able to properly assess the effectiveness of the response. For example, it is difficult to know whether improvements in water quality are due to riparian fencing and planting, improved effluent systems or a combination of both. It is difficult to assess effectiveness as there is a lag time for some responses, from when they are put in place to when they are functioning effectively.

Plan effectiveness monitoring is legally required to determine if the water plan is effective over its term; this will help assess the effectiveness of our responses to the current state of the freshwater environment.

Some of the responses described here are generic to all freshwater ecosystem habitats, others are more specific to Southland issues. The section begins with a focus on our most urgent challenge, the state of Waituna Lagoon; then it is split into subsections on urban, rural and general responses across the region.

Waituna Response

The sensitive nature of the Waituna Lagoon has been recognised by environmental management agencies for some years. In 2009, Environment Southland and the Department of Conservation joined together to employ a Land Sustainability Officer solely dedicated to the lagoon catchment. This position was created in recognition of the special values of this area and the risks that agricultural activities pose to the lagoon. The staff member is available for on-farm advice and also advocates the unique values of Waituna at community and education field days.

However, risks to the lagoon were recognised as more urgent in the last year. During this state of the environment reporting process, Environment Southland found the lagoon was in imminent danger of 'flipping' – see the case study at the end of 'Our lakes and lagoons — Ngā roto wāimaori' pg 49. This led to more specific responses, including advice on winter grazing practices, a review of all dairy effluent consents, rule and plan reviews, and detailed scientific catchment and lagoon studies.

Historically the lagoon would have breached to the sea naturally. Since 1908, the lagoon has been artificially opened to the sea for land drainage purposes. In mid-July 2011, the lagoon was opened at a different location to try and minimise direct harm to *Ruppia* (seagrass).

Further information about our response to the Waituna Lagoon can be found on www.es.govt.nz.

Urban

Environment Southland works with urban communities and businesses to increase knowledge about freshwater ecosystems and the way individuals can affect these sensitive environments.

- Environment Southland's Pollution Prevention Officer works with commercial and trade businesses to identify and eliminate sources of pollution. A large focus of this programme is reducing water contamination. The officer actively worked with more than 30 businesses during 2009/10. At the end of 2010, as a result of their involvement with the Pollution Prevention Programme, two manufacturing industries indicated they would renovate yards to improve environmental performance. When finished, systems will capture all gross pollutants, with one company's system then polishing remaining metal, hydrocarbon and sediment contamination from their stormwater output.

- A total of 15.3km of walkways have been built along the watercourses flowing through Invercargill since 2000; 9.3km along the Waihopai, 2.6km along the Otepuni and 3.1km along the Kingswell. These walkways have improved access and recreational opportunities along the city's river margins, making these freshwater ecosystems available for more people to appreciate.
- As a result of a plan change in 2010, reticulated stormwater discharges now need consent and must also meet particular water quality standards.
- In 2010, the Living Streams programme identified that contaminants from Invercargill's stormwater network were entering the Waihopai River. More work is being done by the Invercargill City Council to locate and remove the sources of these contaminants (see Stormwater case study in 'Our estuaries – Ngā wahapu' pg 66).
- Environment Southland undertook an investigation in 2009, in conjunction with the Invercargill City Council (ICC), as a result of poor stormwater quality impacting on Morrison's Beach in Bluff. The ICC is working to identify and eliminate sources of contamination.

Rural

A large focus of Environment Southland's work is in the rural environment, working with farmers, landowners, workers and rural sector groups.

- The dairy inspection programme for 2009/10 was significantly different from previous years: changes made to the inspection programme included:
  - targeting historically poor performing farms, during spring conditions;
  - more extensive consent requirements/ follow-up for new consents, new pond construction details and effluent application testing.
- The Intensive Winter Grazing Rule was introduced and required a minimum 3m buffer between intensive winter grazing crops and water courses, to reduce nutrients and sediment getting into waterways.
- Our soil moisture network continues to be developed and now contains 18 monitoring sites. Farmers can refer to the website to find out whether soil conditions in their location are suitable for irrigation of effluent (www.es.govt.nz).
- Some of our river liaison groups (which were initially set up for flood protection) now also have a biodiversity focus.
- The production of guidelines, such as the 'Farm Dairy Effluent Best Practice Guidelines 2007,' provides famers with guidelines for effluent storage and disposal. Copies of the booklet were sent out to every dairy effluent consent holder in Southland.
- Better understanding and improved relationships are developing between dairy farmers and Environment Southland. Recent moves include the establishment of a Farmer Reference Group; senior Federated Farmers representatives joining aerial inspections of large dairy farms; and a field day where Council compliance and planning / policy staff visited a dairy farm. The reference group has already brought about changes in Environment Southland's inspection regime, which will see compliance staff concentrating on known poor performers before those with a good environmental record.
- Our Land Sustainability Officers provide information and advice on land practices including riparian fencing and planting, soils, shelter belts, wetlands and regenerative plantings. In 2011, the number of Land Sustainability Officers increased from five to six.
- Environment Southland's dedicated Dairy Liaison Officer continues to provide assistance (primarily focused on effluent) to new dairy conversions and with problems on existing dairy farms.

- Environment Southland continues to progressively refine consenting and compliance monitoring to reflect advancements in research and technology.

Across the region

Some actions taken for freshwater ecosystems are not focused on rural or urban areas, but regionwide.

- Compliance Officers continue to monitor consents and undertake enforcement action when necessary. In the last 10 years the penalties imposed by courts following prosecution have risen dramatically.
- Environment Southland runs a 24-hour pollution hotline, which receives over 900 calls per year. Calls are 'triaged', and those with a high risk to ecosystems receive higher priority.
- A programme to control Spartina in the estuaries around Southland was led by the Department of Conservation in collaboration with the Invercargill City Council and Environment Southland. Spartina has now been eradicated from most Southland estuaries, with only small amounts remaining in the New River Estuary.
- Over the past 10 years, Environment Southland has undertaken riparian planting through the catchment management programmes. Additionally the council has facilitated the planting of more trees through its Living Streams programme, and the administration of the Honda Tree Fund. From all programmes 174,700 trees have been planted.

Education programmes covering freshwater ecosystems:

Education programmes supported by Environment Southland that contain information on freshwater ecosystems include:

- *Brucie's Buddies Club* – Children aged between 4–14 receive information on ecosystems and the opportunity (through Brucie's Birthday Bash) to experience this firsthand. The last four birthday bashes were held at: the Waihopai River, Thomsons Bush, the Waituna Lagoon and Forest Hill.
- *Enviroschools programme* – In 2001, there were 20 schools across Southland involved in the programme. Many schools undertake native plantings and learn about freshwater ecosystems through their involvement with this programme. One of Southland's Green-gold Enviroschools, Otama School, has planted over 1400 native riparian plants and is featured in a case study in *'Our Uses'* report.
- *Stream Connections* – a school curriculum based programme which includes a field trip. It allows students to explore and discover their local waterway and identify stream life, particularly macroinvertebrates. On average more than 450 students participate in this programme each year.
- *Plantings* – Undertaken by many schools, generally with assistance from Environment Southland Education, Land Sustainability or Living Streams staff members.

Working with the Community:

- Environment Southland established the Living Streams programme in 2005 as part of our long-term strategy to improve the health of Southland's waterways. Scientists regularly collect water quality information within selected catchments to monitor changes. We visit landowners to provide free information and advice, and help landowners implement sustainable land management practices. The programme provides financial assistance for activities that will enhance water quality. As at February 2011, the programme has spent $186,332 on incentives (subsidies) for riparian works that will help to protect and enhance water quality. These works include:
  - 65km of riparian fencing
  - 1050 riparian plants
  - installation of several stockwater schemes, upgrades to several bridges and stabilisation of eroded banks
- In response to public submissions in 2010, Environment Southland allocated $25,000 for riparian fencing in the lower Waikawa catchment and $36,500 to investigate sources of faecal coliforms in the Waikawa catchment and estuary.
- Many landcare groups and trusts exist around the region and are supported by

our Land Sustainability Officers. Landcare groups are people who work together voluntarily on resource management issues, but seeking outside assistance when necessary. These passionate groups of people look after areas such as Riverton and Otatara, with a broad agenda focused on increasing biodiversity. There are 10 groups operating in Southland.

Communication and planning work supports improvements in our freshwater ecosystems:

- Environment Southland uses a variety of methods to inform Southlanders about our ecosystems and provide guidance on best management practices. These include press releases, website updates, information sheets such as the stormwater guide, and regular newsletters such as Enviromoos, Enviroweek and Envirosouth.
- Environment Southland has prepared a guide for the discharge of stormwater in the Southland region.
- Events such as the Environment Awards and the Wai Tri help raise the profile of our environment and to recognise local champions who are making positive changes and contributions.
- A more holistic approach with respect to wetland clearance and development has been included in the Regional Policy Statement Review.
- The Water Plan, which became operative in 2010, sets out the community's goals for water in our region, and the rules and methods to help achieve these goals. Regulations around winter grazing, drainage of wetlands and obstructing fish passage are some examples of how freshwater ecosystems are provided for through this plan.
- *Ngāi Tahu ki Murihiku Natural Resource Management Plan 2008: Te Tangi a Tauira – the Cry of the People* outlines areas of particular significance, and objectives for environmental management looking forward to future generations. Specific attention is given to species, ecosystem health and climate change.
- The Discharge Plan project, is reviewing the way we discharge to land and will help us to achieve the goals in the Water Plan. The Discharge Plan will include objectives, policies, methods and rules around agricultural, industrial and sewage discharges that have the potential to impact on the environment. It will also address the cumulative effects of existing activities and land use intensification.
- The Regional Pest Management Strategy (RPMS) has a species focus, and identifies species for eradication, containment and exclusion both on land and in our water. Environment Southland has different strategies for different species depending on the threat to our ecosystems. The plan restricts the sale and movement of pest species and, through education and enforcement, aims to reduce impacts from pest animals and plants. The didymo and gorse and broom responses are practical examples of the strategy at work.

Research that informs our freshwater ecosystem management

- The State of the Takiwā programme is a culturally-based environmental monitoring and reporting system developed by Te Rūnanga o Ngāi Tahu as part of the overall Ki Uta Ki Tai – Mountains to the Sea Natural Resource Management framework. Te Ao Mārama Incorporated has been involved with the State of the Takiwā assessments and cultural health index assessments undertaken in the Waiau in 2005, and the Mataura and Waikawa catchments in 2007. A Cultural Health Index for streams and waterways has been developed and is intended as a tool for nationwide use.
- Te Ao Mārama Incorporated has funding for a project that aims to identify and systematically collect, document and store Ngāi Tahu ki Murihiku mātauranga and values of groundwater and groundwater-contributed systems (eg waipuna, repo and awa), and will:
  - identify the culturally significant groundwater emergence sites in Southland/Murihiku
  - use this information to identify and develop cultural indicators for a cultural monitoring framework for groundwater emergence sites in

collaboration with Tiakina te Taiao Ltd and ESR.

- A variety of research projects have been undertaken to help inform our decision-making for management of freshwater ecosystems, including:
  - 2009 Farm Dairy Effluent report commissioned by AgResearch.
  - an Envirolink project looking at tools for characterising and managing dairy sludges and slurries (ie wastes generated by new farm dairy effluent and wintering systems). Environment Southland is leading the $120,000 project, which began in 2011 and runs for two years.
  - a three-year AgResearch research trial, supported by Environment Southland, on the effects of winter grazing on free draining soils at Five Rivers (began 2011).
  - the DairyNZ Southern Wintering Systems initiative (in which Environment Southland is a partner), is assessing a range of wintering systems from a whole of farm perspective, with research on monitor farms, focused on the 60% of nitrogen losses from dairy farms that happen during winter.
  - Sensitive Catchments research (groundwater and surface water) and Cumulative Effects project research.
  - High Value Areas studies.
- Research undertaken in 2009/10 found shellfish retain high numbers of faecal coliforms for up to five days after a fresh/flood. As a result, the guideline in Riverton for not gathering shellfish after a fresh has increased from three days to five days. See the case study on the Riverton/Aparima shellfish study in *'Our Health'*.
- Specific catchment work has been undertaken by Te Ao Mārama Incorporated in the Waikawa catchment, with particular focus on the kanakana (lamprey) mahinga kai species. In 2010, scientists undertook studies on kanakana population and survey techniques. Changes in population can be used as indicators of health of the fisheries and wider ecosystems – see case study on Vincent Leith pg 90.
- Since 2007, Environment Southland has monitored the fish numbers at 16 sites across the region. This is done annually in summer and helps to build up our knowledge of fish populations and species in Southland. One-off surveys have also been undertaken in response to fish kills, consent-related reasons and to fill in knowledge gaps.

Z. Moss

Case Study: Gary Morgan, Land Sustainability Officer

Gary began at Environment Southland (then the Southland Catchment Board) in 1974. After a couple of stints at other jobs, Gary returned to the Council in 1987 where the focus of his role shifted from soil conservation to land sustainability.

Day to day Gary is involved in running the team of land sustainability officers at the Council, which involves a mixture of office and field work. When he's out on the land, his main focus is responding to requests from land owners about plant and tree selection, shelter belts, wetlands, wind breaks, and Good Environmental Practices (GEPs). A large focus for the past decade had been on the interface between land and water, in the riparian zone adjacent to streams, as well as fencing and planting this filtering zone.

Over the time that Gary has been involved in his Soil Conservation and Land Sustainability roles, he has seen many changes benefiting the environment. Nutrient budgeting is more prominent with software tools like OVERSEER®, assisting farmers to help manage the environmental and economic costs and benefits of fertilisers. "Over the years we have seen science strengthening the advice we give," Gary says.

An aspect of the environment that Gary is very passionate about is wetlands, and the value they provide. Wetlands on farms, even small ones, can be helpful for polishing and denitrifying, as well as providing a great habitat for plants and animals. Attitudes to wetlands are slowly beginning to change, moving away from drainage to appreciating what they can offer. Gary speaks of ecosystem services provided by our natural capital, such as the filtering, flood buffering and habitat provided by wetlands. Even though it isn't always easy to put a dollar value on systems like wetlands, Gary believes they are vitally important to our region, and its economy.

Along with changes to nutrient budgeting and wetlands, Gary has also noticed that levels of on farm knowledge have changed. As more farmers have moved into the region, or within Southland, the level of farm specific knowledge has decreased. In the past a lot of local, on-farm knowledge of weather conditions, flooding, drainage networks and planting was built up by families on one single farm, but now it is becoming common practice for farmers to be shifting across many farms within their lifetime.

One of the great strengths of the land sustainability team is how they work with other agencies and community groups, such as the landcare groups and schools. Gary is quick to point out that it isn't just his team on the ground, but a collective effort. He finds working with these groups extremely satisfying, especially as these people are committed to achieving good environmental outcomes.

A. Henderson

Case Study: Vincent Leith, Waikawa whānau

Vincent Leith is a busy yet humble man. Vincent grew up in the Waikawa area and is heavily involved in monitoring kanakana (lamprey) with Te Ao Mārama Incorporated, as well as running his own farm. Vincent has grown up with the age old tradition of harvesting the kanakana/lamprey in the winter/spring/early summer period and continues to do so, as his Tipuna/ancestors did. When not busy in his home catchment, he could be anywhere from in the bush trapping possums, to at the lakes, monitoring and transporting juvenile eels upstream.

Kanakana are important mahinga kai and have been harvested from the same places (Mangai piri/Niagara Falls, and the Top Falls) on the Waikawa River for generations. The kanakana 'run' up the river occurs during a particular phase of the life cycle called the heke, which involves the fish reaching sexual maturity and migrating upstream to small, shady, hard-bottomed streams where they spawn and die. General perceptions were that the kanakana fishery had declined, yet there were no accurate estimates of the species' abundance. So Vincent got to work.

Before he bought his farm in the Waikawa Vincent began monitoring kanakana on the Waikawa, noting down observations, the weather and moon and 'tohu' or signs, like black shags in the kowhai trees (black shags feed on the kanakana). His matauranga (knowledge) continues to contribute to the understanding and research around this important species.

Vincent has continued to be heavily involved in kanakana monitoring and this has led onto a study to determine effective, practical and reliable kanakana population monitoring methods on the Waiakawa River based on matauranga. He has shared his knowledge with over 150 freshwater scientists at the New Zealand Freshwater Association symposium funded by Ngāi Tahu, and attended the 2010 Critical and Sensitive Research Issues Symposium (CSRI) Tangaroa Ki Uta, Tangaroa Ki Tai: Water, Our Future, funded by Ngā Pae o Te Māramatanga.

At a more personal level, soon after Vincent bought his farm, he electric fished some of the creeks that ran through the property. He was pleasantly surprised with what was found. Within a 10m stretch, that looked like there was barely anything there, he found shortfin and longfin eels, inanga, redfin bullies, Koura/Freshwater Crayfish, Kōkopu/native trout, banded kōkopu and freshwater shrimp. "I was pretty ignorant, and it was awesome to see what habitat they were in. They were the sort of places you might run your stock through," says Vincent, demonstrating that even small creeks can support an abundance of life. Vincent's farm borders the Waikawa estuary, an area that is important for inanga spawning, so he is working to improve the farm for fish habitat.

Vincent has worked hard to riparian fence as much as he can, and at some stage would like to see the whole land use back to a state where the native fish are able to carry on as they were without input from humans. One day he hopes to have a boardwalk to show people the special places in his part of the catchment and what species live there, as many of them are cryptic and nocturnal and can usually only be seen at night with the aid of torchlight.

Vincent's whanau, with the help of Awarua Rūnanga and its hardworking tangata tiaki, have successfully established a Mataitai reserve on the lower Waikawa river/estuary and the Tumu Toka/Porpoise Bay area. This means they, and the wider whanau, are more equipped to manage and control the special area and diverse species including Kanakana, Tuna/eel, Patiki/flounder, Paua, Tuaki/cockle. The Awarua Rūnanga and the wider whanau have been instrumental in supporting this local whanau to manage this special area of significance for generations to come. Many of the people have passed but are not forgotten, including Kelly Davis, George Ryan and Harold Leith. The whanau would like to acknowledge everyone's contribution to these projects. Without their knowledge and encouragement these projects would not have been possible. Gail Thompson and Steph Leith also need a special mention for their constant support, knowledge and passion towards the mahinga kai and areas of significance. They are an inspiration to the whanau.

What we don't know and could do better

What we don't know

The previous sections have highlighted the information gaps we have on Southland's freshwater ecosystems. Here we summarise these.

Our monitoring of water quality in our rivers and streams is extensive; however, we have little information on the state of our wetlands, or many of the lakes that are potentially at risk, such as coastal lakes. We also lack information on the cultural health of the majority of our freshwater ecosystems.

We have little information on other contaminants, such as pesticides, PCBs and heavy metals/hydrocarbons, that could also be harming our freshwater ecosystems.

We are currently not able to fully quantify the impact that farming practices are having on freshwater ecosystems. We cannot say, with absolute certainty, which activities are having the most intense, or widespread, effects.

What we could do better

More frequent reporting

The process of compiling the Southland Water 2010 report series, has made it clear that Environment Southland needs to produce more frequent technical monitoring reports and state of the environment reports on our water resources.

Southland's State of the Environment Report for Water was first published in October 2000. Since then the region has undergone significant agricultural intensification, with substantially more development proposed, resulting in increasing stress on our water resources. Environment Southland will be increasing reporting efforts to mark progress against our management responses.

Refinements for future monitoring, reporting and planning

This report has revealed some shortcomings in our monitoring and reporting programmes.

In some instances, we were not able to report on the desired outcomes or the compliance with the standards stated in the Water Plan or Te Tangi a Tauira. This highlights the need to realign our environmental monitoring and planning documents.

Through the reporting process we also identified an absence of water quality standards within the Water Plan for some water bodies, such as the Mataura water body. Some of our freshwater ecosystems, such as estuaries have no Water Plan water quality or ecosystem health standards (or national guidelines).

Natural state areas showing breaches to their 'no change' standard in the Water Plan require further investigation and monitoring, such as Lake Manapouri at Frazers beach and Mokotua Stream at Awarua.

We need to amend some of our monitoring programmes to ensure we can track changes over time; such as our periphyton and estuarine monitoring.

Our reporting needs to include climate variability, to better understand its relationship with measures of ecosystem health, and its potential impact on top of anthropogenic influences.

Monitoring and management needs to better understand the interconnectivity of our systems (eg groundwater and surface water interactions, soils and soil health and water, wetlands and surface water quality) and the cumulative effects our land use has on our freshwater ecosystems.

Our current monitoring can show state and trend in the water bodies we measure, however, we are unable to pinpoint the exact sources, or determine by how much, contaminant loadings need to be reduced in order to protect freshwater ecosystems. The Discharge Plan project will help to address some of these shortcomings, particularly those concerning cumulative effects.

To truly give a holistic view of the environment, we also need cultural monitoring programmes integrated with state of the environment monitoring programmes.

What you can do

Environmental issues in our freshwater ecosystems affect each and all of us. We all have a responsibility to help prevent further degradation of these systems and improve them where possible.

Here are some ideas how individuals, communities and groups can get involved in maintaining and improving our freshwater ecosystems. Some of these are similar to those listed in the Our Health report.

Land management

- Plant riparian margins along your waterways. If you can only plant one side, plant on the northern (sunny) side. Planting will increase local biodiversity, and reduce nutrients and sediments running off the land, as well as reduce the temperature of the waterway. Not sure what to plant? Phone Environment Southland and ask a Land Sustainability Officer for advice.
- Fence off stock from waterways where practicable. Temporary electric fences may be best in some situations.
- Apply farm dairy effluent and fertilisers at appropriate rates in appropriate conditions. Check the soil moisture monitoring site nearest you to help you make an informed decision: www.es.govt.nz
- Look after the wetlands on your property. Not sure what a wetland is or if you have any? Ask a Land Sustainability Officer for more information.

Mahinga kai

- Only take the kai you need.
- Respect fishing seasons, rahui and licence conditions. These are designed with future generations in mind. Check out Fish and Game's website for more information www.fishandgame.org.nz
- Ensure waterways running through your property allow fish, eels and other species to move upstream. Some bridges, culverts, dams and other obstacles in waterways can prohibit natural migration and spawning.
- Avoid disturbing sensitive places, such as remnants of native vegetation and whitebait spawning habitat.

Get connected

- Water is a finite resource. Only use what you need. Every drop counts.
- Find out about the Cultural Health Index – or better still, undertake an assessment yourself. Contact Te Ao Mārama Incorporated for more information.
- Get involved in decision-making by voting, letting Councillors know your ideas/ concerns, as well as reading annual or long-term plans and making submissions on them. Tell us what we are doing well and what we could do better.
- Connect with our inner-city waterways by using the extensive walk/cycleways.
- Visit our lakes and lagoons and find out how important these sensitive areas are.
- Covenant your land to protect it for future generations. You can find out more from our Land Sustainability Officers.
- Get young people involved in learning about the environment we live in. Register your interest to become an Enviroschool and empower young people to build sustainable communities. Or ask your school to participate in the Stream Connections programme, where students can learn about and interact with their local waterway. Contact the Environmental Education Officer.
- Find out what rules plans and policies affect you, your land, your waterways and community. Plans and policies relating to water in Southland are available online at www.es.govt.nz. If in doubt, ask us.
- Paint signs on stormwater drains so people know they flow directly to our streams, rivers and ocean. Stencils are available from Environment Southland's Pollution

Prevention Officer or the Invercargill Environment Centre.

- Do not wash your car on the street. Washwater carries heavy metals, petroleum and soap suds down to our valuable streams and rivers. Wash your car on the grass or at an appropriately set-up wash station.
- Plant for increased biodiversity. Ask our Land Sustainability Officers what plants are appropriate where, or refer to the Southland Community Nursery's website: www.southlandcommunitynursery.org.nz
- Remove pest plants from streams and river banks to avoid seed transfer downstream. Not sure what plants are pests? Find out by contacting a Biosecurity Officer.
- Ensure your septic tank is well maintained and working properly.
- Join a Landcare group, or form one. Contact Environment Southland for more information.
- Stop the spread of aquatic pests:
    - never release plants or fish (including unwanted goldfish, other exotic fish or aquarium weeds) to waterways
    - always check your boat before launching, especially the trailer and propeller, to ensure it is free of weed, juvenile fish and fish eggs
    - wash your boat and fishing gear carefully after you have taken it out of the water to remove any weed, juvenile fish or fish eggs
    - report sightings of plant pests and fish pests to Environment Southland.

Keeping ahead of didymo

The best method to reduce the spread of didymo is to treat all waterways as if they contain didymo and then employ appropriate cleaning measures to all gear that has come in contact with the waterway. There are still hundreds of waterways in Southland without didymo, so all is not lost!

Remember to:

1. *Check:* Before leaving the river, remove all obvious clumps of algae and look for hidden clumps. Leave them at the affected site. If you find any later, do not wash them down drains. Treat them with the approved cleaning methods (below), dry them and put them in a rubbish bin.
2. *Clean:* Soak and scrub all items for at least one minute in either hot (60°C) water, a 2% solution of household bleach or a 5% solution of salt, nappy cleaner, antiseptic hand cleaner or dishwashing detergent. A 2% solution is 200 ml, a 5% solution is 500 ml (two large cups), with water added to make 10 litres.
3. *Dry:* If the above cleaning is not practical, after the item is completely dry to touch, wait an additional 48 hours before contact or use in any other waterway.

Z. Moss

Glossary

Catchment: The area where groundwater or rainfall drains into a river or body of water.

Diadromous: Describes fish species that migrate between fresh and salt water environments

Cultural Health Index: A tool, developed by Ngāi Tahu, that Māori can use to assess and manage waterways in their area.

***Escherichia coli* (or *E. coli* for short):** A bacterium found in animal wastes and human sewage and is used to indicate the possible presence of disease-causing bacteria, viruses and protozoans in freshwater.

Faecal coliforms: A group of six species of bacteria that are found in animal wastes and human sewage. These bacteria can indicate the presence of disease-causing bacteria, viruses and protozoans in water and shellfish flesh.

Fish Index of Biotic Integrity (IBI): compares the native fish species found at a site with those that would normally be expected there, taking into account the natural changes in species numbers due to distance inland and elevation above sea level.

Invertebrate: an animal without a backbone

Lake Flipping: refers to a phenomenon where lakes shift between a clear water state dominated by macrophytes (aquatic plants) to a devegetated, turbid water state.

Lake Submerged Plant Indicators (LakeSPI): An index which assesses the ecological condition of a lake based on the character of native and pest aquatic plants found. Lakes are given an ecological condition score ranging from Excellent to Non-vegetated.

Macroinvertebrates: insects, worms and snails etc in rivers and streams used to indicate stream health. Fish feed on macroinvertebrates.

Macroinvertebrate Community Index (MCI): index based on combining the pollution tolerance scores of all species found at a site to determine the health of the ecosystem.

Macrophyte: an aquatic plant that grows in or near water. In lakes and streams macropyhtes provide habitat for fish and invertebrates as well as releasing oxygen to the water through respiration.

Mahinga kai: refers to food and natural resources valued by Māori and also the places where these resources can be found.

Manawhenua: traditional/customary authority or title over land, and the rights of ownership and control of usage on the land, forests, rivers etc. Manawhenua is held by an iwi or hapū rather than individuals.

Periphyton: algae on the riverbed.

Riparian zone: the area between the land and a river or stream. Riparian zones can have very diverse ecosystems and contribute to the health of other aquatic ecosystems by providing habitat, filtering out pollutants and preventing erosion.

State of the Takiwā reporting: The State of the Takiwā programme is an environmental monitoring approach developed by Te Rūnanga o Ngāi Tahu

Takiwā: tribal region

Trophic Level Index (TLI): Used to report on lake water quality and to measure changes in the nutrient (trophic) status of lakes. The index considers total phosphorous, total nitrogen, visual clarity and algal biomass.

Water Quality Index (WQI): A tool developed in Canada that incorporates standards and guidelines and the frequency and the amplitude with which they are exceeded, with the results being between 0 and 100, where 0 represents the ‘worst’ water quality and 100 the ‘best’.

Acknowledgements

This report is the result of a collaborative partnership between Environment Southland and Te Ao Mārama Incorporated. Neither the report nor the partnership would have been possible without the patience, commitment and vision of Councillors, Chairpersons and staff within those organisations. Here the authors would like to acknowledge all those who have contributed to its compilation.

The role of co-ordination and direction was set by the Core Steering Group, comprising:

Adrienne Henderson, Pat Hoffmann Chris Jenkins, Jane Kitson (Project Manager), Greg Larkin, Steven Ledington, Kirsten Meijer, John Prince, Nikki Tarbutt, Karen Wilson (Environment Southland), Dean Whaanga and Michael Skerrett (Te Ao Mārama Incorporated).

The Core Steering Group is indebted to the project data support of Philippa Jones and Hamish Ogilvie (Environment Southland); the design, layout and production expertise provided by Steven Allan; the digitalisation of the kowhaiwhai design by Emma Kitson; the mapping skills of Ingrid Darragh and Hamish Lough (Environment Southland); the editorial skills of Michele Poole and Sam McKnight (Environment Southland) and Naomi O'Connor; and the secretarial support of Deborah Day and Liz Ryley (Environment Southland).

The following people also contributed significant information, ideas and constructive criticism to this report:

Dr Olivier Aussiel (Aquanet), Sally Chesterfield, Emily Funnell, Pete McClelland and Brian Rance (DOC Southland Conservancy), Keith Hamill (Opus), Dr Inge Hannus (MCI analysis, Aquanet), Shirley Hayward (DairyNZ), Brydon Hughes (Liquid Earth), Dr Mike Joy (Wairesearch Ltd) Dr JoAnna Lessard (NIWA), Zane Moss and Maurice Rodway (Fish and Game NZ – Southland Region), Craig Pauling (Te Rūnanga o Ngāi Tahu), Dr Marc Schallenberg (University of Otago), Dr Gail Tipa (Tipa and associates), Don Mowat (Te Ao Mārama Incorporated), Michael Bennett, Dianne Elliotte, Dr Aaron Fox, Deidre Francis, Kylie Galbraith, Noel Hinton, Roger Hodson, Amy Lagerstedt, Matthew McDowell, Rachael Millar, Randall Milne, Gary Morgan, Tim Riding, Dr Clint Rissmann, Katrina Robertson, Bonnie Rowell, Warren Tuckey and Rachael Webster (Environment Southland)

Our Ecosystems: Southland Water 2010: Part 2

For further information, see www.es.govt.nz

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Groundwater quality	Groundwater scientist, Environment Southland
Fish species present in Southland and the health of our lakes, lagoons and wetlands	Aquatic ecologist, Environment Southland
The health of our estuaries	Coastal scientist, Environment Southland
What you or your school could do to improve water quality	Environmental education officer, Environment Southland
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