# The Southland Economic Project

# URBAN AND INDUSTRY

GORE DISTRICT COUNCIL

environment SOUTHLAND REGIONAL COUNCIL Te Taiao Tonga

Invercargill CITY COUNCIL

SOUTHLAND DISTRICT COUNCIL

Cover photo: Matāura looking south across the Matāura River
Source: Emma Moran

# The Southland Economic Project:

# Urban and Industry

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## Technical Report

**May 2018**

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# The Southland Economic Project

This report has been produced by **The Southland Economic Project** for Water and Land 2020 & Beyond. The aim of this Project is to create ways of understanding the possible socio-economic impacts of achieving 'limits' for fresh water in Southland under the National Policy Statement for Freshwater Management (2017).

The Project is a joint venture between DairyNZ, Beef + Lamb New Zealand Ltd., Department of Conservation, Ministry for Primary Industries, Ministry for the Environment, Southland Chamber of Commerce, Te Ao Mārama, and Environment Southland.

It also closely involves Invercargill City Council, Southland District Council and Gore District Council (the three territorial authorities in Southland), as well as Deer Industry New Zealand and New Zealand Deer Farmers Association (Southland Branch). The Project has had support from Foundation for Arable Research, and Horticulture New Zealand, and forestry companies: Southwood and Rayonier.

The Project is undertaking three major studies that flow on from each other:

**Study 1: Economic Sectors:**

A. Agriculture and Forestry
B. Urban and Industry

**Study 2: The Southland Economy** (The Southland Economic Model for Water)

**Study 3: Community Outcomes**

This report is an output from the Urban and Industry component of Study 1. The report and its related datasets are being used in the development of The Southland Economic Model for Fresh Water within Study 2. Study 3 uses information from this model to understand the connections between Southland's economy and local communities across the region.

# Preface

This report presents research undertaken for **The Southland Economic Project**. The research is contained in **Part C** and its context is described in **Parts A and B**. Specific sections of this report are written with particular authors as identified below. Environment Southland staff contributed to these sections and wrote all other sections. The research includes estimates of contaminant loads from wastewater treatment systems that were calculated as the average concentrations over four years multiplied by the annual flows. This is a 'broad brush' calculation method and it may be different to that used by Environment Southland for the freshwater accounting of contaminants under the National Policy Statement for Freshwater Management. The value of this research is the comparison between the results for a treatment system's existing performance (the base) and its upgrade scenarios.

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# Acknowledgements

As with everything to do with water quality, understanding the costs and effectiveness of municipal wastewater treatment is a complex task and requires a great deal of transdisciplinary knowledge and understanding. The three territorial authorities and two consultancies involved in this research have made substantial commitment to work together with Environment Southland to make this report possible. Each organisation and individual that has brought their expertise to this work has made an investment in the future of the Southland.

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All of these people and organisations have made this commitment to make sure that information and understanding on the possible economic impacts is readily available as Southland enters into the process of setting of limits for water.

**Image 1: Ōreti Beach**
Source Emma Moran

# Executive Summary

Water, and the land it flows through, has a natural capacity for processing (or attenuating) substances, such as nutrients (e.g. nitrogen and phosphorus) and microbiological organisms (as indicated by the presence of *E. coli*). When by-products from human activity (e.g. agriculture, forestry, manufacturing, tourism or local government) end up in water as waste, then this natural capacity is 'used' or taken up. The waste adds to in-stream concentrations and loads (or total amounts) of contaminants, and can cause water quality issues. In-stream concentrations tend to be the focus for rivers and groundwater; while loads are especially relevant for groundwater, lakes and estuaries, which act as 'sinks' for these substances.

Many new initiatives are being introduced that are designed to improve how people use water – in this context the 'use' of water is in a broad sense, as a water take and to receive waste substances (or contaminants). At the centre of these efforts is the National Policy Statement for Freshwater Management (2017), which requires environmental 'limits' to be set to safeguard values, such as ecosystem health and human health. A limit is the maximum amount of a resource available to be used and they must be set for water quantity and water quality.

As part of implementing the National Policy Statement for Freshwater Management (2017), Southland has been divided into five freshwater management units (FMUs) based on the four large river catchments and the mass of smaller river catchments in Fiordland and Stewart Island/Rakiura. These FMUS are: *Fiordland and Islands, Waiau, Aparima, Ōreti, and Matāura*. Planning processes with communities to set limits in these FMUs are planned to start in 2018 within the People, Water and Land Programme[1]. Achieving these limits may require people to change the way they use water, particularly for receiving waste, which is likely to have socio-economic impacts as they transition. The Southland Economic Project was set up to develop robust ways of understanding these possible impacts so that relevant information will be available for the limit-setting process.

This report brings together research on municipal wastewater that Southland's four councils (Gore District Council, Invercargill City Council, Southland District Council, and Environment Southland) have done within The Southland Economic Project. Overall, there are 1.2 million hectares of developed land in Southland. Around 3.3 percent of this land area is used for urban activities, such as residential and commercial areas, transport networks, and industry. These activities create stormwater and treated wastewater that is discharged either directly or indirectly to fresh or coastal water[2]. In Southland, a relatively large proportion of people live rurally (twice the national average) and towns are service centres for their local area. Invercargill and 24 towns in the region are served by municipal wastewater schemes, with most having been developed since the 1960s and 1970s.

The supply of essential services, such as wastewater reticulation and treatment, is a sizeable investment for local communities that makes it possible for people to live and work together. These services form part of a local community's natural and built assets or 'wealth' and, where they are delivered sustainably (in all of its components), they contribute to a community's wellbeing. Water

[1] People, Water and Land is a partnership between Environment Southland and Te Ao Mārama that covers their work relating to fresh water.

[2] Discharges are either via the end of a pipe (point source) or diffuse through or across land (non-point source).

is vital to life but many towns have an uneasy relationship with water, in terms of its quantity and its quality. Most towns and settlements lie on valley floors near rivers and streams (and in some cases, also lakes). Towns are often one of a series or chain within a catchment – lying either upstream or downstream from one another – connecting (through surface water and groundwater) the headwaters of a river, or one of its tributaries, with an estuary. The towns are also connected by the region's land transport networks, which weave around and across these water bodies.

The aim of this research was to develop information on the financial costs of further managing contaminants in discharges of treated wastewater from municipal schemes. The schemes consist of two main components: the reticulation infrastructure (i.e. pipes, pits, and pumps) and the wastewater treatment system. While a scheme's reticulation infrastructure is relevant, the research was specifically about upgrades or 'step changes' in wastewater treatment. In addition to these step changes, there are also possible actions to improve the performance of reticulation infrastructure. These actions can reduce inflows into a wastewater treatment system, increase its effectiveness, and improve the overall efficiency of a scheme.

Agricultural industry groups contributed to similar research on farms across Southland and were the subject of an earlier report: *The Southland Economic Project: Agriculture and Forestry* (Moran *et al*., 2017). Information was not developed for on-site residential wastewater, on-site industrial wastewater, or stormwater for reasons described in the Research Focus Section of this report.

The report highlights Southland's reliance on its towns as service centres, and developed a number of themes. One theme is the role of the environment and natural resources in economic development and, in turn, how this development has modified the environment over the years and made it less resilient. Through resource use, Southland's water, land, and people are highly connected. The environment has less capacity to attenuate waste substances than in the past and people are putting more pressure on the environment. As a result, it is likely that Southland's economy is becoming less sustainable over time. Other themes are the variability within the municipal sector (between towns and between territorial authorities), and the complex relationships between wastewater and other types of essential infrastructure (e.g. transport networks, flood protection, stormwater, and water supply).

All of these themes were important considerations in this research.

## Methodology

To develop information for municipal wastewater in Southland, the region's four councils scoped and commissioned research on the wastewater treatment for eight towns across the region: Te Anau, Ohai, Nightcaps, Winton, Gore, Matāura, Bluff and Invercargill. The research created a set of case studies that investigated:

1. The current performance of municipal wastewater treatment systems in terms of the waste in their discharges; and
2. The effectiveness of modelled scenarios to further improve their discharges and the financial costs of these scenarios.

The towns were selected to cover as wide a range of different situations as possible. Municipal wastewater schemes are largely driven by public health issues, and so population (present and historic) is a determining factor. At a regional scale, Southland's population is relatively stable (deaths and outward migration being balanced by births and inward migration) but there is strong variability between local communities – with growth in some towns and declines in other towns, reflecting changes in the economy. In total, the eight towns represent over 70 percent of the people living in the region.

The case studies were created using a four stage process. In the first stage, Stantec (formerly MWH) used the National Policy Statement for Freshwater Management 2014 as a guide for developing modelling scenarios for upgrading a town's existing wastewater treatment system. In developing these scenarios, Stantec estimated how the upgrades could improve the quality of treated wastewater discharge and their financial costs. Most of the modelled scenarios were 'bolt-ons' or additions to the existing treatment system. Only one of the scenarios (a membrane bioreactor) involved abandoning the existing treatment system and replacing it with an entirely new system. All of the case studies currently discharge to water and the scenarios modelled included upgrades that were land-based discharges. This information, including the specific caveats and limitations for each scenario, is included in the appendices of this report.

The scenarios developed for this research are largely theoretical and not all of the scenarios were modelled for all case studies. The number of scenarios modelled was largely based on each town's existing circumstances. For example, the existence of a new Te Anau wastewater consent for a discharge to land guided the two scenarios modelled. The scenarios modelled are not necessarily viable options or are being considered by any particular council. They would need to be subjected to due diligence, detailed feasibility assessments, consent processes and council consultation processes.

In the second stage, Market Economics used Stantec's scenarios to build an understanding of the relationship between the estimated effectiveness (improvements in the quality of treated wastewater) and costs. The results are a 30 year forecast reported on an annual 'per household' basis to account for the different sizes of the towns – this measure should <u>not</u> be interpreted as a cost to ratepayers. The number of households was calculated using Statistic New Zealand five yearly projections. The results for the scenarios were then compared to the costs and effectiveness of the existing (or base) wastewater treatment system.

In the third stage, Environment Southland translated Market Economics' analysis into a series of easily accessible graphs that are presented in this report. During this stage, new inflow concentration data and valuation became available for the existing treatment system and the data used was updated. The Stantec and Market Economics work is covered by separate disclaimers.

The information from the town case studies is a key input into The Southland Economic Model for Fresh Water, which is a regional model of Southland's economy that is being developed within The Southland Economic Project. This regional economic model will trace transition pathways (or routes) for the economy as it evolves over time in response to limit-setting for water. It will be used to test the economic impacts of 'what if' policy scenarios for achieving limits in each FMU. Additional work is being done on the relationship between economy and outcomes for Southland's communities to give a better understanding of wellbeing.

## Baseline Results

All of the eight case studies currently discharge treated wastewater directly to a surface water body – a stream, river, or estuary. Although these discharges are directly to water, contaminant levels are reduced within the wastewater treatment systems via a range of treatment methods. Nightcaps and Te Anau use oxidation ponds, Matāura , Winton and Gore also use oxidation ponds augmented with additional process units to improve the performance of the system, namely a wetland (Matāura and Winton), or chemically assisted phosphorus reduction (Gore). Invercargill, Bluff and Ohai use mechanical and biological treatment tank and pond based processes, instead of oxidation ponds.

Gore, Matāura, Winton, Nightcaps and Ohai discharge treated wastewater into Southland's rivers and streams. Te Anau currently discharges treated wastewater into the Upukerora River, just upstream of Lake Te Anau, while Invercargill discharges treated wastewater into New River Estuary. Bluff discharges treated wastewater into Foveaux Strait between Bluff Hill and Stewart Island/Rakiura. There are examples of schemes with discharges to land in Southland (e.g. Otautau) but they were not selected as case studies because they were considered likely to be less of a priority in the setting of limits for water quality in Southland.

The baseline results are for each town's existing wastewater treatment system. Two of the eight case study towns, Bluff and Ohai, did not have scenarios modelled because their specific circumstances mean that the treatment systems are unlikely to be upgraded. Ohai currently produces effluent of a similar quality as that estimated for the scenarios modelled for the other towns. A minor upgrade is planned for Ohai to maintain current levels of performance for *E. coli*. Bluff does not currently achieve the quality estimated for the scenarios modelled for the other towns but there are potential cost efficiencies of centralising its treatment with Invercargill's system at Clifton. It is more likely that Bluff wastewater is piped to Clifton, rather than changing the Bluff system itself. This solution is highly location specific, and not transferable to other towns across Southland, so it was not modelled as part of this research.

To date, wastewater treatment systems have usually been designed to reduce suspended solids and biochemical oxygen demand. There is a wide range in the type of technology used across the towns, with more complex treatment systems generally being used where there are larger urban areas. Despite the range of technologies used, the towns were relatively consistent in their performance for suspended solids and biochemical oxygen demand. Considerable reductions are also achieved for *E. coli* but for this contaminant even a very small amount remaining still indicates a potential risk to human health from the discharge. The level of *E. coli* reduction that the existing treatment systems achieve varies across the towns. Nutrients are a more recent focus – e.g. the specific treatment of phosphorus in the Gore wastewater treatment system was introduced in 2008. The reduction of nutrients was even more variable across the towns.

Table 1 shows the current performance of the wastewater treatment systems as measured by the proportion of contaminants removed from the inflow and the level of contaminants in the discharge. Reduction of *E. coli* (measured in colony forming units or cfu/100mL) is not reported as a percentage in this table because the wastewater treatment systems reduce *E. coli* concentrations by more than 99.9 percent (from 10 million cfu/100mL to less than 10,000 cfu/100mL). The water quality standards for stock drinking, contact swimming, shellfish gathering and drinking water require lower concentrations than those <u>generally</u> achieved by the treatment systems.

**Table 1: Baseline performance of case studies**

| Case Study | Forecast average number of households 2016 to 2046 | Suspended solids (kg/HH/year) | | Biochemical oxygen demand (kg/HH/year) | | Total nitrogen (kg/HH/year) | | Total phosphorus (kg/HH/year) | | E. coli (cfu/100mL) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Removal | Discharge | Removal | Discharge | Removal | Discharge | Removal | Discharge | Discharge |
| Gore | 4,035 | 86% | 19 | 95% | 7 | 76% | 6 | 83% | 0.7 | 4,600 |
| Matāura | 823 | 90% | 6 | 97% | 2 | 79% | 2 | 80% | 0.3 | 900 |
| Winton | 1,287 | 85% | 7 | 94% | 3 | 56% | 4 | 46% | 1.0 | 3,800 |
| Nightcaps | 161 | 89% | 6 | 97% | 2 | 80% | 2 | 76% | 0.4 | 8,600 |
| Ohai | 126 | 96% | 3 | 96% | 3 | 93% | 1 | 71% | 0.7 | 100 |
| Te Anau | 1,022 | 79% | 16 | 92% | 6 | 51% | 7 | 4% | 2.0 | 1,200 |
| Invercargill | 20,904 | 92% | 8 | 97% | 4 | 43% | 12 | 34% | 2.0 | 1,300 |
| Bluff | 886 | 81% | 20 | 93% | 8 | 36% | 14 | 46% | 1.6 | 300 |

Notes:

1. Due to the nature of the available consent data, the information provided for Ohai is for ammoniacal nitrogen rather than total nitrogen, and for faecal coliforms rather than *E. coli*.
2. For Te Anau, the average TP in discharge (based on nine years data) is 6.4, which improves the removal percentage slightly.
3. The number of households is estimated from Statistics New Zealand five yearly projections. The number of households is used to adjust for the size of the towns. It differs from the number of rating units (i.e. ratepayers) and the number of residential, commercial and trade waste connections to a wastewater scheme.
4. The estimates of contaminant loads used in this research were calculated as the average concentrations over four years multiplied by the annual flows. This is a 'broad brush' calculation method and it may be different to that used by Environment Southland for the freshwater accounting of contaminants under the National Policy Statement for Freshwater Management. The value of this research is the comparison between the results for a treatment system's existing performance (the base) and its upgrade scenarios.

## Key Findings

Based on the scenarios modelled, the key findings were:

1. There were marked differences between the town case studies, particularly between the smaller and larger municipal wastewater schemes. These differences are driven by variability in the relative contributions of domestic, commercial and industrial waste streams, and the types of existing technologies being used to treat these waste streams within each scheme. On a per household basis, the quality of treated wastewater discharged was roughly similar in most cases.
2. Location is important for many reasons. A town's context or position within the landscape influenced settlement and development, essential infrastructure, and the downstream receiving environment. Many, but not all, towns in Southland are part of a chain along a river catchment. For some of the scenarios to be viable, there needs to be suitable land available and, in parts of Southland, environmental conditions are likely to be limiting factors.
3. The capacity to further remove contaminants depends on the contaminant in question and the design of the existing wastewater treatment system. Where a large proportion of a contaminant (e.g. suspended solids and biochemical oxygen demand) is already removed there is less capacity for further removal. Conversely, where a small proportion of a contaminant is currently removed (e.g. total nitrogen and total phosphorus) there is more

capacity for further removal. Further removal is also influenced by the nature of the wastewater streams and the characteristics of the site.

4. In general, the scenarios that were designed for further treatment of a specific contaminant were lower cost, and the scenarios that were designed for further treatment of several contaminants were higher cost. The higher cost scenarios usually involved sophisticated technology (mechanical and biological plants) that can bring with it increased risks of failure.
5. The 'discharge to land' scenarios assumed land treatment rather than just land disposal, and their performance was relatively effective for most contaminants. Key site conditions needed for treatment are sufficient depth to groundwater and suitable soil types. A preliminary review of the land within 4 kilometres of the towns indicated that these conditions are unlikely to exist for most towns. In some cases, Southland's soil and climatic conditions are likely to mean that a discharge to water will need to be retained.
6. The treatment processes for reduction of phosphorus and *E. coli* on their own are relatively simple and were the lower cost scenarios modelled. Reduction of nitrogen is more difficult and the relevant scenarios cost considerably more. The treatment process to reduce nitrogen also reduces phosphorus, although not as effectively as the process that is specific to phosphorus reduction. The more advanced treatment processes modelled for Gore, Winton and Invercargill resulted in a higher degree of reduction of a number of contaminants but were at a much higher cost.

The variations in costs between similar scenarios for different towns were driven by the size and nature of the existing wastewater scheme. The context, particularly the environmental conditions (climate, soils and groundwater), was relevant to the performance of the discharge to water and discharge to land scenarios. For discharges to water, water flows (volume) in the receiving environment are also relevant because they influence the effects of a discharge on the water body. The performance of some scenarios may vary at different times of the year (e.g. biological nutrient reduction and slow rate infiltration). During limit-setting it will be important to understand the water quality issues of the receiving water body for each scheme because different scenarios are relevant for different contaminants.

## Limitations

The research modelled step changes in wastewater treatment to give a general understanding of financial costs and effectiveness of improving existing systems. The scenarios modelled were all pre-feasibility options and in some cases additional technology may be needed. Treatment performance was measured as the difference between the contaminants in the discharge and the contaminants in the wastewater inflow (i.e. the removal of contaminants). None of the scenarios allow for population growth beyond Statistics New Zealand five-yearly predictions for the future.

There were considerable differences between the eight case studies, in terms of the nature and performance of the existing treatment systems, and also the treatment processes that may improve these systems. In some cases the existing system acts as a constraint on future options. There were also important differences in the nature of the receiving water body. The design of a wastewater treatment system depends on its purpose (i.e. the contaminants it needs to address). Any generalisation of these results across other towns in Southland needs to consider these differences.

Information on the quality of the discharges was taken from monitoring data required for consents. The quality of the existing datasets varied between the towns used as case studies because they were collected for different purposes. There were extensive datasets available for the larger towns but much less data available for the smaller towns. As a result, there is a range of accuracy when determining the quality of the existing discharges and certain seasons may be under-represented in the available data. A detailed review of the operation of the treatment systems has not been undertaken because the focus of this research was on step changes for the setting of limits for fresh water. The age of the consent can be a factor in the quality of monitoring data available, with consents granted more recently likely to have more involved monitoring requirements.

It was assumed that the concentrations of contaminants in the inflow of wastewater to a treatment system were the same across all eight case studies. Monitoring data for the wastewater inflow was available for Invercargill, Bluff and Gore and these treatment systems were generally consistent with each other and with that which was generally assumed. Some variations were identified in the performance of the treatment systems for other towns that may be because of differences in their wastewater inflow compared to the assumed contaminant concentrations.

The cost estimates did not include the costs of implementing a wastewater treatment scenario (e.g. consultation with the community and the resource consent process). Implementation costs can be extremely expensive, particularly where there is strong opposition to a wastewater treatment option and a lack of viable alternatives. Achieving community acceptance is an important component of the total cost of a wastewater treatment system.

While some improvements may be achieved by minor operational changes, they will generally not achieve substantial changes in a wastewater treatment system's performance. Step changes are not undertaken as small scale, year on year, iterative improvements. They require considerable capital expenditure, which are typically undertaken once a generation, and often result in increased operating expenditure.

Generally, the scenarios modelled are stand alone. Some of the scenarios can be added together because they consist of different treatment processes (i.e. *E. coli* reduction, phosphorus reduction and land treatment scenarios). Others will require further examination. The treatment processes will interact with each other and result in different discharge characteristics and costs. Case by case assessments are undertaken for resource consent processes. These more detailed investigations may identify solutions not included in this research. The scenarios modelled here may not be the same as a treatment system that is actually implemented in response to the limit setting process, even in the case study towns identified. The costs reported identify the possible step changes and range of costs for each town as a result of the limit-setting process for water.

The research in Part C of this report was done to create a town dataset to use in the Southland Economic Model for Fresh Water for broad scale economic impact assessments. It was the first time that research of this type has been done across a region. The research is a snapshot and did not consider future technological change. It also did not consider how any upgrades could be funded, which is likely to be an important factor during limit-setting. The cost to ratepayers will require additional in-depth analysis. The research also did not investigate improvements in the performance of industrial wastewater treatment systems, stormwater schemes, and actions to improve reticulation infrastructure. These are all opportunities for further research.

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# Introduction

In response to declining water quality in many places in New Zealand, government and non-government organisations are introducing a range of initiatives that are designed to improve how people 'use' water. In this context, the use of water is in its broadest sense – from situations where water is taken from a water body (e.g. a lake, river, stream, or aquifer) to circumstances where waste, such as surplus nutrients (nitrogen and phosphorus) and microbiological organisms (also known as micro- organisms or microbes), end up in a water body.

These initiatives are non-regulatory (e.g. education) and regulatory (e.g. policies and rules in regional plans), and they are generally aimed at changing people's behaviour. At the centre is the Government's **National Policy Statement for Freshwater Management (MfE, 2017)**. It requires, among other things, 'limits' to be set on the total amount of a resource (e.g. water or land) available for use – once enough of the resource has been put aside to make sure that values like ecosystem health and human health are safeguarded. These limits will be set for water quantity and water quality.

For water quality, limits relate to the environment's capacity to process (or 'attenuate') waste substances from human activity. When this capacity is reached, additional waste can overwhelm a system, creating pollution and contributing to water quality issues, such as algal growth and poor water clarity. To address these issues, environmental limits on the use of fresh water will be set for either part, or all, of a catchment that relate to loads (a total amount over a specific time period – daily, monthly, annually) and concentrations (a rate, or amount within a specific volume) of specific waste substances. Loads are particularly relevant where a catchment contains a water body that can act as a sink for waste substances, such as a lake or an estuary.

Although awareness of water quality issues has improved over recent years, the economy's use of fresh water (for water takes and to receive waste substances) continues to increase in Southland and elsewhere in New Zealand. One reason is that standard assessments of productivity do not usually include an activity's use of natural resources over the longer term. In other words, they are partial assessments of productivity, and do not necessarily reflect sustainability. Where an activity's use of water is not accounted for, and it impacts on other values, then all of the community is, in effect, subsidising that activity. This is the case regardless of the economic sector being considered (e.g. agriculture, forestry, manufacturing, tourism or local government).

Regional councils, including Environment Southland, are required to implement The National Policy Statement for Freshwater Management (2017), which includes setting limits for fresh water within freshwater management units (or FMUs). In Southland there are five FMUs[3], based on the river catchments, and four main substances creating water quality issues: surplus nutrients (nitrogen and phosphorus), fine sediment, and micro-organisms (for which *Escherichia coli*, or *E. coli,* is used as an indicator). These substances are waste products from economic activities in rural and urban areas. They flow in water across, down or through the surrounding land, and end up in the region's rivers, lakes, groundwater, wetlands and estuaries.

[3] Southland's FMUs are described in Part A of this report.

Towns are the centre of local communities that can include surrounding rural areas. They are usually relatively affordable and amenable places for people to live and work, supporting economic activity in the local area, and fresh water is vital to their existence. Water is used in towns as an input for drinking, washing and in manufacturing processes. Water also transports waste substances as wastewater and stormwater[4]. When waste substances reach a water body they use up some of the water body's capacity, and this pressure can contribute to declining water quality. Although wastewater schemes for Southland towns were originally relatively basic, many have had some form of upgrade over recent years to improve their capture and treatment of waste substances (technically known as contaminants[5]).

Upgrades to a wastewater scheme are examples of improvements in the levels of service but they come at a cost. Managing municipal wastewater in ways that transport most, but not all, waste substances has a value to local communities in the short-term, including people who live in surrounding areas and rely on towns as service centres. This value may be reduced in the longer term if the remaining substances create water quality issues. In Southland the proportion of the population that is working is declining, while in some areas greater numbers of tourists is increasing pressure on infrastructure. The Royal Society Report, *Our Futures* (2014) concluded that local authorities face the challenge of matching ongoing responsibilities with fewer resources to meet them. Understanding the relationship between management of substances in treated wastewater and the costs of management is at the heart of this research.

In Southland, the planning processes to set 'limits' with communities are planned to start in 2018 within **People, Water and Land**[6]. Future policy options to achieve these limits may mean people in these communities need to change the way they use water, particularly for receiving waste substances such as surplus nutrients. Changing people's use of water is likely to have impacts as they go through a period of transition. **The Southland Economic Project** was set up to develop robust ways of understanding these possible impacts so that relevant information will be available during limit-setting. This report brings together research that the region's four local councils have done within The Southland Economic Project specifically for the municipal sector.

The purpose of this research was to develop information on the financial costs of further managing waste substances in discharges from municipal wastewater[7] schemes. These schemes consist of two main components: the reticulation infrastructure (i.e. pipes, pits, and pumps) and the wastewater

[4] Water supply, wastewater and stormwater are sometimes referred to as "three waters". Stormwater is the surface run off after precipitation from the roading network and residential, commercial and industrial zones.

[5] Contaminant is defined in the Resource Management Act 1991. It includes any substance (including gases, odorous compounds, liquids, solids, and micro-organisms) or energy (excluding noise) or heat, that either by itself or in combination with the same, similar, or other substances, energy, or heat— (a) when discharged into water, changes or is likely to change the physical, chemical, or biological condition of water; or (b) when discharged onto or into land or into air, changes or is likely to change the physical, chemical, or biological condition of the land or air onto or into which it is discharged.

[6] People, Water and Land is a partnership programme between Environment Southland and Te Ao Mārama Incorporated, who represent tangata whenua interests in resource management and other aspects related to local government for iwi in Murihiku/Southland. People, Water and Land has superseded Water and Land 2020 & Beyond.

[7] Wastewater is commonly called sewage - sewers are wastewater pipes, and sewerage (or sewerage system) is a network of wastewater pipes and pump stations (i.e. the reticulated infrastructure that carries sewage). Other common terms are influent (an inflow), effluent (an outflow), and treated effluent (an outflow from a wastewater system). For simplicity, sewage, influent and effluent is generally referred to as wastewater in this report.

treatment system. While a scheme's reticulation infrastructure is relevant, the research was specifically about step changes (or upgrades) in wastewater treatment. Specifically, it focused on a set of towns across Southland and investigated:

1. The current performance of municipal wastewater treatment systems in terms of the waste in their discharges; and
2. The effectiveness of modelled scenarios to further improve their discharges and the financial costs of these scenarios.

The methodology and results of this research are summarised in **Part C** of this report. In completing this research, the councils involved have created a comprehensive source of information about these towns. The modelled scenarios are 'pre-feasibility' (i.e. whether they can actually occur or not for a particular town has not been ground-truthed). The report gives an overview of the range of industries in the region and explains why similar research was not undertaken for their wastewater treatment systems. It also describes why research was not undertaken for stormwater schemes at this stage.

This research covered total suspended solids (including sediment), biochemical oxygen demand (influences a water body's oxygen content), nutrients (nitrogen and phosphorus), and *E. coli* (an indicator of micro-organisms). This list is a wider set of waste substances than those included in similar research for the agricultural sector in Southland (where the focus was on nutrients). The difference is purely because the modelling approach used in this research was more flexible. Waste substances, particularly sediment and *E. coli*, are also an issue to the agricultural sector. There are also other substances, particularly heavy metals like copper and zinc, which are relevant but have not been covered in the modelling for The Southland Economic Project.

In general, wastewater treatment is influenced by specific factors: the source, its management, and the local environmental conditions (particularly climate, soils and topography). These factors were used to shape the general approach to the research methodology in **Part C**. **Part A** outlines general information on Southland, including its climate and soils. **Part B** describes Southland's towns and industry, with specific reference to water.

The wide variation in environmental conditions across Southland is one reason this research was undertaken as a set of case studies. The variation also means that reducing the level of waste substances takes more effort in some places than others. To some extent it comes down to location. One theme that runs through this report is the role of Southland's climate, topography and soils in wastewater management. Other themes are the diversity between towns across Southland, and the connections with the surrounding areas.

**Parts A, B and C** are designed to be read together, with **Parts A and B** providing essential context for understanding and interpreting the research in **Part C**. Accounting for waste substances from economic activity is a complex topic and the report captures a lot of relevant knowledge. The report does not describe water quality issues across Southland – because these issues are well documented in a series of technical reports available on Environment Southland's website (Environment Southland, 2000; Environment Southland & Te Ao Mārama Inc, 2011a; Moreau & Hodson, 2015; Hodson et al., 2017).

The results of this research give the best estimates of managing waste substances at present, given existing technologies, although are not necessarily what may occur in the future. What actually occurs will depend on how people respond to change (which is always difficult to predict), how much they are asked to do, how much time they have, and the tools they then have to do it. Time is likely to improve people's ability to reduce nutrient losses but it may also increase the amount of nutrients that need to be reduced (i.e. the scale of the task).

This report, *The Southland Economic Project: Urban and Industry* is the second of two reports. The first report, *The Southland Economic Project: Agriculture and Forestry*, which presented research for 95 farms across Southland, was released in April 2017. The datasets from this research will be used in **The Southland Economic Model for Fresh Water** (which is under development and due to be completed in 2018). This model and the two reports will be used in community processes to set limits on the use of fresh water in Southland. The model and its future uses are briefly described at the end of this report.

# Report Structure

The next section explains why this research focused on municipal wastewater schemes and did not include on-site wastewater systems or stormwater schemes. Following that section, the report is divided into three major parts:

**Part A – Southland** outlines background information on the region and helps explain how the environment has shaped, and been modified by, land development. It generally describes the land, water and people (including the economy), the five 'freshwater management units', and relevant information about climate and soils.

**Part B – Towns and Industry** gives an overview of towns and industry in Southland. It builds on the information in **Part A**, and gives the wider setting for the case studies in **Part C**. It describes town settlement, some broad characteristics, and identifies water-related services (wastewater, stormwater, and water supply). **Part B** then gives a snapshot of the towns included in the research in **Part C**. Finally, it outlines industrial development in the region and identifies industries with wastewater consents.

**Part C – Town Case Studies** summarises the methodology and results of the research completed for selected towns in Southland. It covers the general approach to town selection and modelling, the specific case studies, and summarises their results. It also explains how this research will be used in **The Southland Economic Model for Fresh Water**.

In some cases a town or city in Southland shares its name with a district or a river/stream. Where the urban area is being referred to then just its name is used (e.g. Gore or Otautau), and where a district or river/stream is being referred it is followed by those identifiers (e.g. Gore District or Otautau Stream). As well, Southland District and Southland Region share the same name – in this case if just the name 'Southland' then it refers to the region – where it is Southland District it is always followed by 'district'.

# Research Focus – Municipal Wastewater

In 2016 Gore District Council, Invercargill City Council, Southland District Council (the three territorial authorities in the region) and Environment Southland worked with Stantec (formerly MWH) and Market Economics to develop a set of case studies for the municipal wastewater schemes of eight towns in Southland. These towns were: Gore, Matāura, Winton, Nightcaps, Ohai, Te Anau, Invercargill, and Bluff. The methodology and results for the eight case studies are presented in **Part C** of this report. These towns were selected to cover a wide range of situations and, collectively, they include over 70 percent of the region's total population (urban and rural)[8]. Figure 1 shows the location of the towns used as case studies and the other towns with municipal wastewater schemes.

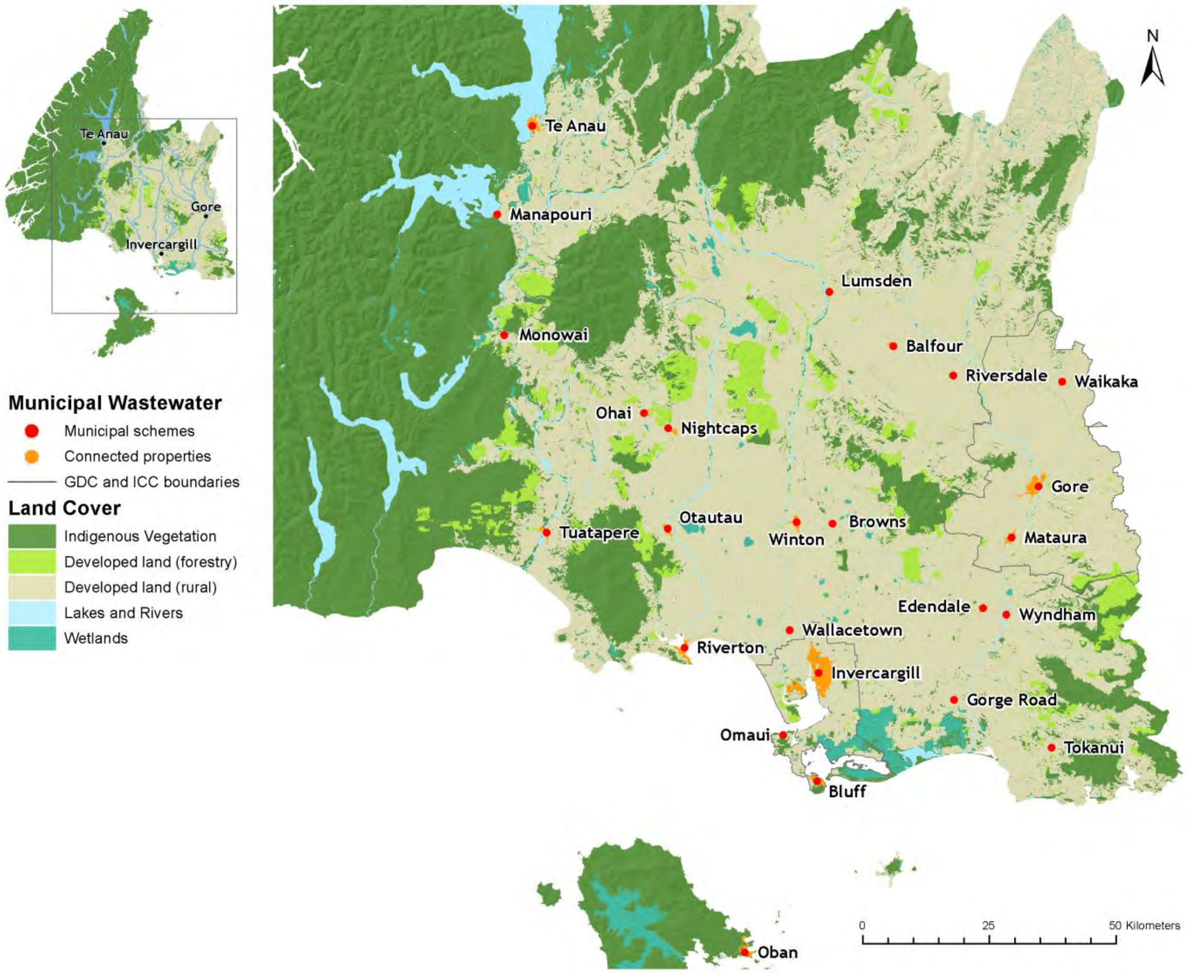


**Figure 1: Municipal wastewater schemes in Southland**
Source Environment Southland
Note: The red dots identify the location of the town (or city) - not the specific site of the wastewater treatment system or discharge.

In focusing on municipal wastewater schemes, the research has captured urban residential, commercial and industrial sources of wastewater. The research did not include on-site wastewater

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[8] The selection process covered a range of factors including political and geographic distribution, both major and minor wastewater schemes, and different levels of service. More information on this process is included in Part C, Section 1.

systems for either residential households (i.e. septic tanks) or major industries, nor did it extend to separate stormwater schemes, even though future policy options for limit-setting may affect both types of infrastructure. This section explains why the research focused specifically on municipal wastewater treatment systems. It also highlights other work done to estimate risks for water quality from rural residential on-site treatment systems and stormwater schemes.

At a broad scale, an economic sector's 'use' of water to attenuate waste depends on two factors: the extent to which a sector occurs across the landscape, the extent to which the sector is a source of waste substances in the environment (i.e. volume, toxicity, concentration). Those sectors that are more widespread and/or create higher flows of waste substances are those that have a greater water use. They are also more likely to be affected by limits on the amount of water available for use (water takes and discharges to water). These were the two main factors used in determining the research focus on municipal wastewater in this report – and also the focus on agriculture in the Agriculture and Forestry Report (Moran *et. al*., 2017). An additional factor that shaped this research was a lack of available information for other sources (separate stormwater schemes and industrial wastewater). The information gaps are discussed further below.

Overall, there are 1.2 million hectares of developed land in Southland. Around 3.3 percent of this land area is used for activities, such as residential and commercial areas, transport networks, and industry, which create discharges of wastewater and stormwater. These types of discharges are technically known as 'point source' (or multiple-point source) discharges because they usually come out of the end of a pipe. In general, wastewater and stormwater is collected and treated (to varying degrees) via municipal schemes and on-site systems. It is then released to a water body at a specific location (usually at the end of a pipe or a drain), either directly or indirectly (via a specific land block) – in some cases applying a waste stream to land is part of a treatment process.

The remaining 96.6 percent of the developed land in Southland is either used for agriculture (1.04 million hectares) or forestry (118,000 hectares) where the flow of waste substances tends to be 'multiple-point source' (e.g. from subsurface drainage systems) or 'non-point-source' discharges (e.g. down through the soil).

## Municipal Wastewater

Municipal wastewater schemes support the viability of local communities across Southland. These communities include both people who live and work in towns and those who live in the surrounding areas and either work in these towns or rely on them for services. This research focused on municipal wastewater, rather than on-site wastewater or stormwater, for several reasons. There are a large number of municipal wastewater schemes across the region and these schemes capture a range of economic activities, including many industries. Wastewater typically has higher levels of toxic waste substances than stormwater, and receives more treatment – stormwater tends to be managed via interceptors that filter some pollutants. There is also a reasonable level of information available on wastewater.

Municipal wastewater schemes began for towns in Southland in the early 20$^{th}$ century, and were funded through a mix of public investment and community fundraising. Managing wastewater usually followed after basic drainage measures for stormwater were installed, particularly in the commercial areas of towns. Most wastewater schemes started with the reticulated collection of wastewater, through the installation of a network of pipes and pump stations (known as sewerage), and its discharge into a water body. Often wastewater and stormwater collection were combined.

Over time, the size and materials used for wastewater and stormwater pipes has changed. Figure 2 shows the material and decade of construction for Invercargill's wastewater reticulation. Some materials were only used for a short time and/or in small quantities: brick (79 m) in the 1920s, cast iron (a total of 60 m) in the 1930s, 1960s, and 1980s, and ductile iron (68 m) in the 1990s. By comparison, almost 237 kilometres of earthenware pipes were used from the 1900s to the 1970s. In contrast to wastewater, the materials used for the stormwater reticulation was largely earthenware (to the end of the 1960s), concrete (continually), and polyvinyl chloride (from the 1950s).

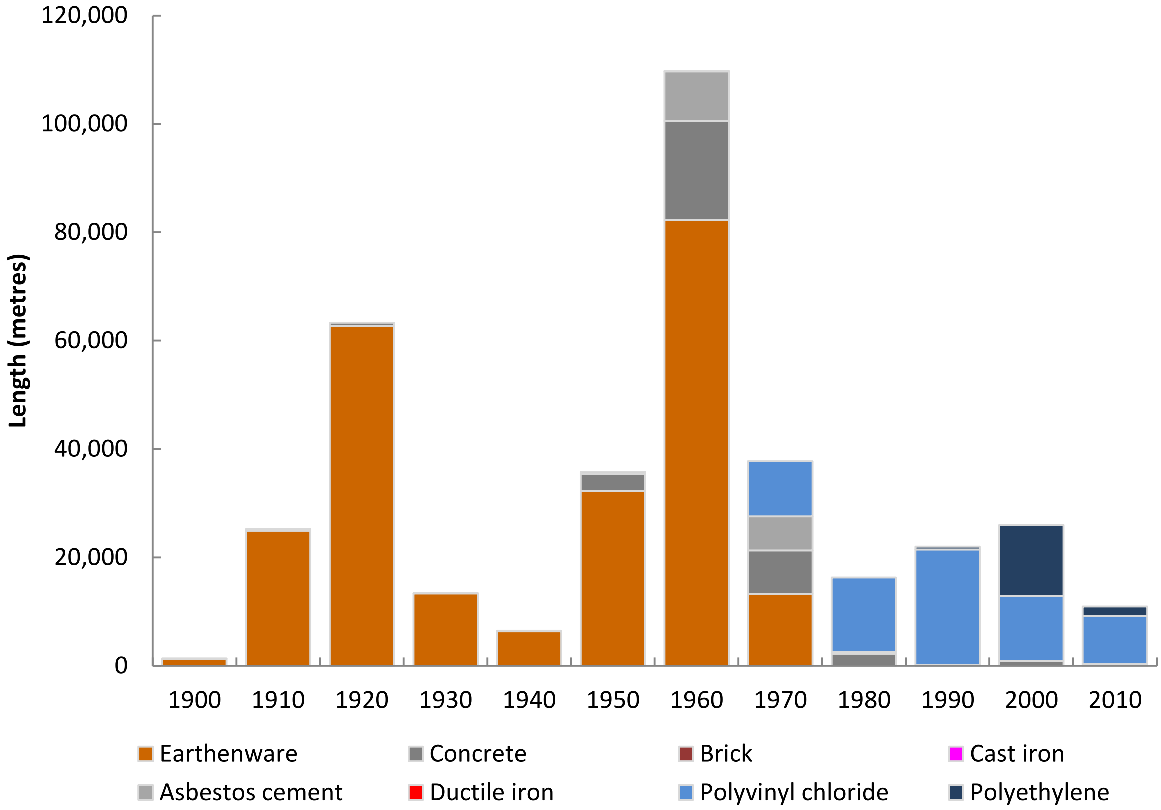


**Figure 2: Invercargill wastewater reticulation**
Source Environment Southland using data from Invercargill City Council

Wastewater schemes later developed to include treatment systems that were usually designed around oxidation ponds. There are three main wastewater streams: residential, commercial and industrial. In a New Zealand infrastructure stocktake in 2004, national wastewater volumes by source were estimated to be: 58 percent domestic, 19 percent non-domestic including trade waste, and 23 percent stormwater infiltration. While wastewater volumes indicate each source's share of inflow, they do not necessarily reflect the amount of treatment required (Market Economics, 2013). In particular, trade waste from industry makes up 19 percent of total volume but it might account for 50 percent of the treatment cost. As wastewater treatment schemes are made up of reticulation and treatment components, industry's lower volumes but higher treatment requirements tend to have disproportionate impacts on the total costs of wastewater schemes (Market Economics, 2013).

In Southland, municipal schemes that are designed largely for residential and commercial users tend to have most of their investment in the reticulation network. Municipal schemes that accept wastewater from industry can need additional investment in their treatment systems. This investment is usually managed through trade waste bylaws.

Wastewater schemes are driven, to a large extent, by population and soil drainage (influenced by soil type and slope). Around 57,000 people (or just over 61% of Southland's population) are concentrated in Invercargill and Gore, and 36,000 people (just under 39% of the region's population) are widely distributed in smaller communities across the rest of the region's developed land (roughly 1.3 million hectares). At a regional scale, Southland's population is relatively constant (deaths and outward migration being balanced by births and inward migration) but there is strong variability between local communities – with both growth in some towns and declines in other town reflecting changes in the economy. The larger towns are where there is usually more industry, and so trade waste.

Over the years, water quality issues related to wastewater have been more visible for towns on poorly drained land than towns on medium to well drained land. Where land is poorly drained, wastewater can pond and flow towards surface water bodies (rivers, lakes, streams and estuaries). Where land is well drained, wastewater flows downwards to groundwater. With the effects of wastewater on surface water being more visible, smaller towns on poorly drained soils tended to have a wastewater scheme early than similar towns on medium to well-drained soils.

There are now a range of different wastewater situations across the region. The wastewater schemes of some towns are relatively unchanged, and have aging infrastructure and capacity issues. Other towns have received either new systems or upgrades (e.g. Browns, Wyndham, Edendale, Gore and Invercargill). There are also towns that have declining populations and could face difficult decisions about their levels of service in the future. A number of towns (e.g. Mossburn, Athol, and Waikaia) do not have a wastewater scheme, with residents relying on on-site treatment systems. A few towns, particularly Te Anau, have seasonal variations in population that places greater pressure on their scheme at different times of the year.

Each council in Southland faces different challenges. In the Southland District there are a large number of small wastewater schemes over an area that extends across much of the region. In the Gore District there are two small schemes and one medium size scheme within a smaller inland area. Parts of these schemes have combined wastewater and stormwater pipe networks. Invercargill City District is dominated by a single large tertiary scheme beside New River Estuary, with an older wastewater pipe network that can cause raw (untreated) wastewater to end up in stormwater[9]. Invercargill City District also includes a small scheme for Bluff, which discharges into Foveaux Strait

[9] The cross-contamination of stormwater with wastewater is addressed through existing policy under the Southland Water and Land Plan 2018. The issues are relevant to this research in so far as any actions taken to meet existing policy may constrain a council's ability to afford the financial costs of new policy introduced through limit-setting under the NPS-FM 2017.

and a smaller scheme for Ōmāui at the mouth of New River Estuary. These councils now produce infrastructure strategies as part of their Long-Term Plans that describe how wastewater schemes and other assets will be managed over the next 30 years, identifying the most likely management scenario and community expectations.

The towns used as case studies in this research were chosen to capture a range of different situations and challenges. Of the eight case studies, four towns are in the Southland District (Te Anau, Ohai, Nightcaps, and Winton), two are in the Gore District (Gore and Matāura), and the final two are in Invercargill City District (Invercargill and Bluff). The research considered scenarios for further improving discharges from the wastewater treatment systems and their financial costs.

## Residential On-site Wastewater[10]

When this research was in its planning phase, the four councils considered including residential on-site wastewater systems. It was decided that, because the effects of these systems on water are more localised, modelling ways of improving their discharges was less of a priority for this research. As well as existing on-site systems not being included in the research, a shift to on-site systems was not considered as a possible measure for the case study towns in the modelling. The main reason was that property owners need to have sufficient land and suitable soils for an on-site system. Any shifts between on-site wastewater systems and municipal schemes usually involve a transfer of costs between individual householders and a wider group of ratepayers. Another reason was there was little information available on residential on-site wastewater.

Southlanders living in some small towns, on lifestyle blocks, and in rural areas have little or no access to wastewater networks, and the main way of disposing of domestic wastewater is via on-site treatment systems (MfE, 2008). It is also the situation for other types of activities in rural areas, such as some schools, camping sites, and milking sheds. The most common form of on-site system is a septic tank, which has two primary components: a settling tank to remove solids and a disposal field (soakage trenches or driplines). There are wide variations in estimates of the volume of wastewater generated in a typical on-site system but it is usually assumed to be roughly 180 litres/person/day (Ormiston& Floyd, 2004) or 140 litres/person/day for houses using roof water (Wheeler *et al*., 2010).

Most of the treatment process occurs within the soil under the disposal field. The soil's characteristics (soil type and drainage) have a major influence on overall treatment effectiveness. In highly permeable soils, wastewater can rapidly infiltrate to underlying groundwater. In poorly drained soils, wastewater can pond on the surface or move laterally through the soil to surface water (rivers, lakes and streams). To treat wastewater on-site, a property needs to be of a sufficient land area and have suitable soils for the disposal field. Figure 3 shows the basic flows to and from an on-site system (before and after treatment) to air and water. It highlights the potential for cross-contamination of drinking water.

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[10] The main source for this section is Liquid Earth (2014) *Contribution of On-site Wastewater Disposal to Cumulative Nutrient Loadings in the Southland*.

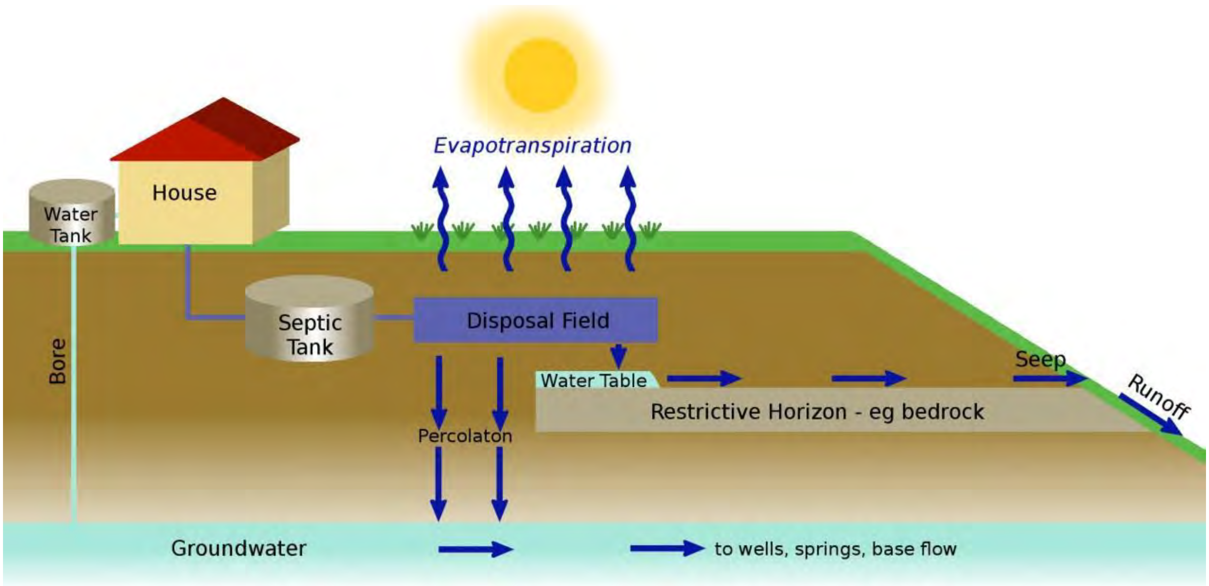


**Figure 3: Flows of wastewater to and from a disposal field**
Source Ministry for the Environment

On-site wastewater systems produce waste substances such as nutrients (nitrogen and phosphorus), chemicals, and micro-organisms that can affect the quality of soil and water. These effects tend to be localised, and depend largely on how the system is managed and its context (e.g. soil type and drainage, rainfall, location – particularly in relation to nearby water bodies). Effects are greater where on-site systems occur close together – such as lifestyle properties on the outskirts of larger towns (e.g. Invercargill and Winton), or small towns or settlements without wastewater schemes (e.g. Waikaia). The potential risk to groundwater varies across Southland. The areas with the highest risk tend to have higher population densities, permeable soils and shallow groundwater. The map in Part A, Section 2.2 shows the pattern of depth to groundwater across the areas of the region where groundwater is mapped.

On a per capita basis, Southland is likely to have a relatively high proportion of on-site wastewater systems compared to other regions[11], with 30 percent of Southlanders living in rural areas - at least twice the percentage as New Zealand as a whole (discussed in Part A, Section 1.3). Using the percentage of people living rurally, with the region's population and average household size, the total number of on-site systems (occupied dwellings) in Southland is calculated to be 11,700. This number is roughly consistent with an estimate in 2013 of 12,400 on-site systems (occupied and unoccupied dwellings): Invercargill City District 1,900, Southland District 6,000, and Gore District 4,500 (Ogilvie et al, 2013).

[11] In 2008 the Ministry for the Environment highlighted that in some regions at least 20 percent of homes rely on on-site systems to treat and dispose of their domestic wastewater (MfE, 2008).

On-site systems contribute to declining water quality in some areas, particularly in terms of human health. In 2014, Environment Southland estimated the contributions from on-site wastewater systems to total loads of nutrients across most of the region[12].

These contributions were estimated using meshblock data from the 2013 census, meshblock spatial coverage, and sub-catchment areas. Within each sub-catchment, the potential load was calculated using population and modified with attenuation factors to produce a total and aerial loading that was summed at the river catchment scale. These estimates were on the basis that these systems were performing well. Annual loads of total nitrogen are between 0.8 percent and 2.2 percent (129 and 366 tonnes) and annual loads of total phosphorus are between 0.4 percent and 0.85 percent (2.7 and 5.4 tonnes) (Liquid Earth, 2014).

The largest contribution to nutrient loads is in the Ōreti catchment, which includes Winton and parts of Invercargill. Here on-site systems may contribute up to 2.8 percent of total nitrogen loads at the bottom of the catchment. Table 2 gives occupied dwellings and nutrient load estimates in Southland's four main river catchments (these catchments are similar but not exactly the same as the FMUs discussed later in this report). Figure 4 (next page) shows the estimated distribution of on-site wastewater systems across Southland. The towns identified by name on this map are those without a municipal wastewater scheme.

**Table 2: Occupied dwellings and nutrient load estimates for Southland**

Source Liquid Earth

| River Catchment | Occupied Dwellings | Annual total nitrogen loads from dwellings (tonnes per year) | Estimated contribution to catchment nitrogen load | Annual total phosphorus loads (tonnes per year) |
|---|---|---|---|---|
| Waiau | 834 | 9.6-27.1 | 0.5-1.3% | 0.20-4.00 |
| Aparima | 825 | 10.8-30.6 | 0.2-0.6% | 0.23-0.45 |
| Ōreti | 4,161 | 55.1-156.0 | 0.5-1.4% | 1.15-2.29 |
| Matāura | 2,586 | 31.9-90.3 | 1.0-2.8% | 0.66-1.33 |

The performance of residential on-site wastewater systems is variable because of a range of factors including geology, climate, design and installation, operation and maintenance, property size, and age of the system. In 2008, the Ministry for the Environment estimated that failure rates for communities with on-site systems range from 15 to 50 percent across New Zealand. A selection of in-depth sanitary surveys suggested the range in performance is even wider. For example, Rotorua Lakeside Community Sewerage Scheme Funding Proposal noted that 90 percent of owners did not clean their on-site systems once per decade (MfE, 2008). Older systems are not likely to meet the New Zealand wastewater design standards.

[12] These contributions were estimated using meshblock data from the 2013 census, meshblock spatial coverage, and subcatchment areas. Within each sub-catchment, the potential load was calculated using population and modified with attenuation factors to produce a total and aerial loading that was summed at the catchment scale.

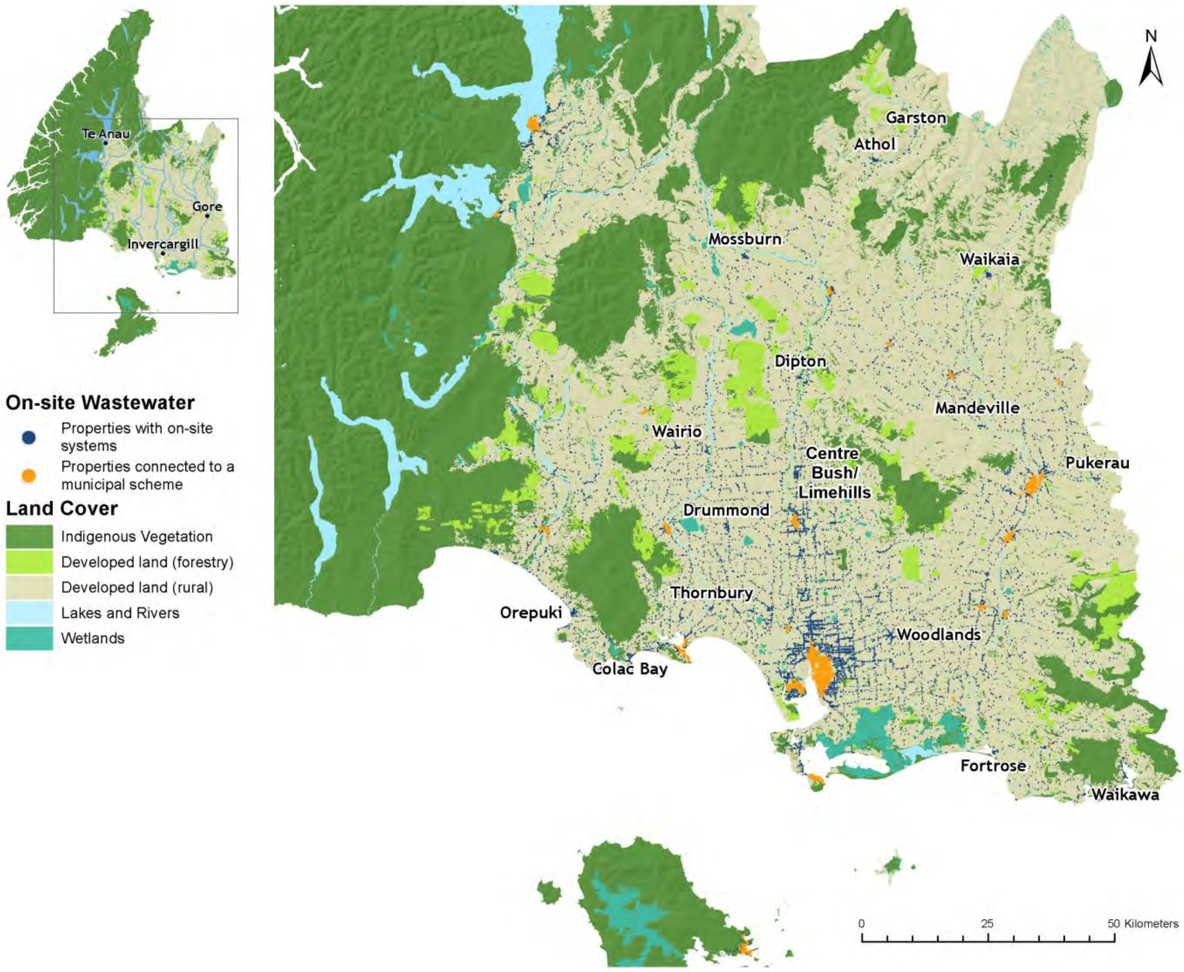


**Figure 4: Residential on-site wastewater systems in Southland**
Source Environment Southland

In 2009 Invercargill City Council created a dataset for 749 of the 1,870 properties in the Invercargill City District in non-reticulated areas. Of this dataset, 21 properties (less than 3%) had recorded comments that indicated the on-site treatment system was anything other than a traditional septic tank system with drainage fields mainly through field tiles (i.e. direct to surface water). Moving from traditional septic tanks to modern on-site systems (i.e. septic tanks with recirculating filters or activated sludge aerobic systems) can be effective in reducing waste substances. The estimated cost of installing these modern systems is between $14,000 and $16,000 (plus GST) (Market Economics, 2013).

## Industrial On-site Wastewater

In Southland, many industries manage their wastewater (trade waste) through municipal schemes, particularly those in and around Invercargill and Gore. All three territorial authorities have bylaws for accepting trade waste in their municipal schemes. These bylaws are usually managed in ways that are not too onerous so as to encourage industries to locate in a district – industries create local employment, process products from the primary sector, and encourage demand for services.

Industrial on-site wastewater systems were considered in the planning phase of this research. It was decided that to include these schemes as case studies within the scope was likely to be too challenging at this stage. There were two main reasons for this decision. First, the case study methodology was not well suited to industrial on-site wastewater – it may appear as if particular industries were being singled out. Second, there is only limited information available on industrial on-site wastewater and the data required for this type of research were likely to be commercially sensitive.

There are a number of industries that have wastewater systems either on-site or nearby. These industries largely occur in the lower Matāura and around Invercargill and include meat, milk, timber processing, and mining. In some cases, sludges from these treatment systems are discharged to land elsewhere than an industry's location. The toxicity of industrial wastewater is variable. Some industries produce specific contaminants, such as sediment from mining. Unlike many other industries, hydroelectric power generation produces a high volume wastewater with low contaminant concentrations. The location of industrial wastewater in Southland is discussed further in Part B, Section 5.

In 2013 the Ministry for the Environment used Alliance Lorneville's wastewater treatment system as a component of its '3 waters' research (covering wastewater, stormwater and potable water) for Invercargill (Market Economics, 2013)[13]. Alliance Lorneville is the largest ovine processing facility in the world, and treats wastewater from its meat processing plant and from Wallacetown (west of the plant) at its treatment system. Treated wastewater is then discharged in the lower reaches of the Makarewa River before it flows into New River Estuary. Alliance is now in the process of implementing major upgrades to the wastewater treatment system to improve the quality of its discharge and reduce downstream environmental effects. The new investment for the wastewater treatment system is around $23.4 million: $19 million for the nutrient reduction and $4.4 million for disinfection (ES, 2016).

While the strength (toxicity and loads) of the waste substances in trade waste differs from domestic and commercial waste streams, the technologies used in industrial on-site wastewater systems tend to be based on similar treatment principles to those used in many municipal schemes. In other words, the investment required for a technology at a particular scale can be expected to be of similar magnitudes.

## Stormwater

As topics, wastewater and stormwater are intertwined, and considering stormwater at some level is almost unavoidable when undertaking research on wastewater. Most towns in Southland lie on flat to rolling land near rivers that are prone to flooding. Much of the last 150 years in catchment engineering has been about managing water quantity, rather than water quality, with the aim being to get water off the land as quickly as possible. In urban areas there are complex stormwater

[13] The research was done as part of the Ministry for the Environment's analysis of water policy decisions for the amendments made in 2014 to the National Policy Statement for Freshwater Management 2011 (subsequent amendments were made in 2017).

networks to cope with the large volumes of water, just as in many lowland rural areas there are extensive tile and mole drainage networks.  Some stormwater schemes are complicated by infrastructure such as stop banks, such as at Lumsden on the Ōreti River and at Gore on the Matāura River, which offer protection from rising water but can also limit drainage capacity.

**Image 2: Standby Generator at Prestonville Pump Station, Waihōpai River**
Source Emma Moran

As with wastewater, stormwater schemes are driven by population.  In 2016 there was reticulated (or piped) stormwater in Invercargill, Gore and 19 other towns across the region.  An important difference with wastewater is that stormwater is usually discharged into a water body at multiple points.  Managing the quality of these discharges generally means slowing the flow of stormwater from the land to allow for some type of treatment system before each discharge point.  Devices used in treatment systems include pre-treatment (e.g. vegetated swales), first flush interception, soakage systems, detention basins, and constructed wetlands[14].  Many of these devices are brought together as stormwater 'treatment trains'.  An alternative approach is public education to prevent waste substances ending up in stormwater in the first place.

[14] More information on stormwater treatment systems is available in Chapter 6 of Christchurch City Council's *Waterways, Wetlands and* Drainage *Guide* (2012) https://www.ccc.govt.nz/assets/Documents/Environment/Water/waterways-guide/WaterwayswetlandsandDrainageGuideWWDGchapter6StormwatertreatmentsystemsMay2012.pdf

**Image 3: Stormwater system at Inverurie Estate, Invercargill**
Source Emma Moran

In Southland, managing stormwater quality generally revolves around existing urban areas. The use of modern stormwater treatment devices are starting to be encouraged in greenfield developments but retrofitting these devices into existing stormwater networks can be difficult. These devices do not deal well with cross-contamination issues with wastewater. There are examples of where alternative approaches are being taken for stormwater in some of the newer subdivisions, such as the Inverurie Estate in Invercargill, and the Delta in Te Anau. Gore District Council is considering a possible long-term project to retrofit technologies such as rain gardens and turn them into community assets.

In some cases stormwater reticulation is combined with wastewater reticulation, with the stormwater increasing volumes passing through a wastewater treatment system. In other cases, there is cross-contamination between stormwater and wastewater, as a result of misconnections, overspill from flooding, and leakage from aging infrastructure. When cross-contamination issues occur untreated wastewater can be discharged from a stormwater scheme, with elevated levels of micro-organisms (e.g. faecal coliforms and *E. coli*) in the stormwater[15]. These issues are a matter of compliance with existing requirements for stormwater and wastewater, and are only indirectly relevant to this research, which is about developing information around further managing contaminants for water quality. The relevance is where addressing these issues constrains a community's ability to fund any new expectations that may result from limit-setting.

[15] The presence of micro-organisms in stormwater does not only occur because of cross-contamination issues – it can come from other sources in the catchment such dogs, ducks and agricultural stock in rural areas.

Each territorial authority is facing its own set of stormwater challenges. Invercargill City Council and Gore District Council are faced with a number of stormwater schemes where parts are still combined with wastewater and cross-contamination issues. In 2008 Gore District Council was granted global stormwater discharge consents for Gore, Matāura, Waikaka and Pukerau. These consents require on-going monitoring and improvement to stormwater quality where issues are identified. Stormwater monitoring can be complex because of the sampling conditions that need to be met to obtain a viable and comparable water quality sample. In 2018 Invercargill City Council was granted 15-year consent to discharge water and contaminants (waste substances) from its reticulated stormwater network with strict conditions. If wastewater contamination is found in stormwater then the Invercargill City Council must conduct an extensive programme to identify and resolve any issues. The resource consent also requires the Council to check stormwater connections from trade and industrial sites.

Southland District Council manages some 27 stormwater schemes of varying size and relative complexity. In the smaller towns, sources of waste substances at risk of contaminating stormwater discharges are relatively limited. In such instances the Council considers that improving the quality of wastewater discharges will be of more benefit for water quality (I. Evans, pers. comm., 2016). The Southland District Council resource consent application for 17 towns is currently being processed with consenting and monitoring conditions being developed based on water quality risk. Seven of the low risk towns are covered by a 15 year resource consent, which requires periodic monitoring, primarily to check for cross-connection problems. Conditions are currently being developed for towns identified as medium or high risk. Risk is based on factors such as size of network, volume, the water body and likelihood of contamination from industrial or trade premises.

In the early 1990s, a review of water quality in each of Southland's four main river catchments was completed in a series of reports for the Southland Regional Council (now Environment Southland). These reports included information on stormwater from industrial land use activities and urban stormwater. At that time an in-depth investigation of Invercargill stormwater was also undertaken for Environment Southland to assess its effects on the city's four rivers and creeks and New River Estuary (Robertson & Associates, 1992; Robertson Ryder & Associates, 1993). Since then most scientific research on stormwater in Southland has focused on Invercargill.

In 2005 Invercargill City Council carried out a study on the Otepuni creek during several storm events over winter 2005 that identified faecal coliforms (a micro-organism) and visual clarity as issues. Invercargill City Council has also identified industrial sites within the city as being the highest risk for stormwater because of the nature of their activities and the substances used and stored on-site (Market Economics, 2013). Environment Southland has completed a range of reports on the effects in the lower Waihōpai River and New River Estuary of activities such as stormwater. These reports have highlighted issues with waste substances in stormwater, such as heavy metals (e.g. zinc and nickel) and *E. coli*.

Monitoring of stormwater is recent and still limited, but the data suggests there are elevated levels of sediment and nutrients, *E. coli*, and heavy metals such as copper, lead and chromium in some towns. In 2013 Invercargill was used as a stormwater case study in economic research that is available in *Southland Industrial and Municipal Water Values* (Market Economics, 2013)[16].

**Image 4: Stormwater outflow into the Waihōpai River**
Source Emma Moran

When the four councils initially scoped this research it included a stormwater component. There was a keen awareness at the time that this component would be challenging because of a lack of past monitoring data for stormwater in Southland[17]. There were also concerns that this component could be of limited value for several reasons, including that the waste substances in stormwater tend to be different from those generally affecting water quality at a regional scale (sediment, nutrients, and micro-organisms). There is also uncertainty about future policy direction and limited measures for managing stormwater, particularly in existing developments and areas of relatively high rainfall.

In 2016, a simple mathematical equation was used[18] from the early 1990s Invercargill stormwater reports to develop a modelling method. This method was used to estimate the amount of waste

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[16] The research was done as part of the Ministry for the Environment's analysis of water policy decisions for the amendments made in 2014 to the National Policy Statement for Freshwater Management 2011 (subsequent amendments were made in 2017).

[17] Monitoring data is now being collected as part of discharge consent conditions for stormwater.

[18] This equation was based on Williamson's (1993) stormwater contaminant yield dataset, which was considered to be a good representation for urban areas in New Zealand (Robertson Ryder, 1995). This dataset can be found in Williamson, R.B. (1993) *Urban runoff data book: A manual for the preliminary evaluation of urban stormwater impacts on water quality.* Water Quality Centre Publication. No.20.

substances in stormwater for each of the eight case study towns. This method was reviewed and the territorial authorities, through Stantec, raised some concerns around its relevance to Southland, a possible risk of over-specifying solutions, and it did not include faecal coliforms or *E. coli*. Two new methods were investigated: one using a wetland footprint and one using treatment devices within the pipe network.

A wetland footprint method used a constructed wetland as an 'end-of-pipe' treatment device. A constructed wetland is effective for removing total suspended solids, copper, zinc, and total petroleum hydrocarbons, with between 30 and 75 percent reduction in load (depending on the source e.g. roofs or roads). This wetland footprint method used a 'rule of thumb' sizing related to two percent of the total land area in each case study, with the costs being split proportionally between the total number of discharge points for a case study. The individual wetlands could be modelled as being progressively installed at the various discharge points in each case study area, or across a catchment.

This wetland footprint method was not developed because a wetland treatment option is unlikely to be feasible for most stormwater networks across Southland. There is a lack of land area and difficulties in achieving the required fall to the wetland. Many of the systems have multiple discharge points, with minimal space in which to bring these disparate discharges into single treatment location, as would be required for a wetland solution.

To provide context for further investigations, the territorial authorities commissioned a review of the available information for nutrient (nitrogen and phosphorus) and *E. coli* to determine the waste substances of concern. This review compared the amounts (loads) of these substances in Invercargill stormwater network with those from the Invercargill wastewater treatment system. It also considered the effectiveness of stormwater treatment devices for removing these waste substances.

The review found that the nutrient load from Invercargill stormwater was minimal in comparison to wastewater (less than 5%). The concentration of micro-organisms in stormwater is an order of magnitude lower than wastewater but treatment devices generally cannot treat for them. Reducing micro-organisms is generally achieved at source, including the removal of wastewater from stormwater. The report recommended the stormwater scope should be limited to the waste substances used in an Auckland Contaminant Load Model (total suspended solids, copper, zinc, and total petroleum hydrocarbons).

Based on the review's recommendation, a proposal was developed for a stormwater case study (for total suspended solids, copper, zinc, and total petroleum hydrocarbons) in the Otepuni Stream, which runs through one of Invercargill's main industrial zones. Ultimately, the Governance Group of the Southland Economic Project choose not to progress this proposal because of its more limited scope, budget constraints, and the importance of completing the wastewater component of this research. Maps of the stormwater networks for the eight case study towns are included in Part C.

In 2017 and 2018, Invercargill City Council and Southland District Council separately commissioned Stantec to investigate the costs of installing in-line treatment systems in specific locations.

1. The Southland District Council investigation focused on the industrial areas of Te Anau and Winton, which discharge to a single point in both towns. The treatment system was

designed to reduce heavy grits, medium fine sediments and small amounts of hydrocarbons, with devices placed in existing stormwater mains to treat lower flows but bypassed by large storm flows. The catchment areas were Te Anau 23 hectares and Winton 12 hectares with construction costs of $150,000 and $75,000 respectively.

2. The Invercargill City Council investigation focused on two downtown areas of Invercargill. These areas included a high traffic volume road and a large area of commercial activity, and the treatment system was designed to achieve a high level of treatment, reducing both particulate and dissolved contaminants. The catchment areas were 5.7 hectares and 2.5 hectares with construction costs of $230,000 and $150,000 respectively.

There are some towns in the Southland District, where stormwater is discharged to direct to groundwater from a soak hole, rather than there being an intervening depth of unsaturated soil before the aquifer. Improvement options were investigated including a renewal of the existing soak hole and an installation of a proprietary oil and grit separation manhole. The estimated construction costs of these options varied dependant on whether the soak hole was in the road or the berm, but ranged from $6,000 to $24,000 per soak hole. There were up to eight affected soak holes in the towns investigated.

# Part A: Southland

## 1. Southland

The environment plays a big part in how the economy has developed in Southland and, in turn, the regional economy continues to modify the landscape and shape local communities. This section gives an overview of Southland's land, water and people (including the economy), highlighting their connections. The section then turns to describe the five freshwater management units, which are the geographical areas where specific limits on the use of water, both as water takes and to receive waste, will be set.

### 1.1. The Land

Southland is New Zealand's most southerly and easterly region, and includes most of Murihiku (the southern part of the South Island), which runs north to the Clutha River catchment in Otago. The region as a whole (including Stewart Island/Rakiura and other offshore islands) has a total land area of 3.2 million hectares (or 12 percent of New Zealand). Of this total area, 59 percent is land in indigenous vegetation (including alpine areas where there is little vegetative cover) – and just over 42 percent of this land is within Fiordland and Stewart Island/Rakiura.

Where indigenous vegetation is at the top of a river catchment it protects the water quality of the headwaters, and where it is further down the catchment, it helps to buffer the effects on water quality from the use of land that is developed. The developed land has been extensively modified with the clearance of indigenous forests and vegetation, the drainage of some lowland soils, the introduction of improved pasture, and the straightening of the rivers. The remaining three percent of the region's 'land' area is taken up with surface water (e.g. rivers, lakes and wetlands).

Southland is shaped by some of the country's most complex geology and it has one of the widest assemblages of soils. The region's northern boundary is marked by the Livingstone, Eyre, and Garvie Mountains (in Southland) and the Blue Mountains (in Otago). The Southland Syncline (formed by geological faulting) is a geological fold in the earth's surface that creates a thick 'belt' running on a north-west to south-east axis from Lumsden through to the Catlins coast, and is partially buried beneath the Southland Plains. Figure A1 shows how the Tākitimu Mountains and the Hokonui Hills (part of the Southland Syncline) divide Northern Southland from the Southland Plains.

Northern Southland stretches from the Te Anau Basin in the west, through Lumsden, then along the Waimea Plains and down to Gore in the east. South from the 'Hokonuis', the Southland Plains extend from the Aparima River in the west, across the Ōreti River to the lower Matāura River. Going west beyond the Aparima, is the Longwood Range and further west the lower Waiau Plains (below the Te Anau Basin). Fiordland lies to the west and is made up of numerous coastal fiords, mountain ranges, and inland lakes. South of the mainland is Stewart Island/Rakiura, which rises almost 1,000 metres to Mount Anglem, and a number of smaller offshore islands, which are not displayed in Figure A1 because of a lack of topographic data.

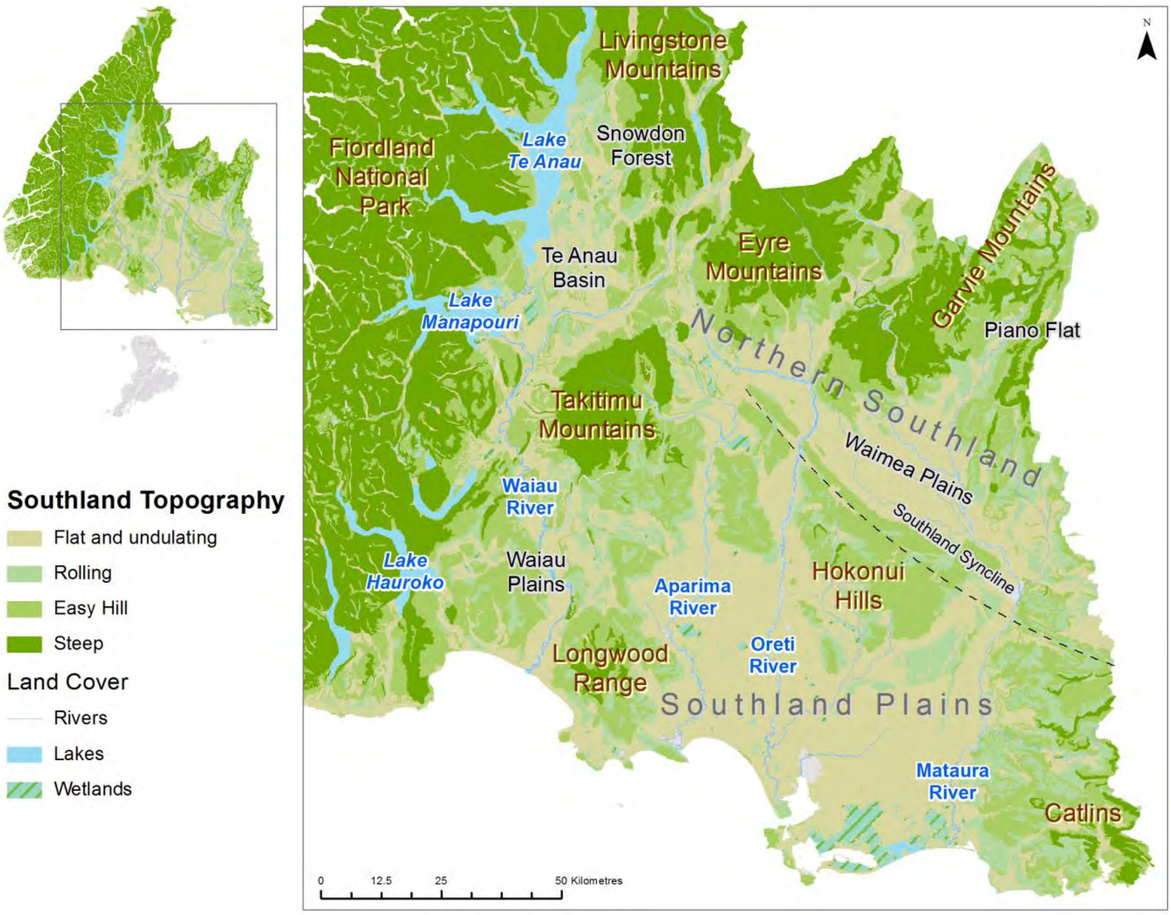


**Figure A1: Major landforms in Southland**
Source Environment Southland using the New Zealand Land Resource Inventory

## 1.2. The Water

Southland contains a large amount of fresh water, both as surface water and groundwater. The region has six of New Zealand's 25 largest lakes (as measured by surface area), including Lakes Te Anau, Manapouri, and Hauroko (which are also New Zealand's three deepest lakes). There are also tens of thousands of kilometres of rivers and streams, including the Waiau, Aparima, Ōreti, and the Matāura Rivers. Together the catchments of these four rivers drain 1.85 million hectares or 62 percent of the Southland mainland. Numerous other rivers and streams drain the remaining land to the coast, including Waituna Creek, Waimatuku Stream, and the Waikawa, Waihōpai, and Pourakino Rivers.

**Image A5: Lake Manapouri**
Source Simon Moran

Since European settlement, parts of some rivers and streams have been confined within stop banks, and in certain cases straightened, which has changed their natural flow paths. As a result, water and nutrient losses flow more rapidly through the landscape. In addition, water is taken from surface water and groundwater for a range of uses. The most obvious example is the Waiau River, where the mean annual flow was reduced from around 560 to 134 cumecs (a 76% reduction of its original flow) for the Manapouri Power Station. This station generates 12 percent (4,800 GW h) of the country's electricity (the largest user of which is Tiwai Point Aluminium Smelter). Figure A2 highlights the extent of surface water in Southland, including the large remnant wetlands. When groundwater is considered as well, few places in Southland are far from fresh water.

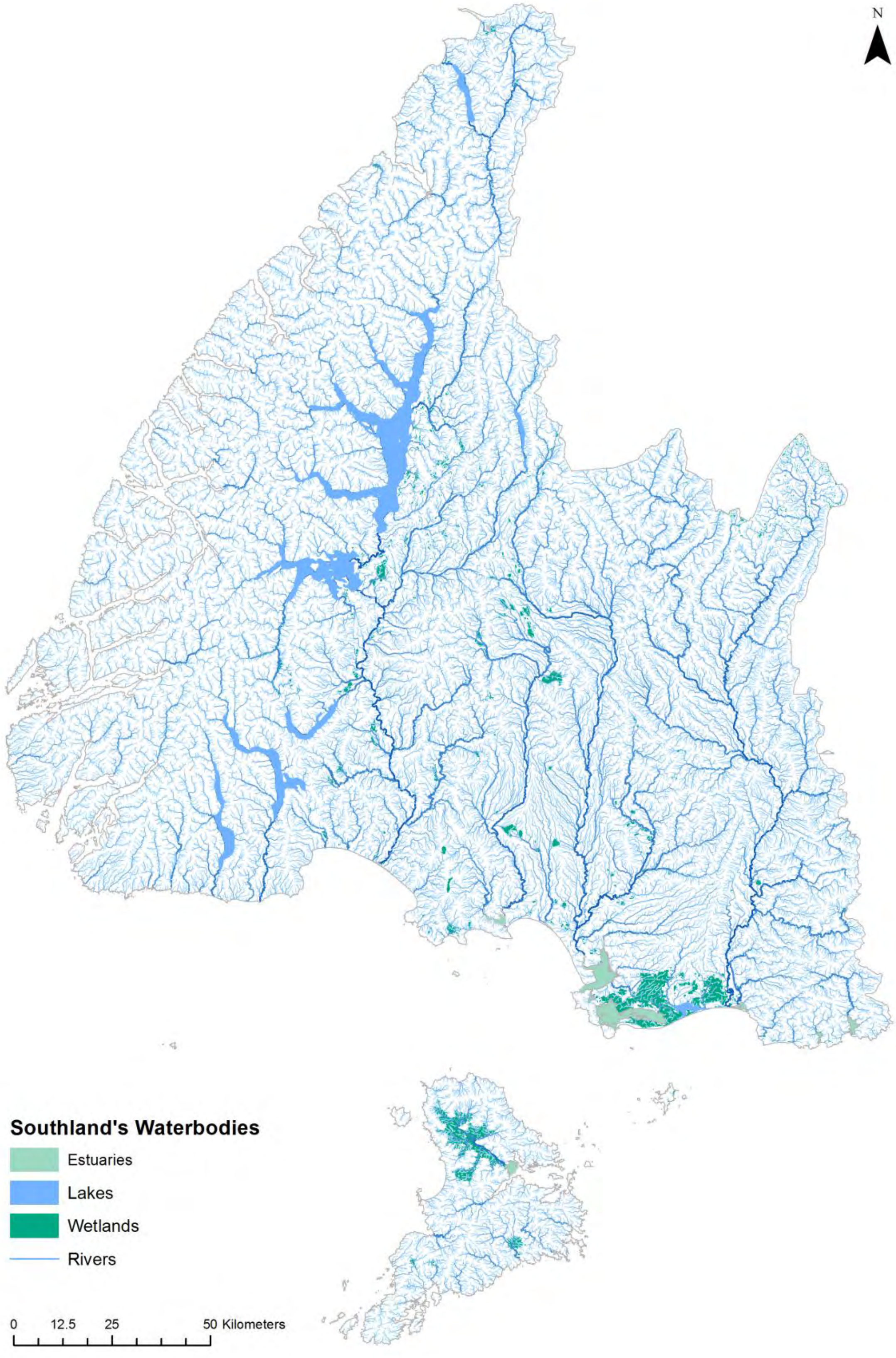


**Figure A2: Surface water in Southland**
Source Environment Southland
Note: The rivers are displayed using lighter colours for the tributaries and becoming darker as they flow toward the main stem.

Before Māori arrival, around 268,500 hectares of land in Southland are estimated to have been in wetlands and swamps, most of it across the Southern Plains. Figure A3 shows the estimated original extent of wetlands in the region. Wetlands perform important cleansing and water storage roles in the environment – they catch and take up nutrient losses, spread and slow down the flow of water, allowing sediment to drop out of suspension. Wetlands are also important connectors between surface water and groundwater. The median static water table in Southland is 2.4 metres below ground level, with many soils in direct contact with groundwater.

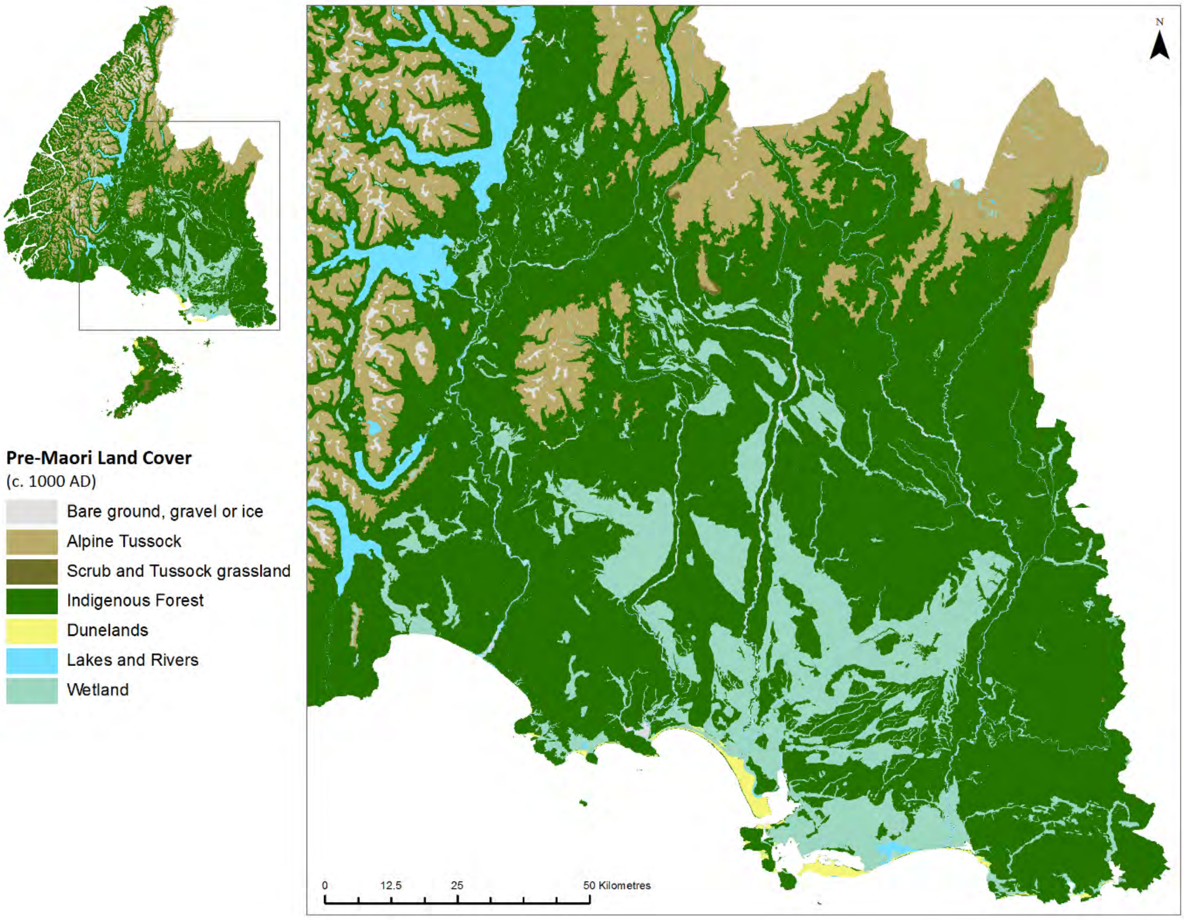


**Figure A3: Pre-Māori land cover in Southland c. 1000 AD**
Source Pearson & Couldrey (2016)
Note: Land Cover is explained in more detail in the Agriculture and Forestry Report (Moran *et al.*, 2017).

In lowland Southland, wetlands originally covered around half of the area (Clarkson *et al.*, 2011). Over the years, these wetlands have been drained using extensive networks of artificial drains for the development of agriculture. Since 1840, it is estimated that the area of wetlands on land which is now in private ownership reduced from around 220,000 hectares to 9,650 hectares (or 3.6% of the original area) by 2007 and to 8,486 hectares (or 3.2%) by 2015 (Dalley & Geddes, 2012; Ewans, 2016). The draining of wetlands has increased pressure on the environment by making more land available for use while reducing the environment's natural capacity to attenuate its effects. The installation of tile and mole drains has created direct channels (or pathways) for waste substances to enter surface water, bypassing some natural processes. Figure A4 shows the remaining extent of wetlands in the region.

The drainage of wetlands, and lowland soils more generally, has changed the regional hydrology across lowland areas so that there is comparatively little time for waste to attenuate before it reaches receiving waters. This circumstance is not unique to Southland – similar large scale changes in hydrology have occurred in other parts of the world where naturally low permeability and high water tables required extensive networks of subsurface drainage to make land suitable for agricultural use (e.g. Illinois, USA and Manitoba, Canada)

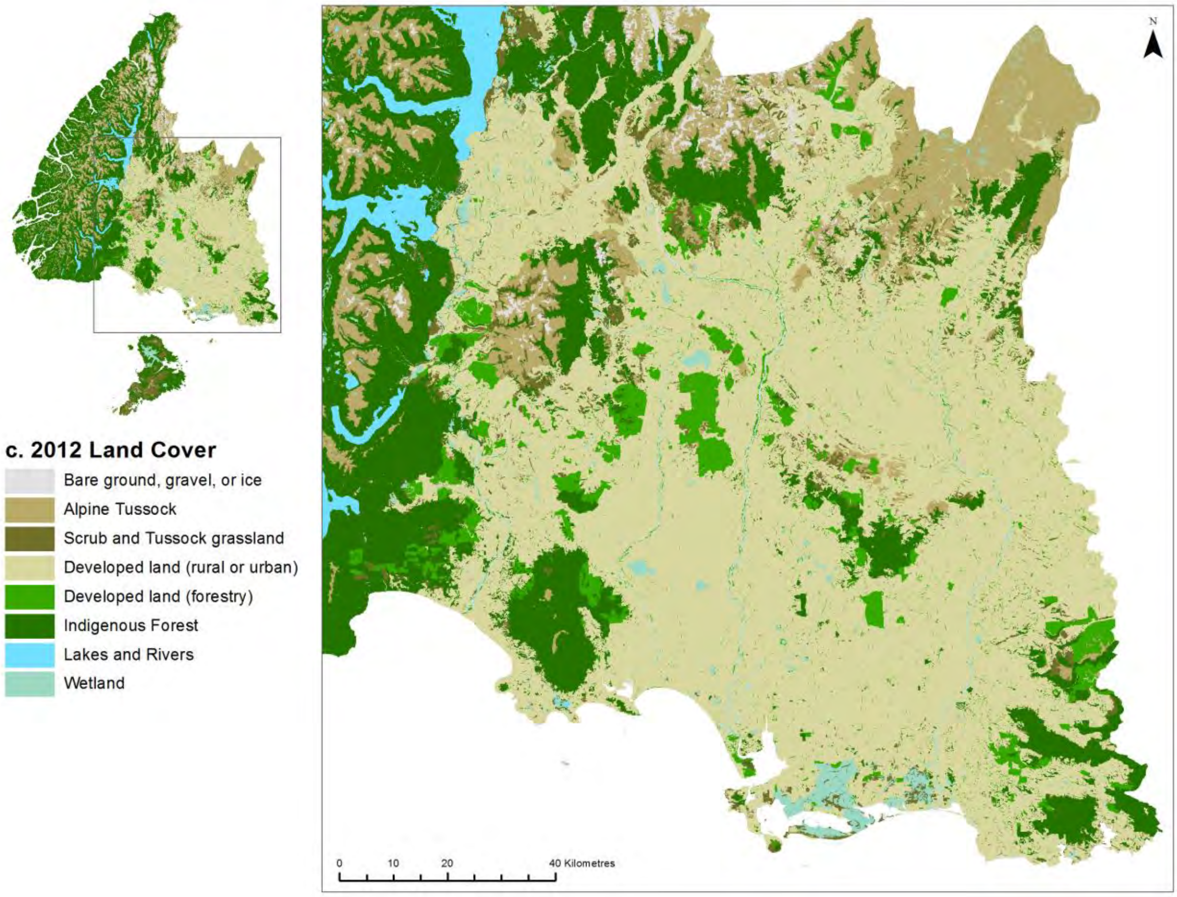


**Figure A4: Land cover in Southland c. 2012**
Source Pearson & Couldrey (2016)

In addition to its wetlands, Southland has a mosaic of unconfined, shallow groundwater aquifers that exchange groundwater to surface water relatively quickly. Approximately 47 percent of all of the water in Southland streams is groundwater from these aquifers (C Rissmann, pers. comms, 2017). The proportion is highly variable across the region, with lowland streams having much more groundwater than alpine streams. The shallow groundwater table, together with a cool humid climate, mean that groundwater within unconfined aquifers are young, with an average residence time or age of less than 10 years. Elsewhere in New Zealand aquifers are often much deeper and can be up to several thousand years in age (e.g. Canterbury and large areas of the Waikato).

Notable exceptions in Southland are a small area within the Te Anau Basin and a few lowland aquifers hosted by ancient alluvial formations, such as the Luggate Shotover Formation (which underlies most of the Waimea Plains and has remnants along the Matāura Valley). The region has a small volume of potable (or drinkable) groundwater, compared with other regions, because its fluvio-glacial gravels form only a thin veneer over poorly permeable basement and Tertiary period rocks. Groundwater within basement rock and tertiary sediments tends to be poorly potable and needs treatment before use.

The consequences of the quick exchange between groundwater and surface water are that there is often limited natural water storage in areas of developed land, and nutrient losses move through the landscape rapidly (i.e. there are short lag times). Accordingly, the modification of Southland's lowland hydrology favours the rapid transport of nutrients, sediment and micro-organisms in water, reducing the time for natural processes to attenuate these substances before reaching water bodies.

Eventually, the mainland's fresh water (and its loads of waste substances) flows into 24 estuaries, Foveaux Strait and the Southern Ocean. Between Te Waewae Bay (at the mouth of the Waiau River) and the Catlins (east of the Matāura River mouth), estuaries occupy 43 percent of the southern coastline (Robertson & Stevens, 2008). There are four basic types: tidal lagoons (e.g. New River Estuary), tidal rivers (e.g. Waimatuku Estuary), coastal embayments (e.g. Bluff Harbour) and fiords (e.g. Milford Sound). In Southland, tidal lagoon estuaries dominate within the developed river catchments.

**Image A6: Waikawa Estuary**
Source Simon Moran

The estuaries contain high levels of biodiversity, including many species that are threatened or endangered, and retain waste from human activity. A few tidal lagoons and tidal river estuaries have mouths that close and open intermittently (e.g. Waituna Lagoon). Some estuaries have been actively modified over the years either through reclamation (e.g. New River) or reduced water inflow (e.g. Te Waewae Bay Lagoon). The deteriorating health of a number of Southland's estuaries, particularly New River Estuary, has been an identified issue for many years (e.g. Robertson, 1993).

Overall, Southland's water and land is highly connected. The environment has influenced development of the economy and, in turn, has been altered by this development. Modification of

Southland's environment through economic development, combined with natural short lag times, means that water and the waste substances carried in it now flow more easily through the landscape. In some areas there are fewer opportunities for attenuation of waste substances than in the past, and so less natural resilience.

## 1.3. The People

As well as the connections between the water and land, the way that Southlanders live, work and play means that there are strong connections between local communities and the environment.

In 2013[19], there were just over 93,000 people living in Southland (or 2.2% of the New Zealand population). Of those people living in Southland, just over 12.4 percent of the population identify as Māori (compared to 14.1% for New Zealand as a whole) (Statistics New Zealand, Released from October 2013 to June 2015). The mana whenua of Murihiku (Southland) are Ngāi Tahu, Kati Mamoe and Waitaha. There are four rūnanga (or rūnaka), each with their own marae: Te Rūnaka o Waihōpai based at Murihiku Marae (Tramway Road, Invercargill); Te Rūnanga o Awarua based at Te Rau Aroha Marae (Bluff); Te Rūnaka o Ōraka Aparima based at Takutai o Te Titi Marae (Riverton/Aparima); and Te Rūnanga o Hokonui based at Hokonui Marae (Gore) and O Te Ika Rama Marae (McNab). Other mata waka marae include Te Tomairangi Marae (Eye Street, Invercargill), Nga Hau E Whā (Conon Street, Invercargill), Te Oruanui Marae (Ohai), and Matāura and District Marae (Matāura).

In 2013 just under 70 percent of the people living in Southland lived in urban areas, which is low for New Zealand where 87 percent of the population is urban. Of the roughly 30 percent of people living rurally, most tend to be in either 'highly rural or remote areas' or 'rural areas with low urban influence'. As a result, many Southlanders tend to live closer 'to the land' than elsewhere and there are strong connections between 'town and country'. Figure A5 shows the proportions of Southlanders living in urban and rural areas compared to New Zealand as a whole.

[19] The most recent census figures available at the time of writing this report.

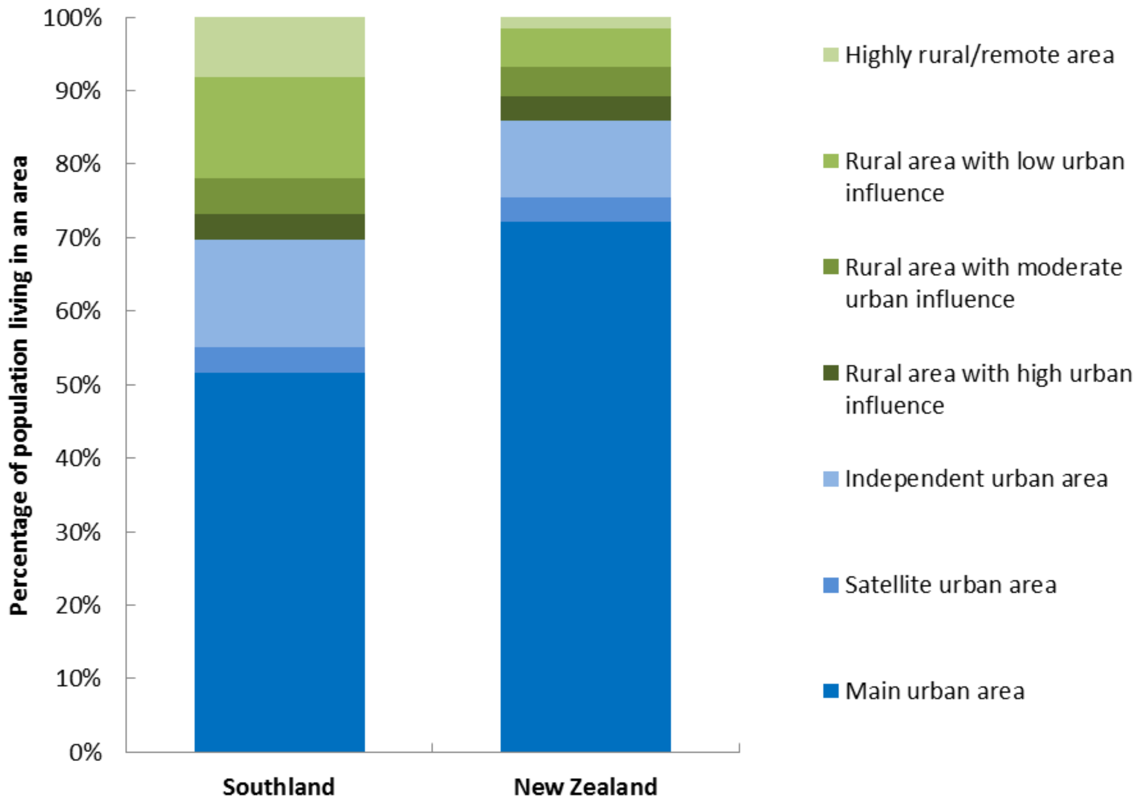


**Figure A5: Urban and rural profiles for Southland and New Zealand**
Source Statistics New Zealand

The relatively high proportion of people living rurally highlights strong urban and rural connections, with most towns supporting economic activity in their surrounding rural areas, and these rural areas reliant on the facilities, services, and amenities supplied in their local towns. It also means there is greater demand for wastewater, drinking water, stormwater services and transport networks across the region, relative to the ratepayer base – and these different types of essential infrastructure are often competing priorities.

The strong connections between urban and rural areas reflect the Southland economy's dependence on natural resources: primary sectors (e.g. agriculture, forestry, fishing, and mining), related processing, metal manufacturing, and tourism. Of these sectors, agriculture has always been central to the economy and tourism is becoming increasingly important. Figure A6 shows agriculture's share of regional GDP from 2001 to 2015, highlighting Southland and other southern regions, and also New Zealand as a whole[20].

[20] Agriculture's share does not include economic activity either up to or beyond 'the farm gate", which is considerable (i.e. interdependencies between agriculture and manufacturing, or agriculture and the service sectors of the economy, such as accountancy firms and farm suppliers).

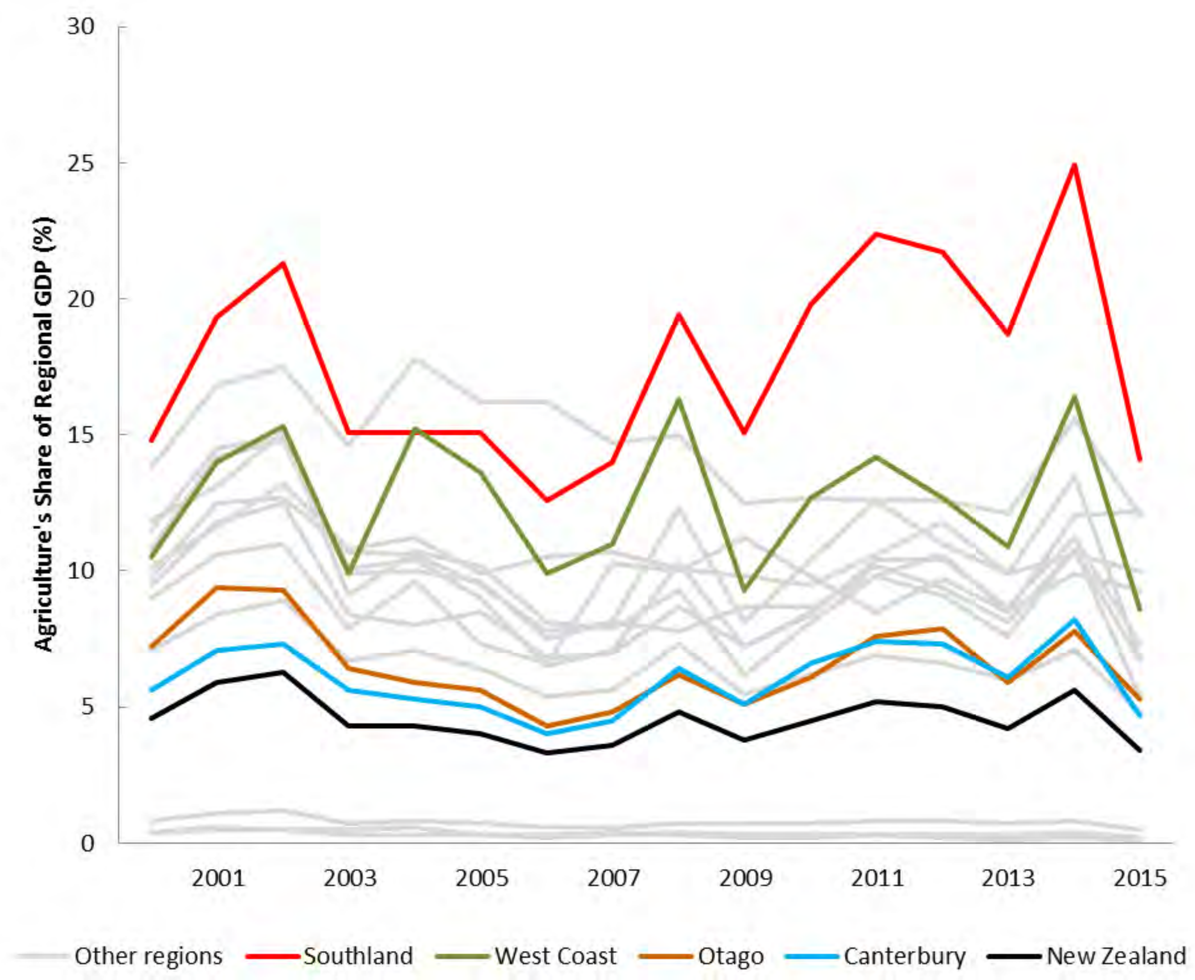


**Figure A6: Agriculture's share of regional GDP (2001 to 2015)**
Source Environment Southland using data sourced from MBIE and StatsNZ

Within the region, Southlanders live in one of three territorial areas: Southland District, Gore District and Invercargill City District. These districts were formed in 1989 under the Local Government Act 1974, and amalgamated a larger number of local authorities[21], including Wallace County, Southland County, Stewart Island County and Invercargill City[22]. Before 1989 county councils were responsible for all facilities and services in county towns (e.g. Te Anau, Otautau, Oban, Edendale, Tuatapere, Ohai, Nightcaps, Mossburn) and rural districts. Larger towns were usually boroughs (e.g. Winton, Riverton, Bluff, Gore, and Matāura) and had their own elected boards and were responsible for their own facilities and services. Figure A7 shows the extent of each of the three districts in Southland – collectively the boundaries of the three districts roughly fit within the regional boundary (there are some places e.g. the Kaiwera Stream where they do not align). Invercargill City District and Gore

[21] This system of local government was created under the Municipal Corporations Act 1876 and the Counties Act 1876. The Counties Act 1876 replaced a system of provincial government that had existed since 1853. During the period between 1853 and 1876, Southland was part of the province of Otago, separated from Otago in 1861, and re-joined Otago in 1870. Southland became a region in 1989.

[22] There were a number of other authorities that merged or disappeared at that time: Southland Catchment Board; Southland Harbour Board; Southland United Council; Southland Pest Destruction Board; and two River Boards (Otautau and Waimatuku).

District are either largely urban or rural areas with high urban influence, while Southland District is largely rural or remote areas. Southland's largest urban areas, Invercargill and Gore, are dependent on the fortunes of its primary sectors.

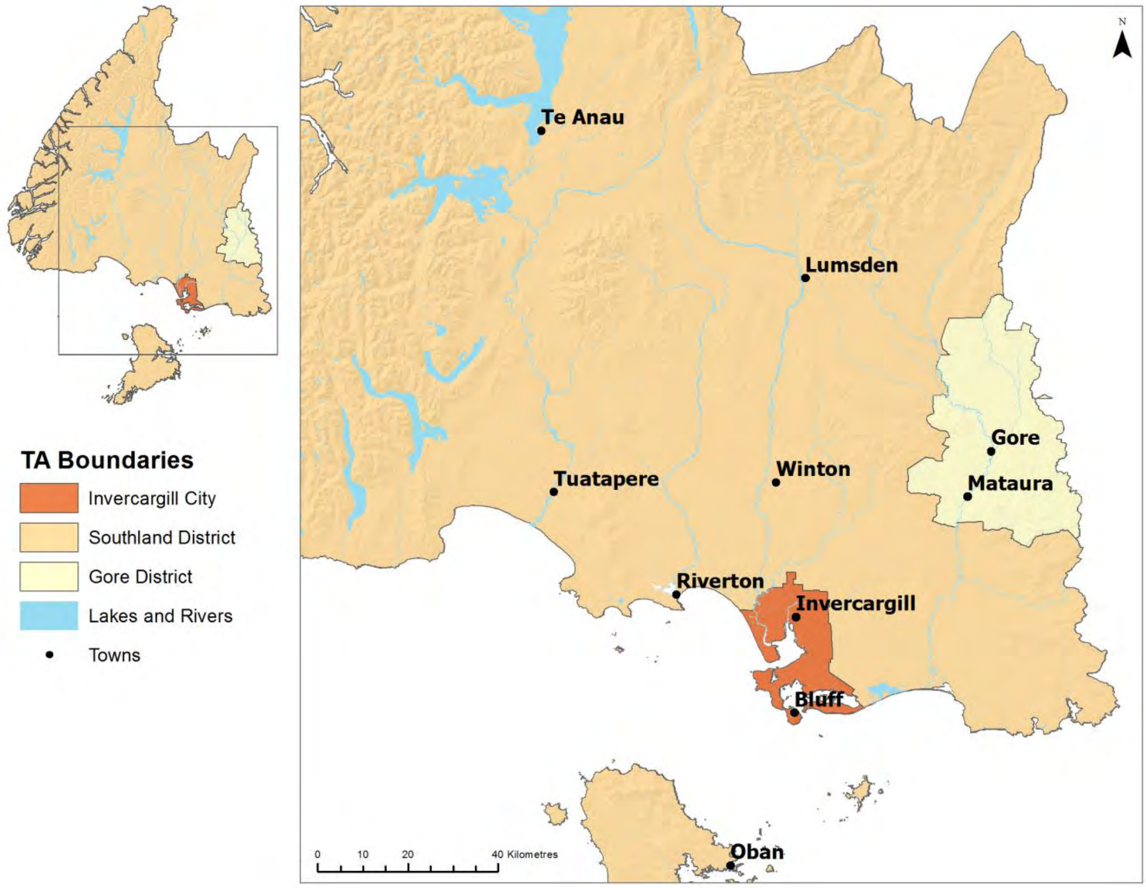


**Figure A7: Territorial authority areas focussed on the developed land in Southland**
Source Environment Southland

As a region, there are slightly more Southlanders under the age of 15 and over the age of 65, and those Southlanders who are over the age of 15 are more likely to be employed than New Zealanders as a whole. In 2013 the median age of people in the region was just under 40 years, with 21 percent of people under the age of 15 and 16 percent over the age of 65 years. The proportion of people in the labour market was 70 percent and unemployment was 4.7 percent. Southlanders typically also have low to moderate incomes[23]. In 2013 people aged 15 years and over had a median personal income of $29,500, with 35 percent of people earning $20,000 or less and 25 percent earning $50,000 or more. As a region there is less income inequality in Southland than New Zealand as a whole, but there is considerable variation between localities (discussed further in Part B, Section 1.2).

[23] In New Zealand in 2013, the median age was 38 years, with 20% under the age of 15 and 14% over the age of 65 years. The unemployment rate was 7.1% and the median personal income was $28,500.

Around 70 percent of Southland households either owned their own home or held it in a trust, and for those that do not, the median rent per household was $180. Average household size was 2.4 people – although more than 10,000 households (or 27.5%) were one person only. All of these characteristics – population size, employment, income distribution, home ownership, and household size – influence the demand for, and supply of, essential services across Southland.

Southlanders work in a small, narrow-based economy. In 2016, the value of goods and services, or total regional Gross Domestic Product (GDP)[24], was just over $5 billion. Although GDP fluctuates over time, $5 billion is a fair indication of the size of the part of the economy for which there are markets for goods and services, such as construction materials, restaurant dining and interest payments. This amount does not include the value of non-market goods and services, like volunteerism, fresh water or bee pollination – which also fluctuate. Figure A8 shows the annual percentage change in regional GDP from one year to the next over this time period. Regional GDP is used here because it is a well-known indicator (with well-known limitations[25]) and there is a lack of alternatives, particularly at a regional scale. It needs to be used with other measures to understand the whole economy, its sustainability and contribution to community outcomes.

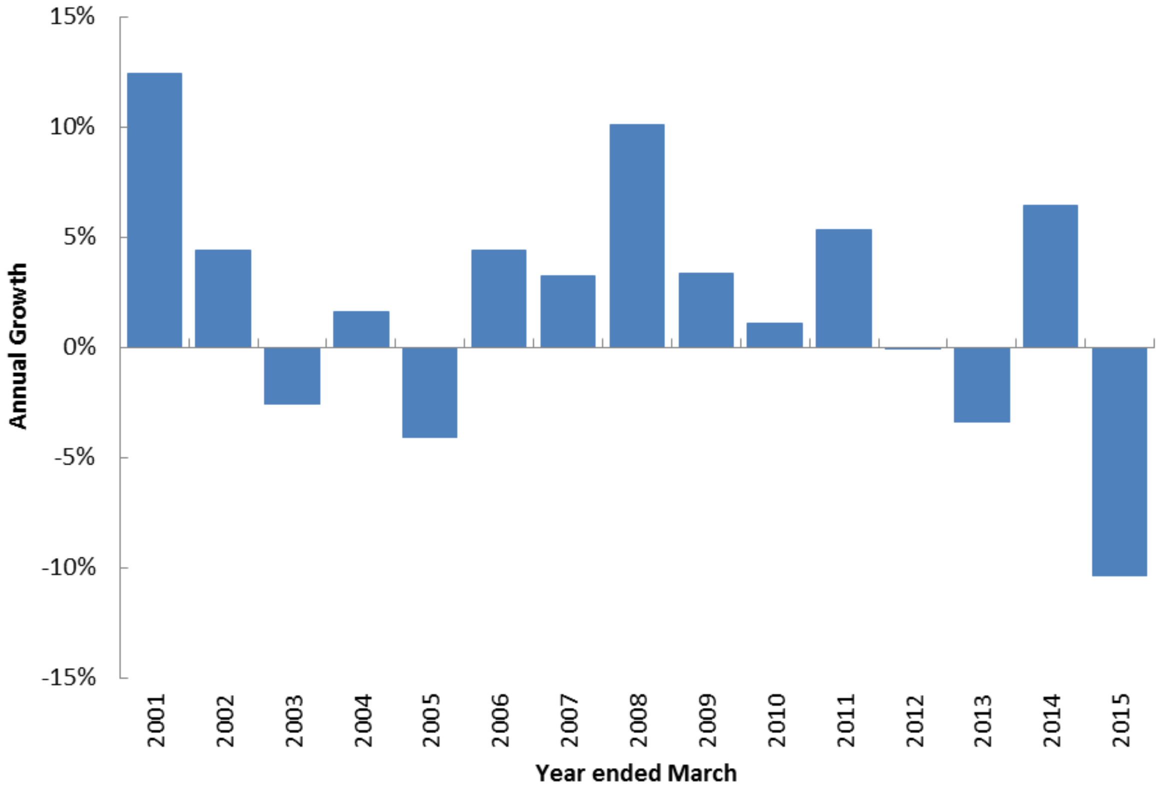


**Figure A8: Percentage growth in real GDP for Southland (2001 to 2015)**
Source: StatsNZ Regional GDP series, RBNZ M1 series

[24] GDP is a partial measure of economic activity, calculated as the financial value of transactions for goods produced and services provided in the economy over a specific time period.
[25] For a full discussion on the limits of gross domestic product refer to the Report by the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz *et al*., 2009).

Southland's economy has two main features that single it out from other regional economies around New Zealand. First, it is a considerable distance from New Zealand's three main urban centres: Auckland, Wellington and Christchurch. Distance is a factor in the region's low population density. Second, it is almost completely reliant on the use of natural resources, both directly and indirectly, and particularly the use of water. Southland's natural resources attract people to the region because of their contribution to living standards, whether it is through the production of food or raw materials or through recreation, health, tourism, and sense of place. To date, the economy has focused on its primary sectors and related manufacturing sectors but it is increasingly developing its service sector.

These two features (distance and reliance on natural resources) both constrain Southland's economy and provide it with opportunities. Despite (or possibly because of) its distance from the major urban centres, the region has looked further afield and produced products based on natural resources for export: pastoral farming and meat and milk processing, forestry and timber processing, hydro-electricity generation and metal processing, and tourism. These exports have a value to New Zealand in terms of its balance of trade but also expose Southland's economy to external forces, particularly changes in the exchange rate, commodity prices and market access.

Southland's economy is not expected to change, at least over the short to medium-term – it is closely aligned with economic activities that have high water use (both in terms of takes and waste substances), and economic growth is increasing pressure on water resources (Market Economics, 2013). A full analysis of Southland's economy is available in Part 1 of *Southland Region: Regional Economic Profile and Significant Water Issues* (Market Economics, 2013)[26]. In summary, the region's water, land and its people are all highly connected. The environment has less capacity to attenuate waste substances than in the past and people are putting more pressure on the environment. Together, these two factors are likely to mean Southland's economy is becoming less sustainable over time.

## 1.4. Freshwater Management Units

Under the National Policy Statement for Freshwater Management (2017), an important step towards setting limits for water in Southland was to divide the region spatially into five freshwater management units (or FMUs) around its water bodies. These units are the geographical areas where limits on water use will be set and existing use may need to change. These limits will be designed around the community's values for water, including ecosystem health and human health. These two values are compulsory for all water bodies across New Zealand under the National Policy Statement for Freshwater Management (2017).

Freshwater management in Southland will consider and recognise Te Mana o te Wai. Te Mana o te Wai is the integrated and holistic well-being of a freshwater body. Upholding Te Mana o te Wai acknowledges and protects the mauri (life force) of the water. In using water there must be

[26] This report was prepared by Market Economics for the Ministry for the Environment as part of its analysis of water policy decisions for the amendments made in 2014 to the National Policy Statement for Freshwater Management 2011.

provision for Te Hauora o te Taiao (the health of the environment), Te Hauora o te Wai (the health of the water body) and Te Hauora o te Tangata (the health of the people).

Running from West to East, Southland's five FMUs are: *Fiordland and Islands*; *Waiau – Waiau Lagoon*; *Aparima and Pourakino – Jacobs River Estuary*; *Ōreti and Waihōpai – New River Estuary*; and *Matāura – Toetoes Harbour*. Figure A9 shows the five FMUs that are described in the following sections. The Fiordland FMU covers western Fiordland and the offshore islands, including Stewart Island/Rakiura. It is predominantly land in natural vegetation held within national parks. The remaining four FMUs (Waiau, Aparima, Ōreti, and Matāura) are based broadly on Southland's four major river catchments – and each FMU also includes a number of smaller coastal river catchments that are not hydraulically connected to the main river in the area.

The coastal boundary of the Waiau, Aparima, Ōreti, and Matāura FMUs is at the mouths of the estuaries, while giving regard to the wider coastal environment through the use of existing monitoring sites. In contrast to the Fiordland FMU, these four FMUs are largely developed land and primarily agricultural and forestry – although 36 percent of the region's land in natural vegetation is located within these four FMUs. The four main river catchments that dominate these four FMUs were characterised in a series of water quality reviews completed for Environment Southland in the early 1990s. A similar assessment was completed at the time for Southland's coastline.

All of Southland's FMUs include Statutory Acknowledgements by the Crown under the Ngāi Tahu Claims Settlement Act 1998 and some FMUs also contain Water Conservation Orders (WCOs). The Ōreti and Matāura FMUs include the RAMSAR[27] Waituna-Awarua Wetland of International Importance. This wetland complex is a 20,000 hectare site (extending from New River Estuary to Waituna) with outstanding biological diversity and cultural values that consists of a coastal lagoon, peatlands, saltmarsh, gravel beach and shallow flats (with extensive eel grass beds), ponds, and lakes. The Fiordland and Waiau FMUs include Fiordland National Park, which is the southern end of the UNESCO[28] Te Wāhipounamu – South West New Zealand World Heritage Area.

The tables and maps in this section are based on the main land use activities occurring on a property:

**Urban:** Industry and Airports, Commercial, Residential, Road and Rail, Public Use (e.g. halls, schools);
**Sheep and Beef:** Sheep and Beef; Sheep; Beef; and Mixed Sheep, Beef and Deer;
**Dairy:** Dairy; Dairy Support; and Dairy Support and Other Livestock;
**Deer:** Mixed Sheep, Beef, and Deer (Majority Deer); and Specialist Deer;
**Arable:** Arable and Mixed Livestock; and Specialist Arable (but not crops grown for winter grazing);
**Other:** Livestock Support; Small Landholdings (5-40 hectares); Lifestyle (<5ha); Other Animals; Sheep Dairy; Horticulture; and Unknown Pasture; and
**Plantation Forestry:** Plantation Forestry (exotics); and Indigenous (native) Forestry.

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[27] The Ramsar Convention (The Convention on Wetlands of International Importance) is the intergovernmental treaty that gives a framework for the conservation and wise use of wetlands and their resources (http://www.ramsar.org/ ). The Waituna-Awarua Wetland Complex was designated as a wetland of international importance in 1976 - along with Farewell Spit, which was designated at the same time, it was the first of six such sites in New Zealand.

[28] The UNESCO (United Nations Educational, Scientific and Cultural Organisation) World Heritage Centre gives international recognition to sites of outstanding value to humanity. Te Wāhipounamu – South West New Zealand World Heritage Area was designated as a world heritage area in 1990 and extends over 2.6 million hectares - two-thirds of the park is covered with southern beech and podocarps, some of which are over 800 years old.


**Figure A9: Freshwater Management Units in Southland**
Source Environment Southland

### 1.4.1. Fiordland and Islands FMU

The Fiordland and Islands FMU extends over west Fiordland, Stewart Island/Rakiura and the region's outlying islands. This FMU covers an area of around 1,073,400 hectares (33.5% of the region), most of which is land managed by the Department of Conservation, and includes part of Fiordland National Park (which sits within Te Wāhipounamu – South West New Zealand World Heritage Area) and all of Rakiura National Park.

The FMU lies entirely within Southland District and is the least populated of the five FMUs in Southland, with 534 residents[29] (399 of whom live on 'The Island', as Stewart Island/Rakiura is known by many of the locals, and the remaining 135 people living in Fiordland or on other off-shore islands). The main towns are Milford Sound/Piopiotahi and Oban and there are a small number of water takes, wastewater and/or stormwater schemes (e.g. Milford Sound/Piopiotahi and Oban). Table A1 gives estimates of the extent of land use activities within the Fiordland and Islands FMU. Around 1,500 hectares, or 0.1 percent of the land, is developed as Fiordland and Stewart Island/Rakiura have few farms (mainly on off shore islands) and multiple tourism operations.

**Table A1: Agriculture, forestry and urban areas in the Fiordland and Islands FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)
The 'other' category covers livestock support, small landholdings and lifestyle blocks, other animals, horticulture, and 'unknown' pasture.

| Land Use | Total area of land use in FMU (ha) | Share of developed land in FMU | Share of total land use in region that is present in FMU | Number of properties in FMU |
|---|---|---|---|---|
| Urban | 414 | 27.6% | 0.9% | 543 |
| Sheep and beef | 592 | 39.5% | 0.1% | 6 |
| Dairy (incl. support) | 0 | 0% | 0.0% | 0 |
| Deer | 4 | 0.3% | 0.0% | 1 |
| Arable | 0 | 0% | 0.0% | 0 |
| Horticulture | 0 | 0% | 0.0% | 0 |
| Other | 489 | 32.6% | - | 55 |
| Forestry | 0 | 0% | 0.0% | 0 |
| **Totals** | **1,498** | **100.0%** | **0.1%** | **605** |

According to Ngāi Tahu tradition the fiords were formed by Tū Te Rakiwhānoa, who through a powerful karakia and his adze blade, carved the entire Fiordland coast. Milford Sound/Piopiotahi has great spiritual value for Māori - Piopiotahi refers to a lone piopio, a long-extinct native bird, who it is said flew to Milford Sound in mourning at the death of Maui. Milford Sound was also the destination of ancient Māori treks for a precious rare form of pounamu, tangiwai or bowenite. A Statutory Acknowledgement applies to Hananui (Mount Anglem), Lake Hauroko, Toi Toi Wetland,

[29] Statistics New Zealand (2013): numbers may vary as census meshblocks cross FMU boundaries so some may have been counted twice.

Whenua Hou and Tautoko as well as a tōpuni[30] for Tūtoko, to recognise the significance of these areas. Figure A10 shows the distribution of land uses within the Fiordland and Islands FMU.

The Fiordland FMU has numerous freshwater lakes and coastal water lakes (all natural state), including Lake Alabaster, Lake Hauroko, and Lake Poteriteri, Lake Mckerrow and Lake Hakapoua – all in Fiordland National Park. The seasonal influx of tourists to Milford Sound is at least 850,000 people (K. Murray, pers. comm., 2018) – up from 450,000 people in 2005 (Department of Conservation, 2007). Also, four of New Zealand's eight Great Walks (the Kepler, Milford, Routeburn and Rakiura Tracks) are in either Fiordland or Stewart Island/Rakiura and large numbers of people visit Southland for recreational tramping.

**Image A7: Milford Sound, Fiordland**
Source Simon Moran

[30] The concept of tōpuni comes from the traditional Ngāi Tahu tikanga (custom) of persons of rangatira status extending their mana and protection over a person or area by placing their cloak over them or it. A tōpuni now confirms and places an 'overlay' of Ngāi Tahu values on specific pieces of land managed by DOC.

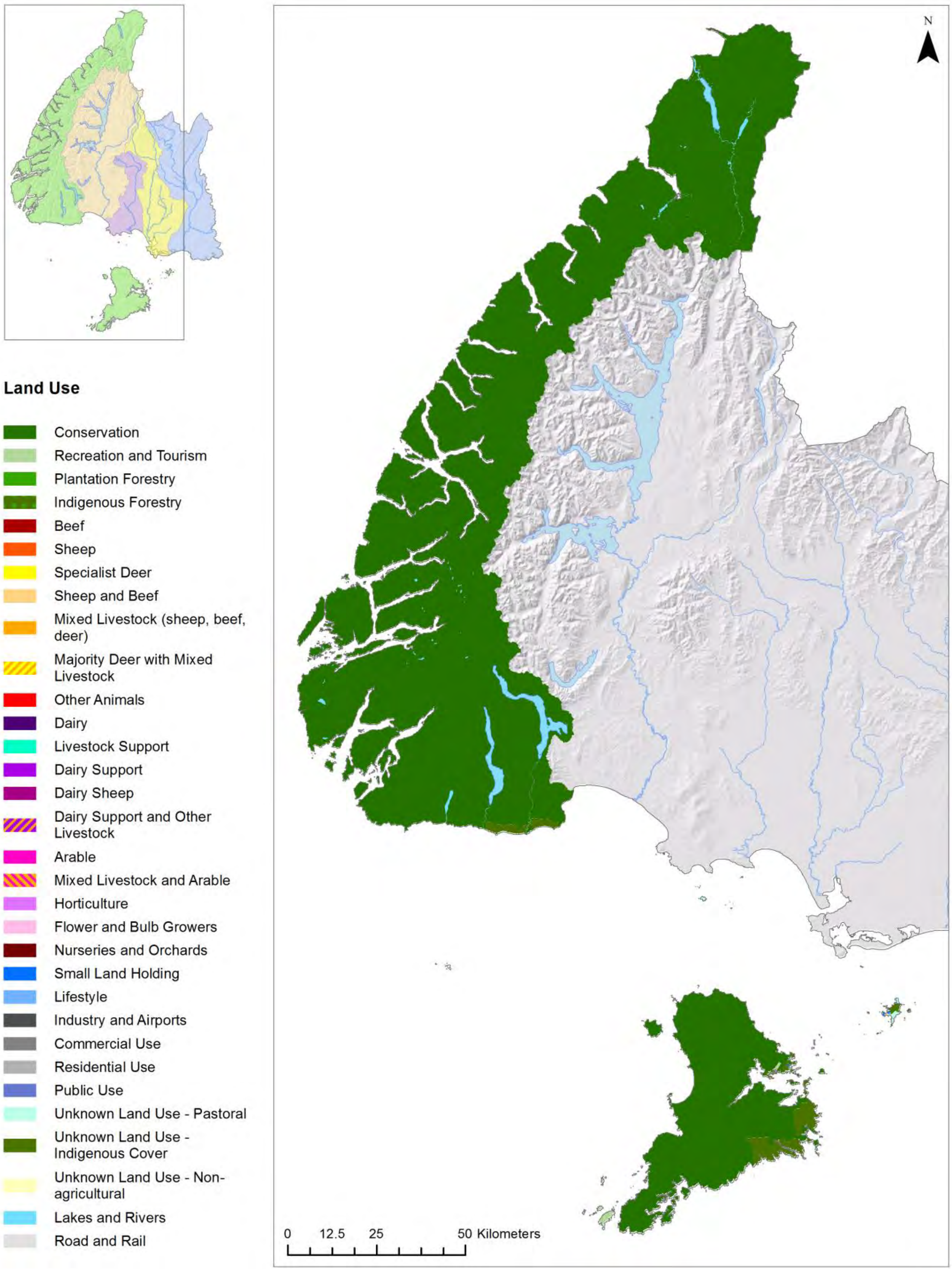


**Figure A10: Land use within the Fiordland and Islands FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

### 1.4.2. Waiau FMU

The Waiau FMU covers around 862,700 hectares (26.9% of the region) and is the largest of the four main developed FMUs in Southland. It contains a large amount of public conservation land, including part of Fiordland National Park in the west (which sits within Te Wāhipounamu – South West New Zealand World Heritage Area) and the Tākitimu Conservation Area in the east. Around 240,000 hectares or 28 percent of the FMU is developed land. The FMU lies entirely within the Southland District, there are around 5,044 residents (or less than 1 people/$km^2$) and a number of towns including Tuatapere, Te Anau, and Manapouri, with water takes, wastewater and/or stormwater schemes. The FMU contains tourism and large drystock properties, and a smaller area of dairy farming. Table A2 gives estimates of the extent of land use activities within the Waiau FMU.

**Table A2: Agriculture, forestry and urban areas in the Waiau FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

| Land Use | Total area of land use in FMU (ha) | Share of developed land in FMU | Share of total land use in region that is present in FMU | Number of properties in FMU |
|---|---|---|---|---|
| Urban | 13,764 | 5.8% | 29.9% | 3,173 |
| Sheep and beef | 148,113 | 61.9% | 19.4% | 272 |
| Dairy (incl. support) | 19,450 | 8.1% | 7.4% | 64 |
| Deer | 15,938 | 6.7% | 36.8% | 68 |
| Arable | 16 | 0.0% | 0.1% | 1 |
| Horticulture | 26 | 0.0% | 0.0% | 2 |
| Other | 9,805 | 4.1% | - | 397 |
| Forestry | 32,129 | 13.4% | 34.3% | 75 |
| **Total** | **239,242** | **100.0%** | **18.6%** | **4,052** |

The Waiau FMU includes Lake Te Anau, Lake Manapouri, Green Lake and Lake Monowai (large natural state lakes in Fiordland National Park), and fresh water that ends up in Te Waewae Lagoon. There is a Marine Mammal Sanctuary in Te Waewae Bay, and a strong whitebaiting community. The Waiau FMU also contains the Monowai and Manapouri hydroelectric power schemes. The Manapouri scheme has reduced the mean annual flow of the Waiau River below the Mararoa Weir from around 560 cumecs in the years before the scheme to 135 cumecs for the years between 2006 and 2016[31]. This reduction in flow is altering the environment in the Lower Waiau Catchment and Te Waewae Lagoon. A Statutory Acknowledgement applies to the Waiau River, Moturau (Lake Manapouri), Te Anau (Lake Te Anau), Manawapōpōre/Hikuraki (Mavora Lakes) and a tōpuni for the Tākitimu Range. The name Waiau (wai: water, au: current) comes from the swirling nature of its waters. The river was a major travel route for pounamu that connected Southland, Fiordland and the West Coast. Numerous archaeological sites and wāhi taonga are evidence of the history of

[31] In 2010 the Ministry for the Environment noted that the scheme takes water from the Waiau River and discharges it to sea in Deep Cove (Fiordland) constraining other water use and non-use values (Aqualinc, 2010). At this time the consented weekly allocation for this scheme accounted for over 40% of New Zealand's total weekly consumptive allocation.

occupation and use of the river by Ngāi Tahu and Ngāti Māmoe. Figure A11 shows the distribution of land uses within the Waiau FMU.

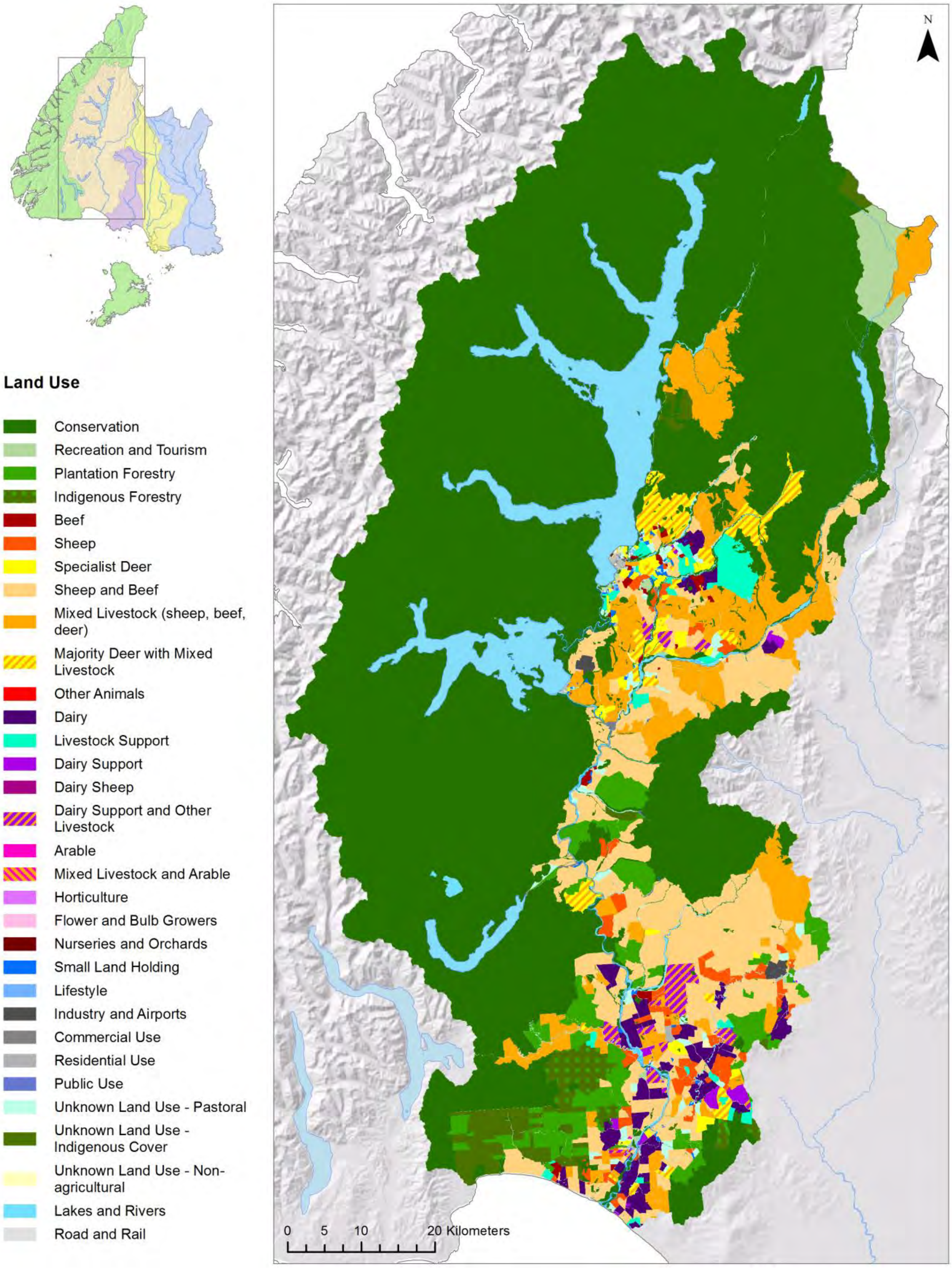


**Figure A11: Land use within the Waiau FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

### 1.4.3. Aparima FMU

The Aparima FMU covers around 206,700 hectares (6.5% of the region) and is a smaller FMU in comparison with the other FMUs in Southland. Around 168,000 hectares or 81 percent of the FMU is developed land and it also contains large areas of public conservation land. There is also a large beech forest management area in the Longwood Range (this area is part of the Waitutu Block Settlement Act 1997). The Aparima FMU lies entirely within Southland District and there are around 5,937 residents (2.9 people/$km^2$). The towns include Otautau, Drummond, Colac Bay and Riverton/Aparima and have domestic water takes, wastewater and/or stormwater schemes. The agricultural land consists mostly of dairy and drystock properties. Table A3 gives estimates of the extent of land use activities within the Aparima FMU.

**Table A3: Agriculture, forestry and urban areas in the Aparima FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

| Land Use | Total area of land use in FMU (ha) | Share of developed land in FMU | Share of total land use in region that is present in FMU | Number of properties in FMU |
|---|---|---|---|---|
| Urban | 4,163 | 2.5% | 9.1% | 2,802 |
| Sheep and beef | 68,616 | 40.9% | 9.0% | 353 |
| Dairy (incl. support) | 56,550 | 33.7% | 21.5% | 291 |
| Deer | 3,529 | 2.1% | 8.1% | 20 |
| Arable | 4,495 | 2.7% | 19.2% | 32 |
| Horticulture | 210 | 0.1% | 0.0 | 1 |
| Other | 6,977 | 4.2% | - | 533 |
| Forestry | 23,175 | 13.8% | 24.7% | 49 |
| **Total** | **167,715** | **100.0%** | **13.0%** | **4,081** |

The FMU includes Lake George, the Waimatuku Estuary and Aparima River, and Jacobs River Estuary. Jacobs River Estuary is a small base port for commercial fishing vessels and recreational vessels and is highly valued for mahinga kai and recreation. It is also the discharge point for Riverton's stormwater. Whitebaiting is highly valued within this FMU.

Aparima was named after the daughter of the rangatira Hekeia who was bequeathed all of the land that he could see as he stood on a spot at Otaitai, just north of Riverton (DoC, n.d). A Statutory Acknowledgement applies to the Aparima River and Uruwera (Lake George) and a Tōpuni for the Tākitimu Range.

The mouth of the river was a permanent settlement, with urupā (burial sites) and other archaeological sites nearby. It was also a tauranga waka (landing place) from which sea voyages were made to and from Te Ara a Kiwa, Rakiura and the tītī islands. The river is an important source of mahinga kai, particularly shellfish, tuna (eels) and inanga (whitebait) – an eel weir was built at the narrows where the Pourakino River enters the Aparima. The relationship of the Aparima River to the Tākitimu Hills is an important part of Ngāi Tahu's relationship to the river.

Figure A12 shows the distribution of land uses within the Aparima FMU.

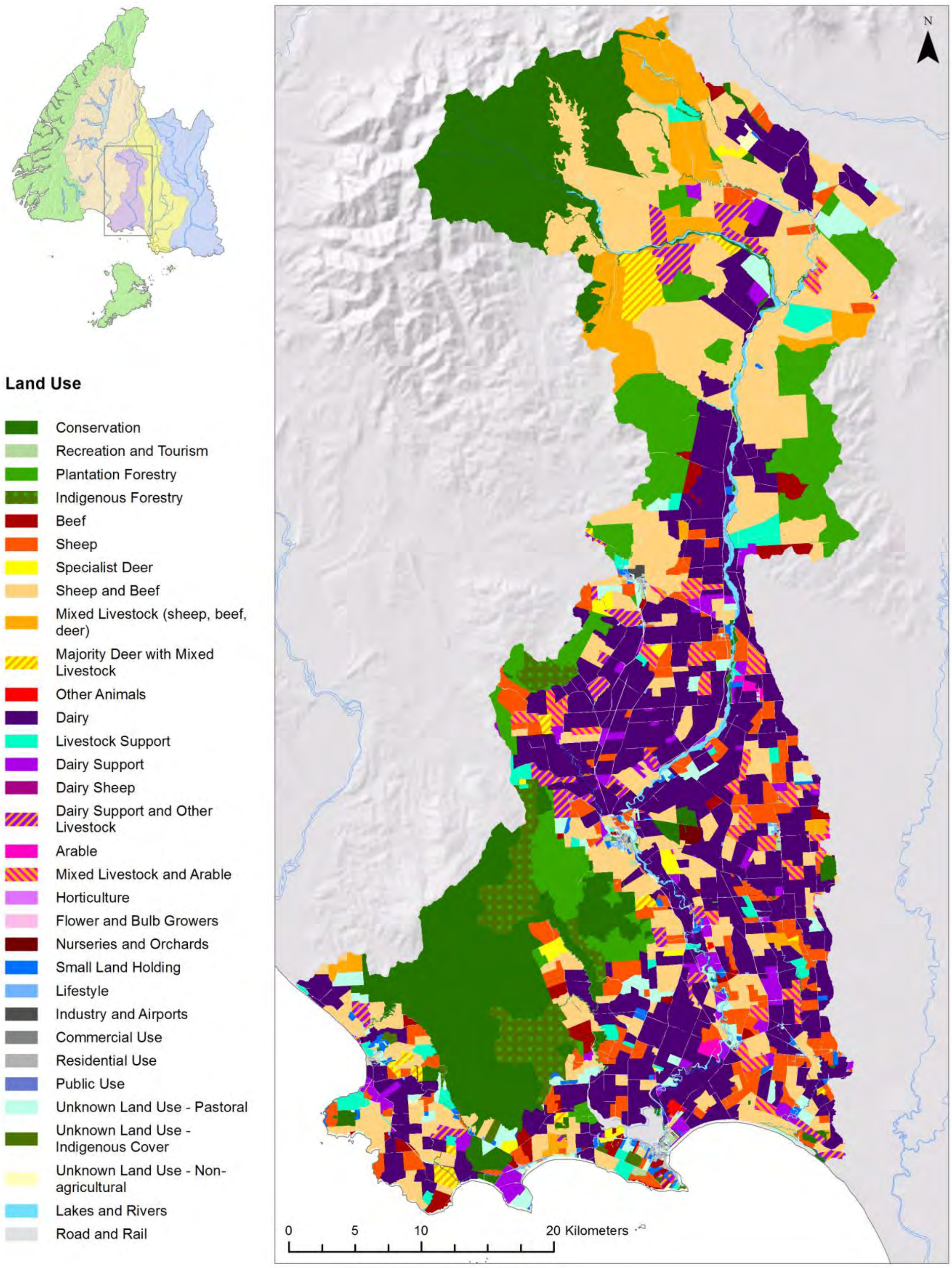


**Figure A12: Land use within the Aparima FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

### 1.4.4. Ōreti FMU

The Ōreti FMU covers around 420,400 hectares (13.1% of the region). Around 330,000 hectares or 78.5 percent is developed land and there are also large areas of public conservation land. The Ōreti is the only FMU that extends across all three districts: the Southland District, Invercargill City District, and a small part in Gore District. This FMU is by far the most populated in the region, with around 61,264 residents (or 14.6 people/km$^2$) mostly concentrated in and around Invercargill. Other towns include Lumsden, Browns, Waikaia, Waianiwa, Wallacetown, Winton, and Bluff – most of which have water takes, wastewater and/or stormwater schemes. The agricultural land is primarily dairy farming in the south and a mix of pastoral properties in the north. Table A4 gives estimates of the extent of land use activities within the Ōreti FMU.

**Table A4: Agriculture, forestry and urban areas in the Ōreti FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

| Land Use | Total area of land use in FMU (ha) | Share of developed land in FMU | Share of total land use in region that is present in FMU | Number of properties in FMU |
|---|---|---|---|---|
| Urban | 17,221 | 5.2% | 37.5% | 25,671 |
| Sheep and beef | 152,156 | 46.1% | 20.0% | 1,091 |
| Dairy (incl. support) | 100,198 | 30.3% | 38.1% | 541 |
| Deer | 10,538 | 3.2% | 24.3% | 94 |
| Arable | 6,376 | 1.9% | 27.2% | 62 |
| Horticulture | 245 | 0.1% | 48.8% | 9 |
| Other | 23,595 | 7.1% | - | 2,890 |
| Forestry | 19,923 | 6.0% | 21.7% | 114 |
| **Total** | **330,253** | **100.0%** | **25.6%** | **30,472** |

Fresh water from the Ōreti ends up in New River Estuary, Bluff Harbour and Awarua Bay, which form part of the RAMSAR Waituna-Awarua Wetland of International Importance. New River Estuary originally covered more than 6,209 hectares but since European settlement an estimated area of 1,652 hectares has been reclaimed and the estuary's current area is 4,557 hectares (roughly 27% less than its original extent). The estuary directly and indirectly receives discharges from Invercargill's wastewater and stormwater schemes. The current total area of the estuary is 4,560 hectares, and an estimated 1,650 hectares has been reclaimed. The reclaimed land contains Invercargill's airport, a closed landfill, an industrial area and farm land. There is a Water Conservation Order (2008) for the Ōreti River, covering 'specific waters' in the Ōreti catchment. The river provides a habitat for brown trout, black-billed gulls and an angling amenity. The direct Māori translation of Ōreti is obscure but it may relate to it being a place to snare.

A Statutory Acknowledgement applies to the Ōreti River and Motupōhue (Bluff Hill), as well as a tōpuni for Motupōhue. The Ōreti River forms one of the main pounamu trails from inland Murihiku to the coast. There are many archaeological sites in the upper catchment, including some relating to stone resources that are amongst the oldest in New Zealand. Figure A13 shows the distribution of land uses within the Ōreti FMU.

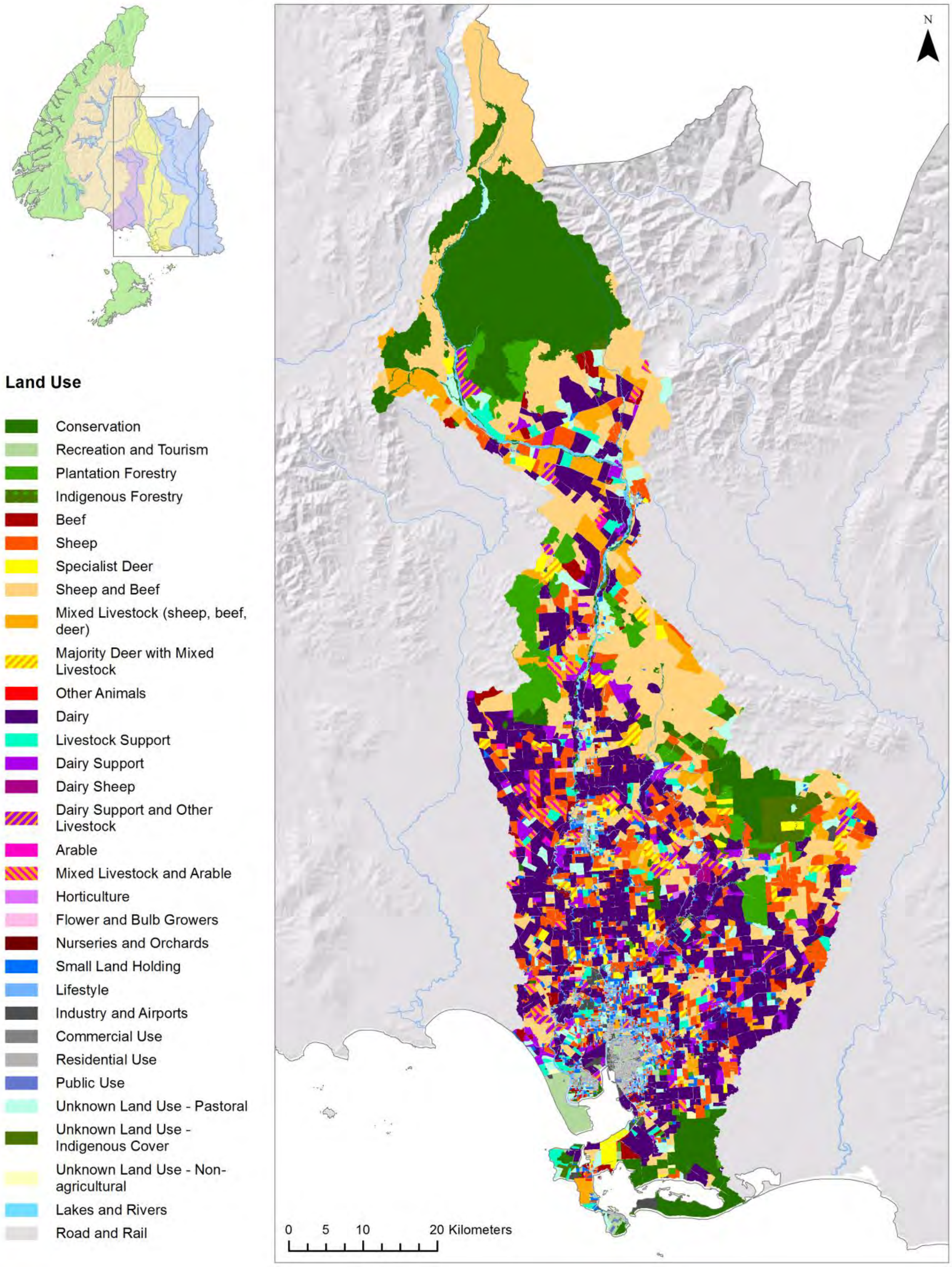


**Figure A13: Land use within the Ōreti FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

### 1.4.5. Matāura FMU

The Matāura FMU covers around 640,000 hectares (20.0% of the region) and it is the second largest developed FMU in Southland. Around 550,500 hectares, or 86 percent of the land, is developed (the highest percentage of the five FMUs in the region) and there are also large areas of public conservation land. It is also the second most populated FMU with about 18,035 residents (or 2.8 people/km$^2$). The FMU lies within Southland and Gore Districts and towns include Edendale, Wyndham, Waikaia, Gore and Matāura with water takes, wastewater and/or stormwater schemes. The FMU has mostly dairy farming on the plains and a mix of drystock properties in the hills. It also includes several large high country stations that straddle the regional boundary with Otago that include Crown Pastoral Lease Land. Table A5 gives estimates of the extent of land use activities within the Matāura FMU.

**Table A5: Agriculture, forestry and urban areas in the Matāura FMU**
Source Southland Land Use Map, Pearson & Couldrey (2016)

| Land Use | Total area of land use in FMU (ha) | Share of developed land in FMU | Share of total land use in region that is present in FMU | Number of properties in FMU |
|---|---|---|---|---|
| Urban | 10,397 | 1.9% | 22.6% | 6,958 |
| Sheep and beef | 392,399 | 71.3% | 51.5% | 1,062 |
| Dairy (incl. support) | 87,083 | 15.8% | 33.1% | 471 |
| Deer | 13,294 | 2.4% | 30.7% | 35 |
| Arable | 12,522 | 2.3% | 53.5% | 66 |
| Horticulture | 232 | 0.0% | 46.1% | 10 |
| Other | 16,394 | 3.0% | - | 1,051 |
| Forestry | 18,139 | 3.3% | 19.4% | 87 |
| **Total** | **550,460** | **100.0%** | **42.7%** | **9,740** |

Waituna Lagoon is a sub-unit within this FMU and forms part of the RAMSAR Waituna-Awarua Wetland of International Importance. Lake Brunton is a shallow brackish coastal lagoon located in Waipapa Bay. This FMU has a strong whitebaiting community. Fresh water from the Matāura FMU ends up in a number of coastal environments, including Waituna Lagoon, Toetoes Harbour, Haldane Bay, Waikawa Harbour, Lake Brunton and Lake Vincent.

The Māori origin of the name 'Matāura' is unknown but it possibly means reddish, brown, or glowing face. A whaling station was established at the village of Toitois, now called Fortrose, on the edge of the estuary at the mouth of the Matāura River. The estuary was dubbed 'Toetoes Place' by the whalers and Toetoe was the name later given to the estuary/harbour and the bay.

There is a Water Conservation Order (1997) for the Matāura River to protect fisheries and angling amenity features. Statutory Acknowledgements recognise the significance of the Matāura River and Waituna Wetland. The Matāura River is linked to several important Ngāti Māmoe and Ngāi Tahu tūpuna. A freshwater mātaitai reserve recognises the importance of the river for customary food gathering. The Matāura Falls is an important source of kanakana and inanga (whitebait) and a feature of the cultural landscape. Toetoe estuary is a particularly important location for customary food gathering. Figure A14 shows the distribution of land uses within the Matāura FMU.

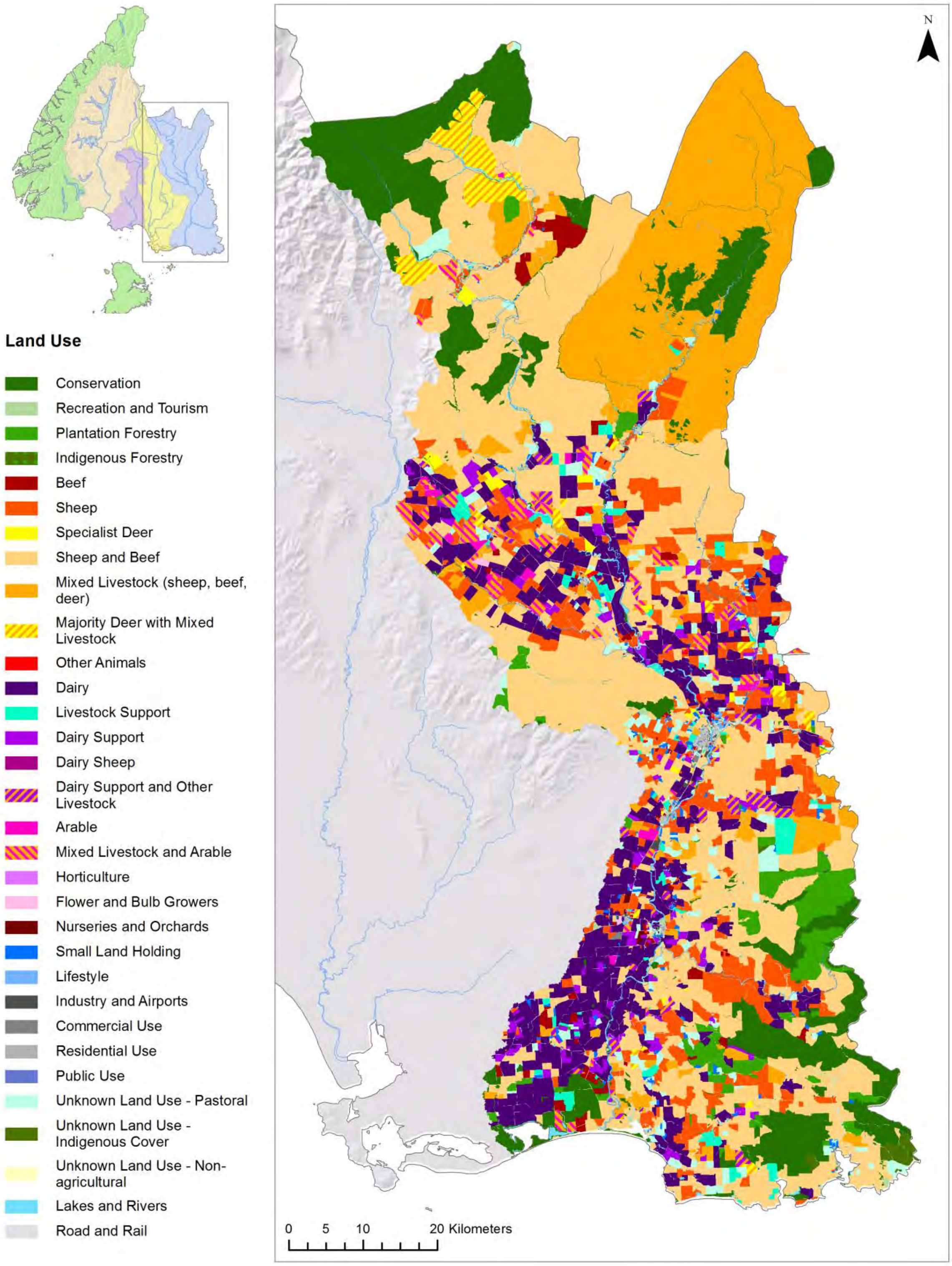


**Figure A14: Land use within the Matāura FMU**
Source: Southland Land Use Map, Pearson & Couldrey (2016)

# 2. Environmental Conditions

Environmental conditions influence how and where wastewater management can occur in Southland. Climate, soils and groundwater are both inputs into, and constraints on, wastewater treatment systems. The capacity of soils is used in some treatment systems to adsorb and naturally purify wastewater. Also, some local conditions can mean that wastewater treatment requires more management or that some treatment technologies are less viable.

How contaminants interact with the soil zone and vadose zone (the unsaturated zone above a water table) influences water quality. The ability of water to move through the soil depends on soil properties such as soil drainage. Topography is also an important factor in determining drainage and wastewater treatment options.

This section describes Southland's climate, soils and groundwater because of their importance to patterns of settlement (**Part B**) and wastewater treatment (**Parts B and C**). Rainfall, soil depth, soil texture, and depth to water table are particularly relevant because they are key factors in determining the viability of different wastewater treatment technologies.

## 2.1. Climate

Southland's climate is characterised by westerly airflows, a general eastwards progression of weather systems, and lower temperatures compared to regions further north. The climate has a major influence on the urban areas and industry, the volume and timing of streams of waste substances from these sources, and also the technologies available to manage them.

The interaction between the prevailing weather conditions and the mountainous terrain creates variation within the region. The Fiordland mountain ranges (e.g. Murchison, Darran, Cameron) act as a barrier to westerly airflows. Consequently, the area experiences extremely high rainfall as the maritime air rises and condenses. Areas to the east, especially north of the Hokonui Hills, receive relatively low rainfall, with inland valleys and basins more sheltered from the strong westerly winds prevalent along the region's south coast.

### 2.1.1. Temperature

Air temperatures show a small annual range in Southland, with July usually being the coldest month and January the warmest. The average annual variation in daily temperature range ($T_{max}$ to $T_{min}$) is about 9°C in Invercargill and Gore, increasing to around 10.5°C in Lumsden and Manapouri (Macara, 2013). Variation in temperature tends to be less in low elevation coastal areas because of the sea's moderating effect.

Winters in Southland can be severe by New Zealand standards. The mean maximum temperature in Invercargill in July is only 9.5°C, compared with 11.3°C in Christchurch and 14.7°C in Auckland (Grant, Updated 2015). Frosts occur relatively frequently across most of Southland, particularly in the inland basins. Between 1981 and 2010, an average of 104 ground frosts per year was recorded in Invercargill.

In addition to frost, snowfalls also occur occasionally in lower elevation areas of Southland, usually only settling for a day or two. Invercargill, on average experiences five days of snow per year (Macara, 2013). At higher elevations seasonal snowfields develop over winter. This accumulation of snow influences the volume of water in the major river systems with stable base flows during the winter months, followed by an extended period of elevated flows during the spring and early summer melt.

These climatic conditions can be a limiting factor to wastewater management across the region. Temperature affects biological reaction rates with less activity occurring in cooler temperatures (discussed further in Part C).

### 2.1.2. Sunshine Hours and Growing Degree Days

Southland receives relatively low annual sunshine hours compared to the rest of New Zealand. Invercargill has an average of 1,682 sunshine hours each year, compared with 2,003 hours in Auckland, and 2,142 in Christchurch (Grant, Updated 2015). South-western areas of Southland are particularly cloudy receiving less than 1,300 hours of sunshine annually. As with temperature, the amount of sunlight is also a limiting factor to wastewater management. Many micro-organisms are sensitive to sunlight - sunlight reduces micro-organisms in wastewater oxidation ponds and artificial ultraviolet (UV) radiation is also a common treatment method for reducing the health risks of micro-organisms in wastewater.

### 2.1.3. Rainfall

Weather patterns over southern New Zealand are characterised by westerly airflows and the general eastward progression of weather systems. Interaction between the prevailing weather conditions and the mountainous terrain results in strong variability in rainfall across Southland. This spatial variability occurs within the context of wider patterns of temporal variability, in particular the El Niño Southern Oscillation, and other factors such as sea surface temperature and natural oscillations in Pacific weather systems. Heavy or prolonged rainfall causes river flows to rise to a level which flushes away in-stream accumulations of periphyton (slime algae).

The mountains of Fiordland form a partial barrier to the prevailing westerly airflow and consequently receive extremely high rainfall totals. To the east, the topography of Southland is relatively complex with large mountain ranges separated by basins, river valleys and alluvial plains. This topography means that average precipitation on hills and ranges increases with elevation, but considerable spill-over and rain-shadow effects can occur in the inland basins. In general, the inland valleys of Northern Southland are relatively dry receiving only between 800 and 1,000 millimetres of rainfall per year.

The exposed location and channelling of air through Foveaux Strait mean the southern coastline experiences a high frequency of strong westerly winds. Along this coastline, limited shelter is afforded from the prevailing westerly conditions and consequently rainfall tends to be higher and slightly more frequent than areas further inland. Mean annual rainfall recorded in Southland ranges from around 700 millimetres in the Riversdale area (Matāura) to 6,500 mm/year at Milford Sound (Fiordland). Figure A15 shows the distribution of average annual rainfall across Southland.

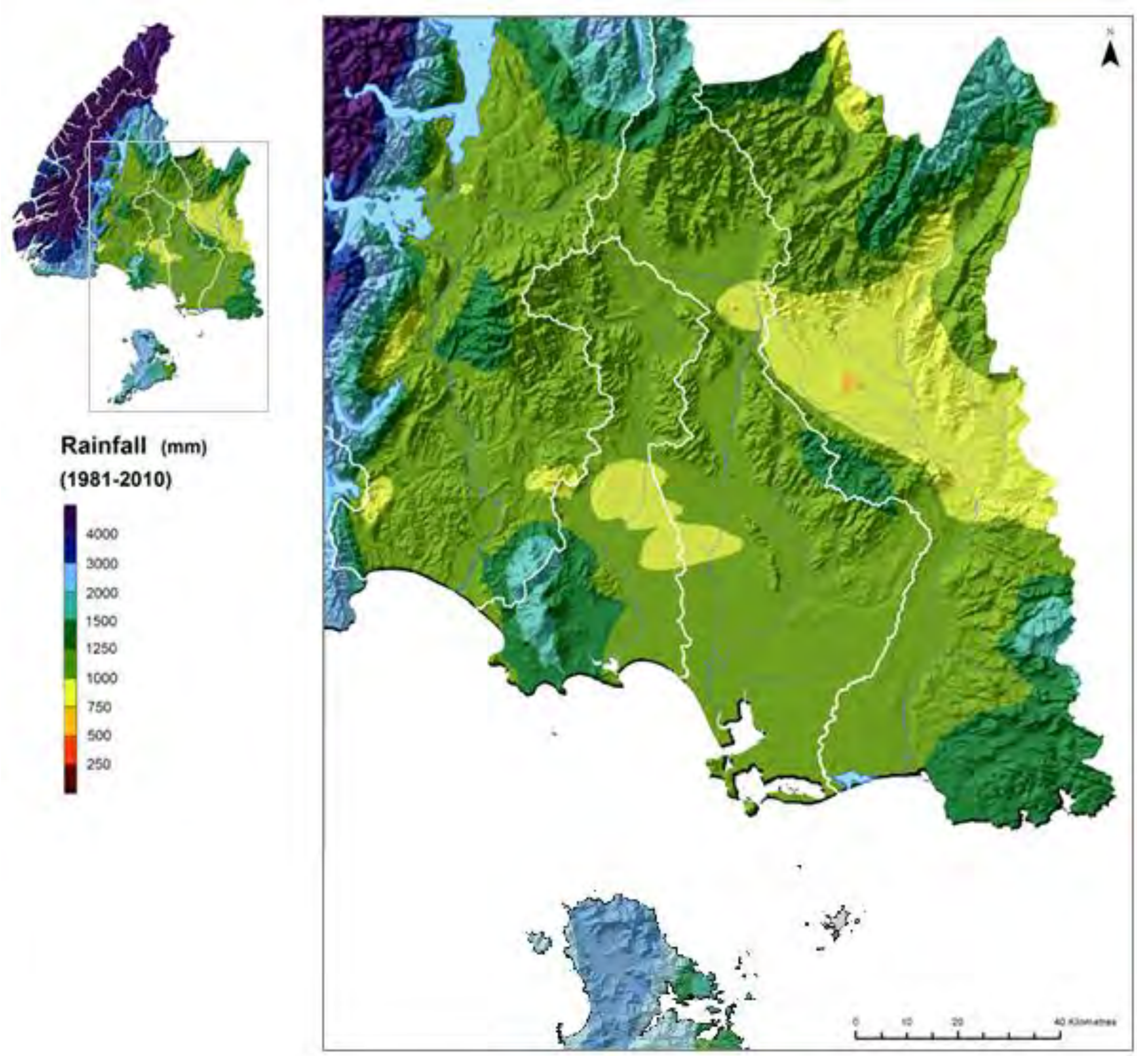


**Figure A15: Average annual rainfall map for developed land in Southland 1981-2010**
Source National Institute of Water and Atmospheric Research (NIWA)
Note: The white lines on the map indicate the Freshwater Management Unit (FMU) boundaries discussed in Section 1.4.

Compared to the rest of New Zealand, variation of rain days (more than 0.1 mm/day) and wet days (more than 1 mm/day) between seasons in Southland is relatively small. Monthly rainfall totals are generally highest in late spring and early summer (October to January), influenced in part by prevailing westerly air flows. Rainfall patterns and snow-melt from alpine headwaters mean that monthly river flows are generally highest during spring. Contaminant concentrations can be diluted in water bodies which are fed by pristine snow-melt.

More southerly air flows during the winter months bring drier air and lower rainfall (July is generally the driest month). Coastal areas of Southland generally experience frequent rainfall with between 140 and 160 wet days per year (greater than 1 millimetres per day) occurring over much of the

Southland Plains. Rainfall frequency increases to more than 200 wet days per year along the south coast and decreases to less than 130 days per year north of the Hokonui Hills.

Southland also experiences episodes of high rainfall, typically related to the passage of westerly fronts over the region during the summer and autumn months. During such events 24-hour rainfall totals may be more than 25 to 50 millimetres over a lot of the region, resulting in surface flooding and high flows in the major rivers and streams. Thunderstorms also occur in inland areas during the summer months, resulting in localised, intensive rainfall. Extreme rainfall events can overwhelm stormwater and wastewater systems. These events limit opportunities for maintenance, and increase the occurrences of infiltration of wastewater into stormwater (White *et al*., 2017).

### 2.1.4. Soil Moisture

Soil moisture typically is at or near field capacity[32] for extended durations over much of Southland, particularly on heavier soils in central, eastern and coastal Southland. Soil moisture in these areas may remain elevated for more than 150 days from late autumn through to spring. Over this period, soil temperatures are also low preventing uptake of nutrients for plant growth. Such conditions can limit natural processes within the soil (i.e. attenuation). They also increase the potential for losses of nutrients, sediment and micro-organisms via overland flow, artificial drainage and recharge to underlying aquifers.

Extended periods of elevated soil moisture levels may impact on denitrification and sorption rates, particularly in seasons where wetter and/or colder than average conditions arrive early or persist through spring. When soil moisture is elevated, excess water can drain down to the water table. This recharge to aquifers can cause groundwater levels to rise, increasing the contamination risk of leakage or failure of land disposal wastewater systems.

In general, Southland experiences a temperate climate with rainfall evenly distributed throughout the year and modest evapotranspiration rates. Parts of the region, particularly northern Southland and the Te Anau Basin, can experience periods of prolonged below average rainfall resulting in considerable soil moisture deficits (soils have different water holding capacities). These drought events are usually of limited duration and tend to impact on part of the growing season. Drought can disrupt gravity-fed wastewater systems by slowing flow and blocking pipes and can affect biological treatment processes, creating functional and safety concerns (White *et al*., 2017).

### 2.1.5. Wind

The exposed location and channelling of air through Foveaux Strait mean the southern coast experiences a high frequency of strong westerly winds. Invercargill is New Zealand's second windiest city, after Wellington, recording an average annual wind speed of 17 km/hour with an average of 48 days of strong winds (daily mean wind speed >30 km/hr) per year. Average wind speeds decline in inland areas reflecting the sheltering effects of the surrounding topography with

[32] Field Capacity is the state of the soil after rapid drainage has effectively ceased and the soil water content has become relatively stable (McLaren and Cameron, 1996).

Gore, Lumsden and Manapōuri all recording an average of less than 15 days of strong winds per year. The frequency of strong wind gusts (>60 km/hr) also decreases in inland areas compared to the south coast. Windy days in Southland tend to be seasonal, with between 30% and 40% of strong winds in spring and the lowest frequency of strong winds in winter (Macara, 2013).

**Image A8: Wind-wrought trees near Fortrose**
Source: David Moate

High wind, particularly in inland areas, may worsen seasonal soil moisture deficits and result in soil erosion. For wastewater treatment, wind strength and direction is important to determine the risk of drift of droplets from spray irrigation to sensitive receivers. This risk can be mitigated by irrigator selection and barriers. Wind can also influence evaporation and evapotranspiration and be an important aeration method for oxidation ponds.

### 2.1.6. Climate Change[33]

Current climatic conditions are changing – there are projected increases in temperature, overall precipitation (particularly over autumn and spring), and the frequency of dry days (especially in summer) that are all likely to have consequences for Southland's communities. These changing conditions will put biodiversity and the health of ecosystems under pressure. As well, sea level rise

[33] The main source for this section is Dr. Christian Zammit (Group Manager and Programme Leader - Hydrological Processes and Water Resources), National Institute of Water and Atmospheric Research (NIWA) and The Ministry for the Environment's summary of how climate change might affect Southland, available at: https://www.mfe.govt.nz/climate-change/how-climate-change-affects-nz/how-might-climate-change-affect-my-region/southland.

will increase flooding risks[34] – any land below three to five metres above mean sea level can generally be considered to be under threat (Environment Southland & Te Ao Mārama, 2011b). In 2006, it was estimated that just over 50,000 people (or 54% of the population in Southland) live within five kilometres of the coast (compared to 65% for New Zealand as a whole)[35]. The number of people living near the coastline is unlikely to have changed markedly.

Climate change is highlighted because of its relevance for the future outlook of towns and industries in Southland and for its potential impact on all water infrastructure. Most of Southland's towns and industries are located beside rivers and lakes or near the coastline, as is the region's critical infrastructure, including its commercial deepwater port (sited on reclaimed land at Bluff) and regional airport (sited on low lying reclaimed land beside the Waihōpai River and New River Estuary and protected by floodbanks).

The effects of climate change will put essential infrastructure at risk and key impacts have been identified for transport networks, electricity generation and transmission, water (including stormwater, flood protection and wastewater), and telecommunications (e.g. NZTA, 2009; PCE, 2015; Climate Change Adaptation Technical Working Group, 2017). An impact on any one of these services is expected to flow on to another because they are interconnected (MfE, 2017). For wastewater and stormwater, seawater may flow into stormwater pipes, impacting on drainage capability. More intense and frequent heavy rain events will also put pressure on land drainage, stormwater schemes and flood protection. There may be overloading of wastewater networks causing increases in overflows. There is also increased potential for inundation of pump stations located in low lying areas[36] (PCE, 2015).

Climate change projections depend on future levels of greenhouse gas emissions, which are uncertain. NIWA has simulated the four main global emission scenarios[37] for Southland up to 2120. These emission scenarios used different carbon emission levels (from low to high)[38] to predict changes in temperature and precipitation (rain and snow only[39]). The predicted changes for each scenario are calculated for the twenty years from 2031 to 2050 (referred to as 2040) and from 2081 to 2100 (referred to as 2090). Together the predicted changes across the four scenarios give a range of results that is then compared to what the climate was like from 1986 to 2005 (referred to as 1995).

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[34] The main effects are faster coastal erosion, increased seawater inundation, and drainage issues. Seawater inundation and impeded drainage can heighten the risks of freshwater flooding and its likelihood is directly related to height above sea level (Our Threats – ES).

[35] http://archive.stats.govt.nz/browse_for_stats/population/Migration/internal-migration/are-nzs-living-closer-to-coast.aspx

[36] More information on the possible effects of climate change on stormwater and wastewater is available https://motu.nz/our-work/environment-and-resources/climate-change-impacts/climate-change-and-stormwater-and-wastewater-systems/

[37] NIWA used a suite of regional climate models to simulate the emission scenarios, which technically are "radiative forcing" scenarios (known as "Representative Concentration Pathways"). Radiative forcing is the change in energy in the atmosphere as a result of greenhouse gas emissions.

[38] The four emission scenarios tested were a low emissions scenario, which involved the removal of some of the carbon dioxide ($CO_2$) (RCP2.6), two 'business as usual' scenarios with emissions stabilising in different time periods (RCP4.5 and RCP6.0), and a high emissions scenario (RCP8.5).

[39] Climate change models do not have the complexity required to predict hail as a component of the precipitation.

In Southland, the predicted changes in average temperatures tend to increase under each of the four emission scenarios. Compared to 1995, temperatures are likely to increase by between +0.6˚C and +0.9˚C by 2040, and between +0.7˚C and +2.8˚C by 2090. Southland is expected to become warmer, particularly during autumn and winter, and least in spring. By 2090, it is predicted that there will be up to 16 extra days a year where maximum temperatures are above 25˚C, with around 10 to 30 fewer frosts a year. The region is also likely to experience marked decreases in conditions that are favourable for seasonal snow (i.e. precipitation and temperature below 0 degrees)[40]. The number of snow days experienced annually could decrease by up to 30 days in parts of the region by the end of the century. The duration of snow cover is also likely to decrease, particularly at lower elevations. It is unknown whether there will be more or less snow.

A general increase of precipitation in Southland is highly likely this century. Unlike temperature, the predicted changes in average precipitation tend not to grow across the four emission scenarios. Compared to 1995, precipitation is likely to increase by between two percent and four percent by 2040, and between six percent and nine percent by 2090. Southland is expected to become wetter, particularly during winter and spring. Under the highest emissions scenario, extremely rainy days may become more frequent by 2090. The most common pattern of annual precipitation change is for an increase in the west-east gradient, peaking over the Southern Alps ridge. In Invercargill, winter rainfall is predicted to increase by 7 to 22 percent in Invercargill by 2090.

The frequency of dry days (where precipitation is below 1 mm/day) is also likely to increase, despite the general increase in precipitation – although in Fiordland the frequency of dry days is likely to decrease, reflecting an expected increase in the west-east gradient. These effects are likely to change the current seasonal precipitation patterns in the region. The frequency of extremely windy days in Southland is likely to increase by between two and seven percent by 2090. Changes in wind direction may lead to an increase in the frequency of westerly winds over the South Island, particularly in winter and spring. Future changes in the frequency of storms are likely to be small compared to natural inter-annual variability. Some increase in storm intensity, local wind extremes and thunderstorms is likely to occur.

Less winter snowfall (snow will be more limited to higher elevations) and an earlier spring melt may cause marked changes in the annual cycle of river flow in the region. Places that currently receive snow are likely to see increasing rainfall as snowlines rise to higher elevations due to rising temperatures. For rivers where the winter precipitation currently falls mainly as snow and is stored until the snowmelt season, there is the possibility for larger winter floods.

New Zealand tide records show an average rise in relative mean sea level of 1.7 millimetres a year over the 20th century. Globally, the rate of sea level rise has increased, and further rise is expected in the future[41]. It is projected that sea level rise globally will be 0.2–0.4 m by 2060 and 0.3–1.0 m by

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[40] Not taken into account in the analysis were other variables, such as wind, solar radiation and relative humidity, and also the volume of accumulated snow. An increase in precipitation could result in more snow but snowing often. The snow line will rise in altitude under climate change but it is likely that snow will still be present in Southland.

[41] The Ministry for the Environment's 2017 guidance on coastal hazards and climate change, including sea level rise is available at: https://www.mfe.govt.nz/publications/climate-change/preparing-coastal-change-summary-of-coastal-hazards-and-climate-change . The Ministry for the Environment's stocktake report on adapting to climate change in New Zealand is available at: http://www.mfe.govt.nz/sites/default/files/media/adapting-to-climate-change-stocktake-tag-report-final.pdf

2100 depending on the emission scenario. The collapse of parts of the Antarctic ice sheets could substantially increase this range and in New Zealand sea level rise could be up to 10 per cent more than the global average[42]. Statistics New Zealand now reports on coastal sea level rise as a national indicator within its environmental reporting series[43].

In Southland, climate change is expected to increase the risk of flooding, landslides and erosion. The capacity of stormwater schemes may be exceeded more frequently because of heavy rainfall events, which could lead to surface flooding, damage to infrastructure and road closures. Water security is most likely to be an issue in areas where drought is already a major constraint. Droughts are likely to increase in both intensity and duration over time. There is likely to be increased risk to coastal roads and infrastructure from coastal erosion and inundation, increased storminess and sea level rise.

## 2.2. Soils

Soils are an essential component of wastewater management systems and are a non-renewable resource because they take centuries to develop. Soil properties reflect the age, parent materials, climate, topography, and biological activity (micro-organisms and vegetation) in which the soil was formed under (Molloy & Christie, 1998). Soils are key factors in determining wastewater treatment options, where different options can occur in the landscape, and how treated wastewater flows from them to water. Soils treat wastewater in two ways: through their physical characteristics where contaminants are adsorbed or held immobile by minerals in the soil, and as a site for biological activity with organisms feeding on the organic matter (University of Nebraska, 2011).

The distribution of the soils, along with the climate, has driven land development and settlement in Southland. Overall, eleven New Zealand Soil Classification (NZSC) orders have been identified in Southland, which is a similar range to other regions within the South Island. The distribution of the soils, along with the climate, influences the suitability and efficacy of treatment systems types. Information on the main soil orders is contained in Appendix 1 of the Agriculture and Forestry Report (Moran *et al*., 2017), including:

- The New Zealand Soil Classification (Hewitt, 1993; Hewitt, 2010);
- A map showing the distribution of the eleven soil orders across Southland; and,
- A table of Southland's soils by series (local name), New Zealand Soil Classification, extent (hectares) and drainage class[44].

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[42] The extent to which New Zealand varies from the global average depends on whether more ice melts from the Greenland or Antarctic ice sheets (MfE, 2017). The melting of the Greenland ice sheet would result in New Zealand experiencing a greater sea level rise than the global average, while the reverse is true if melting is mainly from the Antarctic ice sheet. This effect is because gravitational attraction between ice and ocean water is reduced in the area around a melting ice sheet and land tends to rise as ice melts.

[43] More information on New Zealand's coastal sea level rise (relative to land) can be found at: http://archive.stats.govt.nz/browse_for_stats/environment/environmental-reporting-series/environmental-indicators/Home/Marine/coastal-sea-level-rise/coastal-sea-level-rise-archived-19-10-2017.aspx

[44] An interactive map of soils in the region can be found at http://gis.es.govt.nz using the TopoClimate soil maps. This can be used to get soil maps suitable for farm scale (± 100m) along with detailed report cards for each soil series.

There are areas of Southland where the nature of the soils (e.g. texture, depth, permeability and drainage) can be problematic for wastewater treatment and discharge. Areas with either low or high soil permeability (or drainage) can limit the treatment time and effectiveness. Clay soils will not readily transmit wastewater through the depth profile causing wastewater to drain through the soil profile very slowly. While this results in a high degree of treatment within the soil profile, the amount of wastewater applied per unit area is low, and so larger areas of land are needed. In free draining soils, wastewater can be transmitted quickly through the soil and vadose zones, receiving minimal treatment in the soil before reaching the underlying aquifer.

## 2.3. Groundwater

Shallow groundwater can influence the design, construction and management of wastewater systems. It is also a risk factor to public health as contamination of groundwater poses a risk to drinking water supplies and may increase the occurrence of algae blooms (MfE 2003; Christchurch City Council, 2005). In addition, wastewater systems can become overloaded by stormwater and shallow groundwater during wet weather, resulting in overflows and increasing the contamination risk of leakage or failure of the system.

In New Zealand, on-site effluent wastewater disposal fields have a minimum separation distance of 0.6 metres between the effluent discharge point and underlying groundwater table (MfE, 2008). The groundwater table is relatively shallow in Southland, with an estimated average depth of 4.1 metres below ground level. Generally, the groundwater table is shallowest along the margins of major river systems where the majority of towns are located, and deepest under terraces along the outer edges of river valleys. Between seasons and years groundwater depth can vary considerably and groundwater can be closer to the surface of the land. Figure A16 shows the general pattern of shallow to deep groundwater (i.e. the likely average depth to groundwater below the soil) across areas of Southland where groundwater is mapped. The map does not show the abundance or volume of groundwater resources.

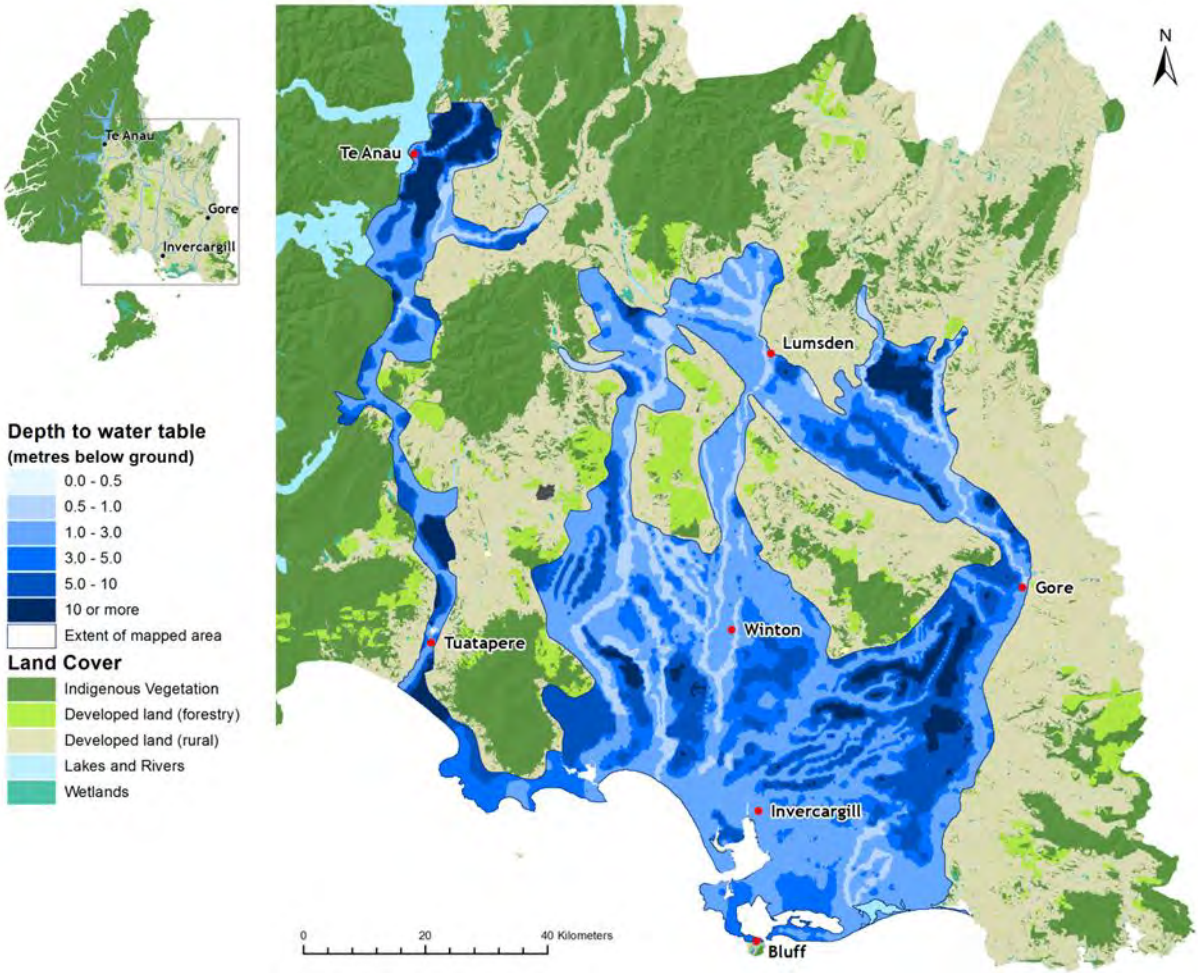


**Figure A16: Depth to the groundwater table in areas where groundwater is mapped**
Source Ogilvie *et al*. (2013)

The areas in Southland with the highest risk to groundwater quality tend to occur where there are thin, permeable (well drained) soils and a shallow water table. The areas in the region with thicker, less permeable soils and a deeper water table have the lowest risk. For example, in the Te Anau Basin, in those areas where there are thin soils overlying gravel moraine and deeper groundwater, the risk to groundwater is medium based on these factors. Most of the main towns are located in areas which have medium to high risk to groundwater. Figure A17 indicates the relative potential risk to groundwater quality within the region from on-site wastewater treatment systems. This map also gives a reasonable indication of the groundwater risk for discharges to land from municipal wastewater treatment systems. There are other factors that are also relevant to the suitability of land for wastewater but not discussed here, such as the potential risk to surface water quality.

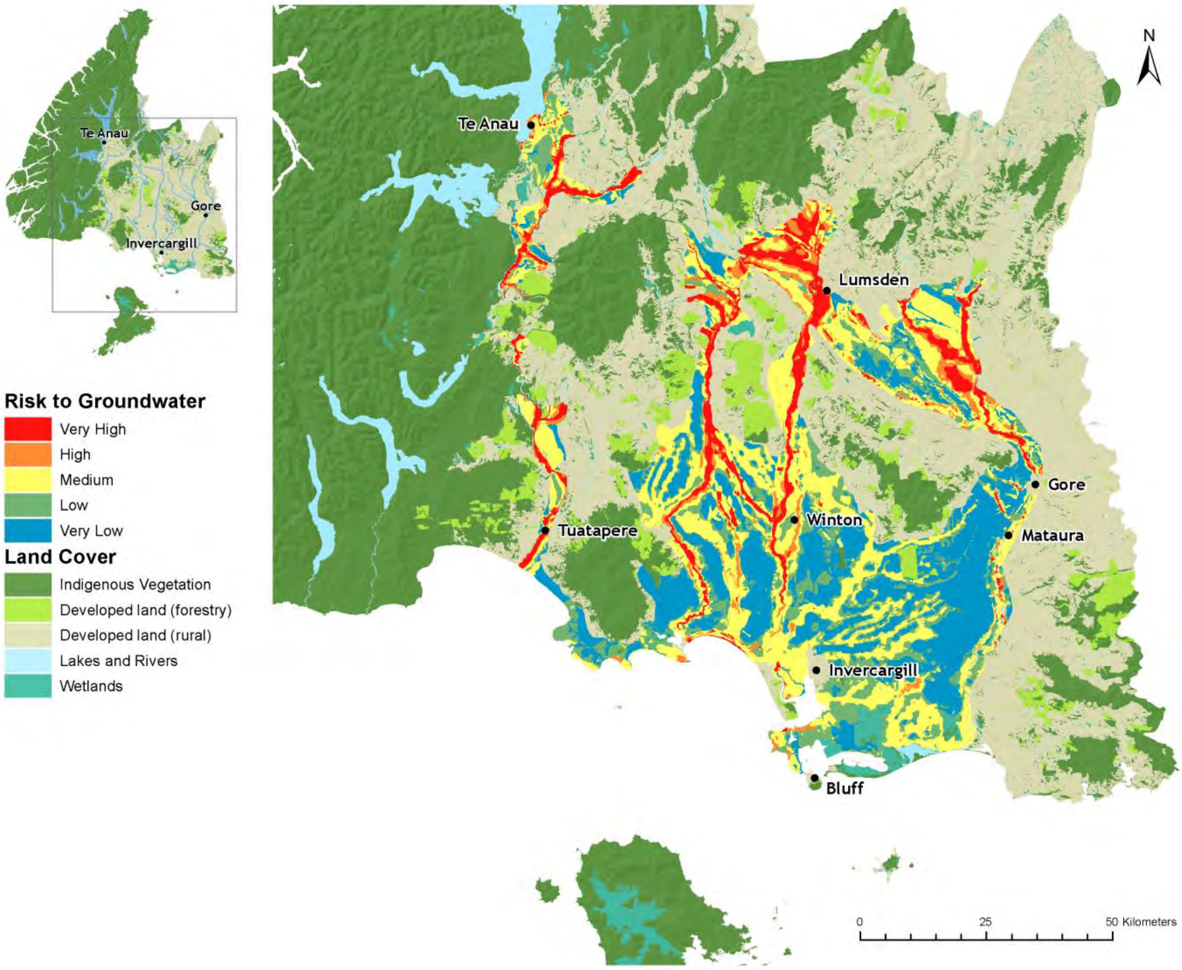


**Figure A17: Risk to groundwater quality from on-site wastewater disposal**
Source Ogilvie *et al*. (2013)

# Part B: Towns and Industry

**Part B** gives an overview of towns and industries in Southland. It builds on the outline of Southland in **Part A** and describes the wider setting for the eight case studies in **Part C**. This context in **Parts A and B** gives the 'lie of the land', which is helpful for understanding the research in **Part C**. In particular, **Part B** describes some of the background, connections and diversity of urban areas and industry within the region, which shaped the methodology and results. It underlines the importance of the specific circumstances relating to each town, and each wastewater scheme, when thinking about this research.

**Part B** is made up of five sections:

**Section 1** is a general introduction to towns in Southland, and includes a description of their settlement, some broad characteristics, and the municipal services relating to water (wastewater, stormwater water and water supply).

**Section 2** to **Section 4** consider in turn each of the three districts and, more specifically, the towns within each district that were used as case studies in this research. These towns were: Gore, Matāura, Winton, Nightcaps, Ohai, Te Anau, Invercargill, and Bluff.

**Section 5** describes the development of the main processing and manufacturing industries in Southland: meat, milk, wood and timber, metal processing, mineral extraction and hydro-electricity generation. It also lists the industries in the region with consents relating to wastewater.

"A nation that forgets its past can expect no future."

**Winston Churchill**

## 1. Southland's Towns

This section describes patterns of town settlement across Southland. Where a town is located determines its topography, soils, subsoils, climate, and water bodies within the vicinity. These characteristics in turn shape the nature of the town's wastewater infrastructure, and its other essential services, such as roading, water supply, flood protection and stormwater. Location has some bearing on the length of history of a town, and so the age of much of its essential infrastructure. It also determines a town's receiving environment, both within its locality and downstream, and how it is affected by water takes and discharges upstream. In most cases, the region's towns were not planned settlements and they evolved over time.

This section also outlines some broad characteristics of Southland towns – highlighting connections between wastewater and stormwater, flood protection and transport networks – and also within the environment and the economy. These other services are relevant because delivery of all of a town's essential services is strongly interconnected. For example, land transport (e.g. roading, bridges and culverts) can constrain wastewater and stormwater in both a physical sense (i.e. creating barriers) and a financial sense (i.e. competing priorities). The interconnections are important in Southland because the region has an extensive roading network, high rainfall, and long, narrow river catchments.

It then identifies those towns with municipal wastewater, stormwater and potable (drinkable) water supply schemes. Finally, the section outlines the development of wastewater schemes, using three Southland towns as examples (although not those included as case study research).

## 1.1. Town Settlement

Early Māori migration to Murihiku (Southland) began almost 1,000 years ago. Since this time, human settlement along the coastline and inland has been constantly changing. Even in the past 200 years there have been long periods of expansion and consolidation in the number and size of towns. Throughout this history, settlement has largely followed patterns of natural resources (both in the ocean and on the land) and ease of access. With the arrival of Europeans, settlement traced land development – which was influenced by factors such as a supply of willing settlers, access to water, a supply of available land, and the effort needed to develop it. The evolution of complex transport networks has influenced land development and settlement across the region.

The location of towns in Southland determines the demand for essential drinking water, wastewater, and stormwater services, and also the transport networks that connect these towns and their surrounding rural areas. The supply of these essential services is a sizable investment for local communities but they make it possible for people to live and work together (i.e. support development). Where the services are delivered sustainably (in all of its components – financially, socially, culturally, and environmentally) they contribute to a community's wellbeing.

The first people to journey to and settle in Murihiku were Waitaha, Ngāti Mamoe and then Ngāi Tahu in succession[1]. The southern coastline was attractive as a place to site settlements, including pā (fortified settlements[2]). It was particularly important as a source of mahinga kai (customary food gathering sites) and kaika (villages) were situated near food gathering places and canoe landing sites (Robertson, 1993). The coast was also a major highway and trade route, especially where travelling over land was challenging. Prominent headlands were favoured for their defensive qualities. Through conflict and allegiance, iwi merged in the whakapapa (genealogy) of Ngāi Tahu Whanui. A stable and organised series of hapu developed in settlements on the coast and inland. Ngāi Tahu

[1] Waitaha originated from the east coast of the North Island (https://my.christchurchcitylibraries.com/ti-kouka-whenua/tribal-history/ ). Ngāti Mamoe and Ngāi Tahu both originated from the Hawkes Bay region (Ngāi Tahu Claims Settlement Act 1998).

[2] The main source for this section is Schedule 104: Statutory acknowledgement for Rakiura/Te Ara a Kiwa in the Ngāi Tahu Claims Settlement Act 1998, with additional information sourced from Robertson (1993).

travelled seasonally between an intricate network of mahinga kai[3] connected to lakes, rivers, streams, wetlands and estuaries[4].

Some settlements were permanent, such as Ōraka (Colac Bay) and Pahi (Pahia)[5], while others were used at certain times of year. In and around Foveaux Strait, there were settlements at Ruapuke (Ruapuke Island), Stewart Island/Rakiura, Whenua Hou (Codfish Island), Ōmāui and Ōue (on either side of the mouth of New River Estuary), Mokamoka (southern inlet, New River Estuary), Turangitewaru (New River flats, Invercargill), and Te Whera (Ocean Beach, near Bluff). On Rakiura, The Neck, a peninsula at the eastern end of Whaka a Te Wera (Paterson Inlet), was a favoured location and the Ngāi Tahu rangatira (chief) Te Wera built two pā in the area, but there were also settlements down the eastern side to Tikotaitahi (or Tikotatahi) Bay, including another pā at Port Adventure, and a settlement in the south at Pikihatiti (Port Pegasus) – where there are still numerous middens and cave dwellings. There is a long tradition of Māori harvesting tītī (muttonbirds) from the islands surrounding Rakiura.

On the mainland, Mokamoka was sustained like other settlements by mahinga kai taken from the estuary and adjoining coastline, including shellfish and patiki (flounder). Ōue was where the coastal track to Riverton/Aparima began, and Honekai, a principal rangatira of Murihiku, lived there in the early 1820s. After his death, many inhabitants of Ōue and other coastal settlements moved to Ruapuke Island, which became the Ngāi Tahu stronghold in the south and was where The Treaty of Waitangi was signed. Despite this relocation, there were thought to still be 40 people living at the kaik at Ōmāui under the rangatira Mauhe in 1850. Inland there were settlements such as Tuturau.

To the east towards the Catlins, there were settlements at Toe Toe (mouth of the Matāura River, Fortrose) and Waikawa (the Waikawa River and Harbour are a nohoanga[6]). And to the west, from Aparima to the Waiau River Mouth, there were settlements and pā at Aparima (Riverton), Ōraka (Colac Bay), Kawakaputaputa (Wakaputa), Pahi (Pahia), Pahees (Outata Point), Matariki (island off Cosy Nook), Taunao (Orepuki), Rarotoka (Centre Island), Te Wae Wae (Waiau River Mouth). Aparima was named after the daughter of Hekeia, who bequeathed to her all of the land he could see from Ōtaitai, just north of Riverton/Aparima. Rarotoka was a safe haven at times of strife for those living at Pahi, Oraka and Aparima on the mainland opposite. Pahi was one of the larger and oldest pā in Murihiku, where 40 to 50 whare (houses) were reported in 1828. Other settlements in western Southland were more transitory, such as at Mamaku, Tamatea (Indian Island, Dusky Sound)[7].

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[3] The abundance of mahinga kai determined the welfare and mana of each tribal group and it is one of the ways whānui (families) today connect with their ancestors.

[4] Pre-European agriculture was largely limited to north of Taumutu (beside Lake Ellesmere in Canterbury), and northerners swapped the produce from their gardens for the kai moana of the south.

[5] Both Ōraka and Pahi were well-established settlements lying on the coast between Orepuki and Riverton/Aparima (a distance of 30 kilometres). Orepuki was an example of a stone working site.

[6] Nohoanga (literally meaning a place to sit) traditionally refers to the seasonal occupation sites that were an important part of the Ngāi Tahu lifestyle. Under the Ngāi Tahu Claims Settlement Act 1998 an allocated nohoanga site is a specific area of Crown owned land (usually 1 hectare in size) adjacent to lakeshores or riverbanks that Ngāi Tahu Whānui have temporary but exclusive rights to occupy for the gathering of food and other natural resources. Other Southland nohoanga identified in Schedule 95 of the Act are noted later in **Part B** of this report.

[7] Captain Cook first sighted the settlement on Mamaku, a 168 hectare low lying forested island, in 1773 and evidence of the settlement is still visible today (http://www.fiordlandconservationtrust.org.nz/general/indian-island-project ).

European settlement in Southland started with shore whaling[8] in and around the southern coastline, and particularly Foveaux Strait, and followed a similar pattern along the coastline. Some whaling stations went on to become towns – Fortrose, Riverton/Aparima, Bluff, and Waikawa. On Stewart Island/Rakiura, sealers and whalers joined the Māori settlement at The Neck[9]. After the boom and bust of shore whaling, ex-whalers turned to pastoral farming along the coastline. By the 1850s, there was also keen demand from outside of the region for sheep runs as most of the suitable country in Canterbury and Otago was already occupied (e.g. Robson, 1967). Some pioneers occupied land while it was still in Māori ownership. They claiming either to have permission or to have purchased land directly from Māori, which was at odds with the Treaty of Waitangi 1840 and the Native Land Purchase Ordinance 1846.

**Image B1: Acker's Cottage, Halfmoon Bay**
Source Emma Moran

In 1853 Walter Mantell, Commissioner of Crown Lands in Dunedin, negotiated the Murihiku Deed of Purchase of over seven million acres (2.8 million hectares) of land for £2,600 with the reservation of 4,875 acres in seven reserves. This purchase was to some criticism from Māori, including for the insufficient protection of Māori rights, the comparatively small purchase price, the inadequacy of the reserves. There was also controversy over the fate of Fiordland. In 1864 Henry Tacy Clarke, on

[8] Whalers targeted the slow-moving Southern right whale (*Balaena australis*) that came into the bays during the winter to calve. The calf was killed first and then its mother when it invariable stayed with its dead calf (Hall-Jones, 1976).
[9] An ex-whaler, Lewis Acker, built a stone house in 1835 in Halfmoon Bay (near Oban), which is one of the oldest buildings in New Zealand.

behalf of the Crown, negotiated the Rakiura Deed of Purchase of 420,000 acres (170,000 hectares) for £6,000 and the reservation of 935 acres in nine reserves. The Rakiura Purchase was the last of the major land purchases in Te Waipounamu (the South Island). Controversy relating to this purchase has focused on the fate of the outlying Tītī Islands. These outlying islands have now been returned to the Owners by the Crown.

The purchase of the Murihiku Block opened up mainland Southland for European settlement in the 1850s (McLintock, 1966). Land development began in earnest on the more accessible land and new settlements and towns followed. The Crown surveyed land and encouraged its development through a variety of freehold and leasehold arrangements. The 'hundreds' system was used to survey land in the lower Matāura Valley and on the Southland Plains (the lower Ōreti and Aparima river valleys) as far north as what is now Hundred Line Road. It was into these areas that the first run holders moved in the early 1850s – Frederick Miéville took up the Glenham Run and John Bennetts settled at Seaward Bush (Robson, 1967). Further north up the river valleys land was surveyed as small districts and within two or three years this land also started to be developed. Early towns to be surveyed included Orepuki, Matāura Bridge, Wyndham, Longbush, Gore, Matāura, Winton and Otautau (Lawn, 1977).

It is no accident that towns in Southland are most often located on the migratory trails of Ngāi Tahu – trails that went up the river valleys and were used to gather natural resources, particularly pounamu, mahinga kai, and native plants such as flax and speargrass. As European explorers, and later settlers, travelled inland they used Ngāi Tahu guides. As a result, many towns lie either at, or close to original Ngāi Tahu villages and settlements. Some towns have Māori names, such as Otautau. In Māori oral tradition, Otautau has come to be known as "the meeting place of the rivers" or "quiet water" (Bye, 1988, p. 13). The actual translation of Otautau is "the place of the greenstone ear pendant with a straight shank curved at the lower end", which is a good description of "the shape the rivers make as they encircle the town (Bye, 1988, p. 13).

The nature of the ground cover and the expanse of wetlands made travel times long. A drover, James Smiths recalled "The country between the Matāura River and the Ōreti was without any sign of cultivation or habitation, covered in some places with bush and in others with snowgrass as high as a man, the whole intersected with swamps and creeks" (Robson, 1967, p. 17). In 1855, David McKellar's journey with 3,000 ewes from Mokomoko Inlet (near Bluff) to the Longridge Station at Waimea took a year or more (Beattie, 1979). A Cobb & Co. coach journey from Invercargill to Bluff in the 1860s threaded between swamps and sandhills, and had to be timed to avoid the tide (Hall-Jones, 1976). By necessity, towns in the 19th century were usually located no more than a day's travel apart, either by horseback or coach.

Before the railway, there was a regular stream of waggons from Invercargill and from Riverton/Aparima to Lake Wakatipu in Central Otago, and towns like Otautau and Winton were waggon stops on each route. The only piece of formed road on the Invercargill route for many years was the part from Invercargill to Wallacetown, where a corduroy road (formed using logs placed at right angles to the direction of the road) was laid down because the area was a deep swamp (Southland Times, 1925).

Over time, remoter areas became more accessible and the distance that could be travelled in a day increased. Towns included in the region's extensive railway network usually grew faster than others, although most of the branch lines are now long gone. Lowther (now a locality between Lumsden and Five Rivers) was a thriving settlement that was planned as the main centre for northern Southland, up until Lumsden (roughly nine kilometres to the south) became the major junction for several railway lines and branch lines (Hamilton 1995)[10]. Development of the Tokonui Branch Line and the Catlins River Branch Line led to the decline of the port towns of Waikawa and Fortrose. Pine Bush (now a locality between Wyndham and Fortrose) was a busy settlement that included a school, church, community hall, and relied on the Tokanui Branch Line up until it closed in 1966 (Cyclopedia Company Ltd, 1905)[11]. The increasing use of private vehicles meant Southlanders became more mobile, and as people's horizons broadened, many of the smaller towns and settlements in the region declined.

As well as becoming accessible, land also became more available. Some existing runs and estates were broken up for closer settlement and more intensive farming practices, for example the large sale in Gore of Crown land in 1877. In its Annual Report for 1900, The Department of Land and Survey noted that "The work of settlement depends directly on the amount of land available, but in this respect the colony has no large supply of 'raw material' in the shape of agricultural land left. What remains is scattered in small areas, difficult of access and requiring much capital to bring it into use." After 1900, many settlers were being drawn south from Canterbury by the "cheap Southland farms" (Waghorn & Thomson, 1989). Land development turned to the hill and high country and areas of peat wetlands where it was assisted after the Second World War through the Marginal Lands Act 1950. Seaward Moss, an area of deep peat and clay soils, was described as probably the most difficult land development in Southland's history (Waghorn & Thomson, 1989).

For the first hundred years, the main priority for local government was the building, maintenance, and upgrade of roads, footpaths and bridges (Miller, 1977; Bye, 2000). Roading was a physically demanding and time consuming task that was made more difficult in Southland by the large geographic area, vast tracts of wetlands, and a sparse population. By the mid-1960s the towns had sealed streets, and most footpaths had been surfaced with concrete or asphalt. Priorities then turned to water: water reticulation, wastewater, health, tourism and hydropower-generation (Bye, 2000).

## 1.2. Broad Characteristics

At present, the urban areas in Southland consist of one city (Invercargill), six larger towns[12] (Bluff, Gore, Matāura, Winton, Riverton/Aparima and Te Anau), and over 30 smaller towns and larger settlements – all within a patchwork of around 1,000 localities (water and land). These 'towns' and surrounding local areas are connected by 777 kilometres of state highways (managed by the New Zealand Transport Authority) and 6,418 kilometres of local roads – roughly 59 percent of which are unsealed. The annual cost of maintaining this large roading network is around $80 million, and is

[10] The Invercargill-Lumsden section of the 'Great Northern Railway' railway, and the Lumsden-Kingston section opened in the 1870s (Dore, 1992). As well, the Waimea railway line (Lumsden-Gore) going east, and the Lumsden-Mossburn line going west, opened in the 1880s (Dore, 1992).

[11] The Tokonui Branch line, which joined the Seward Bush Branch line to Invercargill, used to stop just to the south of Pine Bush at Titiroa.

[12] In the context of this report, larger towns are those with a population of between 1,000 and 10,000 people.

funded from petrol tax, road user charges, and district council rates. The region has one urban bus network in Invercargill and most Southlanders rely on private transport for longer journeys.

Towns and settlements tend to be closer together south of the Hundred Line Road (this road runs from Centre Bush to Scotts Gap, north-west of Otautau), and within roughly a 50 kilometre radius from Invercargill. Some towns like Tuatapere service relatively rural communities – in 1966 the town's population reached a peak of almost 1,000 people (Williams, 2009). The ebb and flow of towns has seen migration from the region's smaller towns towards some of its larger towns. Southlanders are now able to work in a different place from where they live, and commute some distance each day. Migration between communities is increasing.

While every town in Southland is unique, there are broad characteristics or features that these towns often share. The towns usually have common origins and purpose, they all sit within the same regional landscape, and the transport networks thread them together. They generally reflect the European, and particularly Scottish, heritage of their settlers. Athol is likely to be named after Atholl in Perthshire (Beattie, 1979), and Fortrose is named after a coastal town near Inverness. All of the original streets in Invercargill's one square mile were named after rivers in Scotland (with the exception of The Crescent), and many of the streets in Bluff the names of rivers in Ireland[13] (McArthur, 2006). Wallacetown, and all of its streets, were given Scottish names – most being places in Ayrshire (McArthur, 2006).

Using as many examples as possible, this section is an overview of the character of Southland towns, highlighting their close connections with water, pastoral farming, and industry. It also points to a town's place within a community, a history of self-reliance and a strong identity. Finally, specific characteristics are highlighted at a district and ward level: formal qualifications, household income, occupied households and home ownership.

Most towns and settlements lie on valley floors near rivers and streams (and in some cases, also lakes). Many are part of a series or chain within a catchment – lying either upstream or downstream from one another – connecting (through surface water and groundwater) the headwaters of a river, or one of its tributaries, with an estuary. The Matāura River and its tributaries connect in a single chain Garston, Athol, Balfour, Riversdale, Gore, Matāura, Tuturau, Wyndham and Edendale, and Fortrose. Similarly, the Aparima River and its tributaries connect Nightcaps, Wairio, Otautau, Riverton/Aparima. Ohai is connected to Clifden and Tuatapere on the Waiau River. These town chains largely follow the road network but, in some cases, they diverge – such as Garston, Athol and Lumsden or Lumsden and Balfour.

Towns tend to sit across these river catchments, at the centre of a wider area of influence, and their effects flow downstream. The Ōreti River connects Mossburn at one end with New River Estuary at the other. A centennial history of Dipton (Milligan, 1977) described the Ōreti River: "Rising as it does in the Thomson Mountains east of Lake Mavora and also drawing water from the western part of the southern catchment of the Eyre Mountains and the north-eastern Takatimu Mountains it flows 106 miles into the sea at Sandy Point on the Invercargill Estuary." There are some small coastal towns and settlements, such as Drummond, Waikawa, Orepuki, and Colac Bay (between Orepuki and

[13] The streets in Bluff may have been named after rivers in Ireland as a tribute to John Spencer, who was Irish (Hall-Jones, 1976).

Riverton/Aparima), that are not part of a town river chain. Figure B1 shows many of the chains of towns and settlements connected by rivers and streams in Southland.

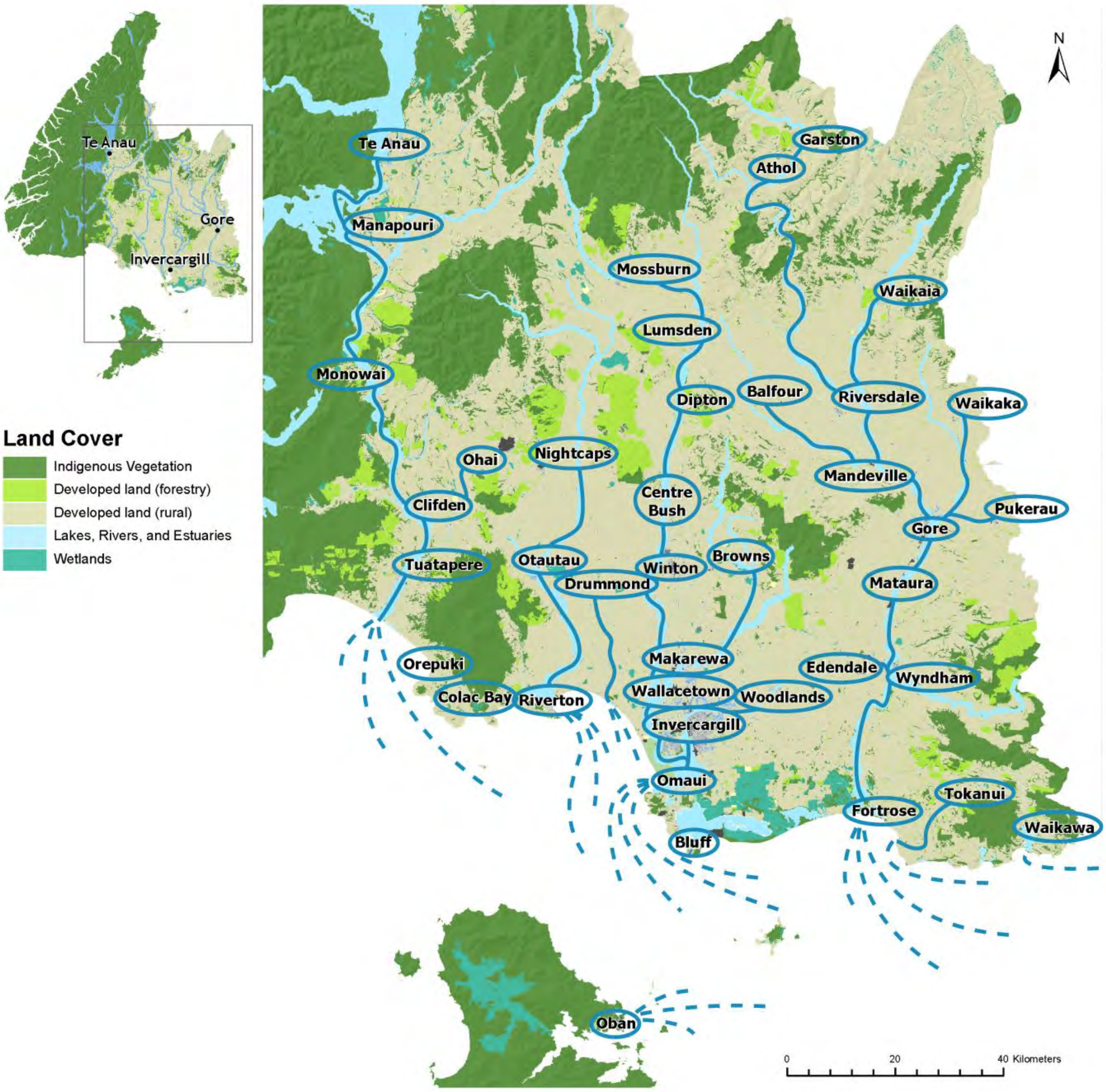


**Figure B1: Southland towns and settlements connected by rivers and streams**
Source Environment Southland

Southland's towns are located near water – because water is vital to life. Water bodies have their own mauri (or life force) that binds the physical and spiritual elements of all things together, generating and upholding all life. The mauri of the water is recognised and protected when Te Mana o te Wai (the mana of the water) is upheld[14]. Water is used for drinking, washing, recreation (especially fishing), aesthetics, navigation, power generation, and to remove waste. European explorers and settlers navigated up the rivers in whaling boats – going at least as far as Tuturau on

[14] Te Mana o te Wai is the underlying philosophy of the National Policy Statement of Freshwater Management 2017.

the Matāura River, although with the original winding course of the river this took around three days (Robson, 1967), and Otautau on the Aparima River. In normal times a river is identified as an asset (e.g. Milligan, 1977).

A centennial history of Otautau (Bye, 1988, p. 13) explains the town's location at the confluence of the Otautau Stream and Aparima River:

> *"Otautau, like many other New Zealand towns, is not a "planned town". Its site was not deliberately chosen as someone's grand vision for a settlement to serve as the centre of Western Southland. What geographer or surveyor would choose a site so vulnerable to the vagaries of the rivers so near at hand? Why, then, did the township of Otautau develop in its present location? The answer lies in that same water, and its ability to meet the two basic needs of … rest and refreshment."*

Otautau grew not as a result of a plan, but in direct contrast to a plan – in 1850 the area was surveyed and an elevated site for a settlement to be known as Hodgkinson was chosen to the north-east of the present town (Bye, 1988). Despite the advantages of this site, Otautau grew beside the Aparima River where it could best meet the needs of travellers passing through.

**Image B2: Looking towards Otautau with the Aparima River in the foreground**
Source Emma Moran
Note: The proposed elevated site of Hodgkinson was on the near side of the river to the right of this photo.

In Southland, as elsewhere in New Zealand, towns and localities include 'wai', which as a noun translates as water, stream, creek, river and tears. Just a handful of examples and possible meanings[15] are: Waituna (water of eels), Wairio (dried-up water), Waikawa (bitter water), Waimatuku (bitter water), Waikiwi (kiwi waters), Tiwai (to steer a waka badly) and Waimea (forgotten or hidden stream). Towns often also either share their names with specific water bodies, such as Te Anau, Manapouri and Matāura, or their name refers to water in some way, such as Riverton and Riversdale.

Lumsden was referred to as 'The Elbow' because it is located near the point where the Ōreti River turns at a right angle from east to south. The 'burn' in Mossburn is a Scottish word for stream[16] and the town shares its name with a local stream in the area. Otautau is "a word which has at its heart the idea of water" (Bye, 1988, p.13). Although now a locality rather than a town, Five Rivers recalls five streams (Oswald, Acton, Dilston, Cromel and Irthing) that rise in the Eyre Mountains and are tributaries of the Ōreti River[17]. A history of Five Rivers was dedicated to these streams because they have influenced the lives of every person who has lived in the district and will continue to run, as they have done for thousands of years, "far outlasting human habitation" (Hamilton, 1995).

Although water is vital to life, many towns have an uneasy relationship with it, in terms of both water quantity and quality. Water is managed in towns through the use of extensive stormwater drainage networks, flood protection schemes, and water supply schemes. Also critical are the region's transport networks' many bridges and culverts. In Tuatapere, "the opening of Clifden Bridge (over the Waiau River) in 1899 was a singularly important event in giving rise to the new township" (Williams, 2009). The 1905 Cyclopedia of New Zealand (Otago and Southland Provincial Districts) described many of the districts in Southland as "well-watered". In his history of Wallace County, Bye (2002, p.37) noted that "(r)ivers might be crossed and their waters diverted, but taming them is much more difficult."

Despite the abundance of rain in many parts of the region, it does not all arrive as effective rain and water is also managed through water shortage measures. The landscape today is more prone to water shortages because of its reduced water storage capacity (e.g. removal of tussock grasslands), extensive drainage and river straightening. Flood events and drought are likely to become more of an issue as the effects of climate change intensify.

[15] Sources used for this paragraph are websites https://nzhistory.govt.nz/culture/Māori-language-week/1000-Māori-place-name and http://nzetc.victoria.ac.nz//tm/scholarly/tei-Cyc04Cycl.html

[16] There are at least 148 "burns" in Southland. Other examples are Spirit Burn near Dipton and Boggy Burn north-east of Winton.

[17] The junction of the Oreti River and the Irthing Stream is a nohoanga. During the 1850s, the Five Rivers run was known as "The Punjab", so called because it means five rivers in Indian and the Punjab District in India also has five rivers that meet to form the Indus River (Hamilton, 1995).


**Image B3: Balfour trout fishing signpost**
Source Emma Moran

The first towns were the ports – Bluff, Riverton/Aparima (formerly Jacobs River), Fortrose (formerly Russelltown) Waikawa, Invercargill and Oban – dotted amongst the string of estuaries that protect the southern coastline[18]. These towns shipped primary products (wool, grain and timber) and later fish (e.g. blue cod, crayfish, oysters, flounder and paua). Bluff, sheltered from Foveaux Strait by Bluff Hill, was a relatively safe harbour. Riverton/Aparima was also a "safe haven" and grew continuously

[18] K.J. Hargest notes in the Foreword of *Bluff Harbour (*written for the centenary of the Southland Harbour Board in 1977) that "navigation and human activity was probably more prevalent on the South Coast than in northern New Zealand, where the history of European settlement has been generally accepted as being of more importance" (Hall-Jones, 1976, p.xv).

from its settlement in the 1830s[19] – and by 1862 it was designated a customs port of entry (Pankhurst, 1985).

**Image B4: Riverton Port**
Source Simon Moran

Timber was exported from Waikawa until sediment from the cleared land silted the harbour. Mrs Harvey (nee Wybrow) recalled "Fortrose became an important little town" with a population between 300 and 400 people, three hotels, three stores, a butcher, baker and barber (Robson, 1967, p. 22). Despite this start, the southern climate meant Fortrose and Waikawa could be difficult harbours to get in and out of and limited their development. After the Rakiura Deed of Purchase in 1864, European settlers bought surveyed sections around the sheltered Halfmoon Bay (Oban) and by 1870 it was a "bustling little village" (B. Howard as cited in Peat, 2010, p. 37).

[19] The actual date for the founding of Riverton/Aparima is difficult to in-point. John Howell established a whaling station at Jacob's River (now known as Riverton/Aparima) in 1836 and Europeans were known to be in the area when he arrived, and so it can safely be assumed that Riverton/Aparima was a going concern in 1835, the year from which the town's centenary was dated (Pankhurst, 1985).

**Image B5: Oban, Halfmoon Bay, Stewart Island/Rakiura**
Source Emma Moran

After the ports, towns grew across Southland to support economic activity in surrounding rural areas. The town of Longridge developed a few years after the McKellar brothers established the Longridge run on the Waimea Plains in the 1850s (Hamilton, 1952) – this town soon changed its name to Balfour. Mossburn started to grow in the 1870s (Bye, 2000). Technological changes, such as refrigerated shipping and the use of lime fertiliser, made farming more profitable. Larger estates, such as Greenvale[20] and Gladfield, were broken up into smaller farms for closer settlement and nearby towns grew. Drummond "came alive" after the 11,000 acre Gladfield Estate (4,451 hectares) was subdivided in 1893 into mixed arable farms of 200 to 300 acres (three farms were much larger) (Blanch, 1978). Otautau's purpose changed as it began providing services to permanent settlers as farming and sawmilling grew - the town became a "hub of a small but important Western Southland wheel, the spokes of which converged on the town" (Bye, 1988, p. 35).

In addition to port and rural service towns, industry towns developed, such as Waikaia and Waikaka (gold), Matāura (meat, paper, and coal), Ohai and Nightcaps (coal), Browns (lime), and Manapouri and Te Anau (tourism and hydro-electric power generation). Waikaka had about thirty dredges working in the locality in 1904-05, and many of these secured "handsome returns of gold" (Cyclopedia Company Ltd, 1905). Orepuki, started as a gold mining town in 1865, grew to include a

[20] Around 22,600 acres (9,145 hectares) of the Greenvale Estate in the Chatton, Glenkenich, and Greenvale districts was broken into farms and sold in 1894. It was reported at the time that 8,600 were turned into 38 farms, (https://paperspast.natlib.govt.nz/newspapers/ST18940331.2.27 ), which suggests that the total area sold could have been turned into 100 farms.

coal mine and shale oil operation, a sawmill, and a flaxmill, with two branch lines and a population of 3,000 people – with these industries now gone, the settlement, now of around 100 people, is turning to tourism, with popular Gemstone Beach nearby.

The fortunes of towns have been mixed over the years as particular industries have come and gone. Since World War Two, pastoral farming has seen conversions from dairy towards more sheep and then to deer and more recently back to dairy and dairy grazing. Many stock sale yards in towns around the region, such as at Mossburn, Lumsden, Dipton, and Otautau, are now gone. The last 25 years have seen major changes in farming methods and practices and dairying is now seen in many areas north of the Hundred Line (Baird, 2003). Fonterra's milk processing plant at Edendale has expanded while Silver Fern Farms' venison processing plant at Mossburn (established in 1962) has closed. A large proportion of town businesses focus on rural services – in Gore and Winton there are as many farm machinery outlets as car dealerships. The strong connection with pastoral farming is still obvious at the Wyndham, Waiau[21], Gore, Winton, and Southland[22] 'A&P' (Agriculture and Pastoral) Shows, Edendale's 'Crank Up'[23], and the Southern Field Days at Waimumu near Gore.

Orepuki is one of the Southland towns or settlements on the Southern Scenic Route, which is now a major visitor or tourist road that runs south from Dunedin (Otago), through the Catlins to Invercargill, on to Riverton/Aparima, Tuatapere and north to Te Anau, Mossburn and Queenstown (Otago). The Southern Scenic Route was a Tuatapere innovation[24] that opened in 1988 and promoted Southland as a tourist destination. Other smaller towns are on or near the Route – Waikawa, Tokanui, Fortrose, Bluff, and Manapouri – along the way. Trout fishing also brings tourism to many towns across Southland – towns like Wyndham, Matāura, Gore, Waikaia, Lumsden, Athol, Garston, Mossburn, and Te Anau. Once completed, the Around the Mountains Cycle Trail will circle the Eyre Mountains in Northern Southland, linking Kingston (Otago), Garston, Athol, Lumsden, Five Rivers, Mossburn and Walter Peak (Otago).

[21] The Waiau A&P Show is held at Tuatapere.
[22] The Southland A&P Show is held in Invercargill.
[23] The Edendale Vintage Machinery Club's annual "Crank Up" weekend is an event that celebrates classic tractors and other (generally) farm machinery, and attracts thousands of people from around New Zealand.
[24] The force behind the Southern Scenic Route was John Fraser, an entrepreneur and the pharmacist at Tuatapere for more the 40 years, and the Tuatapere Promotions Group that he formed.


**Image B6: Orepuki Beach Café, Southern Scenic Route**
Source Emma Moran

Between 2001 and 2013, the proportion of Southlanders who had lived at their usual residence for longer than 15 years was constant at just over 20 percent. There was variability between the three districts and, while there were increases in Gore and Invercargill City Districts, the proportion of more recent residents has increased markedly in Southland District. Community change has been highlighted in local histories such as Thompson (2011) Mossburn: Winds of Change and Baird (2003), Changing Years: Dipton 1977 - 2002.

## 1.3. Community Assets and Variability

Southland's towns and settlements each have a collection of facilities, services, and amenities – such as a river, community hall, primary school, local library, medical centre, sports ground, reserve, estuary and beach, and essential infrastructure – that are the community's assets or wealth, and many are funded through council rates. A community's assets are both natural and built. These assets make a town the focal point for the surrounding area and are often the heart of local communities.

**Image B7: Tuatapere Domain**
Source Emma Moran

Many assets, including wastewater schemes, were originally gained through the fund raising efforts of communities (and in some cases, specific industries) and central government subsidies. Despite the source, limits on funding usually influenced the design of these assets in ways that can constrain the potential for future upgrades – for example, often the minimum amount of land was purchased for wastewater treatment systems. Once gained, locals also fight hard to retain their community's assets – recent examples are the region's remaining rural maternity centres and Te Anau's rescue helicopter.

Although central government has provided funding for many assets in Southland, there is also a strong history of self-reliance (e.g. Guttery, 2015). Notable examples include the Monowai power station, the Ohai railway, the Southland Frozen Meat Company, Gore's community-owned hospital, Bluff's island port, and Tuatapere's Southern Scenic Route. The strong community spirit in Dipton has meant a generous response to local projects, many of them for the local school (Baird, 2003). A 'Brush up on Bluff' day saw volunteers clean up and paint the frontages of 32 businesses along the town's mainstreet (Coote, 1994). There is also a long history of local communities in Southland coming together after major events, such as fires and floods, and this history fosters a sense of caring (e.g. Bye, 1988).

A town's capacity to formally raise funds for its assets (e.g. wastewater schemes), through either subscription or accepting rate increases, varies across the region. There are socio-economic indicators that can be used to show the difference in capacity between towns. The four indicators used here are: formal qualifications, household income, occupied houses, and home ownership. In general, where multiple indicators are relatively high (e.g. a greater proportion of post-secondary qualifications and home ownership) then a town is likely to have growing pressure on infrastructure assets, as a result of population growth or high service expectations. Correspondingly, there is likely to be more capacity to fund these assets. A town with multiple low indicators is likely to have less capacity to sustain existing assets or upgrade assets to meet changing expectations.

The following information for the four indicators is presented by region, district and ward. Wards are used rather than towns because the marked differences in the population size between towns distort the relative percentages in the graphs. Another possible indicator is the make-up of occupied households, for example whether they are one-person or one-family, and this more detailed information is reported in the snapshots for each of the eight case study towns further on in Part B.

Overall, Southland has a largely practical workforce but there are some differences in education, skills and experience between local communities. One indicator of education and skills is a person's formal qualifications[25]. In 2013 around 30 percent of people aged 15 years and over across the region had no qualification, which was a decrease from almost 36 percent in 2006. At the other end of the spectrum, almost 12 percent of people in 2013 had at least a bachelor's degree as their highest qualification[26], which was an increase from eight percent in 2006. In other words, the level of formal qualifications in Southland is reasonably low but improving over time. Formal qualification levels across the three districts are roughly consistent with those for the region. Figure B2 shows the distribution of formal qualifications for each district in 2013 – secondary school qualifications are coloured blue and post-school qualifications are coloured green.

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[25] A qualification is a formally recognised award for educational or training attainment that has required full-time equivalent study or three months or more. A secondary school or post–school qualification is assigned to one of ten levels of the New Zealand Qualifications Framework (NZQF) based on the complexity of the learning. At secondary school, students work towards NCEA (National Certificate of Educational Achievement), which covers levels 1 to 3 of the NZQF. At the other end of the scale, a master's degree is Level 9 and a doctoral degree is Level 10.
http://www.nzqa.govt.nz/studying-in-new-zealand/understand-nz-quals/

[26] In Southland, 1% of people aged 15 years and over has a master's or a doctorate degree.

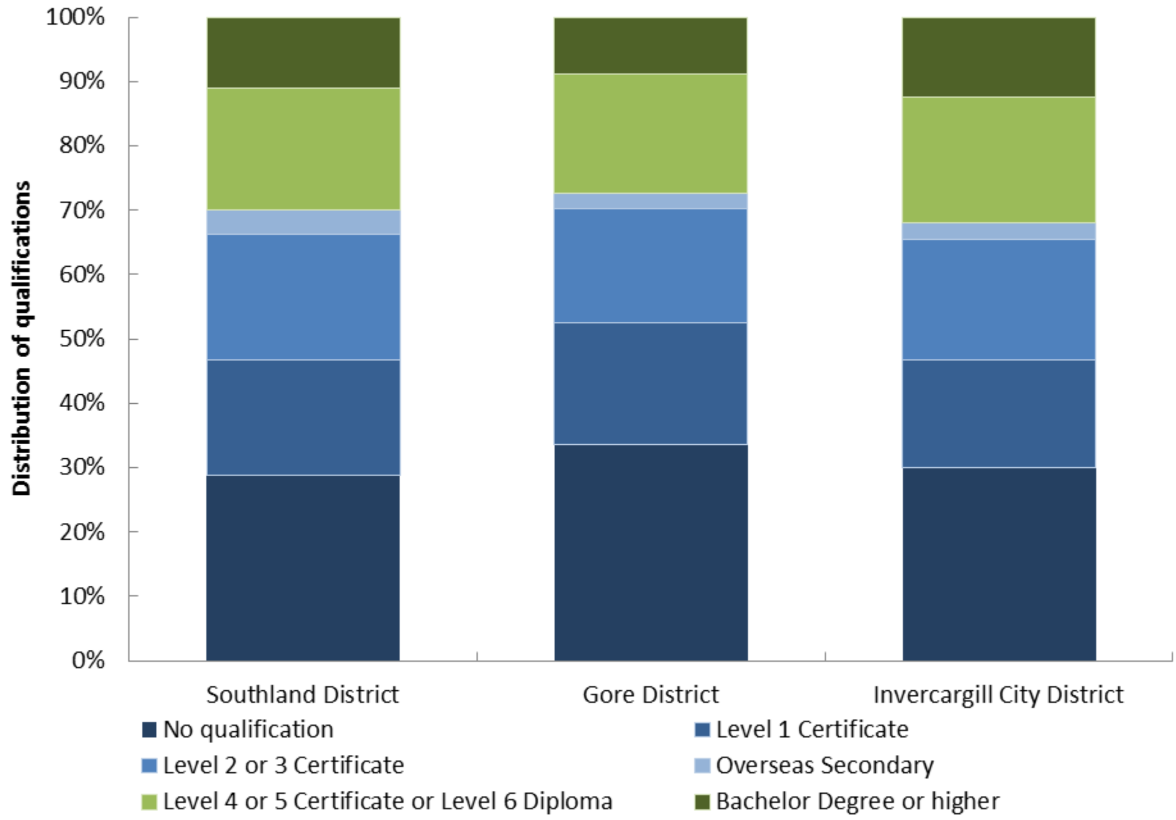


**Figure B2: Distribution of formal qualifications by district**
Source Statistics New Zealand 2013 Census

Below the district level there is strong variability between both wards and towns within these wards. Figure B3 shows the distribution of formal qualifications in 2013 for Gore District's four wards[27], Southland District's twelve wards[28], and Invercargill and Bluff[29]. The Stewart Island Ward has the highest proportion of post-secondary qualifications but has a relatively small population (381 people). The next highest is the Te Anau Ward (3,393 people). Invercargill (49,902 people) and the Kaiwera-Waimumu Ward (1,770 people) have a similar distribution of formal qualifications but large differences in population size. The wards with proportionally more people with post-secondary qualifications tend to have a larger service sector (e.g. health, education, government, financial services). Qualifications are only part of the picture and other considerations are equally important, such as length of experience in both paid and unpaid occupations.

[27] In 2013 and 2018 the four wards in the Gore District were: Matāura , Gore, Kaiwera-Waimumu and Waikaka.
[28] At the time of the 2013 Census the twelve wards in the Southland District were: Te Tipua, Toetoes, Stewart Island/Rakiura, Waihōpai, Wallacetown, Winton, Waikaia, Riverton, Five Rivers, Wallace, Tuatapere, and Te Anau.
[29] Invercargill City District has no wards but has been divided into its two main urban areas, Bluff and Invercargill, for this analysis.

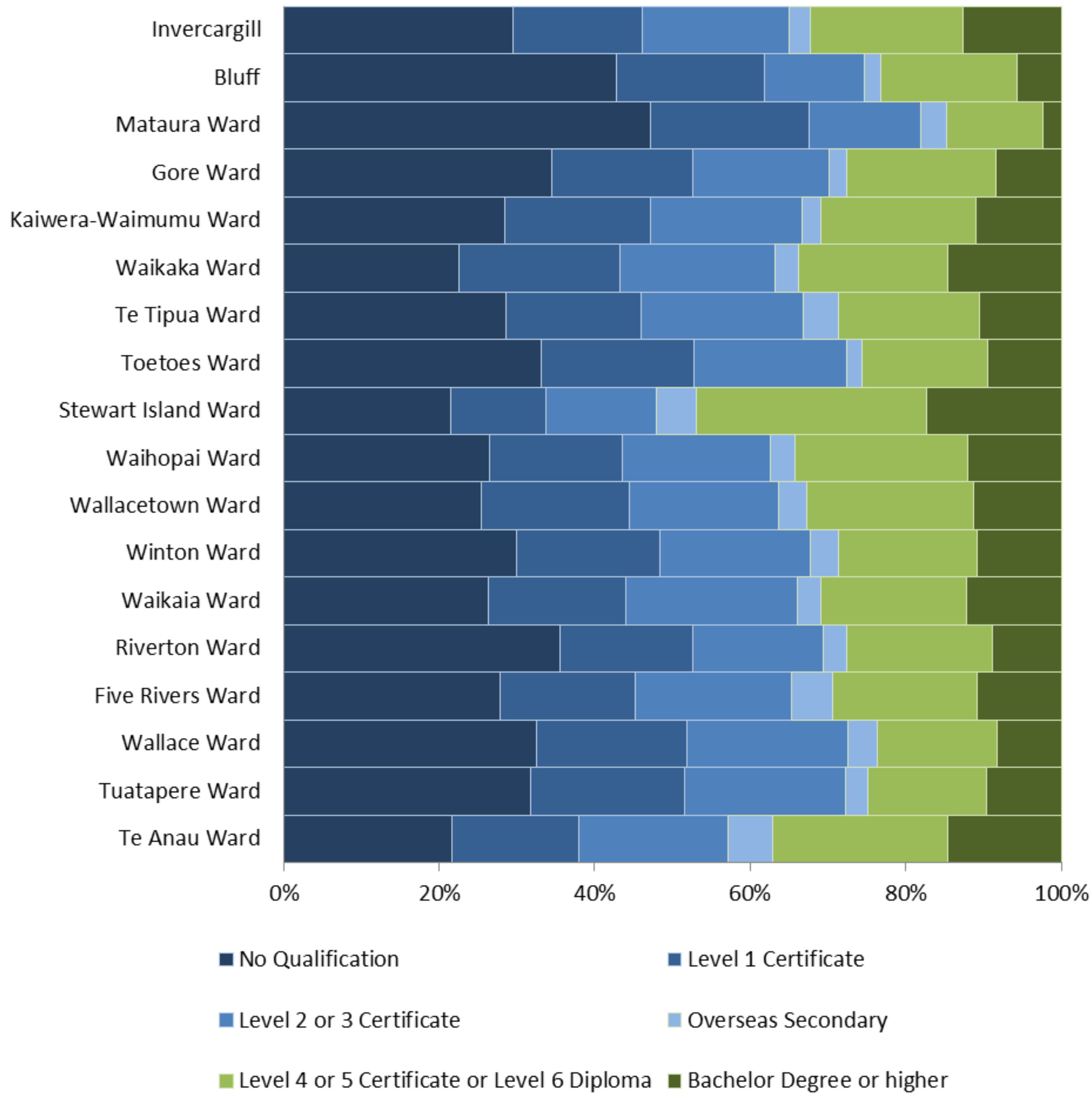


**Figure B3: Distribution of formal qualification by ward**
Source Statistics New Zealand 2013 Census

As elsewhere, Southlanders take the opportunities on offer to use their education and experience to earn a living. In 2013, the median[30] household income for Southland was $57,400. At a district level, the median household income was similar for Gore District and Invercargill City District but it was 15 percent higher for Southland District. The median household income for Southland District was $63,800, for Gore District it was $54,500, and Invercargill City District it was $54,300. Figure B4 shows household income distribution for each district. Household income is an indicator of rates

[30] The median means that 50% of families are above and 50% of families are below.

affordability. As a rough benchmark affordability problems can arise where rates exceed five percent of gross household income[31] (Department of Internal Affairs, n.d.).

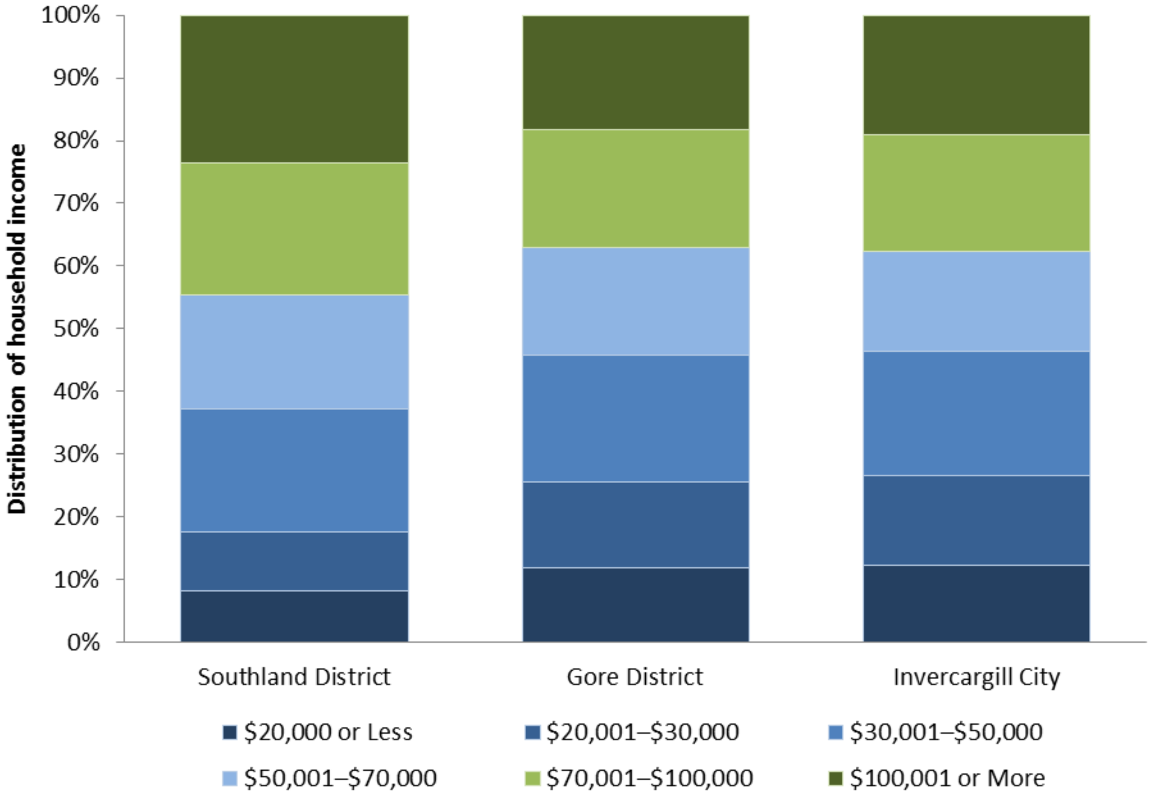


**Figure B4: Household income distribution by district**
Source Statistics New Zealand 2013 Census

Below the district level there is more variability in household income. In Gore District, household income for the urban Matāura and Gore wards was weighted more towards the lower and middle income bands than for the rural Waikaka and Kaiwera-Waimumu wards[32]. In contrast, household income for some towns in different districts was strikingly similar. Bluff (1,794 people) and Riverton/Aparima (1,431 people) are both similar-sized coastal towns and roughly 33 percent of households earnt $70,000 or more – by comparison, the proportion for the region is 40 percent. Within towns there can be marked differences in household income – this was the case between east and west Gore, north and south Invercargill, and east and west Riverton/Aparima. Figure B5 shows household income distribution in 2013 for Gore District's four wards, Southland District's twelve wards, and Bluff and Invercargill.

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[31] In 2007 the Department of Internal Affairs set up an independent panel to conduct a local government rates inquiry. The focus of the panel's report was on the spending and funding decisions related to network infrastructure (roads and public transport, the 'three waters', plus solid waste disposal), community and social infrastructure (cultural and recreational facilities), as well as a range of regulatory activities (Department of Internal Affairs, n.d.).

[32] In 2013 there were a large number of households in Gore Ward (3,156), and similar numbers in Matāura (624), Waikaka (507) and Kaiwera-Waimumu (606) wards.

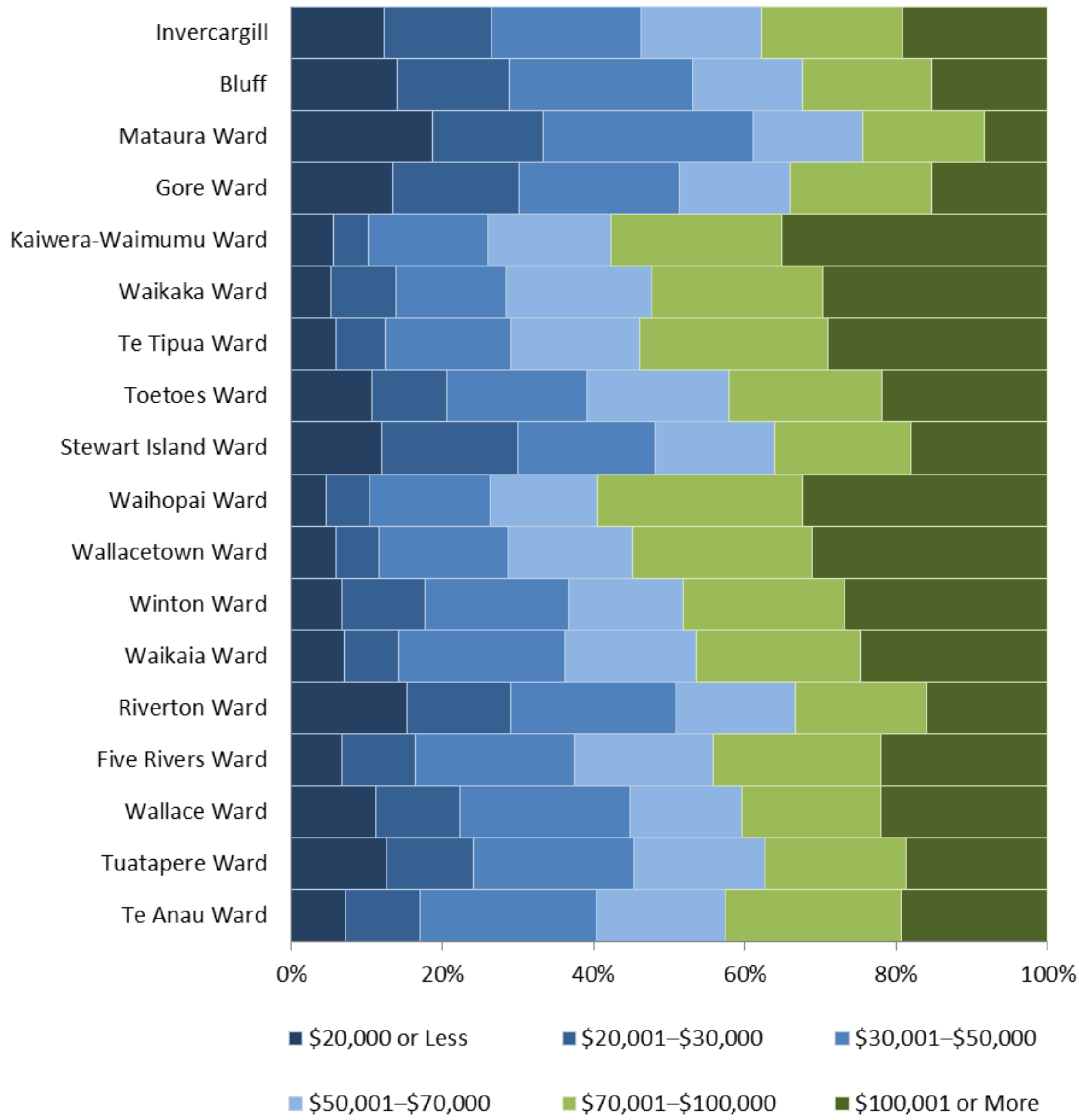


**Figure B5: Household income distribution by ward**
Source Statistics New Zealand 2013 Census

Southlanders use part of their income to build personal assets or wealth, and one of the most important for people living in towns is the family home. In 2013 there were 37,452 occupied houses[33], and home ownership (including houses that are partly owned or held in a family trust) was around 70 percent. At a district level, there were two main housing trends in the twelve years from 2001. First, the total number of occupied houses increased, as people moved into either newly built houses or previously unoccupied houses. Second, home ownership, as a share of occupied houses, decreased as more people rented. The growth in the total number of occupied houses was

[33] Reporting of the total households in occupied private dwellings varies slightly in census data. In addition to the total number of households in Southland's three territorial authorities (Gore District, Southland District and Invercargill City District), there are 27 households in the "Oceanic-Southland Region" area unit.

strongest in Southland District (+10.0%) and Invercargill City District (+8.1%), while the decline in home ownership was strongest in Southland District (-10.7%). Table B1 gives information on occupied houses and share of home ownership from 2001 to 2013 for the three districts. Figure B6 shows the change in occupied houses and home ownership from 2001 for each district.

**Table B1: House occupation and ownership by district 2001-2013**

| | 2013 | | Change from 2001 | |
|---|---|---|---|---|
| | Occupied houses | Home ownership of occupied houses | Occupied houses | Home ownership of occupied houses |
| **Southland District** | 11,517 | 7,332 | +10.0% | -10.7% |
| **Gore District** | 4,893 | 3,351 | +2.1% | -3.5% |
| **Invercargill City District** | 21,042 | 13,986 | +8.1% | -3.7% |

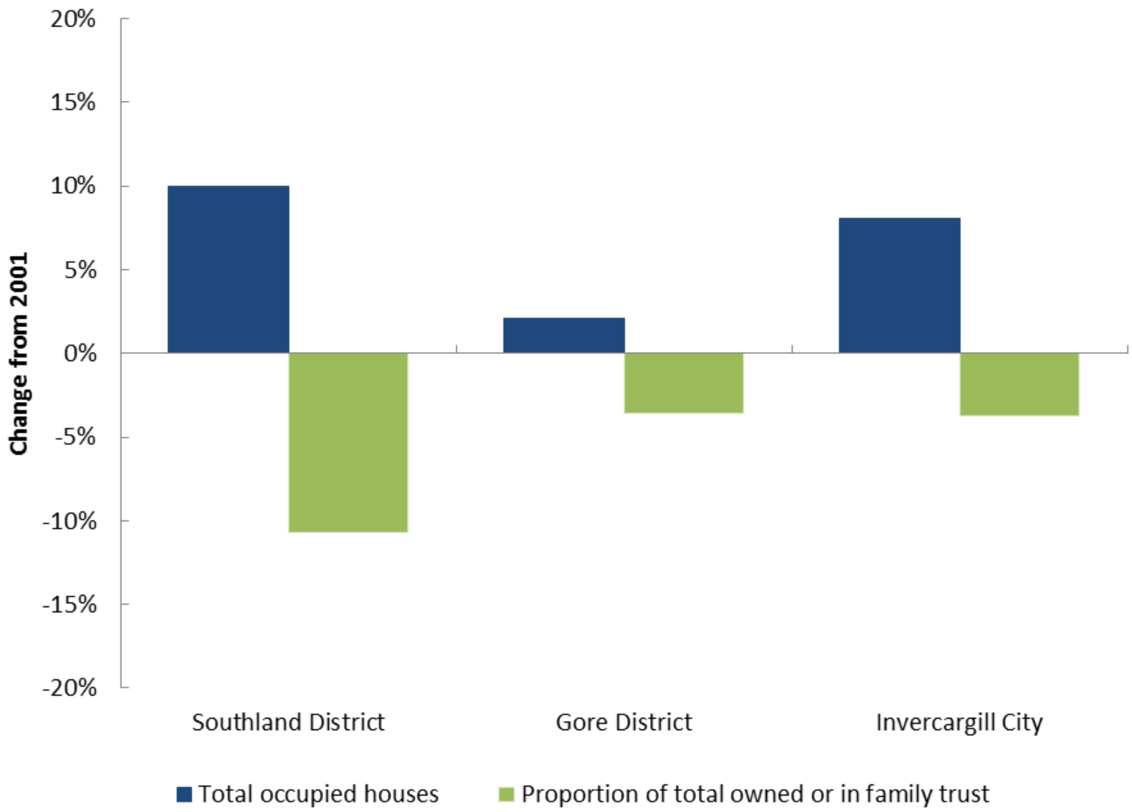


**Figure B6: Percentage change in occupied houses and home ownership by district 2001-2013**
Source Statistics New Zealand 2013 Census

While at a district level there are similar changes in occupied houses and home ownership, locally there were differences. In some places, the total number of occupied houses decreased, rather than increased, such as Riverton West (Riverton Ward), Ohai (Wallace Ward), Matāura, and Riversdale

(Waikaia Ward). In other places, home ownership increased, rather than decreased, such as Manapouri and Te Anau (both in the Te Anau Ward). Changes in occupied house and home ownership give some indication of the communities' recent fortunes. Figure B7 shows the change in occupied houses and home ownership from 2001 to 2013 for Invercargill and Bluff, the Gore District wards, and the Southland District wards.

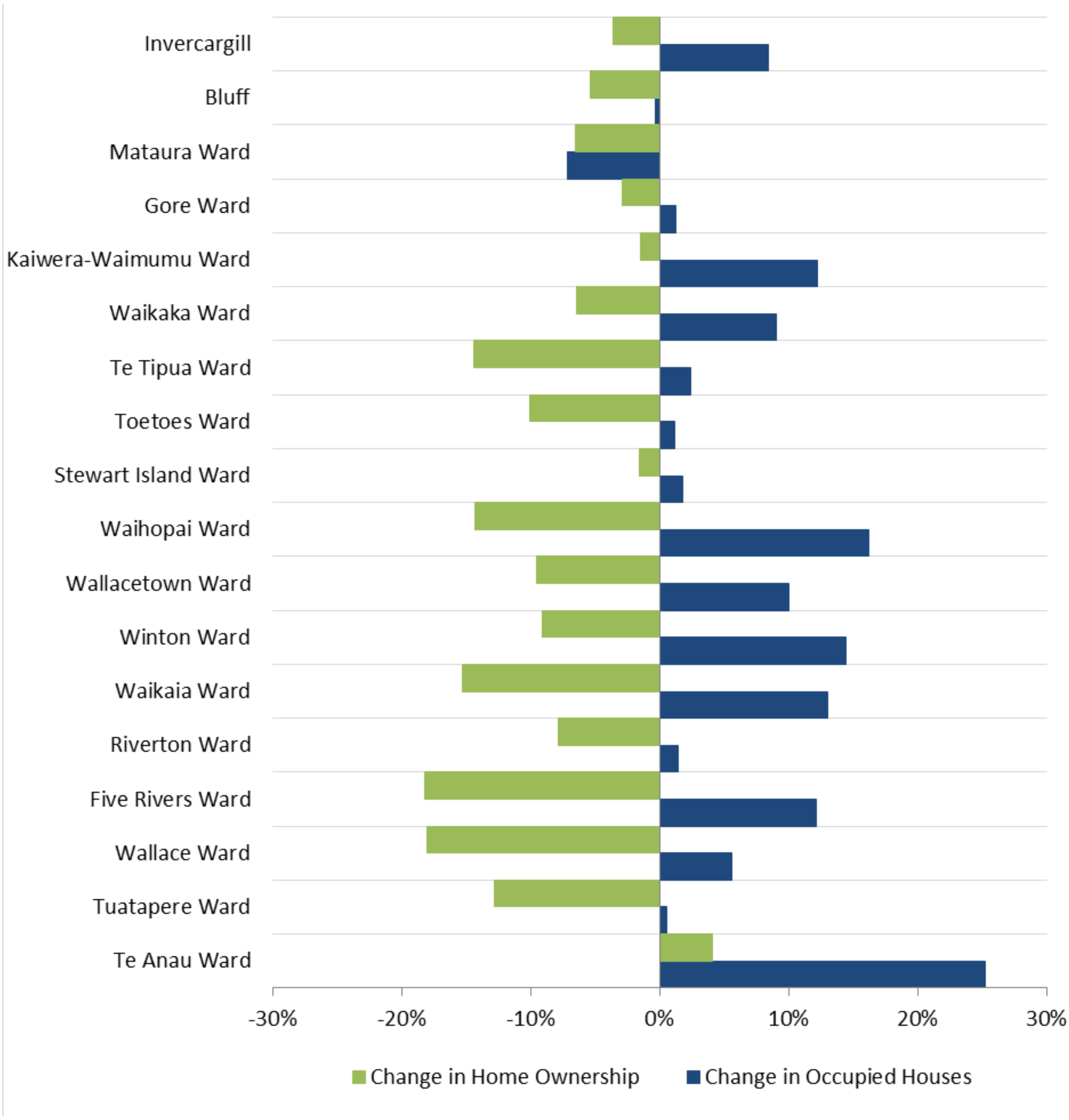


**Figure B7: Percentage change in occupied houses and home ownership by ward 2001-2013**
Source Statistics New Zealand 2013 Census

## 1.4. Municipal Water Services

Invercargill and 38 Southland towns and settlements[34] are connected to one or more municipal water related schemes: wastewater, stormwater, and a potable water supply. In general, a town or settlement gained one or more of these 'three waters' schemes to improve public health[35]. In some cases, the reason for a scheme is now historic, dating back to a time when the town had a larger population or a particular economic activity occurring in the area, such as mining at Ohai. A number of schemes were set up to supply services to more than one town. For example, Bluff is connected to Invercargill's water supply; Edendale and Wyndham are connected for wastewater and water supply. Some towns have specific circumstances, such as Waikaka and Pukerau, where parts of the town and surrounding rural area is connected to a Clutha District Council owned potable water supply scheme.

Table B2 details which Southland towns and settlements are connected to a municipal water related scheme. The towns and settlements are identified by district and ward – both the wards in 2018 (before the representation review) and the wards as they were at the time of the 2013 New Zealand Census[36]. The 2013 wards are noted here because they are used in Section 1.2 to report 2013 census information for the towns and their surrounding area.

In addition to the towns identified in Table B2, Southland District Council has wastewater schemes at Curio Bay (for a Council reserve), and stormwater schemes at Colac Bay and Thornbury. As well, there are wastewater schemes not owned or operated by Councils, such as at Milford Sound and Colac Bay. The two maps in the Research Focus Section at the start of this report show the location of the towns in Southland. The first map shows towns and settlements with wastewater schemes and the second map shows towns and settlements without wastewater schemes.

[34] This total includes Southland District Council's wastewater scheme for the reserve at Curio Bay and stormwater schemes at Colac Bay and Thornbury.

[35] Local Government New Zealand (LGNZ) has a Three Waters project (prepared by Castalia Strategic Advisors) that aims to improve potable water, wastewater, and stormwater in New Zealand. An issues paper prepared as part of this project in 2014, *Exploring the issues facing New Zealand's water, wastewater, and stormwater sector*, gives a national overview of the state and performance of local potable, wastewater and stormwater assets and services.

[36] Councils are required to review their representation system (e.g. the number of councillors, wards and community boards) every six years.

**Table B2: Southland towns and settlements connected to a municipal water-related scheme**

| District | Ward at 2018 Census | Ward at 2013 Census | Urban area | Storm | Waste | Potable |
|---|---|---|---|---|---|---|
| Invercargill City | | N.A. | **Invercargill** | ■ | ■ | ■ |
| | | N.A. | **Bluff** | ■ | ■ | ■ |
| | | N.A. | **Ōmāui** | | ■ | |
| Gore | Gore | Gore | **Gore** | ■ | ■ | ■ |
| | Matāura | Matāura | **Matāura** | ■ | ■ | ■ |
| | Waikaka | Waikaka | **Waikaka** | ■ | ■ | |
| | Waikaka | Waikaka | **Mandeville** | ■ | | |
| | Waikaka | Waikaka | **Pukerau** | ■ | | |
| Southland | Mararoa/Waimea | Five Rivers | **Athol** | | | |
| | Mararoa/Waimea | Five Rivers | **Garston** | | | |
| | Mararoa/Waimea | Five Rivers | **Lumsden** | ■ | ■ | ■ |
| | Mararoa/Waimea | Five Rivers | **Mossburn** | ■ | | ■ |
| | Mararoa/Waimea | Waikaia | **Balfour** | ■ | ■ | |
| | Mararoa/Waimea | Waikaia | **Riversdale** | ■ | ■ | |
| | Mararoa/Waimea | Waikaia | **Waikaia** | ■ | | |
| | Winton/Wallacetown | Winton | **Dipton** | ■ | | |
| | Winton/Wallacetown | Winton | **Limehills/Centre Bush** | ■ | | |
| | Winton/Wallacetown | Winton | **Browns** | ■ | ■ | |
| | Winton/Wallacetown | Winton | **Winton** | ■ | ■ | ■ |
| | Winton/Wallacetown | Waihōpai | **Woodlands** | ■ | | |
| | Waihōpai/Toetoes | Te Tipua | **Edendale** | ■ | ■ | ■ |
| | Waihōpai/Toetoes | Waihōpai | **Gorge Road** | | ■ | |
| | Waihōpai/Toetoes | Toetoes | **Wyndham** | ■ | ■ | ■ |
| | Waihōpai/Toetoes | Toetoes | **Fortrose** | | | |
| | Waihōpai/Toetoes | Toetoes | **Tokanui** | ■ | ■ | |
| | Waihōpai/Toetoes | Toetoes | **Waikawa** | ■ | | |
| | Stewart/Rakiura | Stewart/Rakiura | **Oban** | ■ | ■ | |
| | Winton/Wallacetown | Wallacetown | **Wallacetown** | ■ | ■ | |
| | Waiau/Aparima | Riverton | **Riverton/Aparima** | ■ | ■ | ■ |
| | Waiau/Aparima | Riverton | **Orepuki** | ■ | | |
| | Waiau/Aparima | Wallace | **Drummond** | | | |
| | Waiau/Aparima | Wallace | **Otautau** | ■ | ■ | ■ |
| | Waiau/Aparima | Wallace | **Wairio** | ■ | | ■ |
| | Waiau/Aparima | Wallace | **Nightcaps** | ■ | ■ | ■ |
| | Waiau/Aparima | Wallace | **Ohai** | ■ | ■ | ■ |
| | Waiau/Aparima | Wallace | **Orawia** | ■ | | ■ |
| | Waiau/Aparima | Tuatapere | **Tuatapere** | ■ | ■ | ■ |
| | Waiau/Aparima | Tuatapere | **Monowai** | ■ | ■ | |
| | Mararoa/Waimea | Te Anau | **Manapouri** | ■ | ■ | ■ |
| | Mararoa/Waimea | Te Anau | **Te Anau** | ■ | ■ | ■ |

### 1.4.1. Development of Wastewater[37]

As towns grew around New Zealand, the disposal of wastewater became "a headache" for local authorities and residents alike. In the 19th century wastewater was disposed of in cesspits[38] but towns soon became "pockmarked" with cesspits and the stench became unbearable, especially in warm weather. Inadequate disposal of wastewater became a major health risk and cesspits were banned and replaced with council-managed 'night soil' (wastewater) collections. The problem of disposal still remained but the development of reticulated collection depended on a water supply that could flush waste. Using gravity, wastewater was piped untreated to an outfall and into a water body. When the Department of Public Health was established in 1900 (in response to a worldwide bubonic plague scare) it directed all councils to treat wastewater before its disposal.

In Southland, the reticulated collection of wastewater began in some towns in the early 20th century but others still had nightcarts up until the 1970s. Except for Invercargill, which had an early septic tank, wastewater treatment systems were not introduced in the region until the 1960s and 1970s. The wastewater schemes that were developed at this time were usually funded through loans and also subsidies under the Public Health Act 1956 (e.g. Otatara). These subsidies where phased out by 1989 and at the time it was described as "the end of an era" for wastewater development in rural communities because the likelihood of communities being able to afford a new scheme was remote (Boyle, 2000, p.120). The Ministry of Health reintroduced subsidies in 2003 (the Sanitary Works Subsidy Scheme) for small, semi-rural communities but they ended again in 2009[39].

This section describes the development of the wastewater schemes for Wyndham, Balfour and Otautau. Although these towns were not used as case studies in this research, their stories are included here as examples for two main reasons. First, information on the towns was readily available in local histories. Second, and more importantly, they reflect some of the experiences of many smaller towns in Southland, particularly in terms of soil drainage, flood protection, and stormwater.

#### *The Wyndham Experience*[40]

Wyndham is a town in eastern Southland located east of the Matāura River, opposite Edendale[41]. Drainage and, during high rainfall, flooding has always been a challenge for the town. The Town Board started developing drains in 1884, putting them before footpaths (Thwaites, 2003). Wyndham's stormwater scheme was installed in 1935.

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[37] The introduction to this section is largely based on an account of the disposal of wastewater in New Zealand in Knight (2016) *New Zealand Rivers: An environmental history*.

[38] Cesspits are holes dug in the ground with outhouses built on top.

[39] The Hon. Tony Ryall (Minister of Health) stated in Parliament in 2010 that the Sanitary Works Subsidy Scheme was closed to new applications in June 2009 as the available funding was fully committed (https://www.parliament.nz/mi/pb/order-paper-questions/written-questions/document/QWA_21997_2010/21997-2010-hon-damien-oconnor-to-the-minister-of-health/ ).

[40] This section is based on an account in Thwaites (2003) *The Wyndham Story 1854-2000: Life Between the Three Rivers* and information provided by Southland District Council.

[41] Edendale sits west of the Matāura River on the Edendale-Brydone terrace, which has distinct bluffs or risers marking the erosional boundary between it and the lower elevation Wyndham terrace (White & Barrell, 1996).

Like many towns in Southland (and New Zealand), Wyndham used 'nightcarts' (a horse-drawn dray) for the removal of night soil for years.

> *Before water closets and modern plumbing every dwelling had a little shed in the garden, politely called a lavatory, otherwise the dunny – no toilets or loos then. The Town Board employed a nightman whose job it was to empty the contents of the lavatory regularly.* (Thwaites, 2003, p. 200)

Each property had a collection night although the service was sometimes irregular and the Town Board received complaints. Horse-drawn nightcarts ended in the 1960s and septic tanks started to be installed that were connected to the stormwater drains and outflowed into a branch of the Matāura River.

By the early 1980s, there were 217 septic tanks connected to the town's stormwater drains and steps were being taken to install tanks and connect the remaining 12 properties (Thwaites, 2003). Rather than installing a wastewater reticulation system, a scheme was set up to clean all of the septic tanks on a four-year cycle. In 1992 inspection pits were installed at 70 metre intervals in the town for aqua-jet cleaning. In 1994 some concrete drainage pipes were collapsing and had to be replaced. During the course of this work many of the drains were located and a complete map was made of the town's drainage system (the original plans had been destroyed in a fire) (Thwaites, 2003).

Between 2008 and 2010, Southland District Council built the Edendale – Wyndham Wastewater Scheme at a cost of $13 million to remove the wastewater from Wyndham's stormwater network and resolve issues with Edendale's wastewater. A large share of the overall costs in this instance were subsidised by Ministry of Health and SDC to make it more affordable to ratepayers. Wastewater is now collected through a series of pipes and pump stations and treated at a wastewater treatment system. The treatment process involves a fine screen and biological worm farm followed by chemical dosing and ultra-violet disinfection, before the treated wastewater is discharged into the Matāura River.

### *The Balfour Experience*[42]

Balfour is a smaller town in Northern Southland that sits at the foot of Glenure Hill, which is part of the Hokonui Ranges. Drainage was as issue in Balfour as early as 1898 and the first public meeting on drainage was held in 1913. Following this meeting, the County Council dug a number of open ditches that drained along the town boundaries into a larger open ditch alongside the sports ground. The drains solved some problems but led to others because of poor fall for drainage and the compactness of the sub-soil, which prevented soakage for wastewater. Each household and business had to solve their own stormwater and wastewater issues with often little regard to the overall effect on the town (Wing, 2004).

> *"When the railway was built and buildings began to be erected around the railway siding at Longridge Bridge, no-one could foresee the problems that lay ahead when a*

[42] This section is based on an account in Wing (2004) *Pioneers to Present*.

*township is developed on very level ground which has little natural drainage and poor soakage through the type of sub-soil present in parts of the area. ."* (Wing, 2004)

In 1956 the County Engineer proposed a major septic tank with the wastewater gravitating to a filtration pit for 20 households, with a possible extension for up to another 15 households. The cost of the plant, without piping, was £3,600 (or the equivalent of $181,000 in 2017[43]). Some financial assistance was allowed for the County but the cost for these households was deemed to be prohibitive at the time. In 1957, newspaper reports highlighted on-going concerns. Some drains were laid in the town but not all were piped, and there were issues with drains becoming blocked. The drainage of water and "other things" towards the sports ground drain led to a large build-up of wastewater in the area causing a "very disagreeable stench around the playing fields".

In 1961 the stormwater drainage scheme was completed and in 1963 a wastewater treatment system designed for up to 150 households was built. This upgrade was a major step in the progress of the town (Wing, 2004). It did not solve all the drainage problems and the topic was again raised at a public meeting within a couple of years. The difficulties with solutions revolved around the lack of sufficient capital that was able to be raised on such a small rateable base.

### *The Otautau Experience*[44]

Otautau is a town in Western Southland, located on an alluvial floodplain beside the confluence of the Otautau Stream and Aparima River, at the base of the Longwood Range. In 1908 the Council discussed the provision of a waste disposal scheme for Otautau. The system was basic, nightsoil collection, but characteristic of the times. Precise instructions were issued by the Council for the disposal of the nightsoil: "The contractor shall deposit the night soil at the depot and shall spread it as directed evenly and thinly over the surface of the ground, and also plough enough land over to thoroughly cover all material spread. The ploughing will require to be at least six inches deep."

The nightsoil collection service was available to those who needed it until 1979. During those years the basic service altered little, although the means of collection and disposal kept pace with the times – from dray to truck, to tractor to small tractor as the people requiring the weekly call declined. The service "worked well" during those years. There were no public sewers to unblock so that any problems tended to be personal or mechanical in nature.

In 1971 the Council began to seriously consider the possibility of a wastewater scheme for the town, complete with pipes, treatment plant and oxidation ponds. Such a scheme was investigated and designed and arrangements were made to raise a $170,000 loan to finance the project (or the equivalent of between $2.4 million in 2017[45]). Planning continued, but the scheme ran into trouble when a re-estimate of the cost of the scheme put it at $370,000 and then tenders came in well above even this amount. In 1974 the Ministry of Works proposed a different three-stage scheme, the first stage of which alone was to cost $468,000. Despite reservations, the Council sought a

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[43] Estimated using the Reserve Bank inflation calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator.
[44] This section is based on an account in (Bye, 1988) *Trial by Fire, Trial by Water: History of Otautau*.
[45] Estimated using the Reserve Bank inflation calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator.

further loan of $350,000 to cover the additional cost. By now the magnitude of the scheme and the financial burden it would place on the town were clearly over-riding concerns. Public consultation rejected the scheme by a clear majority and the Council put it “on hold”. The continued cost escalation and the absence of sufficient subsidies for such major works convinced the Council to abandon the proposal after ten years of “earnest endeavour”.

The issue was revisited in the 1980s when a pipeline was suggested through the bed of the Aparima River to a treatment system across the river from the town (K. Swinney, pers. comm., 2018). In 1996 the Southland District Council put forward a proposal for a wastewater scheme, where the treatment system was an oxidation pond (1 hectare) and disposal to land of the treated wastewater using border dyke irrigation. In 1998, the proposed method of disposal was changed to slow-rate spray irrigation (sprinklers). Each sprinkler covers a diameter of around 25 metres with a total irrigation area of twelve hectares. The scheme was developed and the reticulation (a gravity pipe network with six pump stations) carries wastewater to the treatment system located roughly 1.5 kilometres south of the town, 300 metres to the east of the Aparima River (with the disposal field 50-80 metres to the east of the river bank). Once developed, ratepayers faced costs to connect to the scheme and were given two options: either pay for the work themselves as a one-off cost, or pay for the connection over time through their rates. Most town properties connected fairly quickly and, although some took up to ten years, all properties should now be connected.

# 2. Gore District

Gore District covers around 125,400 hectares of land and water in north-east Southland, and includes the towns of Matāura, Gore, and Waikaka (as well as their surrounding rural areas). These communities are distributed across just over 120,000 hectares of developed land (ES Land Use Map, Pearson & Couldrey, 2015). The District also contains slightly less than 3,900 hectares of land in indigenous vegetation that includes Croydon Bush and Dolamore Park Scenic Reserves (ES Land Use Map, Pearson & Couldrey, 2015). In 2013, the District’s total population was around 12,000 (or just under 13 percent of people living in Southland) – roughly 10 people for each square kilometre of developed land. There were almost 5,000 dwellings (just over 90% occupied) in the District, and median personal income was $28,800. Within the Gore District there are 3816 rating units in Gore, 800 rating units in Matāura and 1348 rural rating units (GDC Website).

Gore District Council manages physical assets and services that support its local communities. These assets and services include around 900 kilometres of roads[46], two urban water supplies, one rural water supply, three wastewater schemes, as well as complex stormwater schemes, libraries, cemeteries, community halls, reserves and parks, and other activities. The District’s rural and urban ratepayers contribute to the cost of these assets and services through general, targeted and uniform annual general rates (based on the capital value of their property). A large proportion of revenue from rates is spent on essential infrastructure. In 2015/16 the proportion of rates revenue was around 37 percent, with $2.38 million of rates funding spent on roading and transport (with total

[46] Of this total length of roads in Gore District, 60% (540 km) is sealed and 40% (360 km) is unsealed.

funding, including National Land Transport Fund assistance, around $3.49 million), and $2.92 million of rates spent on the three waters assets (water, wastewater, and stormwater) (GDC 2015/16 Annual Report).

In comparison to Southland District, Gore District Council manages a handful of wastewater schemes. These schemes are located at Gore, Matāura and Waikaka and the treatment systems centre on oxidation ponds, although Gore also has invested in an Actiflo plant for phosphorus removal. In addition to the treatment systems, the schemes have a combined total of 103 kilometres of pipes and 13 pump stations. These schemes all remove and treat wastewater from residential properties, businesses and community facilities. Gore has a medium-size scheme and receives considerable volumes of trade waste from local seasonal industry, which requires a high level of treatment. Gore District has a trade waste bylaw for limiting volumes and strength of waste and hazardous substances. Parts of Gore's wastewater scheme are connected to its stormwater scheme – which adds more complexity. The three schemes discharge either directly into the Matāura River, or a tributary of the Waikaka Stream, which eventually flows into the Matāura River.

The three wastewater schemes are an important investment for local communities – in 2016 the District's wastewater assets had a total replacement value of around $41 million. The Matāura treatment system was built in 1962 (upgraded in 2008), the Gore treatment system in 1973 (upgraded in 2009), and the Waikaka treatment system in 1986 (upgraded in 2007). Funding for these schemes was originally provided through a mix of central government subsidies and local government loans. To manage the costs for the District's ratepayers, the Council plans upgrades of its wastewater schemes around the duration of discharge consents. The suitability of current wastewater treatment facilities (centred on oxidation ponds) and long term operational viability of these schemes will be key decisions for the Council over the next 10 years. Gore District's Operations and Maintenance Budget for wastewater activity for 2017/18 is just under $1.7 million (GDC Annual Plan 2017/18).

This section describes the two case study towns in the Gore District: Gore and Matāura. The information included for each town covers its location and role, settlement and development, present situation and future outlook. It is intended to help give some context for the research in Part C. At the end of this section is an overview of some of the environmental issues related to water quality for these towns.

The main water body flowing through Gore District is the Matāura River but there are many others, including the Waimea Stream, Waikaia River and the Waikaka Stream, which are tributaries. The Matāura River valley is known as Maruawai ('valley of water') because of the river's natural tendency to flood the full width of the valley. Over the last century, major floods have occurred frequently, including 1913, 1948, 1957, 1967 (the Wahine Storm), 1978, 1987 and 1999; although in the early year's data on water flow were not recorded. Separate stopbanks now protect communities along parts of the Matāura River (there are substantially less stopbanks on the Matāura River than on the Ōreti River, and few above Gore). These stop banks have altered the natural flow of water over the land. Similarly, other engineering works such as rock reinforcement of river banks also attempt to restrict the natural migration of the river channel.

Maruawai[47] was a valued trade route for Ngāi Tahu, who have used its land and water resources for nearly a thousand years, and many place names reflect this history. Several important Ngāti Māmoe and Ngāi Tahu tūpuna (ancestors) have links with the Matāura River. The area of the Matāura River above the Matāura Falls was traditionally used by the descendants of the Ngāti Māmoe rangatira, Parapara Te Whenua. Another famous tupuna connected with the river was Kiritekateka, the daughter of Parapara Te Whenua who was captured by Ngāi Tahu in Te Anau.

The Matāura River and the Toetoe estuary near Fortrose are highly valued for mahinga kai. Native species gathered seasonally included kanakana (lamprey), wai kōura (freshwater crayfish), inanga (whitebait), waikakahi, tuna (eel), native kōkopu, pārera (grey duck), pūtangitangi (paradise shell duck) and weka. There were numerous tuna camps, and resources such as silcrete (silica cemented soil and/or silt) were made into tools using water as part of the manufacturing process. Species, such as inanga and kanakana, are still important resources but kanakana and tuna fisheries have declined in recent years.

Te Au Nui (Matāura Falls), meaning the great current, is a feature of the river's cultural landscape, particularly for its abundance of kanakana. A 10 kilometre stretch of the Matāura River including Te Au Nui forms New Zealand's first freshwater mātaitai reserve, Matāura Te Awa Mātaitai (an area where the mana whenua manage non-commercial fishing).

The importance of the Matāura River to Ngāi Tahu is recognised under the Ngāi Tahu Claims Settlement Act 1998. There is a nohoanga on the Matāura River at Ardlussa and another on the Waikaia River at Piano Flat. Māori freehold land blocks, issued under the South Island Landless Natives Act 1906 (SILNA), are located to the southwest of Gore and Matāura. These SILNA lands were originally allocated in compensation for loss of land and ability to access water bodies during land sales in the 1800s. Restricted land access and declining water quality are increasingly impacting on the use of many mahinga kai sites on the Matāura.

## 2.1. Gore

### 2.1.1. Location and Role

Gore is an inland rural service town that stretches along both sides of the Matāura River. It is located at the point where the Matāura River leaves the Waimea Plain, is joined by the Waikaka Stream, and flows on to southern Southland. The Matāura River is the principal reason for Gore's existence and the town's relationship with the river is intricate[48].

[47] The main source for this section is Schedule 42: Statutory acknowledgment for Matāura River in the Ngāi Tahu Claims Settlement Act 1998.

[48] In 2013, 21 primary schools along the Matāura River, together with artist Janet de Wagt, produced 600 artworks with recycled materials for the Matāura River Art Project – 200 of which were displayed at Parliament. The aim of the project was to celebrate the history, landscape, community and identity related to the Matāura River. The schools also learnt about why the river is so vital to their local community.

**Image B8: Looking northwest over Gore towards the Hokonui Hills**
Source Emma Moran

Originally, Gore was known as 'the Long Ford' (or Longford), and its site was one of the few places people could cross the Matāura River safely by horse and cart. The river divides the town into Gore and East Gore, which are now linked by a bridge, and there are popular recreational areas on its riverbanks. The town's water supply is sourced from Cooper's Wells and Jacobstown Well, with the Matāura River sometimes used to recharge the aquifer. The brown trout fisheries in the Matāura River and Waikaia River are highly valued, and are celebrated with a statue in the centre of the town. The town's treated wastewater is discharged into the Matāura River. Parts of Gore are on the River's flood plain, and while there is a flood protection scheme, there are always risks that the capacity of the stopbanks will be exceeded, or that the stop bank will fail.

Gore is within the Matāura and Toetoes Harbour Freshwater Management Unit.

The town is the second largest urban area in Southland and is some distance from other sizeable towns or cities: the closest being Invercargill 65 kilometres to the south and Balclutha 71 kilometres to the east. It is the central hub of a much wider community in north-eastern Southland. There are retail and business services that are used by most (if not all) people living in Gore District, and further afield in the Southland and Clutha districts, including Riversdale, Waikaka, Waikaia, Tapanui, and Matāura – and the town depends on the economic activity in these areas. Its residents are employed in local meat, milk, and wood processing industries and tourism linked to the brown trout fisheries. The town also has a full range of other services, such as education (both primary and secondary schools) and healthcare (including a hospital), which are used by locals far beyond the town boundary.

**Image B9: The Matāura River at Gore looking north-west towards the Waimea Plain**
Source Emma Moran

### 2.1.2. Settlement and Development

There was no permanent Māori settlement where Gore is now before the arrival of Europeans. The site was used for food gathering and a camp, but it was not considered for settlement because of its swampy and tussocky nature. It was close to trade routes, and the village of Tuturau was further south on the Matāura River. The area west of the Matāura River was Taumatanga Hei Kaungaroa, meaning 'land that is unsuitable for human habitation'. The area east of the River was Onuku – names in honour of Nuku, who camped there with her husband Hautu to gather taramea (speargrass) before dying in a snow storm while journeying further inland to hunt weka.

The Otago Provincial Council purchased the area around Gore as part of the Murihiku land block. In 1856 Alexander McNab, one of the first European settlers, established the Knapdale and Hokonui sheep runs on either side of the Matāura River, along with a small hut at Croydon Bush (just north of Gore) (Beattie, 1979). When gold was discovered in Gabriel's Gully (east of Gore) in 1861, 'the Long Ford' came into its own as a ferrying or stop-off point for supplies and the gold escort between Dunedin and Invercargill. In 1862 the first building, Long Ford House, was built as an accommodation house for travellers, and business grew when gold was discovered in the Waikaka and Nokomai rivers. A small settlement of 12 sections was surveyed and named 'Gore' in honour of Thomas Gore-Browne, Governor of New Zealand (1855 to 1861). For many years, locals were unaware of this name and continued to refer to the town as 'Longford'.

In the 1870s almost 200 sections were released with the break-up of the two original sheep runs that, along with the arrival of the railway, encouraged settlement in the wider area. By 1880 Gore had road and rail links to Invercargill, Dunedin and Lumsden. On opening day of the Invercargill line in 1875, a 40 carriage train brought people from Invercargill and many purchased property in Gore on arrival. When the Dunedin line opened in 1879, locals were surprised to find the name ‘Gore’ painted on the sign, not ‘Longford’. The opening of the Waimea line in 1880 linked Gore to Lumsden and on to Kingston, making the town an important ‘crossroads’ for both gold and agriculture.

During the 1880s the settlements of Gore and Gordon (now East Gore) were amalgamated and Gore was constituted a town under the Town Districts Act 1881 (Cyclopedia Company Ltd, 1905). 1886 to 1900 was a period of rapid growth as Gore grew into its role as a rural service centre and gained the nickname of ‘Chicago of the South’. There was a post and telegraph building with private phones, and two newspapers. The Fleming’s Cremoata Mill was built in 1892, and became the town’s major employer. In 1894 Gore became the first town in Southland to provide a public electricity supply (PowerNet, n.d.). Other early developments included the Gore A&P Association, and sports events, such as highland games and racing.

Gore developed strong education and health care services early. The first primary school in Gore, Gore Main School, opened in the late 1870s, with a secondary school department being added in 1901. It was followed by St Mary’s School and Gore High School, and then after the post-war baby boom, West Gore School and St Peter’s College – the first co-educational day and boarding school in Australasia (St Peter's College, n.d.). The Seddon Memorial Hospital served Gore and the surrounding rural area from 1909 to 1999. The hospital had 130 beds and a full range of services, including a nurse training facility (Gore Health, n.d.). In the 1980s, the Southland Hospital Board decided to close Gore’s hospital and develop a base hospital in Invercargill. The community successfully fought to keep their access to local, quality healthcare and eventually replaced it in 1999 with the community-owned Gore Hospital.

Gore’s early reputation was “something of a hell raising” settlement – and as the town’s population increased so too did its problems with drunkenness (Feeley, 2012). Settlers who started arriving in the town from the 1880s were more conservative and started a movement for the prohibition of alcohol that lasted until 1954. In response to prohibition, moonshine (illicit whiskey) was produced in the Hokonui Hills to the west of Gore up until the 1930s[49]. Another aspect of Gore’s character is country and western music. The Gore country music club was formed in 1973 and has run the New Zealand Golden Guitar Awards for well over 40 years, attracting artists from around the world.

Historically, the town’s water supply has been important for firefighting. The Gore Fire Brigade was established in 1886 and was to become possibly the most practiced fire service in New Zealand (Feeley, 2012). Between 1865 and the late 1930s there were at least 18 large fires in and around Gore. Gore School burnt down twice, as well as four hotels, the local newspaper offices, the railway station, the flour mill and on three separate occasions, whole business blocks in the town centre were lost affecting around 20 shops and businesses each time.

Gore has also been affected by a series of major floods, notably in 1913 and 1978. In March 1913 flash flooding in the upper catchment of the Matāura River caused the river to overtop its banks and water filled the streets to a depth of 1.5 – 1.8 metres (NIWA, 2018). Around 1,800 residents were

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[49] In the late 1930s, a local fish and chip shop owner was well known for selling moonshine along with his fish and chips, but the police could not find the stock. It was not until a fire broke out in the shop that a false wall was discovered, revealing hundreds of bottles of moonshine (Feeley, 2012).

forced to leave their homes and the damage to property and businesses was estimated at £100,000 (or the equivalent of $16.2 million in 2018[50]). In October 1978 the Matāura River at Gore was recorded at 4.69 metres above normal (better monitoring data was available in 1978 than in 1913).


**Image B10: 1913 Flood, Mersey Street, Gore (at around two feet below the flood's peak)**
Source Environment Southland

Gore grew steadily throughout the first half of the twentieth century, and enjoyed three decades of prosperity after the World War Two. Job opportunities, such as at the freezing works and shearing, together with the lifestyle have attracted mātāwaka (all Māori) from elsewhere in New Zealand and their whānau (families) are now part of the community. Since the 1970s, its fortunes have followed the upturns and downturns of the agriculture and mining sectors. The Cremoata Mill closed in 2000.

During local government reforms in 1989 it was proposed that Southland would be served by two districts – Southland and Invercargill. The local community in north-eastern Southland fought strongly to retain its identity and also become a district. It was argued that Gore was economically viable as a district because of the industries in the area – the paper mill, freezing works and coal mining. Gore and Matāura borough councils and parts of Southland and Clutha county councils were amalgamated to form Gore District, which has its main offices in Gore.

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[50] Estimated using the Reserve Bank inflation calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator.

### *3 Waters Infrastructure*

Gore's original water supply was established in 1930 after several attempts at finding an adequate water source. A pump house and well were constructed at Jacobstown, located in the northern part of Gore and a reservoir was built at the top of a hill in the town (Hilbre Avenue) (Sarah Crooks, pers. comm., 2018). Water was pumped from the Jacobstown well up the hill, and treated before entering an open air reservoir. The water was then distributed through copper and cast iron water mains to residents living in west Gore. In 1979 Cooper's well field, on the eastern side of the river, was first developed with two wells – one well failed and it was replaced with another in 1982. This water supply also includes a water treatment plant. Both wells are hydraulically connected to the Matāura River, which has limits on the amount of water that can be taken at low flows. The Gore District Council is currently investigating new water sources to supplement the existing supply during dry periods.

Gore originally had combined wastewater and stormwater networks and its wastewater treatment system, based on a primary oxidation pond, was constructed in 1973. In the 1980s staged projects to separate the networks were completed in many areas of the town but they ceased, possibly due to a staffing change, a new strategic direction, and/or a loss of knowledge of intended infrastructure planning. Around 40 percent of Gore's wastewater network remains combined with stormwater – mainly in the northern parts of the town. In the early 1990s a strong trade waste discharge from the meat processing plant caused the wastewater treatment system to fail, creating a strong odour that lingered around the town until the pond system could be resurrected using aeration. Steps were taken to better manage this trade waste stream but the risk of shock loads from the site still exists.

Stormwater drains collect surface runoff from both the town and surrounding agricultural areas and discharge it untreated either into the Matāura River (or its minor tributaries within the town boundary) and Waikaka Stream. Terrace streams on the outskirts of the town enter the network to flow to the Matāura River. There is consistent base flow in many parts of the network. The stormwater scheme in Gore has eleven discharge points: three to the Matāura River, one to the Waikaka Stream and seven to minor tributaries of the Matāura River that flow through or skirt the town. There is also one discharge from a stormwater ponding area to the Waikaka Stream, which is only used during rainfall events. These discharge points are managed via a stormwater consent.

Hydraulic modelling of the stormwater and wastewater networks has identified capacity problems in areas during intense or prolonged rainfall events – particularly in the areas where wastewater and stormwater is combined. Surface flooding occurs and, in specific areas, residential properties can be inundated. The network can back up and overflow into secondary flow paths. When the terrace streams around the town are also in flood the network quickly becomes overwhelmed. Long term capital investment is planned to reduce these issues.

### 2.1.3. Present[51]

Gore is primarily a rural service centre that supports economic activity in the surrounding districts. The town is home to 7,347 people, representing 61 percent of the District and 41 percent of the Matāura Freshwater Management Unit[52]. Its residents are largely European (93%) and Māori (9%), with some Pacific and Asian peoples (2%)[53]. Te Rūnanga o Hokonui is based at Hokonui Marae in the town and Te Ika Rama Marae is situated at McNab, just to the east. In general, the age distribution of Gore's population tends to be older than for Southland as a whole: the median age is 45 years, with 19 percent of people under 15 years and 23 percent of people over 65 years.

There are 3,486 houses in Gore and their occupancy is 92 percent (and the number of occupied houses in the town is increasing slightly over time). Most households are either one-family (63%) or one-person (33%). Of the family households, most are couples without children (50%), although there are many couples with children (35%), and one parent with children (15%). The average household size is 2.2 people, which is smaller than for the region. Home ownership is around 73 percent of all households – which is three percent less than in 2001. For those who do not own their home, median household rent is $180 per week.

Just over two-thirds of people aged 15 years and over are in the labour force and the unemployment rate is 4.0 percent (which is low for the region). In the 12 years between 2001 and 2013, the total number of paid employees decreased 1.7 percent to around 3,000 people – another 220 people are either employers or self-employed. The median income in Gore is $27,500, with a wide income distribution: 36 percent of people earn below $20,000 a year, and 22 percent earn over $50,000 a year. Many people in Gore are on fixed incomes. In 2013 the Ministry of Health's social deprivation index scores ranged from five in North and West Gore to eight in East Gore (where 1 is low deprivation and 10 is high).

In terms of education, 66 percent of people aged 15 years and over have a formal qualification – and eight percent hold a bachelor's degree or higher. As employers, Gore's largest 'industries'[54] are retail trade and manufacturing, which together account for around 29 percent of paid employees. Other important industries are agriculture, forestry and fishing, and construction. Gore is a central hub for rural supplies and services, retail businesses, and industry. Silver Fern Farms has a processing plant at Gore and there is also an area of light industry in the south end of the town. Alliance's meat processing plant in Matāura (13km south of Gore) is a large employer of people who live in Gore.

Gore has many community groups, and facilities that cater to locals well beyond the town boundary. These include: Gore Volunteer Fire Brigade, a St John ambulance service, police station, MLT and James Cumming Wing event centres, Rotary and Lions clubs. There is also a range of sports clubs and facilities including a racecourse, a golf club, and the Gore Aquatic Centre. Natural amenities include Gore Public Gardens and Bannerman Park, both 'Gardens of National Significance' as well as

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[51] All statistics in the section are from the New Zealand Census 2013, and are for the Gore Ward, which consists of North Gore, South Gore, East Gore, West Gore and Central Gore. Gore Ward is one of the five wards in the Gore District. It will be important to also consider information from the 2018 census when it becomes available

[52] The Matāura Freshwater Management Unit includes most of Gore District and part of Southland District.

[53] These figures add to more than 100% because some people identify as more than one ethnic group.

[54] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

Dolomore Park nearby. The town hosts large events that attract visitors from all over New Zealand. The Southern Field Days is the biggest farming event in the South Island and held biannually in Waimumu (just outside Gore) – in 2018 over 41,000 people attended the three day event (not including children under the age of 16). The Gore 'A&P' Show, Golden Guitar Country Music Awards and the Hokonui Fashion Design Awards are all held annually in Gore.

## 2.2. Matāura

### 2.2.1. Location and Role

Matāura is an inland industrial town that sits on both sides of the Matāura River on the eastern fringe of the Southland Plains. It is located at the point where the Matāura River runs over a sandstone formation to create Te Au Nui (the Matāura Falls). As with Gore, the Matāura River is the primary reason for Matāura's existence and the town's relationship with the river is also intricate.

Originally, Matāura was known as Matāura Bridge, and its site attracted European settlers as a landmark on the route between Dunedin and Invercargill and for its hydro-power generation potential (Muir, 1991). During the town's settlement, Te Au Nui was twice dynamited, destroying its rock pillars, and reducing the drop to six metres (Muir, 1991). The river divides the town into east and west Matāura, now linked by a bridge. There are fishing spots on the outskirts of the town and a walkway along Culling Terrace. The river's kanakana fishery is a taonga for Ngāi Tahu. The town's treated wastewater is discharged into the Matāura River. Parts of Matāura are on the river's flood plain, and while there is a flood protection scheme, there are always risks of stop bank failure or their capacity being exceeded.

The town's water supply is sourced from the Pleura Stream (located roughly seven kilometres from the town) and, during low flows, the Waikana Stream - both streams are tributaries of Matāura to the east of the town. Matāura is within the Matāura and Toetoes Harbour Freshwater Management Unit.

The town is a small urban centre that is situated near to several other towns (although there is no public transport): the closest being Gore 13 kilometres to the north and Edendale 15 kilometres to the south. It is largely focused on meat processing and related services, such as stock transport, to the agricultural sector. As well as meat processing, residents are employed in wood processing and agriculture. The town has some retail, business, education and healthcare services, and relies on Gore for others (such as secondary schools, swimming pool and hospital).

**Image B11: Matāura looking south towards Tuturau and Edendale in the distance**
Source Emma Moran

### 2.2.2. Settlement and Development

There was no permanent Māori settlement where Matāura is now before the arrival of Europeans. Te Au Nui (Matāura Falls) was the site of the annual harvest of kanakana each spring but the closest settlement was at Tuturau, an early kaik (unfortified village), 3 kilometres further south on the Matāura River (Muir, 1991). Tuturau was popular as a natural place to stop while travelling from inland to the coast or to Ruapuke Island because of its plentiful food supplies and flax (Muir, 1991). Māori travelling south to the Tītī (Muttonbird) Islands, harvested and buried flax in the peat swamps to process the fibre and collected it on their return (Muir, 1991). After the arrival of Europeans, Māori used the land for growing potatoes. Local Māori maintained dwellings close by, at a spot known to early European settlers as the 'Fish Market' (Muir, 1991).

Tuturau is well known as the site of the last inter-tribal battle in Te Wai Pounamu (the South Island) in 1836. Te Pūoho, a rangatira from Ngāti Tama and ally of Te Rauparaha, led a taua (war party) from Pākawau (Golden Bay, near Nelson), down the West Coast and through Central Otago, to Tuturau with the hope of skinning the Ngāi Tahu "eel from tail to head"[55]. Te Pūoho initially captured Tuturau but three days later 18-year old rangatira Topi Patuki surprised and shot him with a musket (Muir, 1991). The Tuturau Māori War memorial was erected in 1934 to mark the centennial of the battle.

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[55] https://nzhistory.govt.nz/media/photo/tuturau-Māori-reserve-and-war-memorial

The first European settlers came to the area because of the Tuturau ford downstream of the Matāura Falls and the northern ford above the falls. In 1856 The Otago Provincial Council established a ferry just to the north of the Matāura Falls, as part of an overland route between Invercargill and Dunedin, and built the first building in the town - the Matāura Ferry Hotel on the River's west bank. In 1859 a wooden footbridge was built over the Matāura Falls and the face of the falls was dynamited when its spray made the bridge slippery (Muir, 1991). The footbridge was lost in 1861 to a flood. A more substantial suspension bridge was built in 1868, and the current concrete bridge was opened in 1939. The settlement was known as Matāura Bridge and it was a stop for the mail coach, attracting businesses in and around Bridge Square. Matāura has been affected by a similar series of major floods as Gore, with the Falls acting as a 'bottleneck' on the river.

**Image B12: From Matāura Bridge looking north to the remains of the Matāura Falls**
Source Emma Moran

In 1875 the railway line from Gore reached Matāura. The railway brought industrial development and Matāura became a major industrial centre in Southland. Coal was mined on the banks of Waimumu Stream between 1861 and 1866. A paper mill was built in 1876, a dairy factory in 1887, and the freezing works in 1893, all of which relied on hydro-electric power. The paper mill and the freezing works were located directly over the falls, with its face again dynamited in the process. The owners of the paper mill built a flour mill for the community in response to concerns about its use of hydroelectricity from the falls. The flour mill was later demolished to make way for the freezing works. There were other industries in or around the town, many supporting the larger industries. These industries included: transport, flax mills, stock foods, market gardeners, cordial factory

(Quilters), the Sugar of Milk (lactose) factory, a lignite mine (supplying coal to the paper mill), and sawmills.

Matāura was constituted as a borough in 1895 and grew steadily throughout the first half of the twentieth century and the town swimming pool opened in 1956 (closed in 2017). In the late 1940s the Matāura freezing works introduced a chain system that led to a more seasonal workforce. From the 1950s there was a large influx of Māori to work at the freezing works and many stayed and became part of the community. Matāura's dairy factory closed in 1980 when dairy processing in the area was concentrated in Edendale. In 1997 a medium-density fibreboard plant opened at Brydone, 6 kilometres south of Matāura. In 2000 the paper mill closed, making 155 staff redundant, and the lignite mine closed as a result. Between 2000 and 2013 the population declined but more recently it may have plateaued.

### *3 Waters Infrastructure*[56]

For the first 60 years of settlement, residents were left to manage their 'nightsoil'. It created issues and during this time the Inspector of Nuisances was called in to apprehend people who dropped it over the bridge at night. In 1900 the Matāura Borough Council wrote to the Gore Town Clerk for advice as to "what they did with theirs", and then looked into the cost of collecting Matāura's nightsoil on a fortnightly basis. In 1908, the Council purchased 58 acres (23.5 hectares) of land on the outskirts of the town to develop as a 'sanitary farm' and a weekly nightcart service began. In 1909 the district health inspector concluded bad drainage was responsible for the prevalence of sore throats and diptheria. A committee was appointed "to inquire into the whole matter regarding the disinfection of the borough".

A water scheme was developed from Pleura Stream in 1925 to provide suitable water to the paper mill and drinking water to residents. The water supply meant that flush toilets were possible and 'dunnies' slowly became a thing of the past. Stormwater and wastewater were a combined system and they were discharged untreated through 13 outlets to the Matāura River. In 1982 wastewater was piped to a new treatment system based around an oxidation pond to the south of the town before being discharged to the river. Funding for the new system was helped with Government subsidies to improve public health and to improve the water quality of the Matāura River. The previously combined pipe network is now just used for stormwater and it services less of the town than the wastewater reticulation. There are eight stormwater discharge points to the Matāura River and Waimumu Stream that are managed through a consent.

The quality of the Matāura's water supply is highly variable because the main source of the Pleura Stream is runoff from agricultural land. The water is piped to the Matāura Water Treatment Plant via gravity from the dam where it is treated before being supplied to the community.

[56] The main source for this section is D.C.W. Muir (1991) *Mataura: City of the Falls*.

**Image B13: Matāura Bridge with State Highway 1 in background**
Source Emma Moran

### 2.2.3. Present[57]

Matāura is primarily an industrial centre that supports Southland's agriculture and forestry sectors. The town is home to 1,509 people, representing 12.5 percent of the District and eight percent of the Matāura Freshwater Management Unit. Its residents are largely Māori (30%) and European (76%), with some Pacific and Asian peoples (5%)[58] – and 10 percent of residents speak Te Reo Māori. The Matāura and District Marae is situated in the town. The age distribution of Matāura's population is similar to the region as a whole: the median age is 40 years, with 22 percent of people under 15 years old and 15 percent of people over 65 years.

There are 729 houses in Matāura and their occupancy is 87 percent (the number of occupied houses is declining over time although this situation may have changed since the 2013 census). Most households are either one-family (65%) or one-person (30%). Of the family households, most (42%) are couples without children, although there are many couples with children (35%) and one parent with children (23%). The average household size in the town is 2.4 people, which is the same as for the region. Home ownership is around 67 percent of all households – which is seven percent less than in 2001. For those who do not own their home, median household rent is $150 per week.

[57] All statistics in this section taken from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.
[58] These figures add to more than 100% because some people identify as more than one ethnic group.

Just over two-thirds of people aged 15 years and over are in the labour force and the unemployment rate is 8.4 percent (which is high for the region). In the 12 years between 2001 and 2013, the total number of paid employees decreased 22.3 percent to just under 600 people – another 50 or so people are either employers or self-employed. The median income in Matāura is $23,100, and income distribution is weighted towards lower incomes: 43 percent of people earn less than $20,000 a year, 14 percent earn more than $50,000 a year. Personal median income is $23,100 (22% less than for the region). In 2013 the Ministry of Health's social deprivation index score for Matāura was nine (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, 53 percent of people aged 15 years and over have a formal qualification, which is lower than for the region – and three percent hold a bachelor's degree or higher. By employment, Matāura's largest 'industry'[59] is manufacturing, with just under 65 percent of paid employees, followed by agriculture, forestry and fishing. The most common occupation by far is labourer, followed by technicians and trade workers. There is an Alliance meat processing plant in Matāura that employs people from across the District. Other industries, either in or near the town, are the Ngahere sawmill and the Daiken Southland fibreboard factory and Tullochs Transport.

Matāura has a primary school, a medical centre, and a number of community groups and facilities, including: Matāura Volunteer Fire Brigade, Matāura Community Centre, the award winning Matāura Museum, library, a community vegetable garden, and several sports clubs. Annual events include the Matāura Rodeo, Anzac Day Remembrance Service, the RSA's Daffodil Day celebrations, and a three day Motoring Mad Car Show – organised by the Matāura Scouts (E. Ranstead, pers. comm., 2017).

## 2.3. Environmental Issues Relating to Water

Gore District lies entirely inland, with most of its population concentrated in and around three main towns. The District is located within the upper to middle catchment of the Matāura River, which divides the District and interaction with the river is continuous along its length. The Matāura River has long been used as a fresh water and food source, and over the past 150 years, by towns and industries for hydropower generation, processing and manufacturing, and as an outlet for waste products. Improving public health and the safety of communities led to the development of wastewater and stormwater networks that drained the land and directed water and waste to the river. By the 1930s, parts of the Matāura River were considered severely polluted (Knight, 2016).

Over time it was recognised that urban and industrial activities were having adverse effects on the Matāura River. In 1997 a Water Conservation Order was granted to protect its outstanding fishery and angling amenity. Since this time some industries have closed, as a result of market forces, and the towns and remaining industries have invested in improving wastewater treatment. Trade waste from some industries is received, treated and discharged to the Matāura River via municipal wastewater schemes. Monitoring shows the main contaminants in the Matāura River and its tributaries today are micro-organisms (e.g. *E. coli*), nitrogen and, in some places, phosphorous and sediment. These contaminants come from urban and rural activities throughout the catchment. The

[59] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

environmental issues for Gore District Council are around security of water supply, stormwater and wastewater. Each topic has water quantity and water quality considerations.

Water availability for the towns has long been a challenge for Gore District Council. The water supply schemes rely on water from shallow spring fed wells, shallow groundwater wells and surface water catchments. The shallow wells are recharged through a combination of groundwater, springs and hydraulic connection with the Matāura River. The shallow nature of these water takes means they are affected by hot, dry summers. Gore regularly experiences annual water restrictions and managing water use is a key focus in the summer months. Lignite seams can also impact the quality of groundwater. The Council has put considerable effort into searching for new potable water sources with little success. The effects of climate change mean this situation is likely to continue or become worse with the increasing frequency of warm dry days and expanding use of irrigation for intensive agriculture in the Waimea Plain, north of Gore. Warm, dry days and low flows in the Matāura River also have implications for managing discharges of treated wastewater with contaminant concentrations becoming more of an issue.

Some properties use private bores, water takes or rainwater collection to provide water for commercial or industrial use, such as the car wash business and bulb factory in Gore and the Alliance processing plant in Matāura. Many rural residents use rainwater or groundwater for private household and stock drinking water supplies. The Otama rural water scheme services a large part of Gore District, takings water from a well next to the Matāura River and distributing it to the surrounding community. Water treatment is currently being considered to reduce the risk of contamination.

Water quality also creates issues for Gore District Council. Contaminants enter the Matāura River from rural activities, via surface water run-off and groundwater infiltration, and from urban and industrial activities, via monitored discharges. Residents and visitors rely on the water supplies and enjoy the Matāura River, using it for swimming, fishing, tourism and cultural reasons among others. Their activities can be situated close to, or downstream of, any of these locations.

Large scale flood events have occurred historically and a system of stop banks is now in place along the Matāura River where it passes through Gore and Matāura. Some months of the year drainage of surface water via soakage is not possible because of local soil types. As a result of climate change, high rainfall and flood events are likely to occur more frequently and they have the potential to impact a large part of Gore District. While the stop bank system has been reviewed in recent years, there are some concerns that the existing stop banks and the natural topography north of the town may create a 'bottle neck effect' for the Matāura River at Gore. Flood management is a regional and territorial authority responsibility.

Stormwater discharges directly and indirectly to the Matāura and Waikaka Rivers. Stormwater quality is susceptible to poor behaviours within commercial and industrial properties, overland flow due to heavy rain and localised surface flooding. Irregular monitoring has shown some improvements in stormwater quality as a result of small changes in management and investigations into contamination traces.

Upgrades to wastewater treatment are possible but not all options are practical or financially viable. The Council has explored land irrigation disposal and found it not to be feasible because of unsuitable soil conditions. The most effective options were found to be options that were additional to the existing treatment processes. Gore's wastewater treatment system has the capability to further reduce phosphorus and suspended solids but at a high operational cost, and a project is underway to install an ultra-violet treatment system for *E-coli*.

Periods of infrastructure development in the 20th century, such as the 1950's and 1970's, improved public health and provided opportunities for communities to grow. This infrastructure is now nearing the end of its useful life and many assets will be due to be replaced, and possibly upgraded, within the next 30 years. A combined stormwater and wastewater system still exists in parts of Gore. Gore and Matāura are heavily influenced by rain events and their pipe networks have capacity issues and pump stations need upgrading. The treatment systems in the water treatment plants are planned for replacement to reduce risks to public health.

In replacing infrastructure, the Council's challenge is balancing what is affordable to replace with what is at risk of failure and what is expected as levels of service. Alongside this, encouraging new industry is a priority for the District's economic development and one successful mechanism is developing trade waste partnerships. Several industries rely on Council water supply or wastewater schemes for their manufacturing processes. Most recently Mataura Valley Milk have partnered with the Council to establish a commercial water bore for use at its site.

# 3. Southland District

Southland District covers around 3 million hectares of land and water across the region, which is a considerable part of the region, and includes more than 27 local communities (towns and their surrounding rural areas). These communities are sparsely distributed across just over 1 million hectares of developed land (ES Land Use Map, Pearson & Couldrey, 2015). The District also contains just under 2 million hectares of land in indigenous vegetation, including the Fiordland and Rakiura National Parks (ES Land Use Map, Pearson & Couldrey, 2015).

Southland District's total population is around 30,000 (or just under 32% of people living in the region) – roughly 2.87 people for each square kilometre of developed land. There are almost 15,000 dwellings (just under 80% occupied[60]), and median family income is $75,500 (median personal income is $33,900). Income is more normally distributed across the income bands than for Invercargill and Gore Districts. People in the District live and work in around 20,500 rateable properties (residential and business) (SDC, 2017).

Southland District Council manages physical assets and services that support its local communities. These assets and services include around 5,000 kilometres of roads[61], 12 urban or mixed urban/rural water supply schemes serving 17 communities, nine rural water supply schemes[62], 18 wastewater

[60] In the Southland District many of these dwellings are likely to be cribs (or bachs) in locations, such as Manapouri and Te Anau, and only be occupied at certain times of the year.

[61] Of this total length of roads in Southland District, 60% (3,000 km) is sealed and 40% (2,000 km) is unsealed.

[62] Southland District Council owns and managed 11 rural water supply schemes at Duncraigen, Five Rivers, Homestead, Eastern Bush-Otahu Flat, Kakapo, Lumsden-Balfour, Matuku, Mount York, Princhester, Ramparts and Takitimu. Two of

schemes, as well as a large number of stormwater schemes, libraries, cemeteries, community halls, reserves and parks, and other activities. The District's rural and urban ratepayers contribute to the cost of these assets and services through a general rate (based on the capital value of their property). A large proportion of revenue from rates is spent on essential infrastructure – in 2015/16 it was around half, with $14.0 million of rates spent on roading and transport (not including National Land Transport Fund assistance), and $7.5 million spent on the three waters assets (water, wastewater, and stormwater).

In comparison to many other territorial authorities in New Zealand, Southland District Council manages a large number of small wastewater schemes located across the region: Balfour, Browns, Edendale-Wyndham, Gorge Road, Lumsden, Manapouri, Monowai, Nightcaps, Ohai, Otautau, Riversdale, Riverton/Aparima, Stewart Island/Rakiura, Te Anau, Tokanui, Tuatapere, Wallacetown and Winton. These schemes include wastewater treatment systems that are based around oxidation ponds. In addition, the schemes have a combined total of up to 300 kilometres of pipes, with installation dating back to the late 1950s to early 1960s, and up to 80 pump stations (Ian Evans, pers. comm., 2017).

All of these schemes remove and treat wastewater from residential properties, businesses and community facilities. Southland District receives trade waste, mainly from light industry (particularly in Winton and Te Anau) but the inflow volumes are far more limited than for Gore and Invercargill. Southland District has a trade waste bylaw for limiting volumes and strength of waste and hazardous substances. The wastewater schemes discharge either directly or indirectly (via land) into the District's rivers, streams and groundwater and the coastal marine area (e.g. Riverton/Aparima).

The wastewater schemes are a considerable investment for local communities over many decades and had a total replacement value in 2017 of $124 million (I. Evans, pers. comm., 2017). The stormwater networks have a total replacement value of $35.5 million. The first wastewater treatment system was built in Ohai in 1953 and the latest was built at Edendale/Wyndham in 2009/10. A more recent system was built at the Curio Bay recreational reserve to service a camp ground and natural heritage centre. To manage the costs for the District's ratepayers, the Council plans upgrades of its wastewater schemes around the duration of discharge consents. Current and planned future upgrades include developing Te Anau's wastewater scheme from a discharge to water to a discharge to land, and a substantial upgrade of the Winton wastewater scheme to coincide with its consent expiry in 2023. Southland District's Operations and Maintenance Budget for wastewater activity for 2017/18 is $1.8 million (I. Evans, pers. comm., 2017).

This section describes the four case study towns in the Southland District: Winton, Nightcaps, Ohai and Te Anau. Winton is a thriving rural service town; Nightcaps and Ohai are coal mining towns; and Te Anau is a tourist, holiday and rural service town. The information included for each of these towns covers its location and role, settlement and development, present situation and future outlook. This context is intended to help with understanding of the research in Part C. At the end of the section is an overview of some of the environmental issues related to water quality.

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these schemes – Eastern Bush-Otahu Flat and Lumsden-Balfour – are treated and can be used as drinking water for people (i.e. mixed urban/rural). The rest of the rural schemes are used for stock water supply only.

Southland District includes either parts or all of Southland's four main rivers and their tributaries as well as many of the region's lakes, estuaries and groundwater aquifers. Māori relationships with the Matāura River are highlighted in Section 2.1 and those with the Ōreti River are highlighted in Section 4.1. Māori also have relationships with the Aparima River and the Waiau River, travelling through to Fiordland and Wakatipu or back to coastal areas like Ōraka Aparima (Riverton area). These journeys inland were made on foot and natural resources gathered, such as pounamu and food, were transported down the various awa (rivers) on mōkihi (rafts made from raupō). There are three nohoanga on the Waiau River and Lagoon. To the southwest there are many SILNA (South Island Landless Native Act 1906) landblocks, such as Rowallan and Waitutu, that many Southland Māori, including Ngāi Tahu whānaui, are connected to. Some aspects of the relationships with the Aparima River that relate to Te Anau, Ohai, and Nightcaps are highlighted in the following sections.

## 3.1. Winton

### 3.1.1. Location and Role

Winton is an inland rural service town that sits beside the Winton Stream and close to a braided[63] stretch of the Ōreti River, which the Winton Stream flows into south of the town. The town is located at the centre of a fertile floodplain in Central Southland. Winton Stream and the Ōreti River are important reasons for Winton's existence and the town's relationship with these water bodies is complex.

Originally, the site where Winton is now was a stopping point (in a clearing of what was later called Winter Forest) on the route alongside the Ōreti River to Queenstown and the Goldfields in Central Otago (McArthur, 2006). The Winton Bridge crosses the Ōreti River just north-west of the town and is an access point to the river with a bathing site. The river is also used for jet boating and trout fishing.

Winton's water supply scheme was built in 1956 and is sourced from groundwater in the unconfined gravels near the Ōreti River. This water is treated and stored in a reservoir before being pumped to a water tower and gravitating through the reticulation network. Winton's treated wastewater is discharged into the Winton Stream to the south of the town some 20 kilometres upstream of the intake for Invercargill's water supply. Parts of Winton are on the Ōreti River's flood plain, and while there is an extensive flood protection scheme, there are always risks of stop bank failure or their capacity being exceeded.

Winton is within the Ōreti and Waihōpai – New River Estuary Freshwater Management Unit.

[63] The Ōreti River is partially braided, which is unusual in Southland. Another example is the Mararoa River.


**Image B14: Winton Main Street with water tower in background**
Source Environment Southland

The town is a medium-sized urban centre that is some distance from other sizeable towns: the closest being Invercargill 31 kilometres to the south and Otautau 40 kilometres to the west. It is the central hub of a much wider central Southland community. There are retail and business services and facilities, which are used by people living across the Southland Plains, including Browns, Limehills/Centre Bush, Dipton and Drummond. Its residents are employed in light industries, such as timber milling and transport. The town also has a range of education and healthcare services, such as primary and secondary schools, a medical centre, and a maternity hospital, which are used by locals beyond the town boundary.

### 3.1.2. Settlement and Development

There was no permanent Māori settlement where Winton is now, although the Ōreti River was one of the main trails inland from the coast. The first European settler was Thomas Winton, a stockman whose cattle (at a time when there were no fences) wandered down to what later became known as Winton Creek in the late 1850s (Southland Times, 1925). He camped in the area because the cattle were on excellent feed, and they worked their way up to a small clearing in a vast expanse of bush (later "Winton's Bush"). Although the Central Otago gold rush in around 1861 led to the town's first buildings – the original Railway Hotel, which burned down in 1910, and a police barracks – the town grew because of its central location and the rapid development of agriculture.

Thomas Winton helped surveyor Clement Johnstone with two surveys in 1862 and 1863 – Johnstone named the town in Winton's honour and the streets to connect the town with a great medieval-style tournament held at Eglington Castle, Scotland in 1939 (Southland Times, 1925)[64]. The price of quarter acre sections cut into the heart of the bush was £16 each. In 1871 a surveyor from Queenstown undertook a third survey, altering the position of most of the streets and changing many of the street names (Southland Times, 1926). On this survey the official price of sections was reduced to £8 per section. In 1876 Winton was declared a municipality (Southland Times, 1925) and "considerable revenue is derived from town reserves, with which, together with rates, material improvement has been effected in footpaths, streets and drainage" (Cyclopaedia Company Ltd, 1905).

Waggoners and the railway played an important part in the life of early Winton. Waggoners carted goods up the Great North Road from Invercargill to Kingston (Southland Times, 1925). At first, the road from Invercargill finished two miles south of Winton[65] and then the waggoners continued overland. In 1863 the road was cut through to Winton bush but left unformed at the time because of the cost. An extension to Winton of the Invercargill – Makarewa wooden railway line was started in the same year, with 400 men employed on its construction (Southland Times 1925) - 150 to 200 men at the Winton end (Cyclopedia Company Ltd, 1905). Work stopped on the railway line the next year when the Southland province was declared bankrupt. Winton languished and the locally milled rails were sold for outbuildings. In 1871, the town's fortunes improved when an iron railway line was completed from the Bluff to Winton, but declined again when this line was extended north, reaching Kingston in 1878 – and reducing Winton from a terminus to a side station (Cyclopedia Company Ltd, 1905)[66].

By 1905, Winton had a railway station, school (opened in 1870 – at first in the police barracks), post office, several churches, public halls, hotels, and large stores, and a branch of the Bank of New Zealand. The Post Office housed a large manually operated telephone exchange that employed 40 operators. The local industries included a flour mill, and a meat and rabbit-preserving works (known as "the boiling-down"), sawmills, brick and tile manufacturing, and a "well-appointed" modern dairy factory (Cyclopedia Company Ltd, 1905). Monthly stock sales were held at the yards of the local Sale Yards Company. In 1914 a rabbit canning works was built on Gap Road, south of Winton. In 1940 the Linen Flax Factory was built on the same site, along with ten cottages for staff (a farm equipment supplier is now located on the site). Several limeworks were developed in the limestone formation east of Winton that extends from Forest Hill to Centre Bush – the closest to Winton being Newtons Lime.

[64] The Earl of Eglington was also the Earl of Winton.

[65] In a series of articles written on Winton in 1925, The Southland Times reported that it usually took two to three weeks to get through to Kingston although it was occasionally done in a week in ideal weather conditions – and the worst part of the route was between Invercargill and Winton. The article cited Mr Albert Adams, one of the oldest identities in the district, as recollecting that on several occasions when it took him as long as two weeks to reach Winton.

[66] Winton once had a vision of becoming a railway centre (Watt, 1992). A league was formed to promote building a line east from Winton to Otautau and Nightcaps and to continue a branch line to Hedgehope further east to Gore. Neither proposal eventuated.


**Image B15: Jamieson's Bakery and Restaurant (built in 1894)**
Source Venture Southland

In 1905 the town was described as follows: "Winton's progress has been sure, though slow, and with natural vitality, as well as surrounding country not to be surpassed in New Zealand, it cannot fail to become in time a town of considerable importance" (Cyclopedia Company Ltd, 1905). After a devastating fire in 1921 the Winton Borough Council required all buildings on the main street to be built in brick.

From 1945 to 1971 the population of Winton Borough grew steadily from 987 people to 2,055 people (this growth was faster than for both Southland County and New Zealand as a whole) (Wallace District Council, 1985). Population growth in Winton slowed in the 1970s but by the 1980s it was clear that people who had lived in the surrounding rural areas were choosing to retire in the town. A growing number of new houses were being built and Winton had a relatively large share of people in the 50 years and over age group compared to New Zealand as a whole.

Up until the mid-1980s, the town had relatively low unemployment (unemployment rates varied seasonally following shearing and meat processing) (Borough of Winton, 1986). The Makarewa to Lumsden section of the railway line, which included Winton, closed in 1982. The town suffered a downturn after this time but had recovered by 2001 when Craigpine Timber Ltd. expanded and business confidence grew with dairying (Craigpine Timber, n.d.; TVNZ, 2001). Winton's closeness to Invercargill meant that residents had (and still have) access to a greater number and range of jobs than was available locally.

The town has a wide main street and the main commercial area is on the west side. In 2003 this commercial centre, an area of around four blocks (twenty one buildings), became the Winton Great

North Road Historic Area because of their range of architectural styles (Victorian, Edwardian and Art Deco) and contribution to the town's social history. New earthquake strengthening requirements, following the Christchurch earthquakes, is resulting in the sale and/or renewal of some commercial buildings (Telfer, 2018). There is an industrial area, including the Craigpine Timber Ltd., on the eastern side of Winton. Most of the residential areas are on the western side of the town. Winton has long been the largest service centre for central Southland and parts of Northern Southland (Wallace Borough Council, 1985).

***3 Waters Infrastructure***

Winton's wastewater scheme was built in 1962, shortly after the town's water supply. Previously the town's wastewater had discharged into a combined stormwater scheme. The wastewater treatment system was situated to the south west of the town on Gap Road, with treated wastewater discharged to the Winton Stream upstream of confluence with the Ōreti River. In 1985 it consisted of Imhoff sludge tanks, a clarigester and an oxidation pond – at the time it was considered to have sufficient capacity but was beginning to age (Borough of Winton, 1986). In 1993 two floating aerators were installed on the pond. In 2003, a new consent for the discharge of treated wastewater was granted until 2023 and later a six-cell wetland was installed to improve the discharge. In 2015 a fine inlet screen was installed and the oxidation pond was desludged (with the sludge stored on site in a geobag), and more recently, replacement aerators were installed. In 2016 a stormwater renewal project was started to repair aged pipelines. In 2017 a water main renewal project was started to replace five kilometres of aged water pipes to meet the town's future needs.

### 3.1.3. Present[67]

Winton continues to be primarily a rural service centre that supports economic activity in the surrounding district. The town is home to 2,211 people, representing just over seven percent of the District and 4 percent of the Ōreti Freshwater Management Unit. Its residents are largely European (92%), with Māori (9%) and some Pacific and Asian peoples (3%)[68]. In general, the age distribution of Winton's population tends to be older than for Southland as a whole: the median age is 45 years, with 17 percent of people under 15 years old and 26 percent of people over 65 years.

There are 1,044 houses in Winton and their occupancy is 93 percent (and the number of occupied houses in the town is increasing over time). Most households are either one-family (63%) or one-person (33%). Of the family households, most are couples without children (55%), although there are many couples with children (35%), and some one parent with children (10%). The average household size in the town is 2.2 people. Home ownership is around 76 percent of all households – which is two percent less than in 2001. For those who do not own their home, median household rent is $190 per week – both of which are higher than for the region.

[67] All statistics in this section are taken from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.

[68] These figures add to more than 100% because some people identify as more than one ethnic group.

Just under two-thirds of people aged 15 years and over are in the labour force and the unemployment rate is 3.8 percent (which is low for the region). In the 12 years between 2001 and 2013, the total number of paid employees increased by 21.4 percent to just under 900 people – another 130 or so people are either employers or self-employed. The median income in Winton is $28,300, which is high for the region, with a wide income distribution: 32 percent of people earn less than $20,000 a year, and 24 percent earn more than $50,000 a year. In 2013 the Ministry of Health's social deprivation index score for Winton was five (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, 65 percent of people aged 15 years and over have a formal qualification and nine percent hold a bachelor's degree or higher. As employers, Winton's largest 'industry'[69] is retail trade, with just under 22 percent of paid employees, followed by education and training, and manufacturing. The most common occupation is labourer, followed by technicians and trades workers, and managers.

Winton is a hub for rural supplies and services, retail businesses, and light industry. Industry examples are Craigpine Timber Ltd. and McGregor Concrete Ltd.. There is a range of community groups and services including: Winton Volunteer Fire Brigade, the St John ambulance service, a police station, library, Plunket, and Rotary and Lions clubs. There are also several sports clubs and sporting facilities including Winton Racecourse, Winton Golf Club, the Central Southland Community Swimming Pool and the recently completed skatepark. The town's annual events include the Winton 'A&P' Show, the Winton Fun Run, and the Winton Open Day.

## 3.2. Nightcaps

### 3.2.1. Location and Role

Nightcaps is an inland rural town in central Southland that sits between the Longwoods and the Takatimu Mountains on the north-western fringe of the Southland Plains. Including Tinkertown, Nightcaps is located on both sides of the Wairio Stream, which is a tributary of the Otautau Stream, and eventually the Aparima River. Water is important for Nightcaps and the town's relationship with water is complex.

The town is named after its small twin hills, which look like they are wearing nightcaps (as viewed from Wairio Stream) when there is a light covering of mist on their tops (Thomson, 1979). Coal deposits in the area attracted European settlers and were developed into the Nightcaps Coal Mine. The mining operations involved water in a number of ways: for example, in the early 20th Century around 7,500 gallons of water had to be pumped from the mine each day to keep it free of water (Thomson, 1979). Water from mining operations is now treated and discharges into the Wairio Stream via a wetland and artificial drainage channel. Nightcaps' water supply was an extension of the Ohai scheme in 1972, and is sourced from the Morley Stream. This water is treated. Nightcaps'

[69] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

treated wastewater is discharged into the Wairio Stream. Unlike most other towns in Southland, Nightcaps is sited on elevated land.

Nightcaps is within the Aparima and Pourakino – Jacobs River Freshwater Management Unit.

The town is a small urban centre that neighbours Ohai (roughly 9 kilometres to the north-west) but is some distance from any other towns: the closest being Otautau 22 kilometres to the south and Winton 36 kilometres to the south-east. Although the town is largely focused on coal mining, its residents are employed in forestry, timber milling, transport, and agriculture. It provides some retail, business, education and healthcare services, which are used by its residents and people living in the surrounding rural area, including Ohai where there are fewer services available. For facilities, such as secondary schools, Nightcaps relies on those available in towns like Winton.

**Image B16: Nightcaps Main Street**
Source Emma Moran

### 3.2.2. Settlement and Development[70]

It is unknown whether there was any type of settlement in the Nightcaps area before the arrival of Europeans. The mouth of the Aparima River was the site of a permanent settlement and urupā[71] are located nearby. Ngāi Tahu have detailed knowledge of the whakapapa, traditional trails, safe

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[70] The start of this section is based on Schedule 15: Statutory acknowledgement for Aparima River in the Ngāi Tahu Claims Settlement Act 1998.
[71] Urupā are the resting places of Ngāi Tahu tūpuna or ancestors and are the focus for whānau traditions. These are places holding the memories, traditions, victories and defeats of Ngāi Tahu tūpuna.

harbours, tauranga waka (landing places), places for gathering mahinga kai, taonga and other resources. The Aparima River was an integral part of a network of trails used to ensure the safest journey and there were pounamu trails throughout the wider area. The river mouth was a tauranga waka, from which sea voyages were launched to and from Te Ara a Kiwa (Foveaux Strait), Stewart Island/Rakiura and the Tītī Islands. Mahinga kai such as shellfish, mussels, paua, tuna (eels) and inanga (whitebait) was all taken from the river, estuary, and coastline.

The first European settlers in the Nightcaps area were runholders in the 1850s, such as Captain John Howell[72], who took up the Annandale run (Wrey's Bush) (Thomson, 1937; Thomson, 1979). Māori men working for Captain Howell were the first to discover coal in the Wairio creek bed but the seam was not developed at the time because of the lack of mining skills and transport. In 1878 William Johnston employed the Moncrieff brothers to prospect the coal seam and they built a hut, which was the first wooden building in the Nightcaps area. The Nightcaps Coal Company was established in 1880 and the first tasks were development of the mining operation, survey of the town, and construction of a private railway line from Nightcaps to Wairio.

In 1881 sections were sold and the first wooden residential dwelling in the town was built (still in existence). Within a year there was Johnston's store and post office, a bakery and store, a butcher, two hotels (including Keleher's on the site of the present Railway Hotel), a saddler and a boarding house. The main street was named Johnston Road and William Johnston named the other streets in the town after places near Moffat on the Scottish border. A private railway line from Nightcaps to Wairio opened in 1883 and Nightcaps' first school followed in 1884. The town gained Presbyterian, Methodist, Roman Catholic, and Anglican Churches, and it became an outpost of the Salvation Army[73]. The town celebrated Queen Victoria's Golden Jubilee in 1889 and Diamond Jubilee in 1899 with spectacular bonfires on Little Nightcaps (the smaller of the two hills) (Thomson, 1979)[74]. At the turn of the century, the local baker formed the Nightcaps Brass Band.

Early ratepayers of Nightcaps were dissatisfied for a long time over the conditions of roads, footpaths, drainage and sanitation (Thomson, 1979). In 1912 a request was sent to Wallace County Council asking that the Health Inspector be sent to Nightcaps to make a report on the insanitary conditions of the town. The subsequent report stated "there was no drainage or sanitary services of any description in existence, each householder dealing with his drainage and soil disposal as best he can" (Thomson, 1979, p132). The County declared the town an unsanitary district and looked for suitable sites for depositing nightsoil (weekly collection cost households £5 per year or roughly $455 in 2017 dollars[75]). The other issues were not so easily resolved and a local body was sought. In 1918 a Town Board was constituted and the Nightcaps Town District gazetted, with 102 ratepayers but a

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[72] Before becoming a runholder, Captain John Howell was a sea captain, founder of Jacob's River whaling station and settlement.

[73] The Salvation Army had links with local coal mining: James Quested, a Colour Sergeant of the Salvation Army, opened a coal pit named "The Hallelujah Coalpit".

[74] In 1889 the bonfire was made of a mine prop, a barrel of tar, several drayloads of coal and a pile of railways sleepers that reportedly was visible from Bluff. The bonfire in 1899 burned for days.

[75] Estimated using the "General" Consumer Price Index on the New Zealand Reserve Bank Inflation Calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator. The Inflation Calculator uses price data, mostly from Statistics New Zealand, to calculate the change in purchasing power of an amount of money between two selected dates. The difference between the input value and the Calculator's output value represents the effect of the inflation or deflation that has occurred over that time, as measured by the selected index.

population of more than 500 people (Thomson, 1979). Successive boards gave their attention to street lighting (1925), streets and footpaths (concreted in early 1930s), and the drainage system.

When the Nightcaps Coal Company wound up in 1924 after the coal seams had been worked out, a total of one and a half million tonnes of coal had rolled out in railway waggons from Nightcaps (the trains ran up to 15 times a week) (Thomson, 1979). The closure coincided with the opening of the Ohai Industrial Line, which resulted in a coal mining boom in Ohai and many miners moved towns. Through mining activity in the wider area, Nightcaps continued to develop as a residential and business community (Miller, 1954). Unionism in the area began in Nightcaps in 1913, with the headquarters shifting to Ohai in 1924. Stoppages as a result of union action were rare, the longest strike being from August 1932 until March 1933. The union took an interest in both communities, contributing to better ambulances, fire stations, town halls, and charities, such as the Royal Foundation for the Blind.

**Image B17: The Sinclair Miners Cottage, Nightcaps**
Source Emma Moran

The area became a police centre (sub-district) in 1900 and had a resident constable. Locals raised money for a library, to build a doctors residence to attract doctors to the town, to buy an ambulance, and to buy the land and building for a cottage hospital. These medical services came too late for the 1919 influenza pandemic, with Nightcaps suffering the highest death rate in the country, almost 46 people per 1,000[76]. A maternity hospital also operated from 1932 until it was closed by the Southland Hospital Board in 1966, despite strong local protests. The Nightcaps District High School opened in 1937 (becoming the Takitimu Area High School in 1979) and for several years it sponsored miners' classes (Thomson, 1979). Locals again raised money, this time for a dental clinic and manual training centre. The town had a long list of societies and clubs, which operated on the principle of self-help (Thomson, 1979).

Historically, the water supply has been important for firefighting in Nightcaps. A fire in 1950 burnt down Coronation Hall, the library and Sinclair & Sons workshop and at one stage threatened half of the town. The financial loss of buildings alone was over £32,000 (roughly $2.65 million in 2017[77]). Without a local fire brigade, around 400 volunteers fought the fire and faced water supply problems. Following the fire, volunteer fire brigades first in Ohai and then in Nightcaps were formed and the Memorial Hall was built[78].

In the 1960s the town board faced increasing costs with insufficient income. Nightcaps became a country town of the Wallace County in 1967 with a community council representing local interests. The development of new energy sources coupled with more efficient mining methods, resulted in a major restructuring of the coal mining industry leading to redundancies. Coal mining is still carried out in the Nightcaps area, but on a smaller scale.

***3 Waters Infrastructure***

One benefit of becoming a Wallace County town was the subsequent development of a water supply for the town (Thomson, 1979). In 1972 a water treatment plant was built for the Ohai water supply scheme and at this time the scheme was extended to Nightcaps. Nightcaps' stormwater scheme is believed to have been developed in the 1950s, with part of its reticulation last upgraded in 2014. There is no stormwater treatment in place and stormwater outflows are into the Wairio Stream and the Waicola Stream. The town's wastewater scheme was built in 1988 and is a single oxidation pond.

### 3.2.3. Present[79]

Nightcaps is now primarily a rural service centre that supports economic activity, largely agriculture and forestry, in the surrounding local area. The town is home to 294 people, representing one percent of the District and five percent of the Aparima Freshwater Management Unit. Its residents are Māori (21%) and European (84%), with some Pacific and Asian peoples (2%)[80]. In general, the age distribution of Nightcaps' population tends to be older than for Southland as a whole: the

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[76] 'Nightcaps and the influenza pandemic', URL: https://nzhistory.govt.nz/media/photo/nightcaps-and-influenza-pandemic, (Ministry for Culture and Heritage), updated 2-Sep-2014.

[77] Estimated using the New Zealand Reserve Bank Inflation Calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator .

[78] The Ohai and Nightcaps Returned Service Association donated £5,000 that they had raised for R.S.A. rooms and a room was included in the new hall.

[79] All statistics in this section are from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.

[80] These figures add to more than 100% because some people identify as more than one ethnic group.

median age is 51 years, with 15 percent of people under 15 years old and 22 percent of people over 65 years.

There are 162 houses in Nightcaps and their occupancy is 82 percent (the number of occupied houses is declining over time although this situation may have changed since the 2013 census). Few houses have been built in the town over the past 40 years. Most households are either one-family (57%) or one-person (36%), which is high for the region. Of the family households, most are couples without children (54%), although many are couples with children (27%) and one parent with children (23%), which is also high for the region. The average household size in the town is 2.2 people. Home ownership is around 68 percent of all households – which is six percent less than in 2001. For those who do not own their home, median household rent is $120 per week, which is lower than for the region.

Just over half of people aged 15 years and over are in the labour force and the unemployment rate is 6.8 percent (which is high for the region). In the 12 years between 2001 and 2013, the total number of paid employees decreased 8.8 percent to around 100 people – another 20 or so people are either employers or self-employed. The median income in Nightcaps is $18,500, which is low for the region, with a wide income distribution: 54 percent of people earn less than $20,000 a year, and 17 percent earn more than $50,000 a year. In 2013 the Ministry of Health's social deprivation index score for Nightcaps was nine (where 1 reflects low deprivation and 10 reflects high deprivation).


**Image B18: Sinclair & Sons, Nightcaps**
Source Emma Moran

In terms of education, 46 percent of people aged 15 years and over have a formal qualification and just over one percent hold a bachelor's degree or higher. As employers, Nightcaps' largest industry'[81] is transport, postal and warehousing, with around 44 percent of paid employees, followed by mining, and then education and training. The most common occupation is labourer.

The town of Nightcaps has some rural suppliers and support services, with businesses such as Nightcaps Contracting Ltd. and Transport Services Southland. In terms of industry, Bathhurst Resources Ltd. extracts coal just north of the town at its Takatimu and Coaldale mines, and is in the process of opening a new seam to mine sub-bituminous coal as Coaldale comes to the end of its supply.

Nightcaps has a strong community spirit and a range of community groups and facilities including: Nightcaps Volunteer Fire Brigade, a mobile library (the town's library closed in 2017), Ohai-Nightcaps Rugby Club, Nightcaps Golf Course and Bowling Club. Events include a biennial Ohai-Nightcaps Firework Display to celebrate Guy Fawkes, and a community Christmas barbecue.

## 3.3. Ohai

### 3.3.1. Location and Role

Ohai is an inland rural town that sits north of Scotts Gap between the Longwoods and the Takatimu Mountains, with views of Mount Linton, in western Southland. It is located between the Morley and Orauea Streams to the north and the south, and east of the Wairaki River. The coal found in the Ohai area is highly volatile, good quality sub bituminous and its geological age is estimated at between 60 and 70 million years (Guttery, 2015). As with Nightcaps, water is important for Ohai and the town's relationship with water is complex.

The area was known as Ohai long before the town developed at the start of the early twentieth century. The origins of the name Ohai is unknown although there is a suggestion that it was named by A.W. Rodger (owner of Birchwood Station) (Miller, 1954). The area's pastoral land and coal deposits attracted European settlement.

Ohai's water supply scheme was built in 1953, and its source is the Morley Stream in the north-east of Ohai. This water is treated. Ohai's treated wastewater is discharged into a tributary of the Orauea Stream. The town is sited on elevated land away from the floodplains of any rivers.

Ohai is within the Waiau and Waiau Lagoon Freshwater Management Unit.

[81] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

**Image B19: Looking north-west towards the Takatimu Mountains from Ohai**
Source Emma Moran

The town is a small urban centre that neighbours Nightcaps (9 km south-east) but is some distance from any other towns: the closest being Otautau 30 kilometres to the south and Tuatapere 38 kilometres to the south-west. Although the town was largely focused on coal mining, its residents are now employed in forestry, timber milling, transport, and agriculture. It has some services that are used by its residents and people living in the surrounding rural area. The Ohai community also relies on those services available in Nightcaps such as the primary school, and other towns "down the road", such as the secondary schools at Winton.

### 3.3.2. Settlement and Development

As with Nightcaps, it is not known whether there was any type of settlement in the Ohai area before the arrival of Europeans. The Waiau River[82] was well known to the earliest tupuna (ancestors). Up until the 1960s (when the Manapouri Power Station was built) the river had the second largest flow of any river in New Zealand, and was up to 500 metres across at its mouth (narrowing to 200 m further upstream). This water flow was important for the ecological health, biodiversity and coastal resources. The river was a major source of mahinga kai and Ngāi Tahu used some 200 species of plants and animals in and near the Waiau.

[82] The start of this section is based on Schedule 69: Statutory acknowledgement for Waiau River in the Ngāi Tahu Claims Settlement Act 1998.

The main nohoanga (a seasonal occupation site) was Te Tua a Hatu at the river mouth and the river was a major travelling route for summer expeditions to Moturau (Manapouri) for mahinga kai, and to Te Tai Poutini (the West Coast) for pounamu. Locations along the way were identified for activities including camping overnight and gathering kai. Waitaha had strong links with the Waiau and surviving remnants of their rock art are a taonga of the area. A greater degree of Ngāti Mamoe influence is retained in this area than other parts of the South Island.

The first European settlers in the Ohai area were runholders, with large runs such as Birchwood and Beaumont being taken up in the late 1850s. This pastoral phase gradually changed with the discovery of coal outcrops in the Wairio Stream and then in the Morley Stream, although extremely poor roads restricted the development of the early coal mines up until the 1920s (Thompson, 1973). The first settlement in the area was at Birchwood (just to the west of Ohai) where a school was built in 1910 and a survey subdivided land for dairy farms in 1911. Four farmhouses were built that "sat on either side of the road to Birchwood with no other housing in sight" (Thomson, 1979). A coach service started from Birchwood to Nightcaps for passengers and supplies, with the 10 mile trip over the rough clay tracks taking more than two hours. A trip to Invercargill for the day, particularly in winter, was described at the time as "a major operation" (Thomson, p.206, 1979).

A series of surveys from 1917 onwards made sections available that formed the genesis of the new town. The first house in Ohai on a surveyed section was built for W. (Bill) Dover by Sinclair & Sons of Nightcaps (Thomson, 1979). In 1921 the Ohai area was described as the largest undeveloped coalfield in New Zealand and soon after proven coal deposits covered over at least 3,000 acres (over 1,200 hectares) (Miller, 1954; Thomson, 1979). At this time there were a few huts for single men (amidst the manuka scrub), a boarding house, some houses shifted and sited in the town, two houses for the managers of Wairaki and Linton Mines, the first post office opened, and a grocer's shop. Up until Taylors Hotel was built in 1954, most Ohai patrons made the journey to the Railway Hotel in Nightcaps (Thomson, 1979).

Town residents acquired a hall built for showing films from a travelling projector and paid for the outstanding debt through fundraising (Thomson, 1979). Rugby was the town's first organised sport and the rugby club was founded in 1923, other sports clubs soon followed. The coal mines finally started to boom when the privately owned Ohai Industrial Line opened in 1925[83], connecting Ohai to the Wairo Branch Line – despite objections from Nightcaps (Miller, 1954, p. 126). Many immigrants arrived from the north of England in the late 1920s to meet the demand for miners in the developing mines. Others moved to Ohai from Nightcaps. Ohai primary school opened in 1926. By 1928 Ohai was growing steadily and a daily bus service to Invercargill was established.

A School of Mines was established in the 1930s and ran (with temporary closures) until the 1950s. Occasional mine explosions and underground fires led to the opening of the Ohai Mines Rescue Station in 1943[84]. In the late 1940s, a committee of residents was set up to raise and discuss local needs and, when Parliament passed legislation, Ohai became one of the first county towns entitled

[83] No public funds were used to construct this railway line (Guttery, 2015).
[84] In the first 100 years since mining began in the Ohai/Nightcaps area fifty men have been killed and hundreds of others injured in varying degrees (Thomson, 1979).

to a community council[85]. The Nightcaps fire in 1950 prompted the immediate forming of a volunteer fire brigade in Ohai. Local fund-raising and voluntary labour was used (including making 3,500 concrete blocks) to build a fire station, which opened in 1959 (Thomson, 1979). In 1971 an underground fire and explosion at the Wairaki Mine led to the mine being sealed and eventually closed after 60 years production (Guttery, 2015).

From the 1940s onwards, Ohai's mines were 'nationalised' (sold to the State) which for some years kept them productive and the town's future positive. After World War Two demand for Ohai coal fell as small industries and small dairy factories closed across Southland (Thomson 1979). More widely, New Zealand Rail converted to diesel and diesel electric engines, the environmental lobby had growing influence, and the use of coal in residential heating declined, and hydroelectricity generation capacity increased (Guttery, 2015).


**Image B20: Ohai Fire Station**
Source Emma Moran

Coal demand fell as automatic mining processes were introduced. Automation meant fewer miners needed to be employed, and those that were employed needed different skills. During this time

[85] Ohai, like Nightcaps, was managed by the Wallace County Council from its beginning. The Wallace County Council first conceived of New Zealand's county town concept of rural administration primarily because of Ohai's situation, although it also suited the needs of other towns (Thomson, 1979).

there was a shift from underground mining to opencast mining[86]. Some miners left the district to seek jobs elsewhere and as early as 1964 a special meeting was held to discuss the future of the town (Thomson, 1979). By 1976 the town had a population of over 700 people, with 218 people being employed by the Ministry of Energy (Thomson, 1979). The Government considered closing down the Ohai mines at this time but opposition to this scheme was "immediate and effective" and new coal programmes were developed (Thomson, 1979).

By 1980 the government 'privatised' the coal industry, and unprofitable coalmines were shut (Guttery, 2015). The oil shock in the late 1970s and early 1980s gave some reprieve. In the 1980s the Beaumont mine operated for five years and a new Wairaki underground mine opened, which had a life of twenty years – closing in 2003 (Guttery, 2015). The Ohai Industrial Line closed in the late 1980s and the New Zealand Railways bought the Ohai Railway Board for $1.2 million, which was used to set up the Ohai Railway Fund. This fund currently provides grants and loans to residents[87] of the former Railway Board area for purposes such as tertiary or adult education, employment opportunities, and community facilities. The Ohai ambulance service ended in the 1990s because of a lack of volunteers. The primary school closed in 2003 and children in and around Ohai now travel to school in Nightcaps.

### *3 Waters Infrastructure*

In the early 1950s, the Coal Mining Districts Amenities Council[88] granted £50,000 (roughly $2.87 million in 2017 dollars[89]) towards the capital cost of a high pressure water supply to each house in the town and full reticulation for fire-fighting purposes, as well as a wastewater scheme with a modern treatment plant. The remaining £30,400 capital cost of the project (roughly $1.75 million in 2017 dollars) was met by local ratepayers and the Mines Department met the labour costs. Work began on Ohai's water supply and wastewater scheme in 1953. The wastewater scheme was designed for a population of 1,500 people and at the time it was one of the most modern in New Zealand.

[86] As an example of the scale of these opencast operations - more than 6 million cubic metres of overburden were removed at the No. 16 opencast mine to expose the coal seam and the mine's total output was 421,000 tonnes of coal (Guttery, 2015).

[87] A resident being a person or descendant of a person whose name appeared on the Parliamentary Electoral Rolls in any year from 1960 to 2011 and whose address at the time was within the area of the former board (https://www.southlanddc.govt.nz/my-council-/funding-and-grants-/ ). An example of a project that received funding is the Dr. Woods Memorial Park at Nightcaps.

[88] The Coal Mining Districts Amenities Council was created through the 1950 Coal Mines Amendment Act, and used a levy on coal for use in mining towns to lift the standard of public services and amenities used by miners (Thomson, 1979, p. 293).

[89] Estimated using the New Zealand Reserve Bank Inflation Calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator .


**Image B21: Solid Energy Mine Office 2016, Ohai**
Source Emma Moran

Originally the water supply was untreated but in 1972 a water treatment plant was built. At this time the water supply scheme was extended to Nightcaps, and in 1987 was extended again to Wairio. A further upgrade of the water supply was completed in 2010 with the help of funding from the Ministry of Health. Ohai's stormwater scheme is believed to have been developed around 1950. There is no stormwater treatment and stormwater flows into the Morley Stream and Orauea Stream, which are both tributaries of the Orauea River.

### 3.3.3. Present[90]

Ohai is primarily a mining town that supports economic activity in its surrounding local area. The town is home to 303 people, representing one percent of the District and six percent of the Waiau Freshwater Management Unit. Its residents are largely Māori (51%) and European (61%), with some Pacific peoples (3%)[91] – and 17 percent of residents speak Te Reo Māori. Te Oruanui Marae is situated in the town. In general, the age distribution of Ohai's population tends to be similar to Southland as a whole, although there are a larger proportion of children: the median age is 42 years, with 26 percent of people under 15 years old and 17 percent of people over 65 years.

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[90] All statistics in this section are taken from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.
[91] These figures add to more than 100% because some people identify as more than one ethnic group.

There are 174 houses in Ohai and their occupancy is 74 percent (the number of occupied houses is declining over time although this situation may have changed since the 2013 census). Few houses have been built in the town over the past 40 years. Most households are either one-family (55%) or one-person (43%), which is high for the region. Of the family households, most are couples with children (38%) and couples without children (38%), although many are one parent with children (25%), which is also high for the region. The average household size in the town is 2.4 people. Home ownership is around 69 percent of all households. For those who do not own their home, median household rent is $100 per week, which is low for the region.

**Image B22: State Highway 96, Ohai**
Source Emma Moran

Just under half of people aged 15 years and over are in the labour force and the unemployment rate is just under 8.8 percent (which is high for the region). In the 12 years between 2001 and 2013, the total number of paid employees decreased 31.4 percent to just over 70 people – and a handful of people are self-employed. The median income in Ohai is $17,400, which is low for the region, and income distribution is strongly weighted towards lower incomes: 61 percent of people earn less than $20,000 a year, and five percent earn more than $50,000 a year. In 2013 The Ministry of Health's social deprivation index score for Ohai was 10 (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, 53 percent of people aged 15 years and over have a formal qualification and just under two percent hold a bachelor's degree or higher. As employers, Ohai's largest 'industry'[92] was mining, with 72 percent of paid employees, followed by agriculture, forestry and fishing. The most common occupation is labourer, followed by technicians and trades workers. Since the 2013 Census, Solid Energy Ltd. went into voluntary administration and the Ohai mine was sold to Greenbriar[93].

Although Ohai is a base for local employment, the town no longer has business or retail services. It has a strong community spirit and a range of community groups and services including: Ohai Volunteer Fire brigade, Ohai-Nightcaps Lions Club, the Second Time Around Group[94] and Ohai Country Women's Institute. Sports groups and facilities include: Ohai Bowling Club, Takitimu United Netball Club, Ohai Golf Club and Takitimu District Pool. There is a biennial Ohai-Nightcaps Firework Display to celebrate Guy Fawkes.

## 3.4. Te Anau

### 3.4.1. Location and Role

Te Anau is an inland tourist and rural service town that sits on the "dry side" of the mountains (Hall-Jones, 1983) in the Te Anau Basin, which is located in western Southland beside Fiordland. The town lies on the south-eastern shore of Lake Te Anau, New Zealand's second largest lake[95] and is a 'Natural State' water body[96]. The town is sited on an alluvial plain formed by the Upukerora River, and is adjacent to the eastern edge of Fiordland National Park (Lake Te Anau lies within the park). It primarily exists because of its proximity to Lake Te Anau, and the town and the lake are closely interwoven.

The area around Te Anau-au was known as Marakura (meaning earth) and referred to the red lichen that grew on the rocks (Hall-Jones, 1983). The town was named after Lake Te Anau, which comes from Te Ana-au. There are many suggestions as to the meaning of the name, most of which reference the lake's limestone caves and water. Te Anau is used as a base for many recreational activities, such as visiting the glow worm caves and walking tracks, including three of New Zealand's Great Walks: the Kepler, the Milford and the Routeburn tracks. Many of these walking tracks are based on historic trails used by Ngāi Tahu. Lake Te Anau, Upukerora River, and Eglinton River (Southland's sole "fly-fishing only" river) are valued for brown and rainbow trout fisheries, attracting domestic and international tourists.

Te Anau's water supply has two sources: the primary source is three shallow bores adjacent to Lake Te Anau (north-west of town), and the secondary source is an Upukerora bore. The water is treated

[92] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).
[93] http://www.solidenergy.co.nz/final-milestone-achieved-in-solid-energy-asset-sales/
[94] This group runs an opportunity shop and sells meals in the Ohai Community Hall to raise money for community projects (https://www.stuff.co.nz/southland-times/news/92408960/Voluntary-work-important-to-John-Hogg-in-Ohai-Nightcaps ).
[95] Lake Te Anau is 61 kilometres long and 276 metres at its deepest point.
[96] As defined in regional planning documents.

and when the Upukerora River is in flood there are water quality issues with the supply from the Upukerora bore. Te Anau's treated wastewater is discharged into the Upukerora River, just before the River joins the Lake. Parts of the town are at risk of flooding and rock reinforcement is used to maintain the current course of the Upukerora River. The Manapouri Power Scheme now controls the levels of Lake Te Anau and Lake Manapouri principally for power generation but is required to take into account other considerations[97].

Te Ana-au and Moturau (Lake Manapouri) are both Statutory Acknowledgements Areas and the Tākitimu range is recognised as significant to Ngāi Tahu and has Tōpuni status under the Ngāi Tahu Claims Settlement Act 1998. Te Anau is within the Waiau and Waiau Lagoon Freshwater Management Unit.

**Image B23: Looking east from Lake Te Anau towards Te Anau's Town Centre**
Source Emma Moran

The town is a medium-sized urban centre that is quite some distance from other sizeable towns: the closest being Winton 127 kilometres to the south-west and Queenstown 171 kilometres to the

[97] The levels of Lakes Manapouri and Te Anau are regulated under the Manapouri – Te Anau Development Act 1963. Also relevant is Part 2B of the Conservation Act 1987 Guardians of Lakes Manapouri, Monowai, and Te Anau, which includes consideration of the effects of the Manapouri and Monowai hydroelectric power schemes on the rivers flowing in and out of these lakes.

north-east. Although it is largely focused on tourism and agriculture, the town is also the central hub of a much wider community in western Southland. There are many retail and business services and facilities, which are used by people living in the Te Anau Basin and further afield, including Mossburn and Manapouri towns and Milford Sound – and Te Anau is dependent on the economic activity in these areas. The Department of Conservation has an area office and visitor centre located in the town. There are also a wide range of other services, such as primary and secondary schools and a medical centre, which are used by locals well beyond the town boundary.

### 3.4.2. Settlement and Development[98]

Te Ana-au is a lake referred to in the tradition of "Ngā Puna Wai Karikari o Rakaihautu", which tells how the principal lakes of Te Wai Pounamu were dug by the rangatira Rakaihautu. Rakaihautu and his followers traced the Waiau from its source in Te Ana-au (Lake Te Anau) to the sea at Te Waewae Bay. Māori legend recalls a mythical cave filled with glowing light on the lakeshore. Te Ana-au was sometimes used as a retreat during periods of battles between iwi and hapū – it was one of the last places where Ngāi Tahu and Ngāti Mamoe came into conflict – a Ngāi Tahu party killed the rangatira of Ngāti Mamoe at the end of a series of offenses and retaliations.

There are two nohoanga (seasonal occupation sites) in the area – one at Lake Mistletoe (near Te Anau Downs) and another at Nine Mile Creek – there is also a nohoanga further south at Moturau (Lake Manapouri). The mauri (life force) of Te Ana-au is a critical element of the spiritual relationship of Ngāi Tahu Whānui with the lake. The area was rich in pounamu and pounamu trails existed throughout the wider area. Mahinga kai included moa, takahe, kākāpō, wai koura (freshwater crayfish), pārera (grey duck), pūtangitangi (paradise duck), weka and tuna (eel). Although the tuna populations are still plentiful, some are affected by hydro-electric power stations. Ngāi Tahu whānui work to improve the tuna populations in both Lake Te Anau and Manapouri – transferring elver tuna from below the Mararoa dam to above the dam to allow them to continue their life-cycle.

There were seasonal settlements at the headwaters of the Waiau River, Marakura on the shores of Lake Te Anau and other places. O Whitianga te Ra (the place of the shining sun) was a Waitaha Pā close to the southern end of Lake Te Anau, close to the outlet of the Waiau River. Te Rua-o-te Moko was an eeling pā at Lake Te Anau. Te Kowhai Pā was also located at the southern end of the lake, halfway between Bluegum Point and the mouth of the Upukerora River (Hall-Jones, 1983). When Europeans visited Pā Te Kowhai in 1859 they found that it had been almost completely destroyed by fire at some point in the past (Hall-Jones, 1983). Moturau (hundred isles) was a Māori kainga on a stream just north of the outlet of the Waiau River at Lake Manapouri, and occupied by Ngāti Mamoe up until 1865.

In the early 1850s two Māori, Rawiri te Awha and George Wera Rauru te Aroha guided the first Europeans to journey Lake Te Anau (Miller, 1954; Hall-Jones, 1983). Their route went through Scotts Gap (north-west of Otautau) on an old Māori pathway that continued past Te Anau to Anita Bay in

[98] The start of this section is based on Schedule 58: Statutory acknowledgement for Te Ana-au (Lake Te Anau) of the Ngāi Tahu Claims Settlement Act 1998.

Milford Sound (Scotts Gap Book Committee, 2002). Following this exploratory trip, Donald Hankinson established Te Anau station 10 kilometres up the Upukerora River from the lake in 1858, and the Hodge brothers arrived with a large mob of sheep in 1860 to establish a station that is now Te Anau Downs[99] (Miller, 1954; Hall-Jones 1983)). The first European settlers on the lake's south shore, at the site that became the town, were men "who wanted to get as far away from civilisation as possible" - the first being Richard Henry, who lived there from 1883 until 1894, when he became the caretaker of Resolution Island in Fiordland (Hall-Jones, 1983, p. 29).

Tourism started early in Te Anau, with tourists visiting the lake and Milford Sound, after the Milford track opened in 1888 with the discovery of McKinnon Pass (Miller 1954). Soon after, William Homer discovered the Homer Saddle and was the first to advocate for a tunnel through to Milford (Miller, 1954). Visiting artists painted the lakes and their paintings publicised the scenery and helped develop tourism (Dore, 1992). In 1891, Te Anau was described as consisting of "one large inn, two small steamers, one four horse coach, and, as our friend Paddy would say, half a dozen other buildings" (Hall-Jones, 1983, p. 63). These other buildings included a post office, a blacksmith, one house and several huts (Miller, 1954). At this time John Cumine surveyed the town and called it Marakura, after the Māori name for the area, but it "never really caught on and fell into disuse" (Hall-Jones, 1983, p. 64). With better transport and improvements in roading, Te Anau began to acquire a reputation as a holiday and scenic resort and tourists came to stay at the Te Anau Hotel from all over the world (Miller, 1954).

From 1905 the Southland Acclimatisation Society had been introducing Wapiti deer, moose, brown trout and Atlantic salmon, and in 1921 Te Anau's first ranger, Charlie Evans, was employed to manage hunting and fishing (Hall-Jones, 1983). A school site was acquired in 1906 and a limited number of leases issued to permanent residents (Miller, 1954). Problems with access to Te Anau constrained its further development. The town remained much the same up until the 1930s when public demand began for holiday sections. Land fronting Te Anau Terrace and Mokonui Street was made available and the first two holiday homes were built (Millar 1954; Hall-Jones, 1983). All of the sections were sold by 1945 but building control regulations during the war held up further development (Millar 1954). Te Anau "slumbered peacefully on" until after the World War Two without any power or shops, with groceries being sent up by bus from Mossburn (Hall-Jones, 1983).

At the end of World War Two the glow worm caves opened for tourists, the beginning of Fiordland Travel Ltd. (now Real Journeys). Buildings were built on the existing sections and, in response to the insistent demand for holiday cribs, 45 acres were subdivided in 1950 into 119 residential lots and eight shop sites (Millar, 1954). With the opening of the Homer Tunnel to tourist traffic in 1953 the town "took off" with a population explosion, subdivision and building (Hall-Jones, 1983, pp. 100-101). There was a further influx of residents with the Manapouri hydroelectric power station (built between 1963 and 1971) to supply the Tiwai Point aluminium smelter. An intensive programme of aerial top-dressing of the Te Anau Basin converted scrubland into more productive farmland, which provided a "back up for this essentially tourist and holiday town" (Hall-Jones, 1983, p. 101). The first deer farms in the Te Anau Basin were established in the 1970s.

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[99] On arrival the Hodges set fire to the grass, destroying an estimated 30,000 acres of grazing grass and some bush. Hankinson allowed them to run their sheep on 10,000 acres of his run until the grass had grown again (Miller 1954; Hall-Jones, 1983).

### ***3 Waters Infrastructure***

Te Anau's water supply scheme was built in 1966 – the Upukerora bore was the principal source between 1976 and 1993 until the three bores adjacent to Lake Te Anau were developed. A stormwater scheme has developed progressively as the town has grown. Original parts of the scheme servicing the town centre date back to the 1960s and 70s with further expansion continuing with the development of more recent subdivisions. Te Anau's total stormwater catchment area is approximately 336 hectares with a number of separate discharges into Lake Te Anau. The outflow from one of the discharges from the town centre receives basic treatment to remove gross solids. Some of the more recent subdivisions include onsite systems rather than direct connection to Council infrastructure.

**Image B24: Stormwater outfall, Lake Te Anau**
Source Emma Moran

Te Anau's wastewater scheme has evolved as the town has grown. The oldest part of the network was built in 1967 to service the commercial area of town. The reticulated network was extended in 1975 to include the north-western residential area and it has continued to expand as further development occurs. In 1984, the plant was upgraded with the addition of a larger oxidation pond to the two smaller original ponds. This larger pond is now the primary oxidation pond.

In 2004 a screen, aerators, and wetland were installed at the treatment plant, and a ten year consent was granted. This consent included a condition to develop a long term strategy for the future of wastewater management in Te Anau. There was a further upgrade in 2015 when a fine screen was added to the plant and the ponds were also desludged. In 2017 a consent was granted for the irrigation of treated wastewater from Te Anau to land away on the Kepler Block, beside Te Anau Airport, Manapouri (a distance of roughly 20 kilometres).

### 3.4.3. Present[100]

Te Anau is a tourist resort and rural service centre supporting economic activity in the Te Anau Basin and Fiordland. The town is home to 1,911 people, representing just over six percent of the District and 38 percent of the Waiau Freshwater Management Unit. Unlike other towns, Te Anau's peak population (combining visitors and usual residents) rises over 350 percent to over 6,700 people. Its residents are largely European (89%), with Māori (9%) and Pacific and Asian peoples (7%)[101]. Oraka Aparima Rūnaka administer the Te Anau area although there is no local marae[102]. In general, the age distribution of Te Anau's population tends to be similar to Southland as a whole: the median age is 41 years, with 17 percent of people under 15 years old and 16 percent of people over 65 years.

There are 1,467 houses in Te Anau and their occupancy is 61 percent, which is low for Southland. Occupancy in the town is seasonal, influenced by the large number of holiday homes, and the number of permanent homes in the town is increasing over time. Most households are either one-family (66%) or one-person (28%). Of the family households, most are couples without children (56%), although there are many couples with children (32%), and some one parent with children (11%). The average household size in the town is 2.2 people. Home ownership is around 65 percent of all households – which is just under 4 percent more than in 2001. For those who do not own their home, median household rent is $200 per week – both of which are higher than for the region.

Just over three-quarters of people aged 15 years and over are in the labour force and the unemployment rate is 1.7 percent (which is low for the region). In the 12 years between 2001 and 2013, the number of paid employees increased 2.4 percent to around 900 people - another 230 people are either employers or self-employed. The median income in Te Anau is $30,300, which is high for the region, with a wide income distribution: 30 percent of people earn less than $20,000 a year, and 22 percent earn more than $50,000 a year. In 2013 the Ministry of Health's social deprivation index score for Te Anau is four (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, just under 79 percent of people aged 15 years and over have a formal qualification and 13 percent hold a bachelor's degree or higher. As employers, the largest 'industry'[103] in Te Anau is accommodation and food services, with just over 38 percent of paid employees, and retail trade. These industries contribute to the tourism sector. The most common occupation is managers, followed by technicians and trades workers, and then labourers, which is unusual for Southland.

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[100] All statistics in this section are taken from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.
[101] These figures add to more than 100% because some people identify as more than one ethnic group.
[102] Te Waiau Mahika Kai Trust own Te Koawa Tūroa o Tākitimu, which is a culturally significant site close to Te Anau and allows whānau to either connect or reconnect with the area.
[103] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

As the gateway to Fiordland and Milford Sound, Te Anau is a hub for tourist and retail businesses, rural supplies and services for the local community, and some light industry (in the east of the town). Examples of light industry are Fiordland Lobster Company, and several small engineering firms. Te Anau is also the base of Real Journeys, a major South Island tourism company. There is a full range of community groups and facilities including: Te Anau Volunteer Fire Brigade, the St John ambulance service, police station, Te Anau Community Events Centre, Plunket, Rotary and Lions clubs, library, and a community market. There are also many sports clubs and facilities such as the Fiordland Community Swimming Pool and Te Anau Golf Club and annual events include the Te Anau Manāpouri Fishing Classic Competition, Te Anau Enduro (kayak, mountain bike and running) and the Fiordland Big 3 competition (catch a deer, a pig and a trout). The Te Anau Tartan Festival is a festival of Scottish music, dance and Highland Games, usually held over Easter Weekend, which celebrates the Scottish ancestry of many Southlanders.

## 3.5. Environmental Issues Relating to Water

Southland District covers the majority (around 95%) of the region (i.e. inland and coastal), stretching from the tributaries of the river catchments down to the coast and most of the region's estuaries. The District covers a large and varied landscape and is sparsely populated. Within the District there are many types of water bodies and situations. These water bodies have long been sources of fresh water and food, as well as more recently being used to remove waste products and for hydroelectric power generation. Each waterbody has its own set of unique values and the environmental issues relating to water vary considerably across the District. Managing the range of situations is a challenge. Micro-organisms (measured using *E. coli*), nutrients, and suspended sediment, from a range of urban and rural activities, are elevated in parts of the District and contribute to water quality issues.

The main environmental issues for Southland District Council revolve around security of water supply (for both urban and rural schemes), and wastewater and stormwater discharges, often into smaller watercourses that can have water quality issues upstream. Each topic has water quantity and water quality considerations. While some issues are similar to those for the other two territorial authorities, the crucial points of difference are the much larger number of municipal schemes and the relative absence of heavy manufacturing and processing industries across the District, with the exception of Edendale and Alliance Lorneville. Southland District Council holds close to fifty consents for water supply takes, and for wastewater and stormwater discharges. As well as issues relating to the 'three waters', Southland District Council has to deal with the challenges around managing the effects of sea-level rise on communities along the southern coast (excluding Invercargill and Bluff) and climate change more generally.

Southland District has plenty of fresh water but it is not always in the right places at the right times. An increase in irrigated pasture in northern Southland for intensive agriculture has increased the amount of water being taken and many waterbodies are nearing full allocation (e.g. the Cromel Stream and a number of aquifers across the District). While water storage is an option it can change the natural water cycle. The Waiau River in western Southland is also fully allocated because of the diversion of the majority of its flow through Meridian's Manapouri hydroelectric power scheme to Doubtful Sound. It is not possible to take more water from these areas.

A network of flood protection schemes and drainage systems exists across the Southland District. These were originally constructed to prevent the flooding of communities and to improve the productivity of land. These schemes and systems affect how water moves through the District, often restricting channel movement. Extensive tile and mole drainage networks move water rapidly out of catchments, as part of land drainage, and contribute to low water reserves during summer. Southland District Council's wastewater schemes receive largely domestic and commercial wastewater. Although a small number of wastewater schemes receive limited amounts of trade waste, it is mainly from light industry. The Council's stormwater schemes have similar sources to wastewater (i.e. domestic and commercial rather than industrial).

# 4. Invercargill City District

The District of Invercargill City covers 37,600 hectares (376 $km^2$) of land and water in southern Southland, and includes the local communities of Bluff, Makarewa, Otatara, Ōmāui and Kennington (towns and surrounding rural areas) as well as Invercargill itself. These communities are distributed over 30,000 hectares of developed land – including roughly 1,600 hectares of land reclaimed from New River Estuary (ES Land Use Map, Pearson & Couldrey, 2015). Most people are concentrated within Invercargill and Bluff, which extend over 3,000 hectares. The District also contains 7,600 hectares of land in indigenous vegetation, including the Awarua-Waituna Wetlands, and the Motupohue (Bluff Hill) and Ōmāui Scenic Reserves (ES Land Use Map, Pearson & Couldrey, 2015).

Invercargill City District's total population is just under 52,000 (or just under 55% of people living in Southland) – roughly 172 people for each square kilometre of developed land (or just over 1,700 people in urban areas). There are almost 22,650 dwellings in the area (just under 94% occupied), and median family income is $67,800 (median personal income is $27,400). Income distribution is weighted towards lower incomes (37% of people earned less than $20,000 a year and 24% earned more than $50,000). People in the District live and work in around 25,250 rateable properties (ICC Finance Directorate, pers. comm., 2017).

Invercargill City District manages physical assets and services that support its local communities. These assets and services include around 590 kilometres of roads[104], two urban water supplies, three wastewater schemes, as well as complex stormwater schemes, libraries, cemeteries, community halls, reserves and parks, and other activities. The District's rural and urban ratepayers contribute to the cost of these assets and services through a property rate and uniform annual charges for specific services. In 2015/16 46 percent of revenue from rates was spent on essential infrastructure, with over $7.3 million of rates spent on roading services (not including National Land Transport Fund assistance), and $13.7 million spent on the three waters assets (water, wastewater, and stormwater) (M. Loan, pers. comm., 2018).

[104] Of this total length of roads in Invercargill City District, 80% (470 km) is sealed – 290 km in urban areas and 180 km in rural areas.

The proportion spent on essential infrastructure is changing over time – between 2015 and 2028, the drainage proportion rises from 16 percent to 21 percent; water rises from 14 percent to 16 percent; and roading falls from 16 percent to 14 percent. Overall the proportion increases from 46 percent in 2015 to 52 percent in 2028.

In comparison to Southland and Gore Districts, Invercargill City District manages a large wastewater scheme for Invercargill and two small schemes for Bluff and Ōmāui. In addition to the treatment plants, the schemes have a combined total of 368 kilometres of pipes, which range in age up to 100 years, and 31 pump stations. The Invercargill and Bluff schemes remove and treat wastewater from residential properties, businesses and community facilities, while the Ōmāui scheme serves roughly 30+ households.

Invercargill and Bluff also receive trade waste from local industry – trade waste makes up around 15 percent of the inflow volume to Invercargill's wastewater treatment system at Clifton and 25 percent of the inflow volume to the Bluff system. The Council has a trade waste bylaw for limiting volumes and strength of waste and hazardous substances (Invercargill City Council bylaw 2017/1-Trade Waste). The Invercargill wastewater scheme discharges directly into New River Estuary, which is a part of the Awarua-Waituna Wetlands. The Bluff wastewater scheme discharges to the ocean in Foveaux Strait. The Ōmāui wastewater scheme has no obvious discharge. It is likely that either inflows are matched by evaporation and/or there is leakage through the base of the pond. Invercargill City Council monitoring has not yet identified significant groundwater contamination.

The three wastewater schemes are a considerable investment for local communities and have a total optimised[105] replacement value in 2017 of $275 million. Invercargill City District's stormwater network has an optimised replacement value of $322 million. Invercargill's Clifton Treatment Plant was built in 1969 (and upgraded in 1993 and 2003), the Bluff Treatment Plant in 2000, and the Ōmāui Treatment Plant in 1989. To manage the costs for the city's ratepayers, the City Council has a renewal programme to replace and upgrade its pipe network, pump stations and treatment plants at the end of their economic life. The focus of this programme is reducing wastewater contamination of the stormwater network and infiltration to the wastewater network. The Operations, Maintenance and Renewal Budget for wastewater activity for 2017/18 is $7.9 million (M. Loan, pers. comm., 2017). The schemes have consents until 2025 for Bluff, and 2029 for Invercargill (at Clifton) and Ōmāui.

This section describes the two case studies in Invercargill City District: Invercargill and Bluff. The information included covers Invercargill and Bluff's location and role, settlement and development, present situation and future outlook. It is intended to help give some context for the research in Part C. At the end of this section is an overview of some of the environmental issues related to water quality for these two communities.

[105] The optimised value takes account of changes in technology, including materials – the optimised value of pipes is likely to be lower than the replacement value because new materials tend to be a lower cost, while the optimised values of pumps is likely to be higher because of the increasing use of electronics. Overall, in practical terms the two values are likely to be similar (M. Loan, pers. comm., 2018).

## 4.1. Invercargill[106]

### 4.1.1. Location and Role

Invercargill (Waihōpai) is a city on the Southland's southern coastline towards the east of the region. The main urban area is located at the point where the Waihōpai River, Otepuni Stream, and Kingswell Stream flow into New River Estuary. The estuary was the principal reason for Invercargill's existence at this location and over the years the city has woven itself around and into New River Estuary and its tributaries. The name Invercargill was chosen before the site itself: "Inver" comes from Gaelic (*inbhi*r) meaning "river mouth" and Cargill, is in honour of William Cargill (Superintendent of Otago) (Esler, 2006).

The original depth of New River Estuary's channels meant Invercargill was accessible to ships "of a reasonable size" (300-400 tons) (Esler, 2006)[107]. The Waihōpai River, New River Estuary and nearby Ōreti Beach are all popular recreational areas. The city has a single water supply (unusual for a city) that is sourced from the Ōreti River at Branxholme (16 km north of Invercargill). New River Estuary is part of the complex of Awarua-Waituna wetlands and its fisheries are highly valued. Invercargill's treated wastewater is discharged into the Estuary. Parts of Invercargill (including the region's main airport) are on land reclaimed from Lake Hawkins, which was part of the Waihōpai Arm. This land and other parts of Invercargill are on a flood plain, and in some areas water is drained and pumped regularly. While there are flood protection schemes, there are always risks of stop bank failure or their capacity being exceeded. Land reclaimed from the estuary and Awarua are low lying coastal areas at risk from coastal flooding with sea level rise[108].

Invercargill is within the Ōreti and Waihōpai – New River Estuary Freshwater Management Unit.

Invercargill is Southland's only city, and it is some distance from other sizeable towns or cities: the closest being Gore 64 kilometres to the north-east and Queenstown 187 kilometres to the north (in Otago). The city is the central hub for the region. There is a wide range of retail and business services that are used by people living throughout Southland – and the city is equally dependent on the economic activity in the region. Many residents are employed in manufacturing and processing industries to produce products that are largely exported through South Port at Bluff and Port Otago in Dunedin. The city also has a full range of services, from education, healthcare, and sporting and cultural facilities, for Southlanders from the Catlins to the Waiau, and Oban to Athol and beyond.

[106] For the purposes of this report, Invercargill is defined as Invercargill City District excluding Bluff.
[107] The first proposed site for Invercargill was further north-west at the confluence of the Makarewa and Ōreti Rivers, just north of the west end of West Plains Road (Esler, 2006).
[108] The sea level at Bluff has been monitored from at least the early 1990s (e.g. Robertson, 1993).

### 4.1.2. Settlement and Development[109]

There were four known Māori settlements in the area around Waihōpai (Invercargill) and New River Estuary before the arrival of Europeans: Ōmāui, Oue, Mokamoka, and Turangitewaru. Urupā (resting places of Ngāi Tahu tūpuna) are located nearby. The Ōreti, Otepuni and Waihōpai rivers gave access to and from the interior of Murihiku. The Ōreti River stretches almost to the edge of Whakatipu-wai-māori (Lake Wakatipu) and it formed one of the main trails inland, with an important pounamu trade route continuing northward from its headwaters. Other trails starting at Waihōpai led in many directions including Ōraka Aparima, Tuturau, Fortrose, Tuturau and Fiordland. There were also tauranga waka for travelling to Ruapuke, Rakiura or the Tītī Islands. Ōmāui, Oue, Mokamoka, and Turangitewaru were sustained by mahinga kai taken from the, estuary, its tributaries and adjoining coastline, including shellfish and pātiki (flounder).

Ōue, located at Whalers Bay on Sandy Point, was one of the principal settlements in Murihiku and was the start of a coastal track to Riverton. Ōue is said to have got its name from a man Māui left to look after his interests there until his return. Ōmāui was a settlement located opposite Ōue at New River Heads. In 1850 there were 40 people living at Ōmāui under the chief Mauhe. The small knob in the hills above Ōmāui is named after Pukarehu, brother of Honekai (a rangatira and resident of Ōue in the 1820s) who was interred opposite Ōmāui in the sandhills at the south end of the Ōreti Beach. Mokamoka (Mokomoko or Mokemoke) was a settlement in a shallow inlet off the Estuary, and was where Waitai, the first Ngāi Tahu to venture this far south, was killed. Many inhabitants of these settlements relocated to Ruapuke Island as a result of inter-hapū and inter-tribal hostilities in Canterbury. Ōue had been abandoned by 1862 and Ōmāui appears to have been occupied until 1880 (Chandler, 1977).

The whaling stations at Ōmāui and Ōue were abandoned in 1839 and up until 1856 New River attracted visitors and a handful of settlers. In the 1850s land in Southland was being either sold or leased to run-holders and it needed to be stocked, the best option being with sheep and cattle from Australia (Holcroft, 1976). In 1856 Governor Gore Browne ordered a town in the south to be laid out on a suitable site, and he declared this new town (Invercargill) and Bluff as ports of entry (Holcroft, 1976; Chandler, 1977). The area around New River Estuary was selected over other locations (e.g. Winton district and Riverton) because of water (Chandler, 1977):

> *It may seem strange . . . that so much emphasis should be placed on a town site accessible to water transport. However, the generally swampy nature of the coastal fringe and the absence of roads or railways made port facilities desirable, if not permanently essential.*

Originally, Invercargill was planned as a port town. John Turnbull Thomson (Chief Surveyor) decided against the first proposed site on the Makarewa River because, although it was on higher ground, it was still floodable, had few obvious routes inland, and was too far up-river for larger vessels (Holcroft, 1876). Thomson selected a site on the banks of the Waihōpai River near New River Estuary that gave access by water and at the same time was a natural point of access inland. Once

[109] The start of this section is based on Schedule 50: Statutory acknowledgement for Ōreti River and Schedule 104: Statutory acknowledgement for Rakiura/Te Ara a Kiwa (Rakiura/Foveaux Strait Coastal Marine Area) in the Ngāi Tahu Claims Settlement Act 1998.

the site had been selected, vessels began to make calls at New River and small boats took goods for settlement up the Otepuni Stream as far as the former Bank of New Zealand Building (corner of Clyde and Tay Streets). The first sections in Invercargill were sold the next year with a reserve price of £8. The town grew steadily and its success was a reason for Southland gaining independence from the Otago Province in 1861 (Chandler, 1977).


**Image B25: The former Bank of New Zealand building**
Source Emma Moran

1863 is regarded as the best of Invercargill's early years with the promise of wealth from gold but the following year marked the start of a recession, and by the end of the decade possibly only half of the buildings in Invercargill were occupied (Esler, 2006). In 1871 Invercargill became a municipality and in 1906 the council moved into a new town hall and the Civic Theatre was built. Invercargill continued to grow after World War One and became a city with 20,000 people in 1930 (Esler, 2006; Hall-Jones, 2013). A 1966 report on the future of Invercargill predicted optimistically that, with the aluminium smelter, the city would reach 100,000 people in 25 years (Esler, 2006) and there was investment in essential infrastructure in south Invercargill for this expected growth. Over the years Invercargill's boundaries have expanded and in 1989 they changed again to include Bluff, Myross Bush, Otatara and Makarewa (Esler, 2006). Between 1981 and 2001 the population decreased 20 percent but since then it has rebounded.

Reclamation of the tidal flats at the northern end of the estuary began in 1865 (Chandler 1977) and continued over the next century until nearly a quarter of the original estuary was reclaimed. The city's old landfill was used to reclaim part of the land on the eastern side of the Waihōpai channel from the 1950s (Esler, 2006). The channel in New River Estuary was shallow and unable to be deepened (except at enormous cost) for larger vessels. Sedimentation made navigation a challenge from as early as 1863, and it was worsened by the reclamation works (Chandler, 1977). Despite on-going works, the port experienced steady decline, the size and number of vessels decreased as ship traffic transferred to Bluff, which could support larger vessels (Esler, 2006). The port received its final commercial ship visit in 1939 (Chandler, 1977).

Invercargill streets were made twice the usual width, so that drays could pass easily (McArthur, 2006) and there was room for a bullock train to make a U-turn (Chandler, 1977). In the 1860s a coach service started to Dunedin, and Cobb & Co. ran a coach service to Bluff, to Riverton and later to Kingston. The route to Riverton used Ōreti Beach and it was often called 'the road'. The Invercargill railway station, built in 1864, was the first in New Zealand (it was demolished and replaced in the 1970s) (Esler, 2006). Invercargill also had a railway locomotive workshop. In 1881 horse-drawn trams were introduced to Invercargill. The horses were replaced by electric trams in 1912, which continued until 1952. Motorbike races have been held on Ōreti Beach since 1911 (Esler, 2006). The streets were sealed in 1918 using tar from the gas works (Hall-Jones, 2013). The first aerodrome was formed at Myross Bush but it was abandoned in 1942 for a new airport on land reclaimed from the estuary (Esler, 2006).

In the 1870s the Invercargill Borough Council built a gasworks, which occupied three acres of land between the railway and New River Estuary up until 1986, when it closed. Domestic electricity followed in 1914 from a coal fired power station in Invercargill (Esler, 2006). Since the gasworks started, many industries and businesses have been located in Invercargill, some of which continue to operate today. The list includes many companies connected to the agricultural sector, such as Fleming and Company and Alliance Group. It also includes companies providing services such as the Southland Building Society, HW Richardson Group, and The Southland Times. The department store H & J Smith and the hardware store E. Hayes & Sons are iconic Invercargill institutions (Hall-Jones, 2013). From the 1960s many people living in Invercargill have worked at the Tiwai Aluminium Smelter.

In 1860 the first school opened in Invercargill's courthouse (Esler, 2006). Invercargill Girls' High School followed in 1879 and Boys' High School opened two years later (both schools later moved campuses). After World War Two, co-educational high schools opened, such as James Hargest High School (now the largest in Southland). Invercargill's high schools take students from around the region. Southland Technical College opened in 1912 and is credited with keeping the town supplied with tradesmen (Esler, 2006). The Southland Polytechnic opened as part of the College and it became the Southern Institute of Technology in 1999. In 2001 a 'zero fees scheme' was introduced, using community funding to cover student fees, which dramatically increased the number of students.

The first hospital was "a collection of little ponga and sod huts" (Esler, 2006). In 1863 a brick hospital opened on Dee Street (two of its three buildings still exist), which became a maternity hospital after it was replaced in 1937 with a hospital at Kew. The Kew hospital was itself replaced in

2004 with a $70 million building with a capacity for 180 patients – it is the largest public building in the region (Esler, 2006). The city's library had its origins in the Mechanics Institute and the Athenaeum Society. In 1917 the Invercargill Borough Council took over responsibility for the library, and it eventually became the Eve Poole Library in 1989. The Civic Theatre, complete with electric lighting, was built in 1906.

Religion was connected to local government, social services, business and education (Esler, 2006). Settlers to Invercargill built many substantial and elegant churches for different denominations, including the Presbyterian First Church and the Catholic Basilica. After a referendum, alcohol prohibition started in Invercargill in 1905 and continued until the end of World War II (Hall-Jones, 2013). The Invercargill Licensing Trust now holds a monopoly on alcohol in the city, with the proceeds provide funding for an array of community projects (Invercargill Licensing Trust, 2018).

The Otepuni Gardens was the first park to be developed (Hall-Jones, 2013). Queens Park in the centre of the city was originally called Victoria Park and was on the town boundary (Esler, 2006). A purpose-built museum was opened in 1942, as Southland's way of recognising the 1940 Centennial of New Zealand. The art gallery extension, tuatara display and observatory were later additions. The building was redeveloped in 1990 and its structure was altered to that of a pyramid. The museum was an important asset and drew 200,000 visitors annually up until it was closed in 2018 because its structure was defined as earthquake prone under the New Zealand Earthquake Prone Building Legislation. The Anderson Park Art Gallery opened after the museum in 1951 and housed a large collection of art in a house set in 24 hectares of gardens and native bush. The gallery was also defined as earthquake prone and closed in 2016.

Invercargill has experienced several major floods, but in January 1984 a particularly severe event flooded the airport and around 900 homes. The tidal stop banks at the airport prevented the flood water from draining into the estuary, and eventually a hole was blasted through the stop bank. Since then extensive flood protection works have been undertaken along the banks of the Waihōpai and Ōreti Rivers (Hall-Jones 2013).

### *3 Waters Infrastructure*

The first settlers in Invercargill drew water from the Otepuni Stream but the risk of water borne diseases grew because drains emptied into the stream and it was also used for the dumping of refuse. Many wells were dug beneath the town to give a cleaner water supply. The Council searched for a longer term solution for many years but the cost was seen as to be too high. In 1888 water reticulation began when a bore was sunk in the eastern town belt and Invercargill's iconic water tower was completed a year later. It became apparent that the well water was quite corrosive on pipes and hot water heaters, so in 1958 the city received treated river water, drawn from the Ōreti River at Branxholme (Esler, 2006). The supply from Branxholme remains the only water supply for Invercargill today. Any disruption to this supply would affect businesses and industry, firefighting capacity and domestic use, and developing an alternative water supply is a priority (ICC, 2018a & 2018b).


**Image B26: Invercargill waterworks and tower**
Source Emma Moran

Wastewater reticulation first started to be laid in Invercargill in 1910. The wastewater was treated in a large septic tank then discharged through a wooden drain leading into the New River Estuary. Later, a second parallel tank was constructed and the wooden drain was replaced with a cast-iron outfall pipe discharging wastewater to the New River Estuary main tidal channel. By the 1950s the rapid growth in Invercargill's population meant that the wastewater scheme was at capacity and was unable to be extended (Chandler, 1977). The Invercargill City Council used a loan programme to finance development and extensions that included new intercepting and trunk wastewater pipes, new pumping stations, and a new primary treatment plant at Clifton. The new Clifton wastewater treatment system opened in 1969. Invercargill City Council has monitored its wastewater discharge from Clifton since this time.

**Image B27: Clifton Wastewater treatment Plant, New River Estuary, Invercargill**
Source Emma Moran

In 1992 a major upgrade of the Clifton Plant began. This upgrade involved installation of a secondary treatment facility and upgrading of the old equipment. This work was completed in 1992 and provided improved facilities for the treatment of both residential and industrial waste. A further upgrade to tertiary treatment was completed in 2004. This comprised of facultative ponds and wetlands to further improve wastewater quality by reducing bacteria numbers. The upgraded plant has a consent to discharge treated wastewater up until 2029.

Most of Invercargill buildings are connected to Invercargill's stormwater scheme lying beneath the roads. Makarewa, Myross Bush and parts of Otatara drain stormwater through a system of ditches. Stormwater is collected through a stormwater pipe network and discharged through multiple outlets to the coastal marine area or to five streams or rivers that flow through the city before discharging into the New River Estuary. As with all urban drainage systems, the Invercargill stormwater network suffers contamination from wastewater cross connections, and from waste substances that collect on hard surfaces including roads and roofs, and from percolation through natural ground. The stormwater scheme and the wastewater scheme are interconnected to allow one type of water to flow into the other scheme when either is overloaded.

The city's stormwater network covers a large portion of the catchment area of the Otepuni Stream, Kingswell Creek and Clifton Channel, and a much smaller portion of the catchment of the Waikiwi Stream and Waihōpai River. All of these water bodies flow into New River Estuary. Invercargill City Council has monitored its stormwater discharges since 2011. This monitoring indicates that nutrient concentrations upstream of the city, through the city, and downstream of the city are relatively consistent. It also indicates that runoff and stormwater drainage from the city increases water volumes and contributes to nutrient loads. Some parts of the stormwater network contribute heavy metals and concentrations of microbes, the latter generally resulting from sewage cross-connections.

#### 4.1.3. Present[110]

Invercargill is a rural and industrial service centre that supports economic activity across Southland. The city is home to 49,902 people, representing just over 53 percent of the region and 81 percent of the Ōreti Freshwater Management Unit. Its residents are European (88%) and Māori (15%), with some Pacific and Asian peoples (6%)[111]. There are three marae in the city, Murihiku Marae (Tramway Road), Te Tomairangi Marae (Eye Street) and Nga Hau E Whā (Conon Street). In general, the age distribution of Invercargill's population is similar to that of Southland as a whole: the median age is 39 years, with 20 percent of people under 15 years old and 16 percent of people over 65 years.

There are at least 21,540 houses in Invercargill and their occupancy is 94 percent (and the number of occupied houses is increasing over time). Most households in the city are either one-family (65%) or one-person (29%). Of the family households, most are couples without children (43%), although there are many couples with children (38%) and one parent with children (19%). The average household size in the city is just over 2.4 people. Home ownership is around 70 percent of all households – which is 4 percent less than in 2001. For those who do not own their home, median household rent is just under $200 per week – which is higher than for the region.

Around two-thirds of people aged 15 years and over are in the labour force and the unemployment rate is 6.2 percent (which is high for the region). In the 12 years between 2001 and 2013, the total number of paid employees increased 14.5 percent to around 21,000 people – another 2,800 people are either employers or self-employed. The median income in Invercargill is around $27,400, which is high for the region, with a wide income distribution: 37 percent of people earn less than $20,000 a year, and just under 24 percent earn more than $50,000 a year. In 2013 the Ministry of Health's social deprivation index score for Invercargill ranged the full spectrum from one in areas such as Myross Bush and Otatara to 10 in West Invercargill and Crinan (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, around 70 percent of people aged 15 years and over have a formal qualification and just under 13 percent hold a bachelor's degree or higher. By employment, Invercargill's "industries"[112] are health care and social assistance, manufacturing, and retail trade, education and training, and construction. The most common occupations are professionals and labourers, followed by and technicians and trades workers, and managers.

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[110] All statistics in this section are from New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.
[111] These figures add to more than 100% because some people identify as more than one ethnic group.
[112] Australian and New Zealand Standard Industrial Classification 2006 (ANZSIC06 V1.0).

Invercargill is the regional base for many businesses that support the primary sector (agriculture, forestry, fishing and mining), such as suppliers, contractors, consultancies, transport and freight firms, accountancy firms, real estate firms, insurance companies, and banks. The city also has a range of industries that process and manufacture products using outputs from the primary sector. It is the location of the region's main airport (the closest alternatives being Queenstown or Dunedin). Southland Hospital (known as Kew) is located in south Invercargill and Southern Cross Healthcare Group also have a surgical hospital in the central city. There are five high schools that take students from around the region, and the Southern Institute of Technology (SIT) attracts young people to the region. Invercargill is also a base for many government agencies, and some local agencies, such as the Community Trust of Southland and the Invercargill Licencing Trust (ILT).

Invercargill has a wealth of community groups, facilities and services. There are around 150 parks and reserves covering over 3,000 hectares of land, including Queens Park in the central city, Sandy Point Domain, and Thomsons Bush. Cultural facilities include the Civic Theatre and Centrestage Theatre. ILT Stadium Southland and Velodrome complex is a year-round sports facility and conference venue for the region. Others include the Splash Palace swimming complex, Rugby Southland Stadium, Turnbull Thomson Park, and Donovan Park, Ascot Park Racecourse, four golf courses, and Teretonga Racetrack. There are many clubs, such as Rotary, Lions, the Southland Multicultural Council, and the Murihiku Māori & Pasifika Cultural Trust. Other attractions are Bill Richardson Transport World, and Classic Motorcycle Mecca. Events include ILT Kidzone, the Burt Munroe Rally, and the start and finish of the Tour of Southland.


**Image B28: Activities signpost for Sandy Point Domain**
Source Emma Moran

## 4.2. Bluff

### 4.2.1. Location and Role

The port town of Bluff sits on the coastline of the Southland Plains, and is the southernmost town on mainland New Zealand. It is located south of Invercargill (past Greenhillls and Ocean Beach) at the entrance to Bluff Harbour and Awarua Bay, and opposite the Tiwai Peninsula. The town is protected from the prevailing south westerly winds by Motupōhue[113] (Bluff Hill), which rises to 105 metres above sea level. Water is central to Bluff's existence but, being almost entirely surrounded by coastal water, it is a different relationship than for the other case study towns.

**Image B29: Bluff and South Port**
Source Emma Moran

Originally referred to as 'The Mount' and then Old Man's Bluff Point, it then became simply The Bluff or Bluff Hill. Captain W. Cargill (Superintendent of Otago) ordered John Turnbull Thomson to change Bluff's name to Campbell Town in 1856 but it officially reverted to Bluff in 1917 (Hall-Jones, 1976). Locals born and bred in the town are known as "Bluffies" (Coote, 1994). The site attracted sealers and whalers, and later European settlers, because it was a relatively sheltered harbour. The fisheries

[113] The name Motupōhue recalls a history unique to the Ngāi Tuhaitara and Ngāti Kurī hapū that is captured in the line, "Kei korā kei Motupōhue, he pāreka e kai ana, nā tō tūtae" ("It was there at Motupōhue that a shag stood, eating your excrement") (Ngāi Tahu Claims Settlement Act 1998). It has also been translated as meaning the "island of convolvulus" (Hall-Jones, 1976).

around the coastline are highly valued for mahinga kai, recreational fishing and commercial fishing. There are popular recreational areas and coastal walkways at Stirling Point and Bluff Hill. Despite Bluff's relatively high rainfall, there have been frequent water shortages[114] (Coote, 1994). The town is connected by pipeline to Invercargill's water supply. The port and access to the town, Greenhills, Awarua, and Tiwai Peninsula are low lying coastal areas at risk from coastal flooding with sea level rise[115].

**Image B30: Bluff (looking opposite direction from previous photo)**
Source Emma Moran

Motupōhue (Bluff Hill) is recognised as a Tōpuni [116]and a Statutory Acknowledgement area under the Ngāi Tahu Claims Settlement Act 1998. Bluff is within the Ōreti and Waihōpai – New River Estuary Freshwater Management Unit.

The town is a small urban centre that is situated at some distance from other towns: the closest being Invercargill 32 kilometres to the north, and Oban 37 kilometres to the south across Foveaux Strait. Bluff is largely focused on the commercial deep-water port, and is used by the economy's manufacturing and processing sectors, and primary production sectors. As well as the port, the

[114] During one such time, a council circular stated that people should "use only the base quantity of water when bathing" and went on to state that "about three inches in the bottom of the bath is all that is necessary".
[115] The sea level at Bluff has been monitored from at least the early 1990s (e.g. Robertson, 1993).
[116] Tōpuni is an area of land which is administered under the National Parks Act 1980, the Conservation Act 1987, or the Reserves Act 1977, has Ngāi Tahu values, and is declared as Tōpuni.

town is the base for Southland's fishing fleet, including the Bluff oyster fleet. It is also the exit point for Stewart Island/Rakiura, the Tītī (Muttonbird) Islands, Ruapuke Island and New Zealand's subantarctic islands. The town's services include retail, business, education, (e.g. a kindergarten, a bilingual early childhood centre at Te Rau Aroha Marae and two primary schools) and healthcare (medical centre). Bluff relies on Invercargill for other services not available in the town.

**Image B31: Te Rau Aroha Marae**
Source Emma Moran

### 4.2.2. Settlement and Development[117]

Although there was no permanent Māori settlement at Awarua (Bluff) before the arrival of Europeans, Foveaux Strait was a principal thoroughfare, with regular travel to and from Stewart Island/Rakiura, Ruapuke and other islands, and the mainland. Rangatira Te Wero established a transitionary settlement Awa-rakau (Ocean Beach), which was rangatira Te Whera's village in the early 1800s. Te Rau Aroha Marae was established in the late 1800s as a hostel for local Māori who lived on off-shore islands. A large number of Māori families live close to the marae and the lifestyle of many revolve around the seasonal collection of mahinga kai, particularly tītī (muttonbirds), tio (oysters), and other inshore fisheries.

[117] The start of this section is based on Schedule 44: Statutory acknowledgement for Motupōhue (Bluff Hill) in the Ngāi Tahu Claims Settlement Act 1998, with additional information sourced from Hall-Jones (1976), and Tipa (2014).

The headland itself was referred to as an island and named Motupōhue. It was the departing place to Ruapuke, Rakiura (Stewart Island) and the Tītī Islands, and a trail led out to Fortrose. Oral traditions are that Ngāti Mamoe rangatira Te Rakitauneke and Tū Te Makohu are buried on the hill. Te Rakitauneke had a saying that translated meant “Let me gaze upon Foveaux Strait”. Māori tended to land at Tapu Beach, a sandy beach on the seaward side of Tiwai Peninsula, because of a strong tidal rip at the entrance to the harbour (Hall-Jones, 1976).

Mahinga kai and other resources in the area included tī kōuka (cabbage tree), paru (raupō leaves), harakeke (flax), totara, raupō, toheroa, pipi, tuangi, tio (oysters), kōura (rock lobster), inanga (whitebait), pātiki (flounder), pateke (brown teal), parera (grey duck), weka, moa, kererū and pūkeko. An outcrop of argillite rock near the tip of Tiwai Peninsula was the site of an early adze factory, which Māori used during the summer months around 1500. Some of the first contacts with Europeans in the area were for flax. In 1823 Te Whera was visited at Awa-rakau by the captains of the *Snapper* and the *Mermaid*, and he exchanged flax for gifts and payment (Hall-Jones, 1976). These good relations led to the early settlement in the south and Rangatira Tuhawaiki, who sold land to Europeans, including sections at Bluff.

In 1824 James Spencer landed at Bluff and founded a whaling supply depot. His settlement went on to become the town of Bluff, one of the first European settlements in New Zealand and the earliest that went on to become a town (Hall-Jones, 1976). Spencer bought land from Tuhawaiki (that included the summit of Bluff Hill) and cleared 60 acres to cultivate grain and vegetables crops, and imported cattle and pigs (kept on Spencer’s Island) – the first animals to be imported to Southland. He then set up a fishing station, employing 21 Europeans and Māori, and built another six cottages for them to live in (Hall-Jones, 1976).

Bluff grew as whaling flourished along the south coast in the 1830s but whaling was short-lived as an industry (Hall-Jones, 1976). Bluff’s whole waterfront was sold off in sections to Europeans well before the Treaty of Waitangi in 1840 (a unique circumstance in the history of New Zealand). John Turnbull Thomson surveyed the town in 1856 - the first town to be surveyed in Southland. Bluff was also declared a port of entry and a custom house was built.

Early impressions of Bluff were as the “Gibraltar of the South” (Hall-Jones, 1976). It had a fine harbour that was deeper and more accessible from the sea but the head of the harbour was too shallow to land goods and the locality was cut off from “the interior” of Southland by a “great swamp” (Seaward Moss) (Hall-Jones, 1976). At first there was only a temporary road that threaded between swamps and sandhills, and was dependent on the tide (Hall-Jones, 1976)[118]. Almost all cargo entering Bluff harbour had to be taken around to Invercargill by lighter (a type of flat-bottomed barge). In 1867 the railway line to Invercargill opened, one of the earliest in New Zealand, which determined Bluff’s future as the port of Southland[119]. Its expense contributed to Southland’s failing finances and the province re-joined Otago in 1870.

[118] In 1856 it took the McKellar brothers three weeks to travel with their sheep to Invercargill (a distance of just over 27 kilometres), which was the first time a dray had been taken on an overland route (Hall-Jones, 1976).

[119] At the time there was debate about whether the railway line should go to Bluff or Stanley – eventually the line went to Bluff with a branch line to Stanley. Stanley was a town planned on the southern side of the entrance of New River Estuary (opposite Sandy Point). It was not built beyond a few houses and shops because its wharf development failed (Esler, 2013).

Between 1863 and 1939, Bluff was the first and last port of call for regular mail and passenger services from New Zealand to Melbourne (and later Sydney). By 1877, a weekly ferry service was also in operation to Stewart Island/Rakiura. As well as passengers and cargo, the ferry also took mutton-birders to the southern islands and serviced the local lighthouses. The Southland Harbour Board was formed in the same year and the Port of Bluff began operations. In 1988 South Port New Zealand Ltd was formed, taking over the assets and liabilities of the former Southland Harbour Board[120]. In a normal trading year the port handles over 3 million tonnes of import and export cargo. Unfortunately, shipping over the years has not been without incident – there have been at least 34 recorded shipping disasters (excluding small vessels) in the coastal waters in and around Bluff[121].

In 1960, the Southland Times reported that 365 people were employed fulltime on the wharf and another 300 were needed. In the same year Bluff's Island Harbour port opened, covering 84 acres (34 hectares) of land reclaimed from a sandbank in Bluff Harbour. It was built at a cost of £4 million (or the equivalent of $176 million in 2017[122]) that was funded through public subscription (Coote, 1994)[123] and rates (Bluff Harbour Improvement Act 1952). Land reclamation continued until 1982, when the eighth berth was completed, and Island Harbour now covers 40 hectares. In 2018, South Port employed the equivalent of over 80 full time staff[124].

Commercial oystering first began at Stewart Island in the 1860s, but the industry's base shifted to Bluff after the discovery in 1879 of larger beds in deeper water. For years it was claimed that the supply of Bluff oysters was inexhaustible (Coote, 1994). Bluff also became a base for commercial rock lobster (crayfish), which developed in the 1930s with export markets in Europe and America after World War Two (Hall-Jones, 1976). In the 1970s the total value of fish and shellfish landed at Bluff was greater than any other New Zealand port (Hall-Jones, 1976). In the following years, fishing quota were introduced and the Bonamia parasite affected oyster beds. In 1990 the Bluff Oyster Festival started in the Bluff Town Hall.

Bluff was a "farmers' port" for many years, and its principal exports were meat and wool (Hall-Jones, 1976). A freezing works opened at Ocean Beach in 1892 and was an important source of local employment. From the 1950s there was a large influx of Māori to work at the freezing works and many stayed and became part of the community. In 1955 the Department of Agriculture forecast that Bluff was likely to become the largest meat and wool exporting port in New Zealand (Hall-Jones, 1976). At this time, the Southland Times identified Bluff as one of the wealthiest centres per head of population in New Zealand and stated "No able bodied man (sic) need be unemployed"(Coote, 1994).

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[120] The company is listed on the New Zealand Stock Exchange (NZX), with the Southland Regional Council (now known as Environment Southland) as the majority shareholder (https://southport.co.nz/about-us-and-our-people ).

[121] While many ships were wrecked on rocks at Tiwai and Stirling Point, those within the harbour were also lost because of collisions, explosions and incendiarism – some quite spectacularly (Hall-Jones, 1976).

[122] Estimated using the Reserve Bank inflation calculator: https://www.rbnz.govt.nz/monetary-policy/inflation-calculator.

[123] After central government refused to help fund it, the island port was funded through public subscription and was one of the largest local body loans ever raised in New Zealand (Hall-Jones, 1976).

[124] A presentation on the history of Island Harbour and South Port NZ is available at https://southport.co.nz/assets/downloads/Word_copy_of_photobook.pdf

Other exports were dairy products, grain, timber, and aluminium. Imports included petroleum products, fertilisers, and alumina (aluminium oxide). Bluff's imports and exports, and often local employment, are often directly connected. The Southland Co-operative Phosphate Company[125] built a phosphate factory at Awarua (between Bluff and Invercargill) in the 1950s and uses imported raw phosphate and sulphur. Its super-phosphate (and the region's lime) was used in large land development schemes in Southland, which resulted in a dramatic increase in sheep numbers, and a rise in frozen meat exports. Similarly, the aluminium smelter at Tiwai Point started operating in 1971 and uses imported alumina and exports aluminium ingots.

During the Great Depression in the 1930s Bluff was more resilient than other New Zealand towns, largely because of the availability of seafood (e.g. blue cod, crayfish, oysters, paua, and mussels), and offal from Ocean Beach freezing works[126]. This resilience was needed again during the 1951 waterfront industrial dispute, which lasted 151 days (Coote, 1994), and later redundancies from technological advances in cargo handling, such as the introduction of shipping containers. Bluff was also hit hard in 1991 when Ocean Beach Freezing Works closed after nearly a century of operation, resulting in the redundancy of 117 permanent and 749 seasonal employees (Coote, 1994).


**Image B32: Bluff Main Street**
Source Emma Moran

[125] This company merged with the Bay of Plenty Fertiliser in the 1990s and eventually became Balance Agri-Nutrients Limited (https://ballance.co.nz/Our-Business-and-History ).
[126] A local Reg Ashwell recalled "One family helped one another. This is one place where you could live off the coast" (Coote, 1994).

### *3 Waters Infrastructure*

The first water supply was a small reservoir filled from Palmer's Creek, which was replaced in 1885 with two reservoirs halfway up Bluff Hill built by the Southland Harbour Board. In 1915 heavy rain caused one of these reservoirs to burst, and several million gallons of water swept through the west end of Bluff[127] (Coote, 1994). The reservoir was repaired and eventually another was built to increase capacity. It collected water from the hill above the town through a series of water races and treatment included filtration and chlorination (M. Loan, pers. comm., 2018). The local borough council took over the scheme in 1952 and developed a 25 kilometre pipeline in 1960 to connect Bluff to Invercargill's water supply, which was blended with the local supply. In 1993, the Bluff Hill reservoir was discontinued, and the total Bluff water requirement was supplied from Invercargill (M. Loan, pers. comm., 2018).

Bluff's wastewater was collected in nightsoil buckets up until the mid-1960s when the Department of Health insisted that a wastewater scheme was installed. By 1971 all of Bluff's households were connected to a piped system, which collected wastewater at a pumping station on the Harbour Foreshore. From there it was pumped over the hill and into Foveaux Strait, just south of Ocean Beach. By the 1990s the discharge of untreated wastewater into the coastal environment was no longer acceptable, and the Invercargill City Council began investigating treatment systems. A new plant was completed in 2000 with a 25 year consent to discharge treated wastewater to Foveaux Strait.

### 4.2.3. Present[128]

Bluff is primarily a port town that supports economic activity across the region. The town is home to 1,794[129] people, representing 3.5 percent of the District and three percent of the Ōreti FMU. The town's residents are largely Māori (44%) and European (75%), with some Pacific and Asian people (7%)[130]. Te Rūnanga o Awarua are based at Te Rau Aroha Marae, situated in the town. In general, the age distribution of Bluff's population tends to be older than for Southland as a whole: the median age is 44 years, with 19 percent of people under 15 years and 19 percent over 65 years.

There are 906 houses in Bluff and their occupancy is 89 percent (the number of occupied houses in the town has fluctuated over time). Most households are either one-family (61%) or one-person (34%). Of the family households, around half are couples without children (48%) and half are couples with children (31%) and one parent with children (21%), which is high for the region. The average household size is 2.2 people. Home ownership is around 74 percent of all households – which is five percent less than in 2001. For those who do not own their home, median household rent is $150 per week.

[127] The deluge damaged 15 houses and seven businesses but there was no loss of life because rumbling before the event allowed people to evacuate.
[128] All statistics in this section are from the New Zealand Census 2013 – it will be important to also consider information from the 2018 census as it becomes available.
[129] Gore Ward is defined as the census area units of North Gore, South Gore, East Gore, West Gore and Central Gore. Gore Ward is one of the five wards in the Gore District, with a total population of 12,033.
[130] These figures add to more than 100% because some people identify as more than one ethnic group.

Around two-thirds of people aged 15 years and over are in the labour force and the unemployment rate is 5.2 percent (which is higher than for the region). In the 12 years between 2001 and 2013, the total number of paid employees increased 10.6 percent to around 720 people – another 110 are either employers or self-employed. The median income in Bluff is $28,200, with a wide income distribution: 37 percent of people earn below $20,000 a year, and 21 percent earn over $50,000 a year. In 2013 the Ministry of Health's social deprivation index scores for Bluff was eight (where 1 reflects low deprivation and 10 reflects high deprivation).

In terms of education, 57 percent of people aged 15 years and over have a formal qualification – and just under six percent hold a bachelor's degree or higher. By employment, Bluff's largest 'industry' is manufacturing, which accounts for almost 43 percent of paid employees. Other important industries are construction, and transport, postal and warehousing. The port also provides services for New Zealand's aluminium smelter at Tiwai Point across the harbour. Some Bluff residents commute to Invercargill for work.

Bluff has many community groups and services including Bluff Volunteer Fire Brigade, the St John ambulance service, Coastguard Bluff, Bluff Service Centre and Library. The town also has a number of sports clubs and facilities such as the Bluff Golf Club and Bluff Tepid Pool.

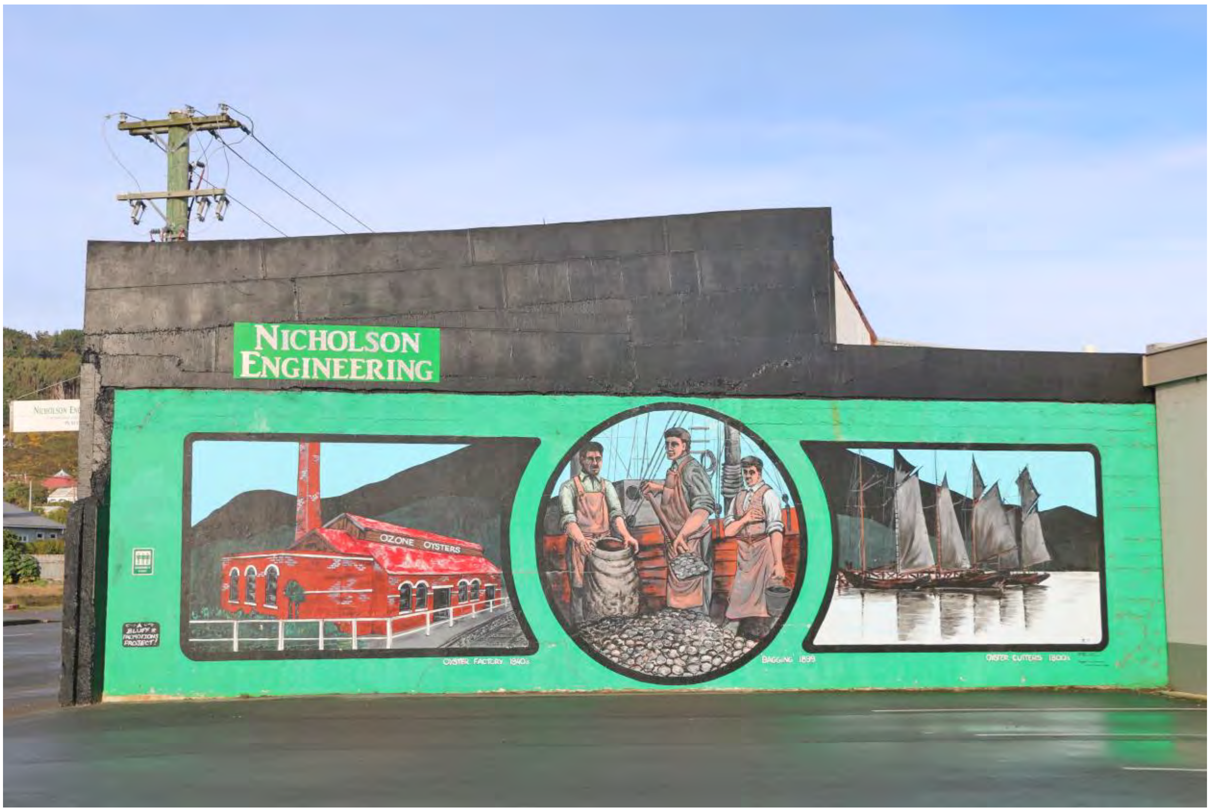


**Image B33: A Bluff Promotions Project**
Source Emma Moran

Bluff is famous for its annual Bluff Oyster and Food Festival, which is a celebration of the Bluff oyster and other kai moana. The festival is run by a local committee and includes oyster opening and eating competitions. It is one of the biggest events of its type in New Zealand (5,000 tickets usually sell-out quickly each year) and attracts visitors from around the country. Other events are the Bluff Hill Climb, which is part of the annual Burt Munro Challenge week (motorbikes), and the Bluff Hill stage of the Tour of Southland cycle race. Natural amenities in the area include the Bluff Hill/Motapohue and Sterling Point areas which provide visitors with spectacular sea and bush views from lookout points as well as walking and biking tracks such as Foveaux Walkway, Topuni Track, Glory Track, Millennium Track, Ocean Beach Track and Pearce Street Track. Other activities include cage diving with sharks and the Bluff Maritime Museum.

## 4.3. Environmental Issues Relating to Water

Invercargill City District lies entirely on Southland's south coast, around the lower reaches of the Ōreti and Waihōpai Rivers and several streams and creeks (e.g. Waikiwi, Otepuni, Kingswell, Clifton, Mokotua, and Waimatua). These waterbodies tend to have poorer water quality as they near the coast because of urban and rural activities occurring throughout their catchments – the Ōreti River begins just to the east of the Mavora Lakes in the Thomson Mountains and the Waihōpai River begins on the plain to the east of Dacre. The water flows into New River Estuary or Bluff Harbour/ Awarua Bay, where the effects of these activities accumulate. Monitoring shows that the degraded areas within New River Estuary are growing from the pressure of elevated nutrient and sediment loads in its tributaries (Environment Southland, 2017). Invercargill is one contributor of these contaminants.

The main environmental issues for Invercargill City Council are around security of the urban water supply, stormwater, wastewater, and flood protection. Each topic has water quantity and water quality considerations. With only a single source, security of water supply is a critical issue and the Council's Long-Term Plan 2018-2028 includes funding to develop an alternative water supply. The Council also has to deal with the challenges around managing the effects of sea-level rise, which is likely to put at risk infrastructure such as the Clifton wastewater treatment system.

Invercargill City District's water is sourced from the Ōreti River and treated at the Branxholme Water Treatment Plant. The treated water is then pumped into reservoir storage for distribution to residential, commercial, industrial consumers both in Invercargill and Bluff and those industrial plants between Invercargill and Bluff. Farms immediately adjacent to its trunk mains between Branxholme and Bluff also receive water supply. The water taken from Ōreti River is affected by activities in the catchment. Since the 1970s there has been a marked increase in the presence of 'earthy' taste and odour producing substances in the Oreti River, particularly over summer. During the 1980s this type of event occurred occasionally but in the 1990s the frequency steadily increased and specialised treatment began. By the 2000s an event warranting specialised treatment was occurring every year but the effectiveness of this treatment reduced as concentrations increased, resulting in the Council upgrading its treatment process in 2017[131].

Flood protection is important for Invercargill, both from further up the catchments and from coastal inundation. Stopbanks and detention dams are located on the major rivers and streams throughout

[131] Between February 1990 and January 2018, 2-Methylisoborneol (an organic chemical with a strong odour) has increased from 21 nanograms per litre to 120 nanograms per litre (A. Murray, pers comm., 2018).

the Invercargill urban area and the Waihōpai Arm of the New River Estuary. These engineering solutions are designed to restrict the natural flow of water from the upper catchments. The Invercargill airport is a regional asset located in a low-lying reclaimed area that requires regular pumping.

The stormwater networks are contaminated from aging pipe networks, property drainage systems, ground surface run-off, washdown water (e.g. sediment, detergents, chemicals) and stormwater from unpainted copper and galvanised roofs (heavy metals such as copper and zinc). The sewerage and stormwater pipe networks range in age up to 110 years and their condition deteriorates over time. Structural defects, leaking joints, and a lack of pipe capacity create opportunities for cross contamination between the two networks[132]. Every property connected to the stormwater network has its own stormwater and wastewater drains that together total a greater length than the public network. These drains have a similar age profile to the public networks. They are often laid side by side in the same trench, increasing the opportunity for cross-contamination, and in some cases are connected, either mistakenly or as a 'quick fix'.

Following rain, runoff from hard ground surfaces, including roads and paved areas, carries contaminants such as hydrocarbons, heavy metals and silts from vehicles, soil sediments and animal faeces. Each ground level stormwater intake has a mud sump that traps sediments and floating hydrocarbons, but does not remove suspended or dissolved contaminants from stormwater. Under its stormwater discharge consent, the Council is required to improve stormwater quality, using methods including: low impact stormwater designs for new reticulation (where appropriate), erosion and sediment control guidelines, regulatory and enforcement options, education and awareness programmes, source control systems, effective stormwater treatment systems in sensitive sites, and avoiding of sewage contamination.

In Bluff, stormwater from the residential and commercial areas discharges into Bluff harbour. Runoff from the regenerating bush areas above the town enters the head of the stormwater network. Stormwater drainage from the port and related industrial areas is managed separately by Southport.

As already noted, the Council manages wastewater for Invercargill, Bluff and Ōmāui. Invercargill's wastewater treatment system at Clifton treats to a tertiary standard and discharges to the New River Estuary, to the south of the Invercargill urban area. Water quality in the estuary is degraded by contaminants discharged throughout the catchment area, including the treatment plant. Wriggle Consulting's sediment sampling in the tidal areas adjacent to the treatment plant discharge in 2006, 2011, and 2013, shows a trend of improving conditions following the most recent plant upgrade in 2004. Wriggle concluded that the discharge has a relatively low impact on the estuary in the vicinity of the discharge channel, or on the wider estuary ecosystem. It is likely that the treatment system will need to be upgraded when the current discharge consent expires in 2029. If the new consent allows the discharge to continue into the New River Estuary then nutrient removal may be required.

The Bluff wastewater treatment system treats to a tertiary standard and discharges to Foveaux Strait. Unlike New River Estuary, the coastal water is high quality and monitoring at ten metres from

[132] There are also a small number of constructed overflows in the networks, which operate infrequently (M. Loan, pers comm., 2018).

the discharge point indicates little or no adverse effects from the discharge. Fish processing effluent, with high salt water content and variable volumes, limits the treatment upgrade options for Bluff. A small oxidation pond treats wastewater from 30+ residents. The treatment system was designed to discharge to land using spray irrigation, but it has not been required because wastewater inflows appear to be matched by evaporation and possibly dispersed leakage through the clay base of the pond. In 2015, bore water sampling in the area between the oxidation pond and a fresh water lagoon on the beach showed elevated nitrate levels, but no *E. coli*. Lagoon water sampling showed no influence from the oxidation pond of the test bores.

The Invercargill City Council also faces issues related to the reclamation of the upper part of New River Estuary during the 20$^{th}$ Century for the airport, farmland and an industrial area. The reclamation also included an unlined landfill along the eastern edge of the estuary at Pleasure Bay. The landfill operated from the early 1900s until 2004, when it was closed and capped, and resulted in more than 100 hectares of reclamation. It is likely that leachate from the closed landfill site seeps into New River Estuary and contributes to water quality issues, but is yet to be quantified.

# 5. Major Industries[133]

This section summarises the development and geographic distribution of manufacturing and processing industries across the region, highlighting connections to towns and other industries. This section also surveys the main companies within each of the industries in Southland at present. Each manufacturing and processing industry has specific environmental issues relating to water. These issues are not covered in this report although the current industry resource consents for wastewater discharges in the region are outlined in Appendix 1. A full analysis of industrial water use (as water takes and discharges) within the Southland economy is available in Part 1 of *Southland Region: Regional Economic Profile and Significant Water Issues* (Market Economics, 2013)[134].

## 5.1. Development

Like the rest of Southland's economy, the region's industries are built on the environment and the natural resources contained within it: land, including its mineral deposits (e.g. gold, coal, and lime), and water (e.g. for hydro power and processing). Consequently, the pattern of development has largely been determined by the location of the resources themselves and access to them.

In the past, Southland's communities often had several local industries, such as a dairy factory, flour mill, abattoir, limeworks, native flax mills (*Phormium tenax* - not linen flax), and/or sawmill. These industries sourced inputs from the local area and their outputs supplied their community, and in some cases, further afield (e.g. flax mills at Gorge Road and Redan). In 1905 Woodlands had a

[133] Most of the information regarding individual companies in sections 5.2 to 5.7 was sourced from the companies' own websites, with additional sources as cited.

[134] This report was prepared by Market Economics for the Ministry for the Environment as part of its analysis of water policy decisions for the amendments made in 2014 to the National Policy Statement for Freshwater Management 2011.

creamery, a stilton cheese factory, an extensive meat preserving works, and a large timber yard at the railway station, which sourced timber from the nearby Mabel Bush sawmill (Cyclopedia Company Ltd, 1905). Towns also usually had light industry, such as blacksmiths, wheelwrights, millwrights, coopers and marine engineers, making a wide range of products (e.g. harrows, steam engines, windmills, pumps, and kitchen ranges). Most of the heavier industries were concentrated in Invercargill, such as foundries, the railway workshops, the gas works, and brickworks.

These local industries often relied on a town's essential infrastructure. In Wyndham, commercial stables, blacksmiths and the dairy factory were required to have cesspits and by-laws required their regular cleaning[135] (Thwaites, 2003). In some cases towns relied on the infrastructure of a local industry. In 1904 the Southland Frozen Meat Company started supplying its excess power to Gore to help meet increasing demand. At present, Wallacetown's wastewater is treated at the Alliance Lorneville's meat processing plant's treatment system, which is located to the west of the plant beside the Makarewa River.

While many towns had a range of industries, some industries were at specific locations because of the availability of particular natural resources, such as gold and coal mining, hydro-power generation and timber processing. For example, the Matāura freezing works and the Matāura paper mill were both located beside the Matāura River for hydro-power. Industries at specific locations are dependent on transport networks, which either helped or hindered access to raw materials and movement of manufactured goods.

As transport networks and trade within Southland, and between Southland and the rest of the world, have developed over time, local communities no longer needed to be as self-reliant. Many industries have consolidated, even those that are location specific like timber processing. Other reasons that industries have consolidated are the costs of replacing aging infrastructure and improvements in technology. In some cases, technological change has resulted in industries returning to an area over time. A fair proportion of the region's major industries are now concentrated in a swathe from Invercargill and Bluff to Matāura and Gore, close to the main trunk railway line and the region's port. Over time, some industries have declined while others expanded.

Figure B8 (following page) shows the location of industries with wastewater across the Southland, including whether the wastewater is connected to a municipal scheme or treated on-site. The map does not include wastewater discharges from hydro-electric power schemes and mines because the nature of these discharges is different from trade waste.

[135] In the 1920s, the Town Board took enforcement steps against the dairy factory because its cesspit had not been cleaned and whey was being put down the town drains (Thwaites, 2003).

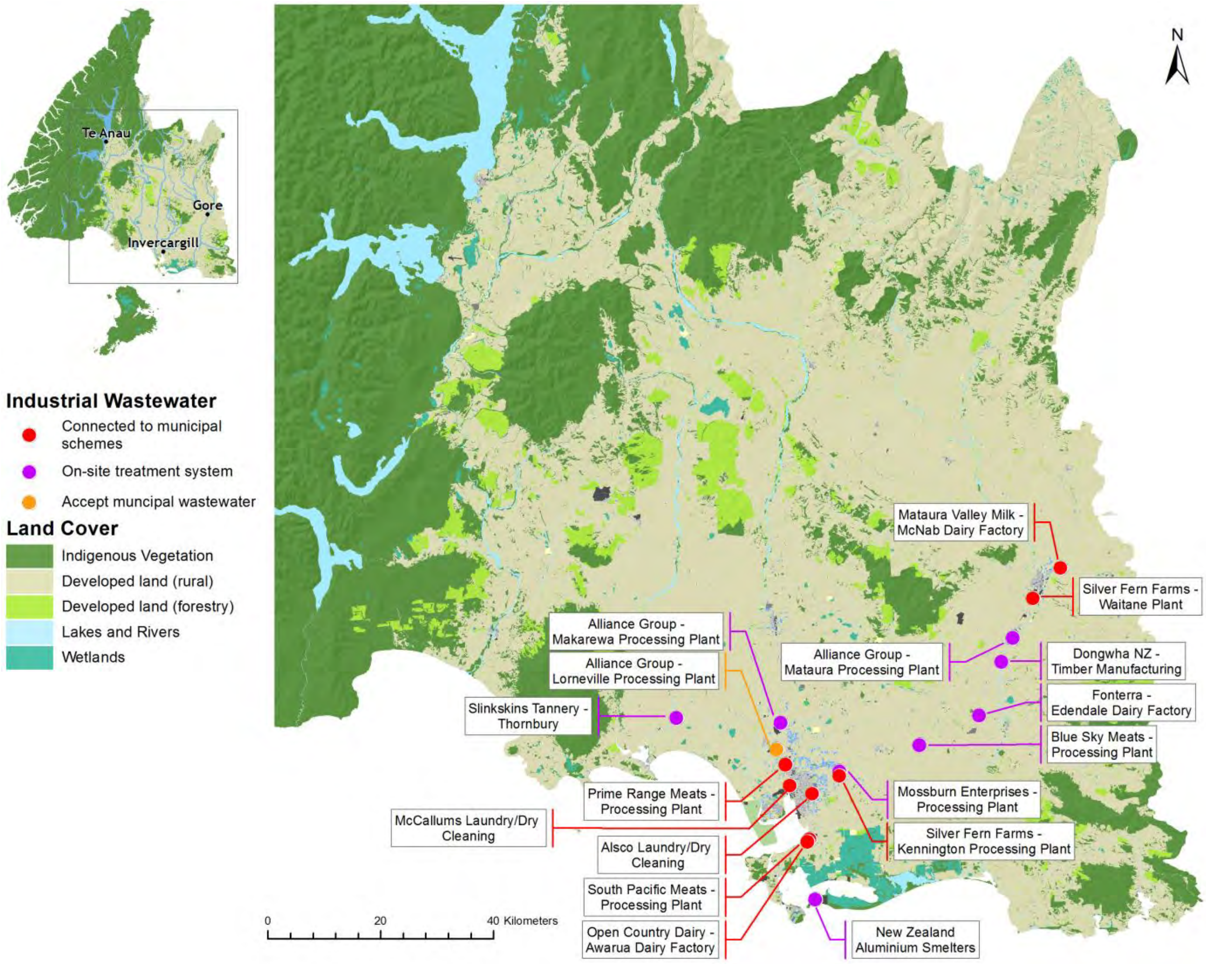


**Figure B8: Location of key industrial wastewater discharges in Southland**
Source Environment Southland

Southland's first known manufacturing industry was the large-scale production of stone tools made by Māori from local argillite at Tiwai Point, which is now the location of New Zealand's Aluminium Smelter – one of the region's most recent industries. Excavations of the site during the construction of the aluminium smelter revealed tonnes of stone flakes, fish hooks and stone tools dating back as far as 1500. Other early industries are muttonbird harvesting, flax harvesting, and fishing. Muttonbird harvesting has long been carried out in autumn by Stewart Island/Rakiura Māori on the Tītī Islands. Flax was harvested by mana whenua for making rope, and later, for trading with early European explorers. Fish was also dried and traded with other Māori or Europeans – Chief Tuhawiki travelled to Sydney to sell a cargo of dried fish, buying guns with the proceeds (Macfie, 2006).

The first European industries to develop in Southland were ship-based whaling and sealing from the 1790s in the Foveaux Strait, followed by shore based whaling stations from the 1820s. The first sites were James Spencer's whaling supply depot at Bluff (1824), which was joined by whaling stations at nearby Stirling Point (1836), and at Cuttle Cove in Preservation Inlet, Fiordland (1829). These were soon followed by the whaling station at Jacob's River Estuary (Riverton/Aparima) (1837), and shorter lived stations at Waikawa, Toetoes Bay (Fortrose), and each of the two Māori villages in the Ōreti (New River) Estuary – Ōmāui and Oue. Whaling occurred at such intensity that the industry was “doomed to self-destruction” (Hall-Jones, 1998, p. 54). As these coastal industries declined, some pioneers turned to agriculture and moved inland.

Southland’s rivers and along the coast has long been fished for survival and trade by Māori and later Europeans. In 1861 Tom Roderique became the first person to commercially catch and sell oysters from Port Adventure, Stewart Island/Rakiura, waiting for low tide and shovelling oysters straight from the seabed into his boat that he then sold in Dunedin (Macfie, 2006). From the 1870s canning and curing factories opened in the region, followed in the 1890s by refrigerated fishing trawlers and freezing depots. By the start of the 20th century around 60 fishing vessels were registered at ports along the Southland coast.

Today, commercial fishing boats are based at Oban, Bluff, Riverton and Milford Sound. The most common inshore species are blue cod and crayfish (spiny rock lobster), paua (abalone) and Bluff oysters. Offshore species include tuna, hoki, dory, squid, monkfish and hake (Macfie, 2006). There is an aquaculture industry, with mussel, salmon and oyster farming at Stewart Island/Rakiura and Bluff, and an eel processing plant at Kennington. Southland’s estuaries are either essential nursery areas for many commercial fish and shellfish species or the species rely on clean estuary filtered water entering the near shore coast.

As Southland’s interior was explored, the region’s first gold deposits were discovered in the Matāura River near Tuturau. Southland’s gold deposits are alluvial – small grains of gold eroded from the source rock over thousands of years that settled in the gravel of river beds – and extracted using a range of methods. By the 1860s there was gold prospecting using a cradle and pan on the Waikaia and Waikaka rivers (tributaries of the Matāura River) in north-eastern Southland. The towns of Nokomai (now a locality near Garston), Waikaia (originally named Switzers), and Waikaka grew up around these workings. The Switzers goldfield was vast, covering approximately 1600 square kilometres. Up to 4,000 miners held claims scattered across the goldfield and the goldfield itself was only accessible by foot from Lawrence (80 km to the north) – this isolation meant miners relied on supplies from runholders for many years. The town of Switzers was moved three times in order to extract the gold underneath it (McKee, 2015).

From the 1880s new hydraulic sluicing and dredging technologies were developed, leading to a renewal of gold mining from the 1890s to the 1920s. Many of the miners were Chinese who came to the goldfields with the aim of earning £100 as quickly as possible to return to China and buy a plot of land. At Nokomai, Choie Sew Hoy, a Chinese businessman and entrepreneur, developed a large water race system through rugged terrain for a hydraulic sluicing and elevator plant (Bauchop, 2018). This innovation gave hope to large numbers of miners who returned to the area to mine gold. The sluice remained in operation until 1943. Choie Sew Hoy also invented a new type of steam bucket dredge, which also reignited interest in gold mining. By 1906 there were 85 gold dredges in Southland, with around 30 dredges on the Waikaka River. Over £1 million worth of gold was retrieved from the Waikaka area between 1897 and 1926– the last dredge closing in 1933.

Gold was also mined at Orepuki Beach (west of Riverton), Coal Island in Preservation Inlet (Fiordland), and Waimumu stream (southwest of Gore). Soon after gold was discovered on Coal Island, around 500 miners were living there in extremely trying and isolated conditions, and the most reliable form of communication with Invercargill was by carrier pigeon (Macfie, 2006). The Waimumu goldfield produced a total of 570 kilograms of gold (Turnbull & Allibone, 2003). One of the richest goldfields was Round Hill at the edge of the Longwoods, which produced Southland's largest nugget (36 ounces) (DOC, n.d.). There were other gold mining operations along the Catlins coast on beaches from Fortrose to Haldane. While mining of most of the remaining gold deposits is currently uneconomic, alluvial gold mining returned to the Waikaia area in 2013.

The influx of prospectors seeking to find their fortune and settlers looking to take up land for farming increased demand for housing and infrastructure. This demand drove development of industries such as timber processing, coal mining, and hydro-power generation. Indigenous (native) species were the main source for timber processing as land was cleared and developed for agriculture, such as around Tuatapere, which was known as "The hole in the bush". Before the purchase of the Murihiku Block, much (but not all) of Southland was covered in podocarp (rimu, totara, kahikatea, miro, and matai) and beech forests – the Southland Plains consisted of pockets of native forest, extensive lowland swamp and tussock grasslands (Macfie, 2006). In the twentieth century, timber processing shifted to exotic species, particularly radiata pine, Douglas fir (grown at higher altitudes), and more recently, eucalyptus, as commercial forests were planted on some of the cleared land.

At first, timber processing was located close to settlements and bullock teams were used to haul logs to the local sawmill. As demand for timber grew, from within Southland, New Zealand and further afield, the location of new sawmills was determined by access to navigable water and/or to rail. Forests within easy reach of ports were some of the first to be felled. On Stewart Island between 1861 and 1931 there were over 40 sawmills in operation (Macfie, 2006). Timber was shipped from Waikawa and used to build cities like Timaru and Dunedin.

Development of the railway network, particularly from Makarewa through to Tuatapere, improved access to forests and timber processing expanded. It also increased demand for timber, which was used for wooden rails and sleepers. As easier podocarp forests along Southland's coastal flats were cleared, attention turned to less familiar silver beech forests on the lower slopes of the Longwoods and further west to the coastal forests in and around Te Waewae Bay (Macfie, 2006). In Tuatapere there has long been a close relationship between sawmills and the local community[136]. The Port Craig sawmill on the west side of Te Waewae Bay operated from 1916 to 1928[137]. Port Craig employed over 150 men, processing up to 1800 cubic metres of timber per month. With a recent closure in Otautau, timber processing now occurs in or around Tuatapere, Winton, Invercargill and Matāura[138].

With settlement came a need for a domestic source of coal that was used for heating, power generation for specific industries (e.g. dairy factories) and transportation (e.g. railways and steamers). As early as the 1860s coal deposits in the north Wairio area (north of Otautau) were noted. Initially, any coal recovered was used locally, but soon the search began for seams large enough to be mined on a commercial scale and sold further afield. Coal mines were developed

[136] Sawmill workers bought food supplies from neighbouring settlers, who in turn bought timber products from sawmills for building and fencing (McClintock and Fitzgerald, 1998).

[137] The timber was transported by tramlines over viaducts before being shipped to cities around New Zealand and Australia. The isolated location of the sawmill meant it was largely self-reliant, with a full range of services for workers and their families on site (e.g. a school, blacksmith, wharf, bakery, library, social hall, and accommodation), and it had a strong sense of community (McMechan, 2014).

[138] More detail on forestry in Southland is available in the Agriculture and Forestry Report (Moran *et al*., 2017)

around Nightcaps, Ohai, New Brighton, Wairio, Mossbank and Mataura. The coal ranged from extensive lignite deposits (a low-grade coal) to sub-bituminous coal (a high-grade coal). Today coal mining is still in operation in the Ohai, Nightcaps and Waimumu areas (near Mataura), new technology making it possible to access and extend previously abandoned coal seams.

From the late 19th century some exploration and extraction of oil and oil shale (a fine-grained mudstone) occurred in central and western Southland, particular at Orepuki, but was short-lived. Off Southland's coast, the Great South Basin (500,000 $km^2$) is one of the largest potential oil and gas fields in New Zealand (Southland New Zealand, n.d). Since the 1970's, companies have obtained exploration permits. Hunt Petroleum was one of the first and they drilled exploratory bores between Southland and the Auckland Islands. To date, work in the Great South Basin has been limited to exploration because of problems with the harsh environment and technical difficulties. In recent years, advances in seismic surveying and drilling technology have renewed interest and several new exploration permits have been granted. In 2017 the government included the Western Southland Basin (land and coastal) in a block offer for oil and gas exploration.

**Image B34: Clifden Limeworks**
Source Emma Moran

New dairy factories attracted early settlers to Southland who bought land to set up dairy farms. From the 1880s limeworks were established to supply regular applications of lime to help control the soil pH for dairying on the newly cleared land. Initially, farmers used burnt lime on the land (calcium oxide) but in 1902 the new practice of using calcium carbonate, a simpler and more effective product, was introduced as a fertilizer. After some initial resistance, many farmers converted and one of the most influential was Alexander Wylie Rodger (Birchwood Station) (Macfie, 2006). From the beginning of the 20th century, limeworks were developed where there were outcrops of limestone, particularly in central Southland. In the mid 1950's there were 13 limeworks in Southland, but new technology led to some being amalgamated or closed. Today just a handful of limeworks remain.

Since European settlement, agricultural processing and manufacturing in Southland has revolved around fibre (wool and flax), meat and animal products, dairy, grain, and from World War Two, vegetables, flax milling (New Zealand flax and linen flax) and tulips[139]. Industrial development has generally followed a pattern of many small local factories that over time consolidated into a handful of large processors and manufacturers either close to South Port and/or the main trunk railway line. This change has largely occurred as a result of improvements in technology, particularly for preserving food (e.g. drying, canning, freezing, chilling) and transport. Along the way some industries have come and gone from the region, such as rabbit canning factories[140], flour mills, and oat mills. At present, processors and manufacturers are located in and around Invercargill, and between Invercargill and Gore.

With farming came food processing industries. In the 1870s canning factories were set up, initially by the Glasgow Meat Preserving Company at Woodlands and Winton (Macfie, 2006). During the war a canning factory at Bluff produced 11,000 cans per day of rabbit, sheep tongues, beef roll, mutton, steak and kidney, and fish (Hall-Jones, 1976). In the 1880s refrigeration made it possible to export whole carcasses of rabbits, sheep, and cattle. The Southland Frozen Meat Company sent their first shipment in 1883, frozen on board ship (Lind, 1981). Soon after, a refrigeration plant was built at Bluff to freeze and store meat before shipping it overseas, followed by a second plant at Mataura in 1891. Other freezing works were built in Southland, at Ocean Beach (by Sir Joseph Ward), Makarewa, Lorneville[141], and a specialist venison processing plant at Mossburn. Today meat processing plants are situated around Invercargill, Mataura, and Gore.

The dairy processing industry benefitted from the introduction of refrigeration, which made exports of butter and cheese possible, the use of lime on pasture, and the development of a rural power supply (discussed later in this section). In the 1880s a dairy factory with cheese making facilities was built at Edendale, which became New Zealand's first large scale dairy factory (Wing, 2012). This was followed by a large number of small dairy co-operatives processing milk for local farmers that reached a peak of 88 in the 1930s (Macfie, 2006). Most factories produced butter and cheese, but some preferred to specialise or diversify. For example, stilton cheese was manufactured by the Saxelby family between 1890 and 1939 at Roslyn Bush and then Woodlands. Highlander sweetened condensed milk was manufactured at Wallacetown from 1892 until 1964, when manufacturing shifted to Auckland.

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[139] More information on the tulip growing industry is available in van Uden (1999) Journeys of Hope – Post World War ll Dutch Settlement in the South of New Zealand.

[140] The first rabbits were released in New Zealand on Sandy Point in Invercargill in 1863 and within five years their numbers had increased to the point where they were considered pests (Esler, 2016).

[141] Much of the development of Southland's meat processing industry is recorded in Lind (1981) *The Keys to prosperity: Centennial History of Southland Frozen Meat Ltd*.


**Image B35: Flemings Flour Mill, Invercargill**
Source Emma Moran

From the 1950s many dairy factories closed for a range of reasons including improved transportation, processing techniques, and, in some cases, a lack of maintenance. By 1981 the only dairy factory in Southland was at Edendale (Macfie, 2006). At present, there are two milk processing plants in Southland, producing a variety of dairy products, including milk powder for export. Fonterra own a plant at Edendale, Open Country Dairy have a plant at Awarua and a third, Mataura Valley Milk, is under construction at McNab near Gore.

Flour mills appeared early in European settlement and played a major role in economic development. For over a century, Southland was one of the most important flour producing regions in New Zealand, reaching a peak of 12 flour mills in the 1880s. The industry's endurance was largely down to Thomas Fleming who bought a mill (with partners) in Invercargill in 1879 before expanding and acquiring all other mills in Southland. Fleming and Company became a household name throughout New Zealand. Mills were also set up in Southland to process New Zealand flax - over 160 mills operated between the 1880s and 1970s. Shorter fibres were used in furniture, packing and floor mats, but most went into woolpacks, cereal bags and baling twine. There were also two flax rope and twine mills in Invercargill. Linen flax mills were also located in Southland when linen flax was needed for essential military supplies in Britain during World War Two[142].

[142] A history of Southland's linen flax industry is available in Trotter (1996) *The Forgotten Flax Fields: Linen Flax in the South*.


**Image B36: Brydone Dairy Factory**
Source Emma Moran

Hydropower, generated using water wheels, was at first limited to specific industries, particularly in Matāura and Stewart Island/Rakiura. As hydropower became a source for generating electricity, small schemes were used to supply towns, such as at Gore, Invercargill and Bluff. As demand for electricity in rural areas grew, particularly from dairy factories, attention turned to the considerable generation potential of the Fiordland lakes. Rather than wait for central government, a local initiative[143] established the Southland Electric Power Board (the world's first power board) in 1919, which gave urban and rural areas equal access to cheap electricity (Buckingham, 2016). In 1925 the Southland Electric Power Board built the Monowai Power Scheme at the confluence of the Monowai River and the Waiau River. When the government took over from the Board in 1936, 95 percent of Southland's power was being generated at Monowai (Buckingham, 2016). The Monowai Power Station was refurbishment in 2007, and now has three turbines, each capable of producing 2.6 megawatts of electricity.

In the 1960s, the Government built an underground hydroelectric power scheme at Lake Manapouri to supply electricity to the aluminium smelter at Tiwai Point (completed in 1971). The original plan included a proposal to raise the level of the lake by 30 metres, effectively merging it with Lake Te Anau. This proposal triggered a nationwide public opposition campaign and it was eventually

[143] In 1914 a group of Southlanders formed the Southland Progress League to promote the region's interests and avoid it becoming a backwater. The Natural Resources Committee, led by A.W. Rodger (Birchwood Station), prioritised the development of renewable energy resources and the League wrote the legislation for the Electric Power Boards Act of 1918.

abandoned (Knight, 2016). The scheme generates up to 800 megawatts of electricity by diverting the majority of the flow from the Waiau River to Deep Cove in Fiordland. The aluminium smelter is the largest single user of electricity in New Zealand, and uses it to convert imported alumina from Queensland into high grade aluminium. The smelter was located in Southland because of the large and reliable supply of subsidised electricity from Manapouri, and specifically at Tiwai Point because of its proximity to South Port at Bluff and the established infrastructure in Invercargill.

## 5.2. Meat Processing

**Alliance Group**: is based in Invercargill and is a co-operative, wholly owned by over 4,000 farmers. It is one of the world's largest processors of sheep meat and New Zealand's largest producer of lamb, but also produces venison, pork and beef products. Alliance Group has a turnover of around $1.5 billion and has three large meat processing plants in Southland at Lorneville, Makarewa and Matāura. Construction has also begun on a new purpose-built venison processing plant at Lorneville, estimated to cost $15.2 million.

**Silver Fern Farms**: is based in Dunedin and is a 50:50 partnership between Silver Fern Farms Co-operative and Shanghai Maling. Its origins are as a farmer-controlled co-operative company, representing around 16,000 sheep, cattle and deer farmer-shareholders throughout New Zealand. It is the largest livestock processing entity in New Zealand, employing around 7,000 people at the peak season. Its annual turnover exceeds $2b, and it operates plants at Kennington and Waitane in Southland.

**South Pacific Meats**: operates a meat processing plant at Awarua and is owned by AFFCO New Zealand Limited, a member of the Talley's group of companies, which is wholly owned by the Talley family.

There are two other companies operating in Southland that process and export smaller volumes of meat:

**Blue Sky Meats**: **i**s a privately held firm with two sheep and lamb processing plants in Southland at Morton Mains and Gore.

**Prime Range Meats Limited**: is a privately held firm with a majority shareholder based in China and a lamb, sheep and beef processing plant at Invercargill.

## 5.3. Milk Processing

**Fonterra**: is New Zealand's biggest company and the world's largest processor of dairy products, responsible for approximately a third of the world's dairy exports. It is a co-operative, owned and supplied by 10,700 New Zealand farmer shareholders with revenue exceeding $19 billion. Fonterra operates a large dairy processing plant in Edendale, one of the largest in New Zealand. Dairy processors have operated on this site since the 1880s, making it New Zealand's oldest manufacturing site. Today Fonterra processes more than 15 million litres of milk per day at its Edendale plant, producing cheese, anhydrous milk fat, milk protein concentrate, casein and milk powder.

**Open Country Dairy**: is a private company which produces milk products for local and global exports. It is the second largest dairy manufacturer in New Zealand with revenue of almost $819 million (2016). Open Country Dairy operates three dairy processing plants, one of which is in Southland at Awarua. The Awarua plant specializes in the manufacture of whole milk powders certified to Halal standards. Open Country Dairy's three processing sites are supplied by 550 independent dairy farmers and between them process around 900 million litres of milk per annum.

**Matāura Valley Milk**: has recently built a new milk processing plant at McNab, near Gore, with production starting in August 2018. CAHB is a Chinese state-owned company which holds a 71.8 percent stake in the plant, 20 percent is held by Southland farmers, the remainder by Hamilton - based milk powder company BODCO and Matāura directors. The plant's focus is on producing infant formula for international markets as well as UHT cream and some skimmed milk powder and is capable of processing 500,000 litres of whole milk a day (Pickett, 2017).

**Other dairy processors**: There are several small boutique dairy processors in Southland that sell products like speciality cheeses and yoghurt, both domestically and internationally e.g. Retro Organics, Tuturau and Blue River Dairy Products Ltd, Invercargill (sheep milk products and infant formula from sheep, goat and cow milk).

## 5.4. Wood and Timber Processing

**Craigpine Timber Limited**: is a private company established in 1923. It owns 4,000 hectares of timber plantation in Southland, supplying wood to their own sawmill near Winton. The sawmill produces 132,000 cubic metres of sawn timber per annum, some for the domestic market, some for export to Asia (China, Taiwan, Singapore, Malaysia, Indonesia, Thailand, Vietnam and India) and USA.

**Niagara Sawmilling Company**: is a family owned company established in 1954, that expanded from three small sawmills to the present site at Kennington, Invercargill covering more than 27 hectares. Over 100 staff are employed by the company. A range of products are produced by Niagara including milled timber and precision building products as well as bark, chip, sawdust, firewood and briquettes. Niagara owns some of its own plantations but also purchases logs from privately owned blocks. As well as producing for the domestic market, the main export destination for Niagara's products is Asia, e.g. Indonesia, China, Thailand and Vietnam.

Both the Craigpine Timber and Niagara sawmills process around 200,000 tonnes of logs per year into sawn timber, but there are also a number of smaller sawmills around the region as well as other companies that process wood into different products (Millar et al, 2015).

**Daiken Southland Limited**: manufactures medium-density fibreboard (MDF) at its plant at Matāura. It typically processes between 350,000 and 390,000 tonnes of chip to produce MDF, with roughly two thirds coming from logs and the remainder from chip residue from sawmills. The Matāura plant exports products to several countries in Southeast Asia, as well as China, Japan and the United States of America (Daiken Southland, n.d).

**Southwood Export Limited**: has a chipping facility at Awarua (near Invercargill). In 2016, around 340,000 tonnes of hardwood eucalyptus logs were chipped at the facility for export to Japanese pulp and paper manufacturers (G. Manley, pers. comm., 2017).

## 5.5. Minerals

**Waikaia Gold Limited**: was recently formed by a group of investors and in 2013 Waikaia Mine was opened at Freshford, near Waikaia (near the original gold town of Switzers). The mine is aiming to extract 16,000 to 20,000 ounces of gold annually over seven years before returning the land to farming. The Waikaia mine employs around 35 staff including contractors (Naidu, 2015).

**Bathurst Resources Limited:** is New Zealand's largest specialist coal company. They produce over 2.2 million tonnes of coal a year and employ over 450 people in New Zealand. Bathurst Resources operates the Takitimu mine at Nightcaps, which provides sub-bituminous coal to local schools, hospitals, food processors and dairy factories. Although the Takitimu mine was exhausted of coal around 2012 and the Coal Dale mine is coming to the end of its supply (Babington, 2017), Bathurst Resources are currently developing the Black Diamond Block, an extension of the Takitimu mine that will provide access to a further 1.8 million tonnes of coal (Bathurst, n.d.). They are also exploring other options at nearby New Brighton which could open up further deposits of the high-grade sub-bituminous coal.

**Image B37: Greenbriar Ltd.'s New Vale Mine, Waimumu**
Source Environment Southland's Compliance Monitoring Report 2015/16

**Greenbriar Limited**: is owned by Palmer MH Group, a collective from Dunedin with experience in mining and quarrying. Greenbriar has recently (2017) taken over Ohai Coal Mine and New Vale/Goodwin Mine at Waimumu from previous owner Solid Energy New Zealand as part of Solid

Energy's liquidation process. Greenbriar employs around 60 local people and sells its coal throughout Southland. The New Vale mine supplies lignite to industries in the south of New Zealand. One of their largest customers has been Fonterra for its dairy processing plant at Edendale, while other customers have been Alliance meat processing group, timber companies, a hospital, a tile drain works and for lime drying (Woolf, 2017). Ohai Mine produces sub-bituminous coal which is used for residential and commercial heating and steam-electric power generation. Ohai's coal has only 0.4 percent sulphur by weight, meaning it is an extremely clean coal.

**AB Lime**: was formed when Awarua Limeworks merged with Browns Lime Company in 1998. Browns Lime Company formed in 1915 and produced lime from its Browns site for 83 years, with around 13 employees in the early years, tunnel blasting, then bagging the lime and transporting it by rail. In 1998 the Browns site was closed and all operations were moved to the present day site on Bend Road, Winton. This is now the biggest limeworks in Southland (Macfie, 2006). AB Lime no longer uses explosives but uses large diggers to access the lime. 28 staff members are employed by AB Lime (2015). The current excavation site is estimated to be able to produce lime for another 100 years (Salter, 2015).

**Ravensdown**: is a co-operative owned wholly by farmers, with its head office in Christchurch. It is the largest supplier of fertiliser products in New Zealand, supplying over half of all fertiliser used in New Zealand (Fusion5, n.d.). Ravensdown operates a lime quarry at Dipton. The Dipton quarry has been operational since the 1920s, with various owners before Ravensdown who progressively modified and rebuilt the works to increase output (Collinson, 2002). A major upgrade was completed at the quarry in 2013, making it one of the most up to date lime processing plants in New Zealand. It has the capacity to produce over 80,000 tonnes of limestone a year. Ravensdown also own another limestone store and quarry at Balfour (MacKay, 2011).

**Fernhill Limeworks Limited**: owned by H. W. Richardson Group (HWR) is located in Kauana north of Winton and is a certified organic quarry producing lime and fertilisers (HWR, n.d).

**Ballance Agri-Nutrients**: is a 100 percent New Zealand farmer-owned cooperative with a core business in fertiliser manufacturing, sales and supply throughout New Zealand. Its revenue for the year 2016 was $893 million, making a profit of $81 million (Green, 2016). Ballance Agri-Nutrients was formed in 2001 after a series of mergers and share purchases between SouthFert, the Bay of Plenty Fertiliser Company, Fernz Corporation and Norsk Hydro (now Yara). Ballance has two plants that manufacture phosphate fertiliser products, one in the North Island and the other in Southland, at the original SouthFert plant at Awarua. Between the two plants they produce approximately 800,000 tonnes of fertiliser a year. The Awarua plant's products are distributed throughout the South Island. Ballance also offers sponsorships and runs the Ballance Farm Environment Awards in an effort to promote and reward good farming practices.

**Southland Serpentine**: is a company formed in 2006 which manufactures a magnesium rich agricultural fertiliser and salt licks mined from serpentine. It is owned by a partnership (McGregors & Pearsons) who reopened the Mossburn Serpentine Quarry. A digger is used to extract the serpentine rock, before transporting it to McGregors Concrete, Te Anau for crushing and processing. From there it is transported to Lumsden for storage and distribution (Southland Serpentine, n.d.).

**Southern Aggregates Limited**: owned by H. W. Richardson Group (HWR), operates a hard rock quarry at Greenhills near Bluff, a sand and aggregate plant at Ōreti Beach near Invercargill, three mobile crushing plants and a mobile screening plant. Their products include roading and construction aggregates and concrete sand and they range in size from serpentine dust, to railway ballast, right up to ornamental boulders (HWR, n.d.).

**International Speciality Aggregates:** is an Invercargill company which exports pebbles and construction aggregates to 12 different countries, principally for ornamental purposes like pool lining and decorative landscaping.

## 5.6. Power Generation

**Meridian Energy**: own and run the Manapouri Power Station, New Zealand's largest hydroelectric power station. It is located on Lake Manapouri's West Arm in Fiordland National Park, Southland and uses water stored in Lake Te Anau and Lake Manapouri. The water used to generate electricity is discharged through two tunnels into Deep Cove, Doubtful Sound. Built almost entirely underground, 200 metres below the surface of Lake Manapouri, it is widely considered to be one of New Zealand's greatest engineering achievements. Manapouri Power Station has seven 122 megawatt generating units which generate enough electricity each year for about 619,000 homes, approximately 15 percent of the country's electricity (850 MW).

White Hill wind farm, located in northern Southland overlooking Mossburn, is also owned and operated by Meridian Energy. It was officially opened in 2007 and was the first wind farm in the South Island. The wind farm covers approximately 24 square kilometres of mainly forestry land, consisting of 29 two megawatt turbines which will produce enough electricity for about 23,000 average households.

**Pioneer Energy:** own and run Monowai Power Station on Lake Monowai in western Southland. Work started in 1921, making it one of the earliest hydroelectric power stations in New Zealand. A refurbishment, completed in 2007, has updated the power station. Each of the three turbines is now capable of producing 2.6 megawatts of electricity, with an annual generation of 45 gigawatt hours.

**Alliance Group**: Matāura has historically had a meat works and paper mill located by the Matāura River next to the Matāura Falls; both were powered by hydroelectricity generated from the river (0.9 MW). The paper mill closed down in 2000 but the meat works owned by Alliance is still in operation and generates some of the electricity it needs.

**Southern Generation Limited Partnership**: is a joint venture between Pioneer Generation Investments Ltd, Electricity Invercargill Limited and The Power Company Limited. The partnership operates Flat Hill wind farm, near Bluff which opened in 2015 and consists of eight turbines, with a total generation capacity of 6.8 megawatts. Flat Hill was built on a 460 hectare site of private farmland chosen for its optimal wind conditions and minimal environmental impact. It connects directly to the Bluff substation and The Power Company Limited's local network, and produces approximately 26 gigawatt hours of renewable energy annually, enough to power 2,600 homes more than enough for all Bluff's energy needs (Pioneer Energy, n.d.).

**Image B38: West Arm, Lake Manapouri**
Source Simon Moran

## 5.7. Metal Processing

**New Zealand's Aluminium Smelter (NZAS)**: opened in 1971 at Tiwai Point, across the harbour from Bluff. NZAS, the only aluminium smelter in New Zealand, is owned by Pacific Aluminium (79.36%) and Japan's Sumitomo Chemical Company (20.64%). The plant produces high grade primary aluminium from alumina sourced from Queensland, Australia. Ever since it opened, the smelter has been New Zealand's largest consumer of electricity – around one third of the South Island's electricity usage and 15 per cent of New Zealand's usage. Approximately 800 people are employed at NZAS. In 2016, 338,556 tonnes of aluminium were produced by NZAS, around 90 percent of which was exported giving NZAS export revenue of over $1 billion as well as contributing $525 million to the Southland economy.

# Part C: Town Case Studies

**Part C** reports on the survey and modelling of municipal wastewater schemes in Southland. It builds on the outline of Southland in **Part A** and the overview of urban areas and industry in **Part B**.

**Part C** is made up of nine main sections:

**Section 1** outlines the general approach to town selection, and the modelling scenarios;

**Sections 2 to 8** describe each case study town and summarises their results; and

**Section 9** describes **The Southland Economic Model for Fresh Water**.

## 1. General Approach

The purpose of this research was to develop information on further managing waste substances in discharges from municipal wastewater schemes so that this information will be available during community processes to set limits for fresh water in Southland. Specifically, this research focused on selected towns across the region and investigated the existing performance of their wastewater schemes, and the effectiveness and financial costs of upgrades or step changes in performance. As outlined in **Part B** of this report, there are a range of urban communities (generally referred to as towns) in Southland and each territorial authority (Gore District Council, Invercargill City Council, and Southland District Council) is faced with a different set of circumstances.

These schemes consist of two main components: the reticulation infrastructure (i.e. pipes, pumps, and pits) and the wastewater treatment system. While a scheme's reticulation infrastructure is relevant, the research was specifically about step improvements in wastewater treatment. In addition to these step improvements there are also possible actions to improve the capacity of reticulation infrastructure. These actions can reduce inflows into a wastewater treatment system, increase its effectiveness, and improve the overall efficiency of a scheme.

This section describes the general approach used in this research, including town selection and the modelling process. This research was a substantial undertaking for all of the councils involved and it occurred between 2015 and 2016. During this time, Environment Southland developed the physiographic zones (refer to Part A, Section 2.4) and notified the proposed Southland Water and Land Plan.

Research of this type is relatively uncommon in New Zealand and it had its challenges, particularly around the development of scenarios to model. It was the first time research has included towns from across a region, and it is the largest analysis of its type to date. It was also the first time all territorial authorities within a region and a regional council have worked together on this type of research. The guiding principle that shaped the research was that it was undertaken in ways that made sense to all of the councils.

In essence, the approach was to develop a set of case studies that included towns in each of the three districts based on information from municipal wastewater schemes across Southland. The case studies were a mix of quantitative and qualitative data and allowed multiple factors to be explored within a real world context. The set of case studies form a body of information which is useful for all towns in the region. This approach allowed a range of different circumstances to be captured and was the most efficient way to cover the range of situations within the region as possible. The case study approach was similar to that used for the agricultural sector (described in Part C of the Agriculture and Forestry Report) and followed the basic process described below.

**In focusing on municipal wastewater schemes, a considerable proportion of the region's industrial discharges (i.e. trade waste) were also captured.**

## 1.1. Town Selection

The selection of towns as case studies was an iterative process of determining the total number of case studies needed and considering the specific towns to include. The number of case studies ranged from a single in-depth investigation to multiple examples that covered the topic lightly. The constraints were the existing information and the resources available (i.e. staff time, existing knowledge, and funding) to undertake this work. The process took account of a range of factors, including political and geographic distribution, and the size and type of schemes.

The most important factor was whether a town's wastewater scheme had a discharge to water (rather than to land). These schemes are likely to be a priority in limit-setting for water quality because they tend to contribute a more direct load of contaminants, and direct discharges to water are less socially and culturally acceptable. Location was also important because of a town's role as a service centre, local environmental conditions, and need for general representation across the region (refer to Part A, Section 1.2). Other factors were a wastewater scheme's connection with stormwater, and the extent of its trade waste component. Eight towns were selected as case studies, and their selection was based on the population and the extent of wastewater schemes within each district. The spreadsheet on the next page summarises the analysis used in the selection process – the eight case studies are highlighted in blue: Gore, Matāura, Invercargill, Winton, Nightcaps, Te Anau, Ohai and Bluff.

The extent of existing consent monitoring information was variable across the region. The larger schemes with mechanical processes and on-site operators have more extensive and frequent monitoring programmes. For example, wastewater inflow and outflow (influent and effluent) characteristics at Invercargill's wastewater treatment system at Clifton are monitored on a weekly basis. The smaller schemes based on an oxidation pond are monitored less frequently. For example, Nightcaps' treated wastewater was sampled twice a year and increased to four times a year under the recently granted consent.

| Freshwater Management Unit | Territorial Authority | Town | Population (% region) | Wastewater discharge | Type of wastewater and stormwater schemes | Industry (wastewater treatment is either via the municipal scheme or on-site) |
|---|---|---|---|---|---|---|
| Matāura | Gore District | Gore | 7.9 | To water | Combined and separate networks | Meat processing, light industry, transport, and other sectors |
| | | Matāura | 1.6 | To water | Combined and separate networks | Meat processing |
| | | Waikaka | 0.1 | To water | Wastewater & some stormwater | |
| | Southland District | Balfour | 0.1 | To water | Wastewater & some stormwater | |
| | | Edendale/Wyndham | 1.2 | To water | | Milk processing |
| | | Gorge Road | 0.2 | To land and water | Wastewater & some stormwater | |
| | | Riversdale | 0.5 | To land and water | Wastewater & some stormwater | |
| | | Tokanui | 0.2 | To water | Wastewater & some stormwater | |
| Aparima | | Nightcaps | 0.3 | To water | Separate networks | Coal mining |
| | | Otautau | 0.9 | To land | Separate networks | Timber processing (recently closed) |
| | | Riverton | 1.6 | To land and CMA | Separate networks | Fish processing |
| Waiau | | Manapouri | 0.2 | To land and water | Separate networks | Hydropower generation |
| | | Monowai | - | To land | Wastewater & some stormwater | |
| | | Ohai | 0.3 | To water | Separate networks | Coal mining (recently closed) |
| | | Te Anau | 2.8 | To water | Separate networks | Light engineering, transport and tourism |
| | | Tuatapere | 0.6 | To water | Separate networks | Timber processing and tourism |
| Fiordland / Islands | | Oban | 0.4 | To land | Separate networks | Fish processing and tourism |
| Ōreti | | Browns | 0.2 | To land and water | Wastewater & some stormwater | Limeworks |
| | | Lumsden | 0.5 | To land | Wastewater & some stormwater | Transport |
| | | Wallacetown | 0.7 | To water | Wastewater via industrial system | Meat processing |
| | | Mossburn | 0.2 | N.A. | Some stormwater only | Transport |
| | | Winton | 2.6 | To water | Separate networks | Timber processing, light engineering, concrete production, and transport |
| | Invercargill City | Invercargill | 53.5 | To coastal marine area | Separate networks, some cross-contamination issues | Meat, milk and metal processing, light industry and other sectors |
| | | Bluff | 1.9 | To coastal marine area | Separate networks | Fish processing |
| | | Ōmāui | <0.1 | To land | Wastewater only | |

In total, the eight case study towns represent over 70 percent of Southland's population. The demographic trends for these towns vary between towns and change over time. Population drives the delivery of services, such as wastewater, and some towns have declining populations. This circumstance presents real challenges for these communities in the future, challenges that are exacerbated where there are relatively low household incomes. Figure C1 shows population changes from 1991 to 2013 for the eight case study towns. The trendline for each town on this graph is coloured by district: towns in Southland District are blue, towns in Invercargill City District are orange, and towns in Gore District are green.

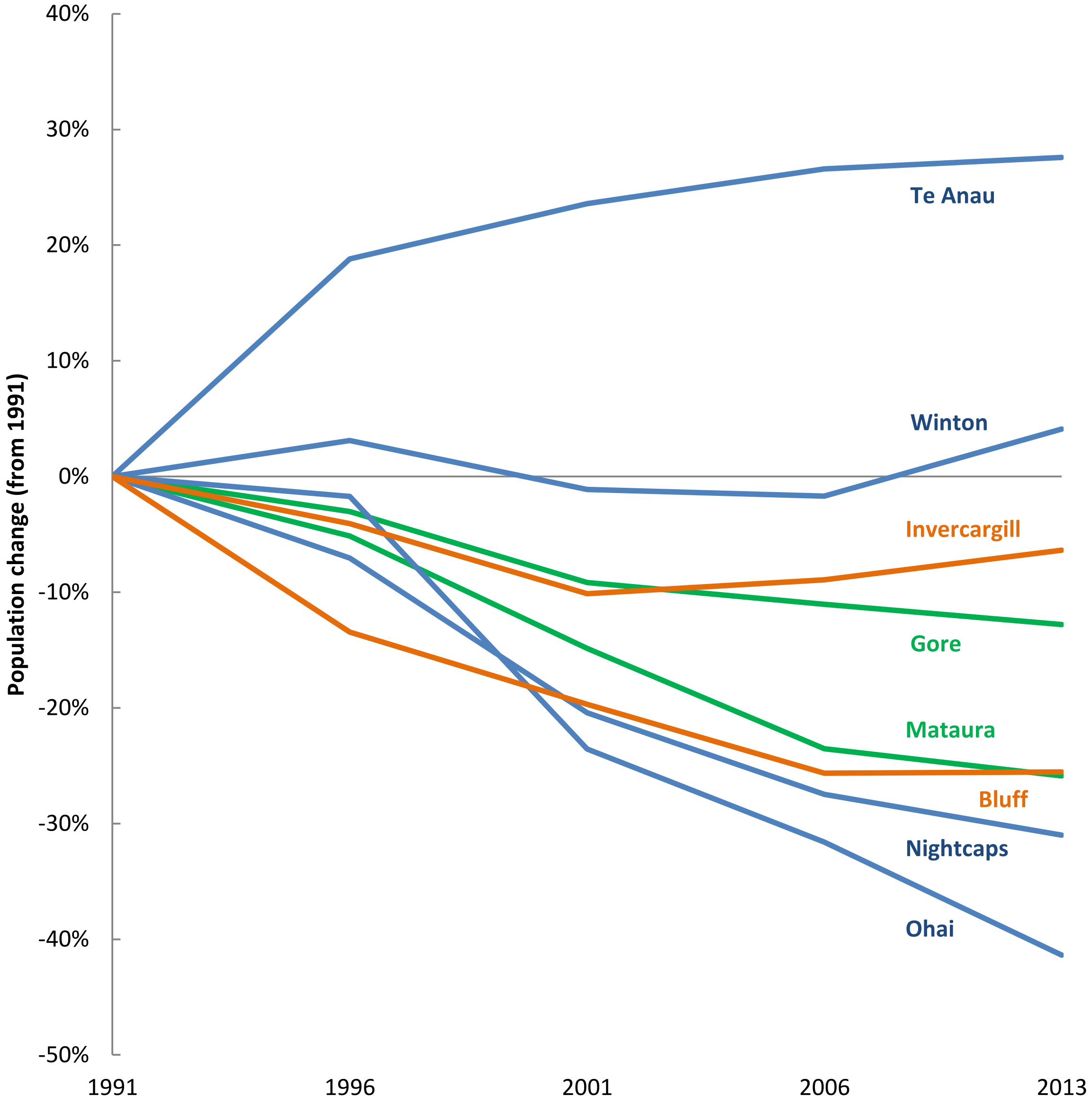



**Figure C1: Population change for the eight case study towns 1991 to 2013**
Source: Statistics New Zealand census data

The population connected to a wastewater scheme directly determines the inflow and contaminant load of incoming wastewater. Factors that change this relationship are connections of large industry, particularly if the trade waste is highly concentrated or in substantial volumes. The extent of stormwater inflow and groundwater infiltration to the system will tend to disproportionately increase the flow of wastewater, particularly during peak flows. As population increases or decreases, the base wastewater flow and load will change similarly but peak flows may not change as much.

Table C1 summarises the annual inflow to the systems for the case study towns. In the table the towns are sorted in order of decreasing inflow to the system. Inflow per household gives an indication of the effects of sources other than residential wastewater on the wastewater scheme. Invercargill, Gore and Bluff all have relatively high inflow per household, reflecting the extent of commercial and industrial wastewater received by these schemes. Stormwater infiltration into the wastewater scheme is also a significant issue for Gore, adding to the volume of inflow requiring treatment. Te Anau receives considerable tourism related flows, which has increased the inflow per household in comparison to a similar sized town like Winton. The elevated inflow per household at Ohai is possibly because of the effects of inflow and infiltration within the network.

**Table C1: Inflow and Households in the Town Catchments for ~ 2016**

| Town | Annual Inflow ($m^3$/year) | Households (hh) | Annual Inflow per household ($m^3$/hh/year) |
|---|---|---|---|
| Invercargill | 9,052,000 | 20,904 | 433 |
| Gore | 2,200,000 | 4,035 | 545 |
| Bluff | 383,250 | 886 | 433 |
| Te Anau | 301,300 | 1,022 | 295 |
| Winton | 257,000 | 1,287 | 200 |
| Matāura | 193,100 | 823 | 235 |
| Ohai | 43,400 | 126 | 344 |
| Nightcaps | 34,900 | 161 | 217 |

## 1.2. Contaminants

The research considered suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus and *E. coli*. These contaminants are measured as concentrations (toxicity) and loads (accumulations) that tend to build up in 'sinks', lakes, groundwater and estuaries. Direct toxicity of contaminants in wastewater (as distinct from secondary effects like toxic algae growth) is typically not a major issue in Southland's rivers because wastewater generally has low concentrations of metals and synthetic organics. Ammoniacal toxicity is usually limited to a relatively small mixing zone when there is sufficient water available for mixing.

Contaminants relating to toxicity effects (i.e. ammonia, heavy metals and synthetic organics[1]) are a focus of the current policy framework and consents, and were not investigated as part of this project.

Wastewater contains solid and dissolved contaminants that can affect the quality of surface water, groundwater, and coastal waters. Solids in wastewater smother benthic communities (organisms that live at the bottom of a water body) if they settle out in the water body; the concentration of suspended solids is reflective of the level of risk. The solids discharged from a wastewater treatment scheme are mainly organic and, together with dissolved organic matter, deplete oxygen in a receiving water body. This effect is characterised by the biochemical oxygen demand of the wastewater, which reflects both solid and dissolved organic matter. Historically, the need to reduce these contaminants (suspended solids and biochemical dissolved oxygen demand) was the main reason for wastewater treatment.

Nutrients, both nitrogen and phosphorus, are a recognised issue in many of Southland's surface water bodies, groundwater, and coastal waters. These nutrients are present in wastewater in different forms. For nitrogen, these forms include ammoniacal nitrogen, oxidised nitrogen (nitrate and nitrite) and organic nitrogen. For phosphorus, these forms include dissolved, organic and inorganic forms. Each form can be determined separately and both nitrogen and phosphorus change between their various forms in water bodies. Total concentrations of nitrogen and phosphorus in the wastewater reflect the overall risk of nutrient accumulation (build up) in water bodies. Wastewater treatment in the region achieves some degree of nutrient reduction, although only Gore has a specific nutrient reduction process. Increasing attention is being placed on reducing nutrients in wastewater treatment.

Wastewater affects public health when people are exposed to its pathogens. Pathogens are agents that cause disease and include bacteria (e.g. salmonella), viruses (i.e. norovirus), and protozoa (i.e. giardia). Exposure to pathogens occurs when water downstream is used for drinking water supply, irrigation and/or recreational activity within the water body such as swimming, fishing and boating. The risk relates to the degree of treatment of the wastewater before discharge, the extent of dilution in the receiving water where there is exposure, and the extent of exposure.

The relevant guidelines for these activities are based on indicators, typically *E. coli*, in water. After discharge, *E. coli* die off in the environment over time. Exposure to sunlight in oxidation ponds causes some reduction in pathogens and *E. coli*, although the extent is highly variable. Ohai and Bluff have ultraviolet disinfection processes to specifically address pathogens. Reducing *E. coli* to make water safer for human activities (e.g. swimming) and cultural values (e.g. mahinga kai) is central to current water quality discussions nationally.

Summer is generally the time when water bodies are used recreationally, therefore, the treatment process is most critical at this time of year. In summer there are usually higher temperatures and lower flows in receiving water bodies than in winter. When the flow in a receiving water body is low, dilution of contaminants is less, and so any wastewater discharge will often have a greater effect

[1] Synthetic organics are manufactured carbon-based chemicals (organic in this context means carbon-based) as distinct from natural organic chemicals, which form part of biochemical oxygen demand (BOD). Synthetic organics is used as a 'catch-all' term for substances such as pesticides, herbicides, additives.

than when the water bodies flow is high. When temperatures are higher there is more biological activity in receiving waters, potentially increasing the risk of algal blooms or slimes as the discharge of treated wastewater contains organic solids and nutrients. However, higher temperatures can also result in better treatment performance within the wastewater system, particularly of nutrient reduction processes (both mechanical and land based), due to the higher biological activity. This is not always the case but is beneficial when it happens or is designed for. Some wastewater treatment schemes have a specific nutrient limit which applies for the warmer months only or an increased limit for colder periods when flows in the receiving water body are higher.

**Image C1: Gore Wastewater Treatment System**
Source Emma Moran

Solids, nutrients and pathogens are reduced in the wastewater through treatment before discharge. The amount of treatment required depends upon the nature of the water body and its catchment. The scenarios used in this research were designed around different treatment processes for one or more of the five contaminants to achieve specific targets to the quality of wastewater discharge:

- Total suspended solids (TSS) – concentrations and loads measured in grams per cubic metre ($g/m^3$) and tonnes per year;
- Biochemical oxygen demand (BOD) – concentrations and loads are measured in grams per cubic metre ($g/m^3$) and tonnes per year;
- Total nitrogen (TN) – concentrations and loads are measured in grams per cubic metre ($g/m^3$) and tonnes per year;

- Total phosphorus (TP) – concentrations and loads are measured in grams per cubic metre ($g/m^3$) and tonnes per year; and
- *Escherichia coli* (*E. coli*) – an indicator of micro-organisms. Concentrations of *E. coli* are measured in colony forming units per 100mL (cfu/100mL).

*E. coli* concentrations indicate the potential presence of micro-organisms in the water column. After discharge, *E. coli* die off over time; they do not accumulate or change form, as nitrogen and phosphorus can. For *E. coli*, measuring concentrations in the discharge and in the water column following dilution is more relevant than loads (total amounts over a specific time period) discharged to a water body.

## 1.3. Treatment Methods

The policy direction in Environment Southland's proposed Southland Water and Land Plan 2016 states a preference for discharges of contaminants to land over discharges of contaminants to water. The Plan also states that "particular regard" shall be given to any adverse effects on cultural values. The discharge of treated wastewater direct to water is abhorrent to tangata whenua. It is understood that this issue generally is not fully resolved through wastewater treatment before discharge.

Where a wastewater system discharges to land, treated wastewater is applied to the soil, where it percolates through the unsaturated soil (vadose zone). Further treatment occurs in the soil through a variety of mechanisms so that most contaminants have been removed by the time the wastewater reaches the groundwater. During the growing season, plant uptake and other processes mean that wastewater may not reach the groundwater.

If discharge to land is year round, as is normally required for municipal wastewater, then some contaminants will generally reach groundwater, primarily nitrogen and possibly bacteria, particularly from late autumn to early spring when groundwater is high. A key issue for discharges to land are the downgradient uses of groundwater (e.g. water supplies). Many rivers and streams in Southland are recharged by groundwater and contamination in groundwater systems can also be transmitted through to the surface water network.

The treatment performance of land based systems depends on the nature of the soils and how they vary through the soil profile with depth. Underlying soils range from free draining gravels, sand, and loam, to highly impermeable clay. In free draining gravels, wastewater travels quickly through the unsaturated zone and receives minimal treatment in the soil before it reaches the groundwater. The environmental impacts of discharges under such conditions can be addressed through treatment of the wastewater before discharge.

Clay soils will not readily transmit wastewater through the depth profile and wastewater will drain through the soil profile slowly. While this process will result in a high degree of treatment within the soil profile, it requires that the amount of wastewater applied per unit area is low, meaning large areas of land being required. Some soils, especially those with iron pans or other confining layers in their depth profile, may not be able to accept applied wastewater. Typically these sorts of conditions result in run-off to surface water.

In slow draining or poorly drained soils, wastewater that soaks into the soil can build up as a mound either on the groundwater or on a limiting horizon (e.g. lower permeability soil layer or hard pan). There are areas of Southland which have low permeability soils and confining layers for which the application of wastewater is problematic. The degree of moisture in the soil profile also influences the soil's ability to accept and store wastewater. Across the region, soil moisture content is typically high in winter, but low in summer. As soil moisture content increases, the soil's ability to accept wastewater reduces, and the risk of run-off to surface water increases. This process is recognised in Environment Southland's advice to dairy farmers on when the application of dairy effluent to land is acceptable.

The effects of rainfall on soil moisture content, and the risks of surface run-off, differ depending on soil type. For example, in areas with tighter clay soils (e.g. Woodlands), smaller amounts of rainfall increase soil moisture level by the same amount as relatively free draining soils (e.g. Te Anau). Free draining soils can also absorb higher rainfall intensities than tighter clay soils. Applying wastewater to land in some areas of Southland can be challenging, even during summer which is normally expected to be good for land application.

The depth to the groundwater table in Southland varies considerably, both geographically and seasonally. During the winter, the groundwater may rise or perch to just below or at the surface. As a result, the unsaturated zone into which wastewater is accepted is reduced, and application of wastewater is made more difficult. Any wastewater that is applied will receive minimal (if any) treatment in the soil before entering groundwater because of the small depth of unsaturated soil where the treatment occurs.

Difficulties in getting wastewater into the ground increase the risk of wastewater potentially running off the land into surface water. Land that is suitable for wastewater application is typically free draining and relatively flat ground. Such land is usually highly productive agricultural land and comes at a considerable cost. An alternative is to convey treated wastewater to less productive land. Issues may arise with conveyance (e.g. distance, pumping systems, emergency bypass provisions), and the land (e.g. drainage, permeability, topography). The dairy industry's decision not to allow contact between wastewater and lactating cows has restricted the area of land available for wastewater application.

Two land-based scenarios were considered that were designed as land treatment, rather than just land disposal. A rapid infiltration scenario requires free draining soil and achieves a lesser degree of treatment before discharge to groundwater. A slow rate irrigation scenario requires a large land area. It achieves a greater degree of treatment before discharge to groundwater if the land has an adequate unsaturated zone. For these two scenarios, it was assumed that the existing treatment method will not be upgraded and the wastewater applied to land is the same as that currently discharged from the existing system. The treatment performance was estimated on the basis of the expected concentrations at the point of discharge to the groundwater in the underlying aquifer, following treatment through the soil and underlying unsaturated zone.

The performance of both land based scenarios was based on the environmental conditions being appropriate. An assessment was done of the likelihood of such conditions being available within a "reasonable distance" (generally 4 km) of the system. For most towns, it was found that such conditions were unlikely to be present, particularly not year round, and the predicted performance of these scenarios may not, in reality, be able to be achieved.

Treatment upgrades can be included in a land based discharge system to improve the quality of the wastewater before discharge, but this type of scenario was not assessed in this research. Combining the scenarios that have been modelled will indicate the potential costs of such an approach. The treatment performance of this combination will not be a simple combination of the performance of each individual component, and will generally achieve less than the sum of the reductions achieved by each system individually.

For scenarios based on a continued discharge to water, there are a range of different processes available and some of these will achieve similar treated wastewater quality. These treatment processes are designed and combined in a variety of ways to achieve the required result. The required quality of the treated wastewater depends on the conditions in the water body (i.e. lake, river, stream, aquifer or estuary) to which it is discharged, or as required by policy decisions. Increasing the degree of treatment can increase the technical complexity of the treatment solution. It can also increase the residual solids that then have to be managed and disposed of. This technical complexity comes with increased risks of failure and costs to local communities.

A combination of water and land discharges in the same scheme (i.e. a mix and match option) may overcome some of the issues with the individual routes. For example, during summer when river flows are typically low and a discharge to water has greater effects, land treatment may be achievable, given appropriate soils and conditions. During winter or wet periods, when discharge to land is problematic, discharges to water have lesser effects than in summer or dry periods. A mix and match option requires construction and operation of two systems, and is generally expensive. This type of scenario was not specifically considered in this research, but the potential cost is indicated by combining the scenarios that were modelled.

While some treatment scenarios targeted further reductions in a particular contaminant in the wastewater discharge, other scenarios were broader spectrum and aimed at further reductions across a range of contaminants. Not all of these scenarios are additional to the existing treatment process. In some cases, implementing a particular scenario requires the existing treatment process to be partly or completely replaced. Replacement is more likely to be the case with high technology treatments, such as a membrane bioreactor.

## 1.4. Scenario Development

Engineering and environmental consultants, Stantec (formerly MWH) developed treatment scenarios for each case study town in consultation with the relevant territorial authority. All of the towns included in the research currently discharge direct to water. The scenarios considered discharges to surface water (with improved treatment) and discharges to land (that included treatment).

The performance of the existing systems was assessed and then scenarios modelled for each town. Six case studies were completed in full and two case studies, Bluff and Ohai, were limited to their existing performance because of their specific circumstances (discussed below). Scenarios achieving similar levels of treatment were modelled for the six towns. In addition, two scenarios achieving more intensive treatment were modelled for Gore, Invercargill and Winton, and a scenario achieving extremely intensive treatment was modelled for Gore only. The relative cost implications of these more intensive scenarios are a guide for other towns in the region.

For each town and scenario, a treatment objective was defined for the relevant contaminant, such as nutrient reduction or pathogen reduction, and a numerical treated wastewater standard was defined for that objective, as a target concentration for each of the parameters considered. A treatment process, or combination of processes, was then developed to achieve the objective and meet the standard. The treatment process selected was that considered to be the most appropriate and "likely" combination of treatment processes that can be used to achieve the objective given the nature of the existing scheme.

Discharge monitoring for the Ohai wastewater scheme indicated that it was already achieving the quality of discharge which was the target of the scenarios modelled for the other towns. A minor upgrade is planned at Ohai to extend the ultraviolet system which will further reduce the pathogens and maintain current levels of performance. The Nightcaps scenarios are relevant for similar sized towns although they depend on the type of treatment system already in existence (i.e. single oxidation pond). Stantec and the territorial authorities (SDC, ICC, and GDC) considered that scenarios being modelled for other towns were not as relevant for Ohai.

The Bluff wastewater scheme discharges to coastal waters outside of any estuary, and monitoring of the discharge has indicated minimal environmental effects. If the Bluff wastewater discharge cannot be consented in its current form (e.g. an upgrade was required) then it is more likely that Bluff wastewater would be piped to Invercargill's treatment system at Clifton. The cost of a pipeline was estimated to be $3 million (M. Loan, pers. comm., 2018). This option transfers the Bluff discharge and its contaminant load from the coastal area to the New River Estuary. It is more site specific than the treatment scenarios included for the other towns. The feasibility and cost depends on the length and nature of the pipeline and the treatment plants involved. Any scenarios for Bluff had low relevance for other towns.

The nature of the existing treatment process influences the types of treatment processes suitable for each scheme. The treatment processes used at each of the eight case studies varied considerably, from highly mechanised systems to oxidation ponds (described in detail at the start of each case study). Table C2 summarises the treatment processes as wastewater flows through the system. Rather than applying generic scenarios across the case studies, each case study was individually assessed with appropriate designs developed and costed for each scenario and town. The individual nature of the case studies is an important consideration when applying the results to other towns in Southland.

The research includes estimates of contaminant loads from wastewater treatment systems that were calculated as the average concentrations over four years multiplied by the annual flows. This is a 'broad brush' calculation method and it is likely to be different to that used by Environment Southland for the freshwater accounting of contaminants under the National Policy Statement for Freshwater Management. The value of this research is the comparison between the results for a treatment system's existing performance (the base) and its upgrade scenarios.

**Table C2: Existing Treatment Processes at Case Study Towns**

| Town | Existing Treatment Processes | |
|---|---|---|
| | **Liquid** | **Solid**[2] |
| Gore | 3 mm inlet screen<br>Primary pond<br>Secondary pond<br>Actiflo (operational during low river flows) | Storage in pond |
| Matāura | Oxidation pond<br>Wetland | Storage in pond |
| Nightcaps | Oxidation pond<br>Rock filter beds | Storage in pond |
| Ohai | Inlet screen<br>Two Imhoff tanks<br>Two stone media filters<br>Two rectangular humus tanks<br>Ultraviolet disinfection | Digested in Imhoff tanks<br>Drying Beds<br>Disposed of to forestry block |
| Te Anau | Inlet bar screen<br>Primary oxidation pond (with aerators)<br>Secondary oxidation ponds<br>Wetland | Storage in ponds |
| Winton | 3 mm inlet screen<br>Oxidation pond<br>Wetland | Storage in pond |
| Invercargill | Inlet screen<br>Pre-aeration<br>Sedimentation tanks<br>Trickling filter<br>Secondary clarifier<br>Facultative ponds<br>Wetland | Digester<br>Sludge lagoons |
| Bluff | 6 mm inlet screen<br>Aerated lagoon<br>Clarifier<br>Ultraviolet disinfection | Sludge Tanks |

Overall, eight scenarios were modelled across the six case study towns: Gore, Matāura, Winton, Nightcaps, Te Anau, and Invercargill. The eight scenarios ranged in complexity and not every treatment process was modelled for each case study. Any of these processes can also potentially be applied to Bluff or Ohai (the two case study towns not given scenarios) – it is a matter of scale. Most of the case studies include two 'discharge to land' scenarios (rather than a direct route to surface water): rapid infiltration and slow rate irrigation. Although these scenarios are to land,

[2] Solids stored in oxidation ponds are removed periodically. The frequency of removal is highly variable and depends on the specifics of the scheme and its management.

contaminants will still have pathways to water. Whether discharge to land (land treatment) is possible will depend on a range of factors, such as suitable soil types and the amount of affordable land available. Table C3 identifies the distribution of the scenarios modelled for each town (with discharge to water scenarios highlighted in blue and discharge to land scenarios highlighted in green).

**Table C3: Distribution of Scenarios Modelled**

| Discharge Route | Treatment objective | Gore | Matāura | Winton | Nightcaps | Ohai | Te Anau | Invercargill | Bluff |
|---|---|---|---|---|---|---|---|---|---|
| Discharge to Water Scenarios | Nutrient reduction | X | X[3] | X | X | | X | X | |
| | Pathogen reduction | X | X | X | X | | | X | |
| | Phosphorus reduction | X | | X | X | | | X | |
| | Nutrients and solids reduction | X | | X | | | | X | |
| | Enhanced treatment | X | | X | | | | X | |
| | Tertiary treatment | X | | | | | | | |
| Discharge to Land Scenarios | Rapid infiltration | X | X | X | X | | | X | |
| | Slow infiltration | X | X | X | X | | X | X | |
| **Total number of scenarios** | | **8** | **4** | **7** | **5** | **0** | **2** | **7** | **0** |

[3] Mataura's existing treatment system already achieves nutrient reduction similar to that achieved by this scenario for the other towns. This scenario for Mataura focused on solids reduction with some nutrient reduction.

Table C4 gives the concentrations of contaminant in the wastewater discharges for the different scenarios. It summarises the quality of the raw wastewater[4], the quality of discharges from the existing treatment systems[5], and the expected quality from the various scenarios[6]. The quality of the discharges for each scenario is shown graphically in the following sections. The specific treatment processes are noted within the case studies and described in more detail in Appendix 2.

**Table C4: Discharge Concentrations**

| Discharge Route | Treatment objective | Suspended Solids (g/m$^3$) | Biochemical Oxygen Demand (g/m$^3$) | Nitrogen (g/m$^3$) | Phosphorus (g/m$^3$) | *E. coli* (cfu/100mL) |
|---|---|---|---|---|---|---|
| Raw wastewater | | 250 | 250 | 50 | 7.0 | 10,000,000 |
| Existing treatment systems | | 10 – 54 | 7 - 21 | 4 - 32 | 1.2 – 6.7 | 90 – 8,600 |
| Discharge to Water Scenarios | Nutrient reduction | 10 – 54 | 7 - 21 | 10 | 1.0 – 6.7 | 880 – 5,000 |
| | Pathogen reduction | 19 – 35 | 7 - 15 | 10 - 29 | 1.2 – 4.6 | 130 |
| | Phosphorus reduction | 10 – 30 | 7 - 13 | 9 - 29 | 1.0 – 2.0 | 1,300 – 5,000 |
| | Nutrients and solids reduction | 15 | 8 - 10 | 9 | 1.0 – 4.6 | 1,320 – 3,800 |
| | Enhanced treatment | 5 | 5 | 5 | 0.5 – 1.0 | 10 |
| | Tertiary treatment | 1 | 1 | 5 | 0.5 | 130 |
| Discharge to Land Scenarios | Rapid infiltration | 1 – 2 | 1 - 2 | 4 - 12 | 1.0 – 2.0 | 250 – 8,600 |
| | Slow rate irrigation | 1 – 2 | 1 | 2 - 9 | 1.0 – 2.9 | 1 – 75 |

[4] The quality of the raw (untreated) wastewater was assumed to be the typical quality in New Zealand based on Stantec's experience. The assumed value is consistent with the advice provided in MfE (2003) "Sustainable Wastewater Management" and USEPA (1992) "Manual for Wastewater Treatment/Disposal for Small Communities". Monitoring results were available for Invercargill, Bluff and Gore schemes and were generally consistent with each other and with the assumed concentrations. Concentrations in raw wastewater for residential on-site systems are higher, reflecting the absence of dilution factors in these smaller systems.

[5] Market Economics derived the quality of wastewater discharges from the existing treatment systems on the basis of the available monitoring records for each scheme.

[6] Stantec estimated the expected typical treated wastewater concentrations for each scenario and town. Where an expected concentration was greater than the existing average concentration, the existing average concentration was used, and the scenario achieved no improvement in quality for that contaminant. This method under-represents the effectiveness of a particular scenario for some parameters, but was appropriate for dealing with the inherent variability of the data sets.

## 1.5. Economic Modelling

Stantec estimated the additional capital and operating costs of the treatment processes for each scenario. Market Economics used Stantec's scenarios to build an understanding of the relationship between the estimated effectiveness (improvements in the quality of treated wastewater) and costs. The scenarios were modelled in Excel and their capability was compared to that of the existing treatment process and an economic analysis was completed for each town.

Environment Southland took the results of this modelling and analysis and converted them into the tables and graphs included in the following sections of this report. The results are reported on a 30 year forecast 'per household' basis to take account of the different sizes of the towns – this measure should not be interpreted as a cost to ratepayers. The number of households was calculated using Statistic New Zealand five yearly projections over the 30 year time period from 2016 to 2046. The results for the scenarios were then compared to the costs and effectiveness of the existing (or base) wastewater treatment system.

Annual total cost is used to reflect potential cost to council of the various options being considered. Annual total cost is the cost to be met and does not consider potential sources of the funding (i.e. rates, loans, or central government).

The baseline costs (i.e. the costs of the existing treatment system) are the current costs of providing the wastewater service for a town. In Southland, rates for wastewater are based on the scheme as a whole, with the reticulation and the treatment system being interdependent. The baseline costs are calculated as the annual depreciated value of the whole scheme (reticulation and wastewater treatment). This annual depreciated value is based on 2016 valuations, rather than replacement value.

The costs of the scenarios were based on their annual depreciated value. Cost was calculated as the straight line depreciation of the capital cost over an average asset life of 25 years. 25 years was considered to be an appropriate approximation of the life of wastewater assets. These assets include mechanical and electrical plants with a 15 year life, pumps with a 25 year life and civil structures with a 50 year life.

The calculation of the annual total cost for the existing system used the following method:

> Annual cost for each year = (2016 annual depreciated value adjusted by annual capex adjustment (compounding)) + (2016 operating costs adjusted by annual opex adjustments (compounding))
>
> 30 year total cost = sum of each year's annual cost
>
> Annual total cost = 30 year total cost / 30 years

The annual capital and operating adjustments are from Business and Economic Research Limited (BERL) indices. Each year BERL produce forecasts of movements in key local government input costs and an overall cost index. The capital expenditure (capex) adjustment reflects that valuations increase year on year not solely because of inflation and value of money. The operating expenditure (opex) adjustment reflects that the cost of operation and maintenance increases as assets age.

## 1.6. Assumptions

This research focused on the liquid waste stream. All wastewater treatment systems also have a gaseous and solid stream, and waste shifts between these streams. Evaporation of wastewater in oxidation ponds can be an important discharge pathway, particularly for smaller treatment systems. Converting organic matter to carbon dioxide, and organic nitrogen to nitrogen gas, also changes liquid and solid components to gases. A primary way of treating wastewater is to remove contaminants from the liquid stream to the solids stream (e.g. sludges), which also needs to be managed, treated and discharged to land. Treatment processes produce different volumes and types of solid material. The solid and gaseous waste streams were not included in this research because of the additional complexity.

The modelling scenarios are pre-feasibility options and intended to give an indication only of likely effectiveness and financial costs of upgrading the existing wastewater treatment systems. Not all of the scenarios are additional to the current treatment process – in some cases, implementing a particular scenario will mean the current process is replaced, for example, if a scenario involves construction of a bioreactor to replace an oxidation pond.

Discharge to land is modelled as a treatment and disposal option. The estimated contaminant concentrations after treatment are for where the wastewater mixes with the aquifer in the zone of saturation, not at the point where wastewater is applied to land. Feasibility studies will be needed to determine whether land scenarios are technically possible in terms of the specific characteristics of available land. Any scenarios involving discharge to land are based on the assumption that suitable land is available, and that conditions are suitable for application all year round.

The discharge to land scenarios included the cost of land at a rate of $40,000 per hectare. While this rate is a typical cost for suitable land, it can be inflated when seeking such land close to towns and in smaller parcels, as is generally the case for land discharge schemes. Recent examples of the areas required for discharge to land schemes are the proposed Riversdale rapid infiltration scheme, which requires approximately one hectare for the discharge area. The proposed slow rate irrigation system at the Kepler Block for the Te Anau scheme required the purchase of an area of about 120 hectares, which will serve four times as much average flow as the Riversdale scheme. This comparison highlights that slow rate irrigation requires far more land than rapid infiltration.

For discharges to land, processes within the soil profile (chemical transformation, microbial degradation, adsorption by soil particles, nutrient uptake by plants and filtration through soil pores) can all contribute to the wastewater treatment. Depending on soil conditions, all of these processes except plant uptake can occur in rapid infiltration. If there is an insufficient unsaturated zone or the soil is too free draining, then an improved form of treatment up front may be needed, especially if the existing system is based around an oxidation pond. Slow rate irrigation is an effective form of treatment, especially for nutrient removal, which uses all of the processes described. The performance of this option is highly dependent on environmental conditions.

# 2. Gore – Maruawai

## 2.1. Gore Wastewater Scheme

Gore is a well-established rural service town in Southland. The primary focus of its businesses and industries is to service the local agricultural sector – and this sector has always been important to the prosperity of the town and Gore District. A town of this size needs a well performing wastewater scheme in place to provide the key service of wastewater disposal. Wastewater services support residents' health and wellbeing, and allow businesses to operate effectively, making it possible for the community to thrive.

Gore is a popular location for young families because of the range of community facilities available and affordable housing but average age is increasing over time. More households will be on fixed incomes such as superannuation. Rates affordability is a key concern for the community and likely to continue to grow as more infrastructure replacements and improvements are required in the future. Level of service provided to the community by infrastructure services may need to be reviewed if affordability is too challenging.

Gore has a combined stormwater/wastewater scheme in approximately 40 percent of the network in the urban area. There also appears to be interconnectivity between the separate stormwater and wastewater schemes. The stormwater scheme is impacted by rainfall events, particularly when terrace streams rise and increase flow through the network. A large amount of this stormwater also gravitates through the combined network and is treated via the wastewater ponds before discharge.

In 2016 the Gore network had 3,793 connections, some using wastewater reticulation only (60%) and others using the combined wastewater/stormwater (40%) reticulation network. Approximately 10 percent of the number of connections to the scheme are commercial or trade properties. The combined wastewater and stormwater network adds complexity to monitoring and treatment. Some wastewater pump stations may use the stormwater network to discharge overflow when the pump station becomes overwhelmed during rainfall events.

The two main contributors of trade waste are Blue Sky Meats Ltd. and Silver Fern Farms Ltd. – Waitane Processing Plant. Trade waste users hold their own consents with the Council to discharge to the network and are closely monitored. Gore's economic development strategy is likely to increase the flow of trade waste over time. The trade waste flows received by Gore will increase with the commissioning of the Matāura Valley Milk processing plant at McNab in 2018.

Gore's wastewater treatment system is located south of the town on Grasslands Road (off Salford Street). The incoming wastewater is initially screened to remove solids then treated into a ten hectare primary oxidation pond that is mechanically aerated. The wastewater then passes into a secondary oxidation pond of the same size for polishing. Depending on river flow conditions, the wastewater may then pass through a mechanical treatment Actiflo Plant to further remove phosphorus before discharge. The site has two discharge points to the Matāura River, and either discharge point can be in operation depending on river conditions.

**Image C2: Looking north across the Gore primary oxidation pond**

The screening plus oxidation pond system is designed to remove organic loading (biochemical oxygen demand) and solids, although it also reduces micro-organisms and nutrients. The screening removes coarse solids, which reduces organic and nutrient loads. The primary oxidation pond also reduces the organic load as bacteria consume organic matter and deposit waste as sludge to the base of the pond. Both ponds reduce micro-organisms, particularly pathogens, through exposure to sunlight, predation by organisms in the pond, and being captured in the sludge.

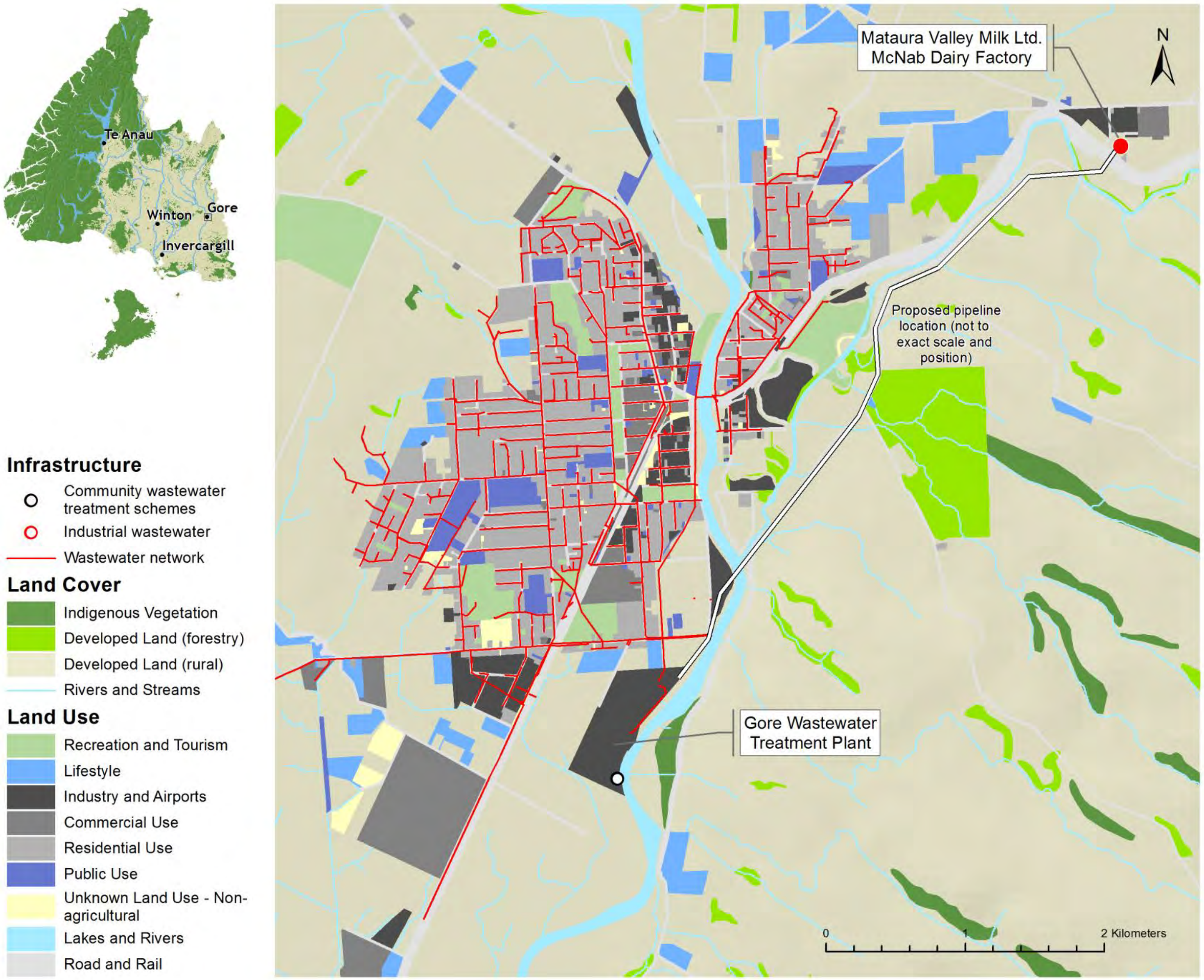
Aeration within the primary pond gives algae the levels of oxygen needed for algal colonies to thrive. Aeration occurs through natural processes, including algal photosynthesis and wave action, and is supplemented by mechanical aeration. Algal growth in the treatment ponds takes up nutrients in the wastewater but the algae cells also become suspended solids in the wastewater (compared to untreated wastewater the suspended solids are reduced). Some contaminants change their form as the wastewater passes through the treatment system. For example, ammoniacal nitrogen (toxic to fish in elevated concentrations) becomes nitrate nitrogen.

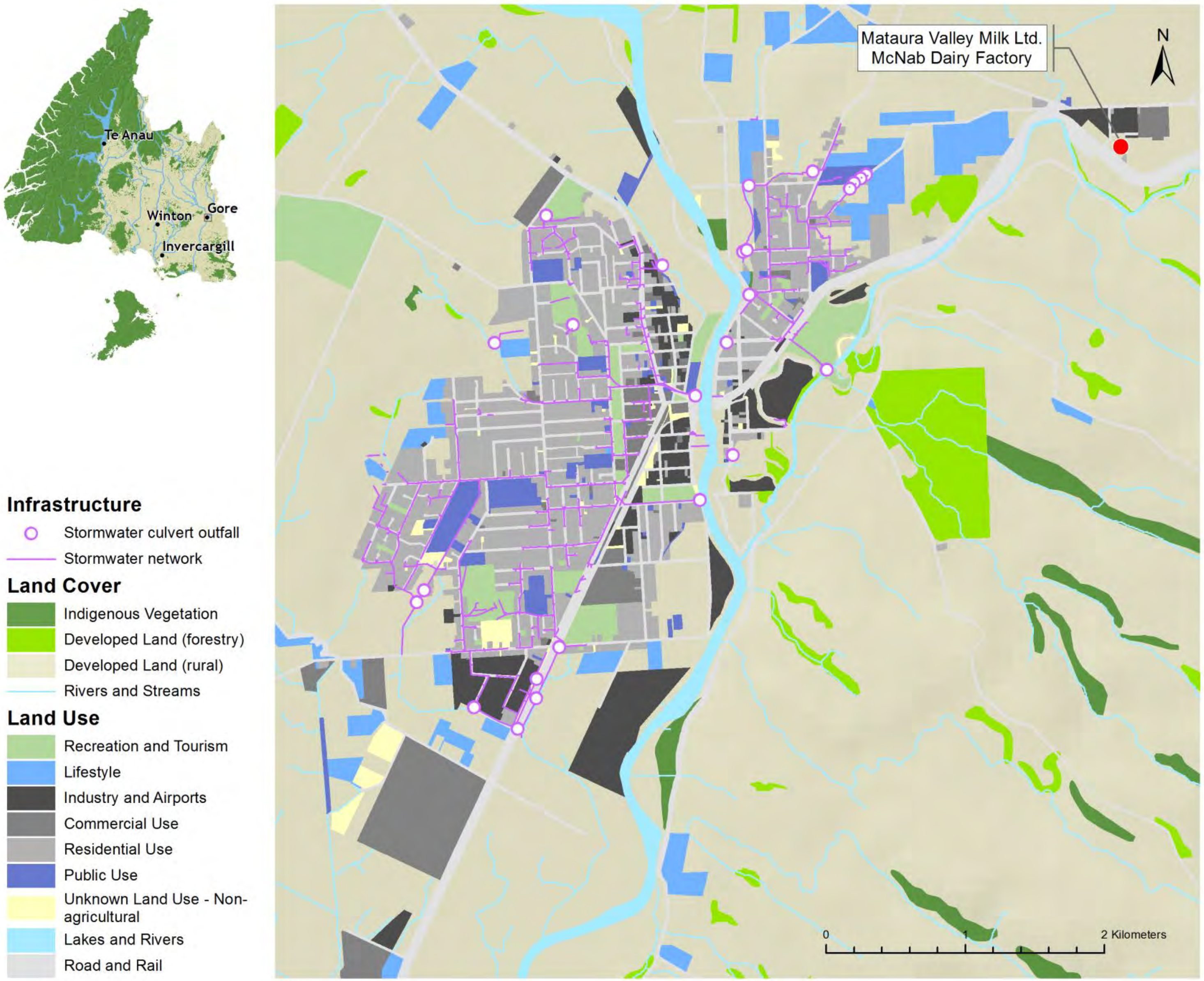
To improve the system, Gore District Council invested $2 million of capital expenditure in an Actiflo plant, which is a chemical treatment process to reduce phosphorous and suspended solids in the treated wastewater. Installation of the Actiflo plant was completed in 2008 and it is operated when the Matāura River is under 60 $m^3/s$. At these times the wastewater passes through the Actiflo plant before being discharged by gravity into the Matāura River. During higher river flow conditions, the treated wastewater is discharged from the secondary pond directly to the river. Further upgrades and installation of new pumps were completed between 2010 and 2011. The removal of sludge from the oxidation pond, accumulated over the past 40 years, is underway and is expected to improve the treatment capacity of the oxidation pond. The estimated cost of around $2.6 million was funded through reserves and a loan, which will be repaid over time using urban rates.

**Image C3: Gore Actiflo plant**

The current resource consent for the wastewater discharge was granted in August 2006 and will expire in December 2023. The existing resource consent was granted after a thorough process, which included a working party of affected parties exploring treatment options to achieve environmental expectations at the time. The Actiflo plant was selected as the preferred option by the working party, and then Council, because of its small footprint, ability to modify treatment quality and capabilities in reducing total phosphorus discharged to the Matāura River. The resource consent consists of a stepped quality expectation that follows average seasonal Matāura River flow conditions. As the river flow reduces beyond certain set points, the wastewater discharge quality must improve dramatically. The Actiflo plant is required to operate when the River is below 60 cumecs to ensure that discharge quality expectations are achieved.

The following two maps show the Gore wastewater and stormwater schemes.


Te Anau
Winton
Gore
Invercargill
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
Mataura Valley Milk Ltd.
McNab Dairy Factory
N
Proposed pipeline location (not to exact scale and position)
Gore Wastewater Treatment Plant
0
1
2 Kilometers


Te Anau
Winton
Gore
Invercargill
Mataura Valley Milk Ltd.
McNab Dairy Factory
N
0
1
2 Kilometers
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail

## 2.2. Baseline Results

This section describes the baseline results for Gore (i.e. what is actually occurring). The total annual inflow of wastewater into the Gore treatment system is estimated at around 2,198,600 $m^3$, with the daily flow ranging between 5,800 $m^3$ and 6,200 $m^3$. Table C5 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C6 gives information on the average quality of the treated wastewater discharged to the Matāura River.

Gore's existing wastewater characteristics are particularly complex because of trade waste and stormwater. A relatively high volume of trade waste is accepted into the wastewater system from meat processing factories, and other industrial and commercial properties. Major trade waste customers are seasonal, which causes wastewater composition to vary greatly throughout the year. As well as high volumes of trade waste, around 40 percent of the reticulated wastewater network is combined with stormwater. In these parts of the town, wastewater and stormwater use the same pipes, and a large volume of stormwater is received at the wastewater treatment system.

**Table C5: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| **Contaminant** | **Total SS** | **BOD** | **Total N** | **Total P** | ***E. coli*** |
|---|---|---|---|---|---|
| **2013 to 2016** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(cfu/100ml)** |
| Average (4 years) | 472.8 | 521.6 | 84.0 | 12.8 | ~9,995,000 |

**Table C6: Annual contaminant concentrations and loads in wastewater discharge**

| **Contaminant** | **Total SS** | **BOD** | **Total N** | **Total P** | ***E. coli*** |
|---|---|---|---|---|---|
| **Concentrations** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **(cfu/100ml)** |
| Average (5 years) | 35.1 | 12.9 | 11.8* | 1.2 | 4,580 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (4 years) | 40.7 to 92.0 | 14.4 to 38.4 | 25.9** | 1.2 to 4.0 | N.A. |
| Estimated loads | 77.2 | 28.4 | 25.9** | 2.6 | N.A. |

Source: Environment Southland consent monitoring data
* Based on two data points only
** Estimated

The total replacement value of all the assets in the wastewater scheme is $33.1 million (2016 GDC Asset Valuation) (around $8,000 per household). The largest contributor is the gravity mains in the pipe network, which accounts for roughly 68 percent of the replacement value. The treatment system (including the Actiflo plant) is valued at $5.7 million. The rest of the scheme's value is made up of assets such as manholes and pump stations.

The annual depreciated value of the wastewater scheme is $504,000 and the annual operating cost is $1,230,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C7 using the methodology described in Section C1.5.

Figure C2 shows the relative performances of the existing system (with and without Actiflo) for each of the five contaminants considered (red and purple) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[7] before being plotted to make it possible to include all five different contaminants on the same graph.

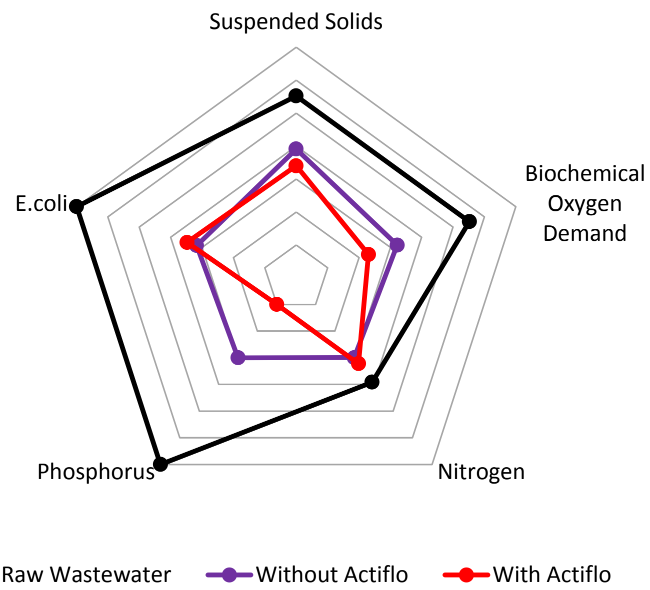



**Figure C2: Gore baseline scenarios (existing system)**

## 2.3. Modelling Scenarios

Eight scenarios were developed for the Gore wastewater system (the scenarios and treatment processes as listed below with more details are in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Further work is needed to determine whether any scenario is technically feasible. Table C7 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 4,035 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

| Scenario | Treatment Process (new units in bold) |
| --- | --- |
| Existing System | Liquid: 3 mm screen, primary pond, secondary pond, Actiflo (operational during low river flows)<br>Solid: storage in pond |
| 1. Pathogen reduction | Liquid: 3 mm screen, Primary Pond, Secondary Pond, Actiflo (operational during low river flows), **UV Disinfection**<br>Solid: storage in pond |

[7] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

| Scenario | Treatment Process (new units in bold) |
|---|---|
| 2. Phosphorus reduction | Liquid: 3 mm screen, primary pond, secondary pond, Actiflo **(operating 365 days/year)**<br>Solid: storage in pond |
| 3. Rapid infiltration | Existing process **+ high rate infiltration (rapid infiltration basins etc.)** |
| 4. Nutrient reduction | Liquid: 3 mm screen, primary pond, secondary pond, **trickling filter, moving bed biofilm reactor, Actiflo (operating 365 days/year)**<br>Solid: as existing |
| 5. Nutrient and solids reduction | Liquid: 3 mm screen, primary pond, secondary pond, **trickling filter, moving bed biofilm reactor, Actiflo (operating 365 days/year), cloth/disc filter**<br>Solid: as existing |
| 6. Slow infiltration | Existing process **+ slow rate infiltration (spray irrigation etc.)** |
| 7. Enhanced treatment | Liquid: 3 mm screen, **fine screen, membrane bioreactor (MBR)**<br>Solid: as existing |
| 8. Tertiary treatment | Liquid: 3 mm screen, primary pond, secondary pond, **trickling filter, ultrafiltration (UF), reverse osmosis (RO)**<br>Solid: as existing<br>**RO Reject Stream Treatment: moving bed biofilm reactor, wetland, UV** |

**Table C7: Gore Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| **Existing scheme** | $72,483,000 | $599 |
| **1. Pathogen reduction** | $76,252,000 | +$31 |
| **2. Phosphorus reduction** | $76,649,000 | +$34 |
| **3. Rapid infiltration (includes partial cost of land purchase)** | $90,883,000 | +$152 |
| **4. Nutrient reduction** | $99,551,000 | +$224 |
| **5. Nutrient and solids reduction** | $105,740,000 | +$275 |
| **6. Slow infiltration (includes partial cost of land purchase)** | $118,617,000 | +$381 |
| **7. Enhanced treatment** | $137,848,000 | +$540 |
| **8. Tertiary treatment** | $228,309,000 | +$1,287 |

Figures C3, C4 and C5 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C2 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater.

Except for phosphorus, the concentrations of the contaminants were transformed[8] before being plotted to make it possible to include all five different contaminants on the same graph.

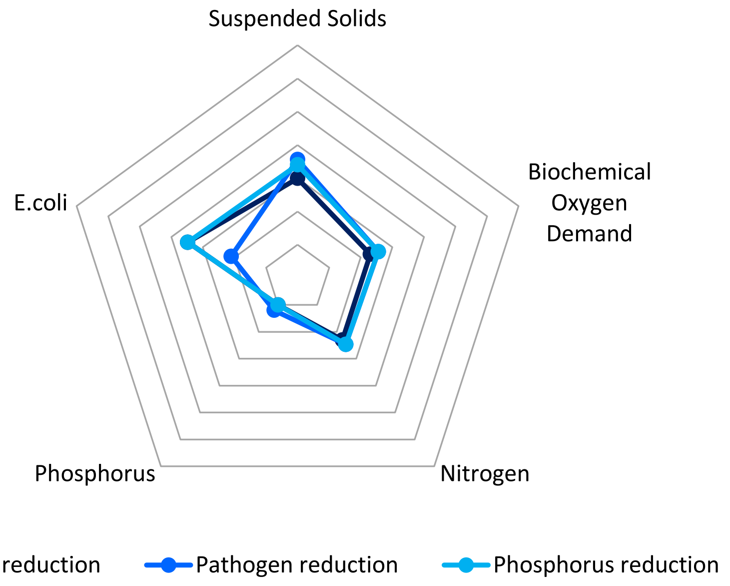



**Figure C3: Gore 'discharge to water' scenarios**

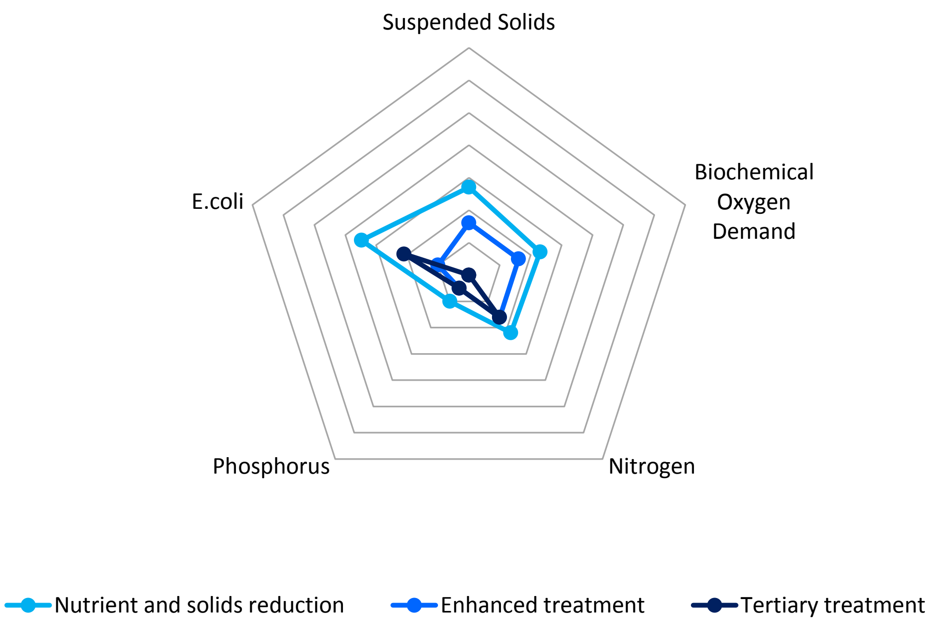



**Figure C4: Gore 'discharge to water' scenarios (continued)**

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[8] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

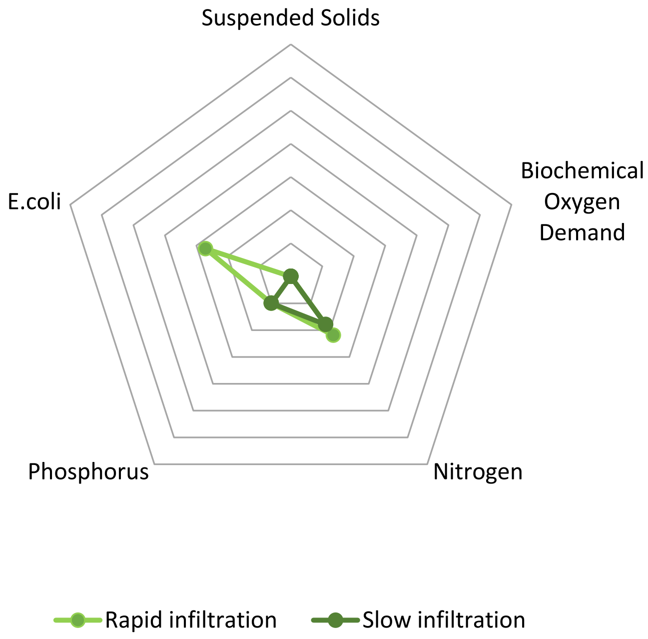



**Figure C5: Gore 'discharge to land' scenarios**

## 2.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*Two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot*** *for the existing level of treatment (i.e. the base);*
- ***blue dots*** *for modelling scenarios representing discharges to water; and*
- ***green dots*** *for modelling scenarios representing discharges to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have* ***a clear black dot****, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 2.4.1. Total Suspended Solids

The existing system (the base) removes a substantial proportion of total suspended solids from the inflow of raw wastewater through its different treatment processes. The screen removes large solids, the ponds add some removal via bacteria and settlement, and the Actiflo plant adds further removal through clarification. Overall, the existing treatment system removes 91.2 percent of the total suspended solids in the wastewater inflow. The Gore system receives a base inflow load of 550.00 tonnes of solids annually, of which 472.78 tonnes are removed through treatment, and 77.22 tonnes are discharged to surface water.

Of the eight scenarios modelled for Gore, Scenario 3: *Rapid infiltration*, Scenario 6: *Slow infiltration* and Scenario 8: *Tertiary treatments* are likely to be the most effective at removing total suspended solids. These three scenarios use additional filtration (mechanical filtration for Scenario 8 and filtration through the underlying soil for the land discharge scenarios 3 and 6) to remove suspended solids over and above the existing system. Scenario 7: *Enhanced treatment* is also relatively effective for this contaminant. The least effective scenario appears to be Scenario 1: *Ultraviolet disinfection,* which is technology designed for treating *E. coli* (pathogens). Table C8 summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). The table also gives the resulting discharge for the base and all scenarios.

**Table C8: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 117 | 86.0% | N.A. | 19 | 14.0% |
| 1. Pathogens | 117 | 86.0% | 0.0% | 19 | 14.0% |
| 2. Phosphorus | 120 | 88.0% | 2.4% | 16 | 12.0% |
| 3. Rapid infiltration | 136 | 99.6% | 15.9% | 1 | 0.4% |
| 4. Nutrients | 125 | 92.0% | 7.0% | 11 | 8.0% |
| 5. Nutrients & solids | 128 | 94.0% | 9.4% | 8 | 6.0% |
| 6. Slow infiltration | 136 | 99.6% | 15.9% | 1 | 0.4% |
| 7. Enhanced | 134 | 98.0% | 14.0% | 3 | 2.0% |
| 8. Tertiary treatment | 136 | 99.6% | 15.9% | 1 | 0.4% |

The four most effective scenarios (Scenarios 3, 6, 7 and 8) have an additional annual cost for wastewater treatment of between $152 and $1,287 per household. Of these scenarios, Scenario 3: *Rapid infiltration* is likely to deliver improvements at the lowest additional cost. Scenario 1: *Ultraviolet Disinfection* will not improve removal of total suspended solids yet its capital cost will increase costs to the households. Scenarios 3 and 6 (the two land-based technologies) are likely to deliver similar improvements for total suspended solids to Scenarios 7 and 8, but have a marked difference in cost and may not be feasible for some of the time around Gore. It is unknown how these costs will change once the full cost of land is included, as land purchases vary considerably.

Figure C6 shows the relationship between the treatment system's improvement in removing total suspended solids and the possible increase in annual cost per household.

Improvement in a wastewater treatment system's performance reduces the concentration of contaminants in its discharge. Figure C7 shows the relationship between the annual discharge of total suspended solids and the annual cost on a per household basis. The results suggest that achieving similar volumes of total suspended solids discharged can have a wide range in costs per household. The better performing scenarios potentially reduce the level of total suspended solids in the wastewater discharge to almost zero, but at a wide range in annual costs per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

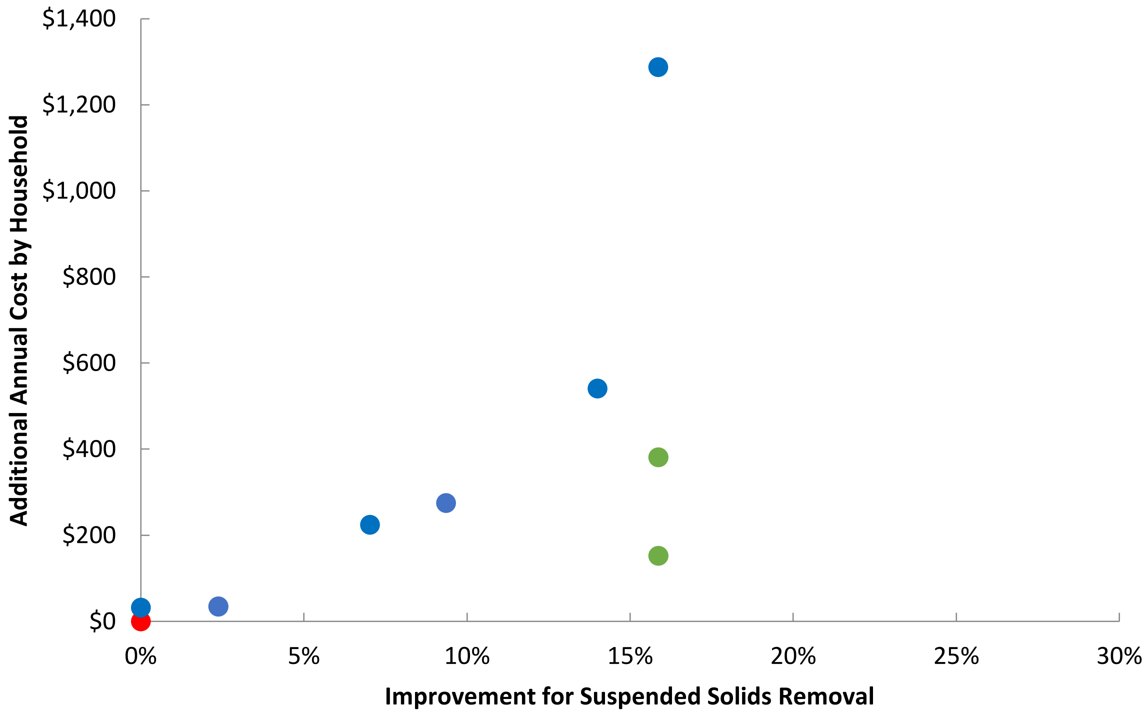



**Figure C6: Gore improvement in treatment for suspended solids**

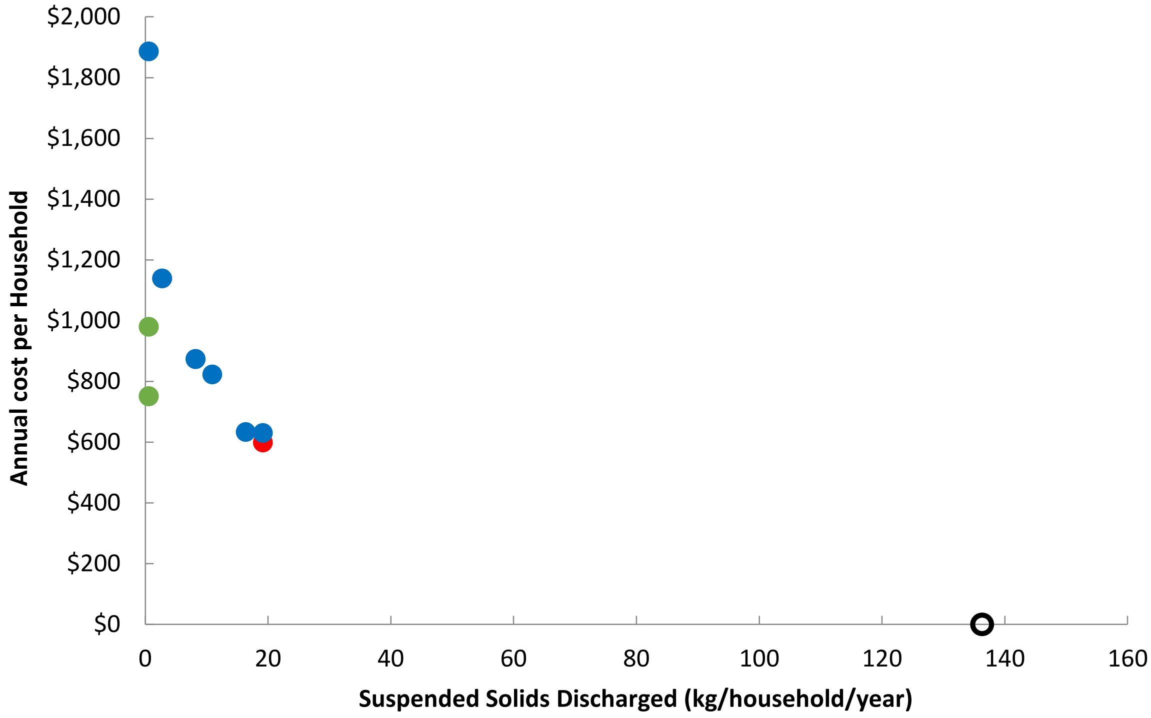



**Figure C7: Gore discharge of suspended solids**

### 2.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing treatment system via the primary and secondary ponds. The existing treatment system reduces 96.3 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Gore system receives a base inflow load of 550.00 tonnes annually, of which 521.62 tonnes are reduced through treatment, and 28.38 tonnes are discharged to surface water.

Of the eight scenarios modelled, Scenario 3: *Rapid infiltration*, Scenario 6: *Slow infiltration* and Scenario 8: Tertiary treatment are likely to be the most effective for further reducing biochemical oxygen demand. They were also the better performing scenarios for suspended solids. Two scenarios, Scenario 1: *Ultraviolet disinfection* and Scenario 2: *Phosphorus reduction*, are less effective for this contaminant because their treatment capabilities are not designed to reduce biochemical oxygen demand. Table C9 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both the wastewater inflow and the base reduction (existing system). It also gives the resulting discharge for the base and all scenarios.

Overall, the different scenarios are likely to make relatively small improvements because the existing treatment system performs particularly well for this contaminant.

**Table C9: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 129 | 94.8% | N.A. | 7 | 5.2% |
| 1. Pathogens | 129 | 94.8% | 0.0% | 7 | 5.2% |
| 2. Phosphorus | 129 | 94.8% | 0.0% | 7 | 5.2% |
| 3. Rapid infiltration | 136 | 99.6% | 5.0% | 1 | 0.4% |
| 4. Nutrients | 131 | 96.0% | 1.2% | 5 | 4.0% |
| 5. Nutrients & solids | 131 | 96.0% | 1.2% | 5 | 4.0% |
| 6. Slow infiltration | 136 | 99.6% | 5.0% | 1 | 0.4% |
| 7. Enhanced | 134 | 98.0% | 3.3% | 3 | 2.0% |
| 8. Tertiary treatment | 136 | 99.6% | 5.0% | 1 | 0.4% |

The four most effective scenarios (Scenarios 3, 6, 7 and 8) have an additional annual cost for wastewater treatment of between $152 and $1,287 per household. Of these four, the two land scenarios (Scenario 3 and 6) are the lowest additional cost but it is not known how these costs will change once the full cost of land is included, as land purchases vary considerably. Figure C8 shows the relationship between the treatment system's improvement for biochemical oxygen demand and the possible increase in annual cost per household. Figure C9 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household. The relatively small improvements that can be made in treatment and discharge for this contaminant are likely to increase the annual cost per household.

The key and explanation for these graphs is included at the start of the modelling results section.

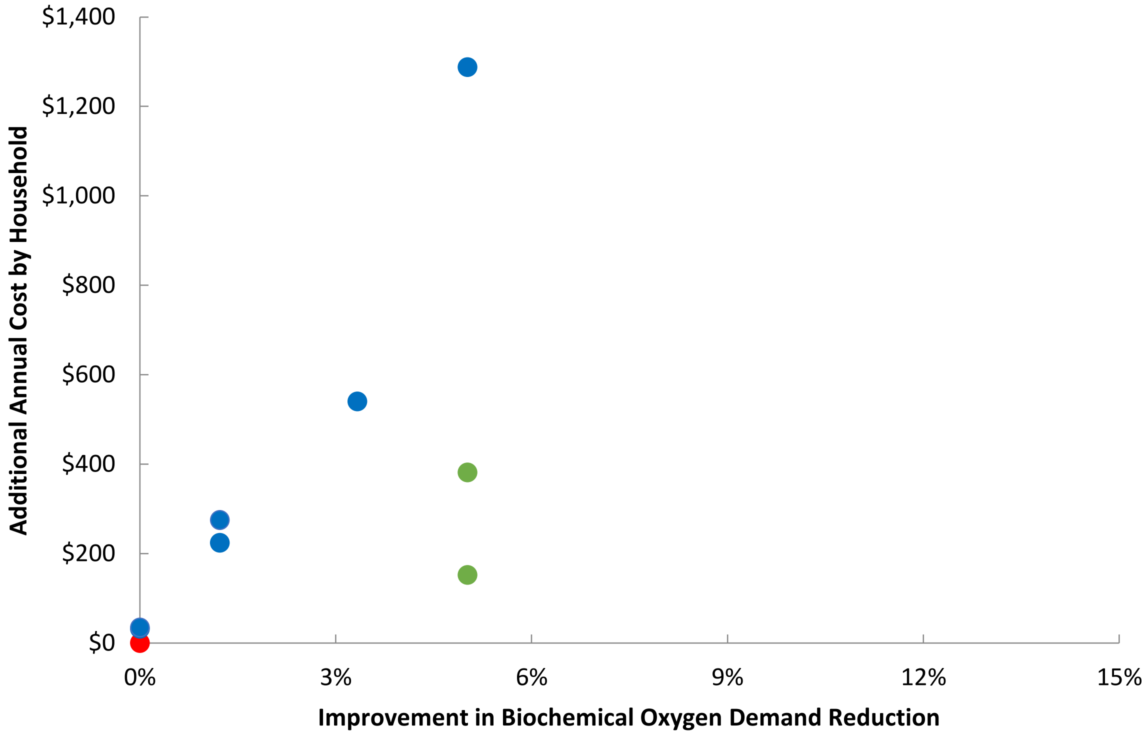



**Figure C8: Gore improvement in treatment for biochemical oxygen demand (BOD)**

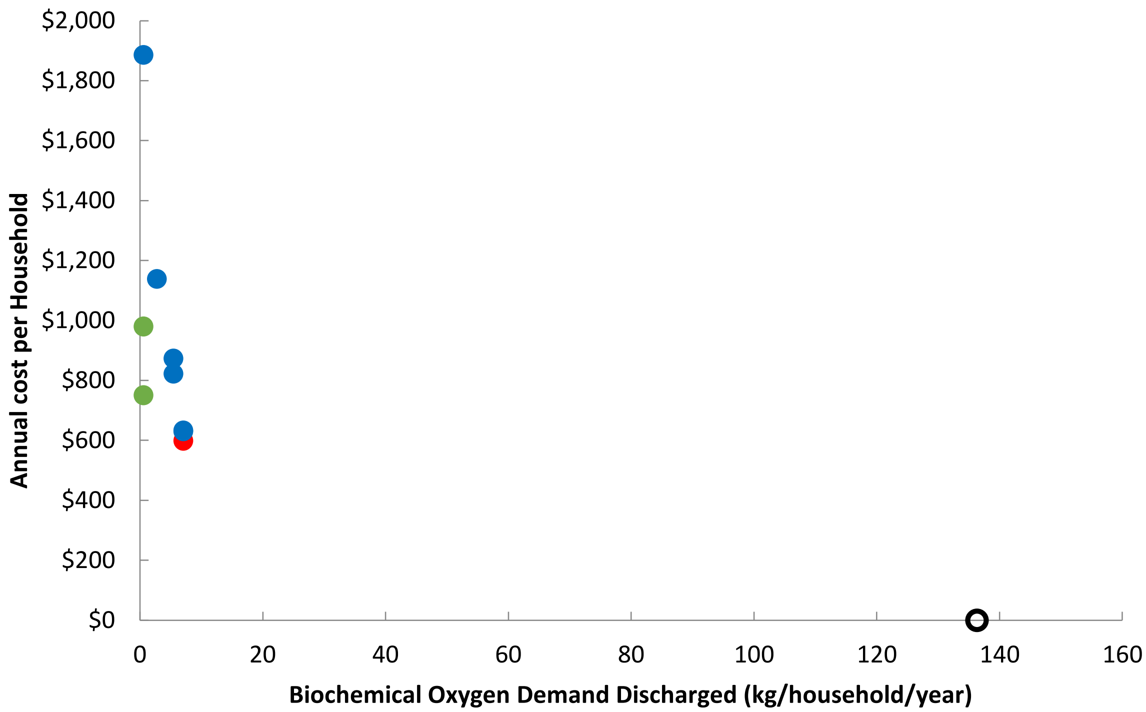



**Figure C9: Gore discharge of biochemical oxygen demand (BOD)**

### 2.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and total phosphorus) from the wastewater via the Actiflo plant. The existing system removes 83.2 percent of total nitrogen from the wastewater inflow, which although still considerable, is a lower proportion than its removal of suspended solids (91%) and biochemical oxygen demand (96%). The Gore system receives a base inflow load of 110.00 tonnes of total nitrogen annually, of which 84.04 tonnes are removed through treatment, and 25.96 tonnes are discharged to surface water.

The most effective scenarios for removing total nitrogen are Scenario 7: *Enhanced treatment* and Scenario 8: *Tertiary treatment*. These two scenarios are likely to halve the total nitrogen in the wastewater discharge (up to 3 kg per household per year). Scenario 4: *Nutrient reduction*, Scenario 5: *Nutrients & solids* and Scenario 6: *Slow infiltration* are moderately effective for total nitrogen. Of the two land-based technologies, total nitrogen is the only contaminant where slow infiltration is likely to be more effective than rapid infiltration. Table C10 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C10: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 21 | 76.4% | N.A. | 6 | 23.6% |
| 1. Pathogens | 21 | 76.4% | 0.0% | 6 | 23.6% |
| 2. Phosphorus | 21 | 76.4% | 0.0% | 6 | 23.6% |
| 3. Rapid infiltration | 22 | 82.0% | 7.3% | 5 | 18.0% |
| 4. Nutrients | 22 | 80.0% | 4.7% | 5 | 20.0% |
| 5. Nutrients & solids | 22 | 82.0% | 7.3% | 5 | 18.0% |
| 6. Slow infiltration | 24 | 88.0% | 15.2% | 3 | 12.0% |
| 7. Enhanced | 25 | 90.0% | 17.8% | 3 | 10.0% |
| 8. Tertiary treatment | 25 | 90.0% | 17.8% | 3 | 10.0% |

The two most effective scenarios for total nitrogen (Scenarios 7 and 8) have the highest additional annual cost for wastewater treatment per household. Unlike the results for suspended solids and biochemical oxygen demand, the two land-based scenarios do not stand out as being relatively cost-effective. Figure C10 shows the relationship between the treatment system's improvement in removing total nitrogen and the possible increase in annual cost per household. Figure C11 shows the relationship between the annual discharge of total nitrogen and annual cost per household.

Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost.

**The key and explanation for these graphs is included at the start of the modelling results section.**

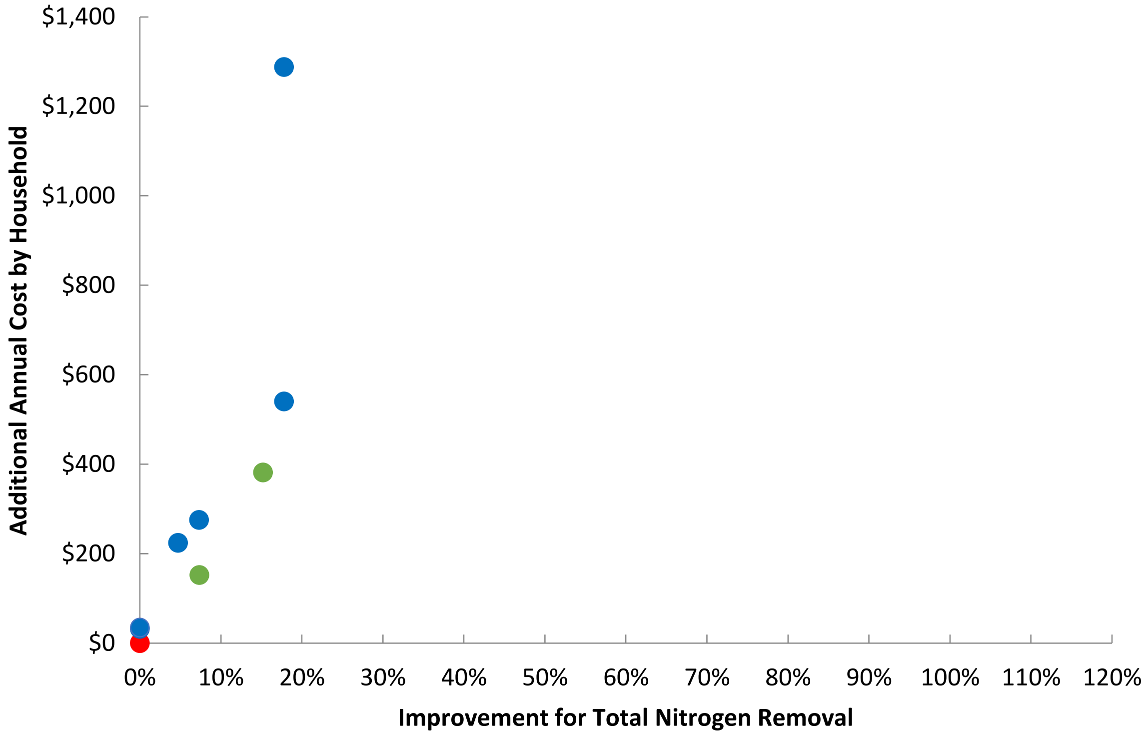



**Figure C10: Gore improvement in treatment for nitrogen**

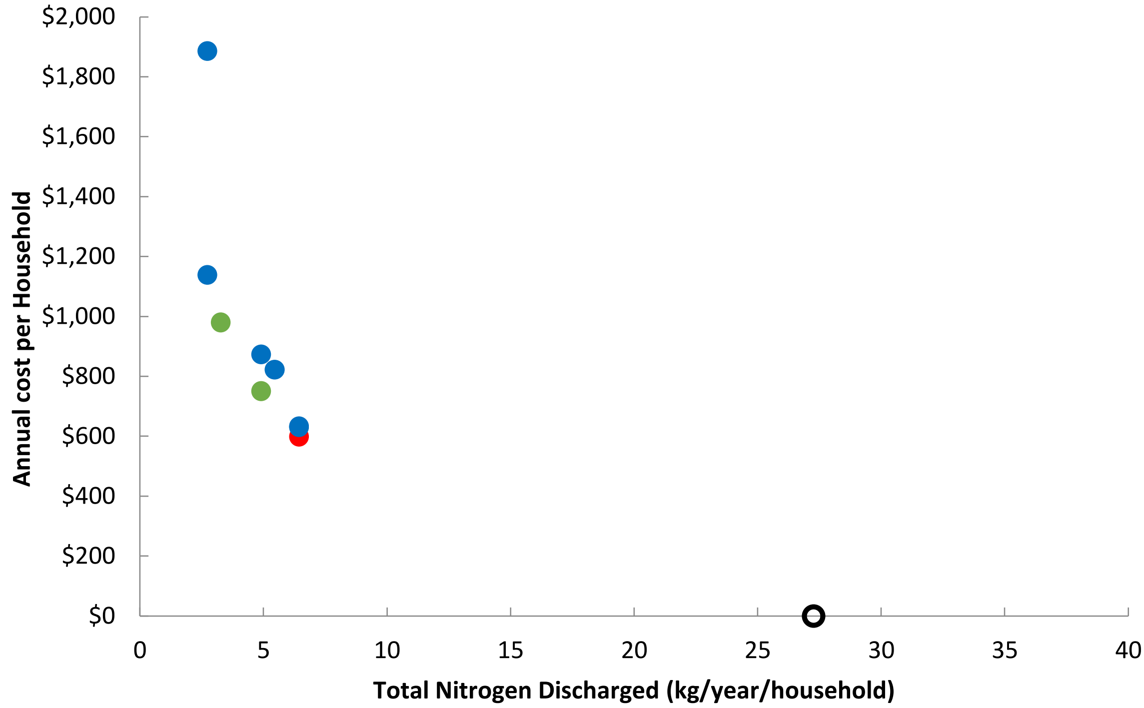



**Figure C11: Gore discharge of nitrogen**

### 2.4.4. Total Phosphorus

In addition to total nitrogen, the existing system also removes total phosphorus from the inflow of raw wastewater. Overall, 90 percent of the total phosphorus from the wastewater inflow is removed, which is a higher proportion than total nitrogen removal (83%). The Gore system receives a base inflow load of 15.40 tonnes of total phosphorus annually, of which 12.76 tonnes are removed through treatment, and 2.64 tonnes are discharged to surface water.

As with previous contaminants, Scenario 7: *Enhanced Treatment* and Scenario 8: *Tertiary treatment* are most effective for total phosphorus of the scenarios modelled. Most of the other scenarios are also likely to be effective for total phosphorus, including Scenario 2: *Phosphorus reduction*, which is specifically designed for phosphorus removal. The two land-based options, Scenario 3: *Rapid infiltration* and Scenario 6: *Slow infiltration*, are as effective for this contaminant as the other scenarios. Scenario 1: *Pathogen reduction* is less effective for total phosphorus because ultraviolet treatment is not designed for removing phosphorus from the wastewater. Table C11 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C11: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 3.2 | 82.9% | 0.0% | 0.7 | 17.1% |
| 1. Pathogens | 3.2 | 82.9% | 0.0% | 0.7 | 17.1% |
| 2. Phosphorus | 3.3 | 85.7% | 3.4% | 0.5 | 14.3% |
| 3. Rapid infiltration | 3.3 | 85.7% | 3.4% | 0.5 | 14.3% |
| 4. Nutrients | 3.3 | 85.7% | 3.4% | 0.5 | 14.3% |
| 5. Nutrients & solids | 3.3 | 85.7% | 3.4% | 0.5 | 14.3% |
| 6. Slow infiltration | 3.3 | 85.7% | 3.4% | 0.5 | 14.3% |
| 7. Enhanced | 3.5 | 92.9% | 12.1% | 0.3 | 7.1% |
| 8. Tertiary treatment | 3.5 | 92.9% | 12.1% | 0.3 | 7.1% |

The five scenarios that are relatively effective for total phosphorus (Scenarios 2, 4, 5, 7 and 8) have a wide range of additional annual costs for wastewater treatment, from $34 to $1,287 per household. Of these scenarios, Scenario 2: *Phosphorus reduction* is likely to deliver improvements at the lowest additional cost, but it was less effective for other contaminants. This result is unsurprising because the scenario specifically targeted phosphorus reduction. Figure C12 shows the relationship between the treatment system's improvement in removing total phosphorus and the possible increase in annual cost per household. Figure C13 shows the relationship between the annual discharge of total phosphorus and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

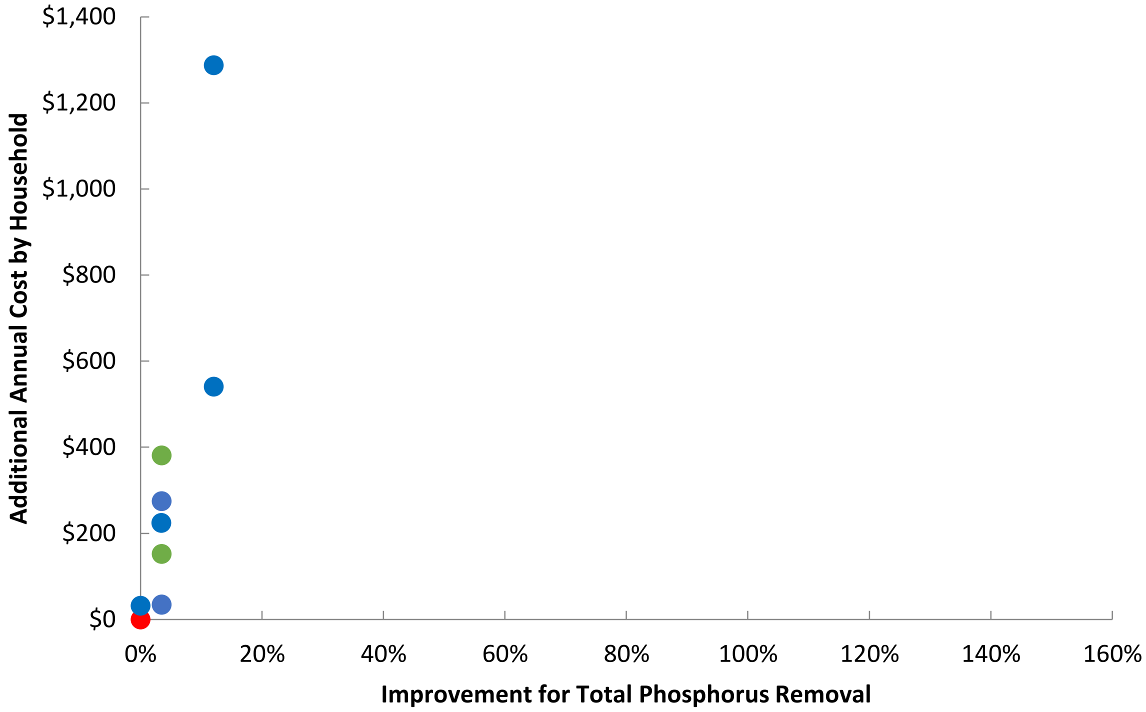



**Figure C12: Gore improvement in treatment for total phosphorus**

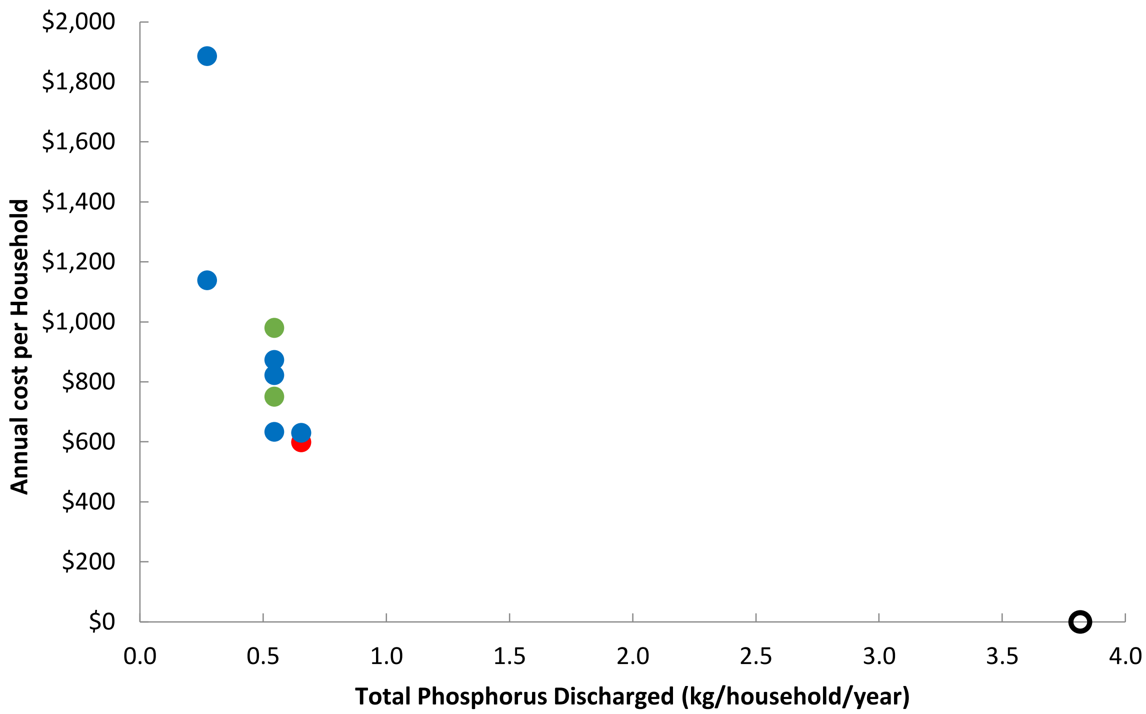



**Figure C13: Gore discharge of total phosphorus**

### 2.4.5. *E. coli*

The existing treatment plant has substantial capability to remove *E. coli* from the raw wastewater inflow through its oxidation ponds and Actiflo plant. On the whole, the existing system removes 99.54 percent of *E. coli*, which is a greater proportion than for any of the other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Gore system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,995,400 cfu/100mL through treatment, so that a concentration of 4,600 cfu/100mL is discharged to surface water.

Of the scenarios modelled, Scenario 1: *Ultraviolet disinfection*, Scenario 3: *Rapid infiltration*, Scenario 6: *Slow infiltration*, Scenario 7: *Enhanced treatment* and Scenario 8: *Tertiary treatment*, are relatively effective for further removal of *E. coli*. These scenarios deliver more than tenfold additional reduction and include the two land-based technologies. Scenario 2: *Phosphorus reduction*, Scenario 4: *Nutrient reduction* and Scenario 5: *Nutrients & solids* are less effective for this contaminant, relative to the other scenarios, as they are not specifically designed to include pathogen reduction. Table C12 summarises the scenario treatment capabilities for *E. coli* compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C12: Annual Concentrations – *E. coli* (treatment removal and discharge)**

| Scenario | Conc removed (cfu/100mL) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge conc (cfu/100mL) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 9,995,419 | 99.95% | 0.000% | 4,581 | 0.046% |
| 1. Pathogens | 9,999,874 | 99.999% | 0.045% | 126 | 0.0013% |
| 2. Phosphorus | 9,997,000 | 99.97% | 0.016% | 3,000 | 0.030% |
| 3. Rapid infiltration | 9,999,491 | 99.994% | 0.041% | 509 | 0.0051% |
| 4. Nutrients | 9,997,000 | 99.97% | 0.016% | 3,000 | 0.030% |
| 5. Nutrients & solids | 9,997,000 | 99.97% | 0.016% | 3,000 | 0.030% |
| 6. Slow infiltration | 9,999,999 | 99.99999% | 0.046% | 1 | 0.00001% |
| 7. Enhanced | 9,999,990 | 99.9999% | 0.046% | 10 | 0.0001% |
| 8. Tertiary treatment | 9,999,874 | 99.999% | 0.045% | 126 | 0.0013% |

The five scenarios that deliver additional capability for *E. coli* (Scenarios 1, 3, 6, 7 and 8) have a wide range of additional annual costs for wastewater treatment. Scenario 1: *Ultraviolet disinfection* is likely to deliver improvements at the lowest additional cost but was less effective for other contaminants, given it specifically targets pathogen reduction. Figure C14 shows the relationship between the treatment system's improvement in removing *E. coli* and the possible increase in annual cost per household. Figure C15 shows the relationship between the annual discharge of *E. coli* and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

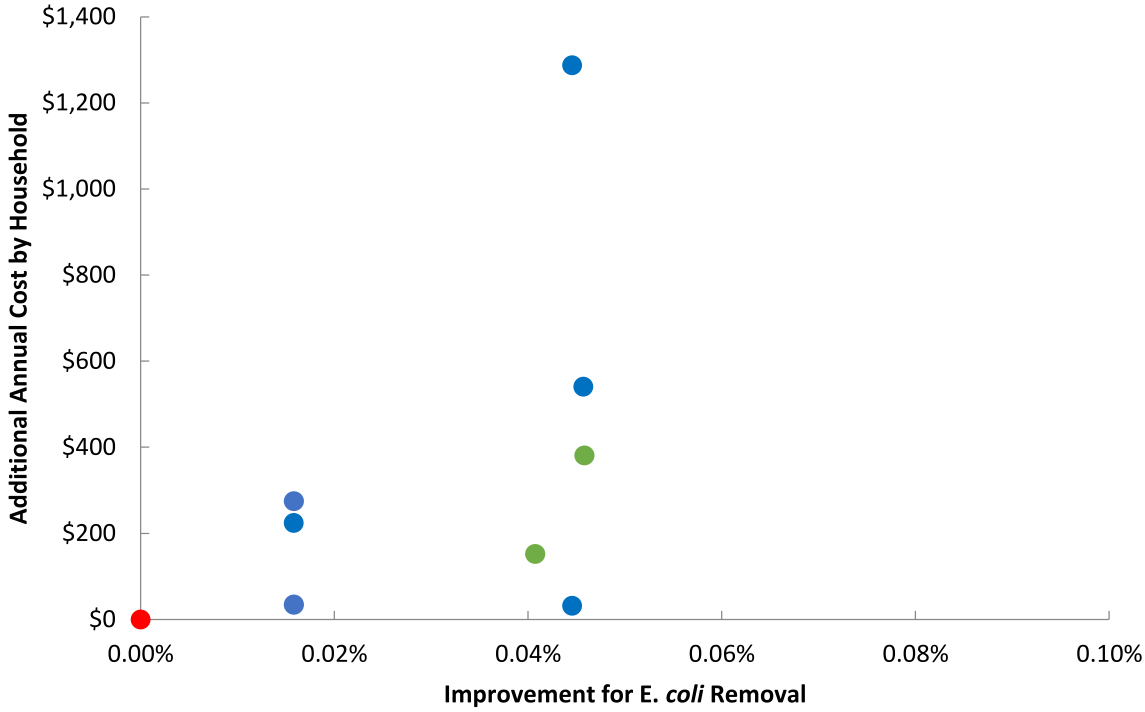



**Figure C14: Gore improvement in treatment for *E. coli***

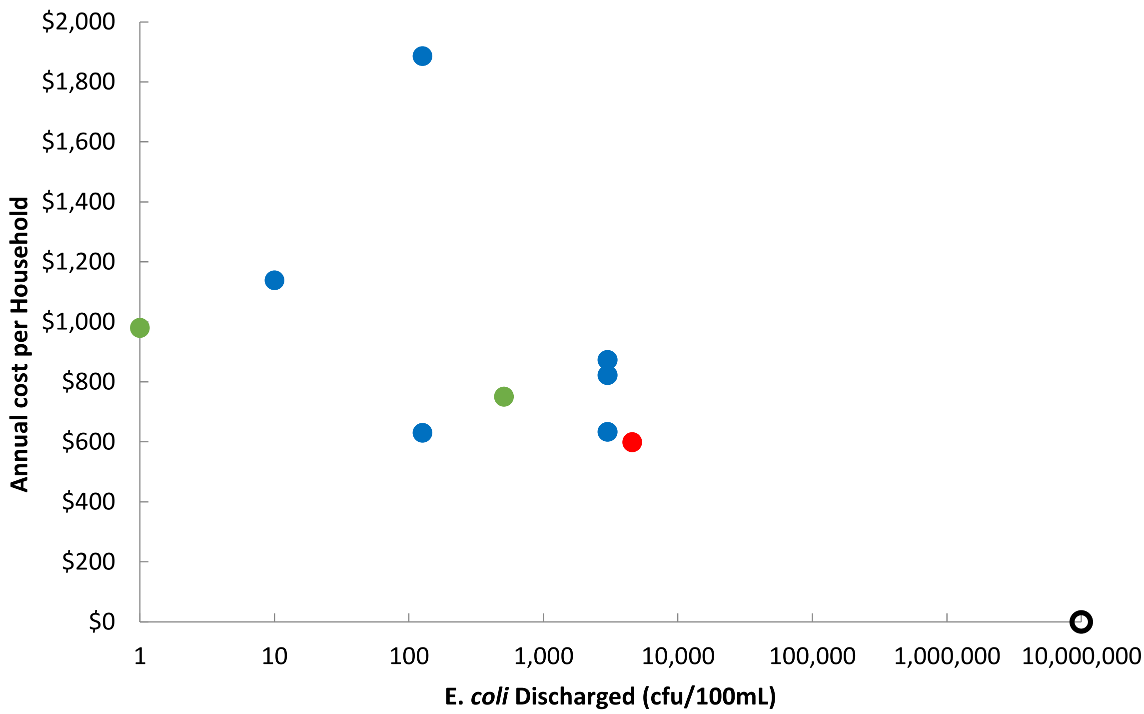



**Figure C15: Gore discharge of *E. coli***

## 2.5. Gore Summary

Gore's primary oxidation pond was established in 1973. The incoming wastewater is screened to remove solids then treated in ten hectare primary and secondary oxidation ponds, and a mechanical treatment Actiflo Plant (depending on river flow conditions), before discharge to the Matāura River. Parts of Gore's wastewater pipe network are combined with its stormwater pipe network and is heavily affected by rainfall. The combined network influences the quality of the wastewater inflow the wastewater treatment system. Gore's existing wastewater treatment capabilities provide a considerable level of contaminant reduction.

Gore's wastewater scheme receives residential, commercial and light industrial wastewater. It also receives large volumes of trade waste from two separate meat processing plants. Trade waste from the new milk processing plant will be treated at the Gore wastewater treatment system and considerable pre-treatment will be done before it enters the existing system.

Eight scenarios were modelled for Gore. Each scenario has strengths and weaknesses in its cost or treatment capabilities for each contaminant. The scenarios include options that are either additional to the existing base system and/or replace the existing base system. The capability of the base system means that the scenarios generally provide a relatively small percentage improvement in contaminant reduction. The scenarios have a wide range of annual costs per household and for Gore the costs do not necessarily relate to each scenario's capability to treat particular contaminants.

## 2.6. Limitations and Constraints

There are a number of limitations on the scenarios modelled. Across the scenarios, redundancy in mechanical plant may be needed to ensure compliance with a discharge consent if one plant has a failure or breakdown of equipment. Redundancy has not been factored into the cost. There are occasional mechanical failures of the existing Actiflo plant and not having redundancy (e.g. a second plant) is currently managed by not needing to run the plant year round for the consent. The Actiflo plant occasionally requires specialist overseas input, which may increase if the plant was to be run all of the time.

Additional sludge production from some scenarios will require pond desludging projects to occur more often increasing lifecycle costs. Costs such as these have not been included in the cost estimates. There is inherent variability in assessing this type of cost. For the land-based disposal scenarios, the likelihood of finding appropriate soils near Gore to receive any land disposal discharge is remote.

Both land-based scenarios do not include the full costs for the purchase of suitable land. The land scenarios are dependent on the availability of suitable land (either owned by the Council or able to be purchased). At present, Gore District Council does not own any neighbouring land to the base wastewater treatment system. Indicative reviews of soils and soil moisture indicate that, at most times of the year, land disposal around Gore may not be feasible.

# 3. Matāura

## 3.1. Matāura Wastewater Scheme

Rates affordability is likely to remain a key concern for this community. Matāura's demographic trend shows that the population is declining and average incomes are decreasing. Households are increasingly likely to be on fixed incomes such as superannuation and welfare benefits. Infrastructure replacements and improvements will be required in the coming years in the town and the level of service provided to the community may need to be reviewed if affordability, already a challenge, becomes an important issue.

As of 2016, Matāura's wastewater network had 730 connections and 983 full drainage rates were rated. The reticulation consists of just under 20 kilometres of pipe made from various materials such as earthenware, concrete and PVC materials. The wastewater assets, which include the treatment plant, pump stations and reticulation for the town, have a total replacement value of $7.2 million (2016 GDC Valuation). Reticulation makes up 68 percent of the total replacement value. The treatment site itself is valued at just under $1.6 million.

The town is serviced on both sides of the river with eight pump stations. These pump stations collect gravity catchments and pump into other catchments. All the wastewater eventually collects at a terminal pump station at the south western end of the town near the old landfill site, which then pumps the wastewater for final processing to the treatment site. The wastewater treatment site consists of a three hectare primary oxidation pond built in 1962. Wastewater from the pond is discharged by gravity into a wetland, developed in 2008, and then from there discharged by gravity into the Matāura River.

Most of Matāura's wastewater network was installed during the 1970s and 1980s. The wastewater scheme was originally a combined stormwater and wastewater scheme, but a separate wastewater network was built in the 1980s using government health grants. The Matāura wastewater network is available to all properties within the town boundaries but the stormwater network is not as widespread. The old combined system is now used for stormwater. It is estimated that about 50 percent of properties still have combined wastewater and stormwater. There is anecdotal evidence that some wastewater pump stations may use the stormwater network to discharge overflow when the pump station becomes overwhelmed during rainfall events.

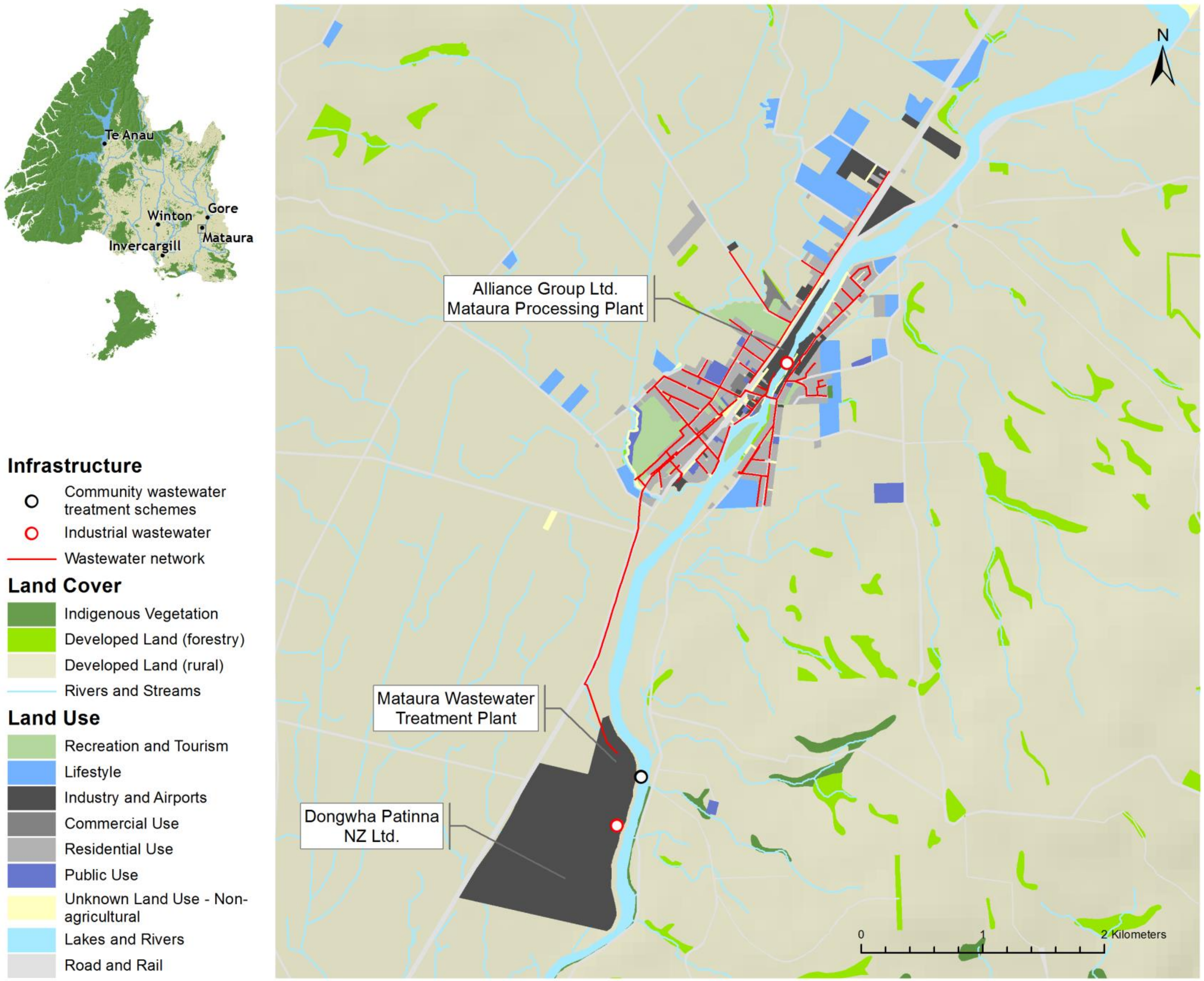
The wastewater treatment system is located approximately two kilometres south of the town, roughly opposite Shanks Road. The primary oxidation pond reduces the organic load as bacteria consume organic matter and deposit waste as sludge to the base of the pond, retention time also assists with treatment. The pond has a baffle curtain which assists with retention time. Algal growth in the treatment ponds is critical as the algae take up nutrients in the wastewater. This process also increases suspended solids in the wastewater. The wastewater then passes through one of six wetland cells that were installed in 2008 as supplementary treatment. The wetlands were established to reduce nutrients in the discharge and assist with lowering suspended solids. The wetlands are also important with regard to mitigating the effects of the wastewater discharge on the mauri (life-force) of the river.

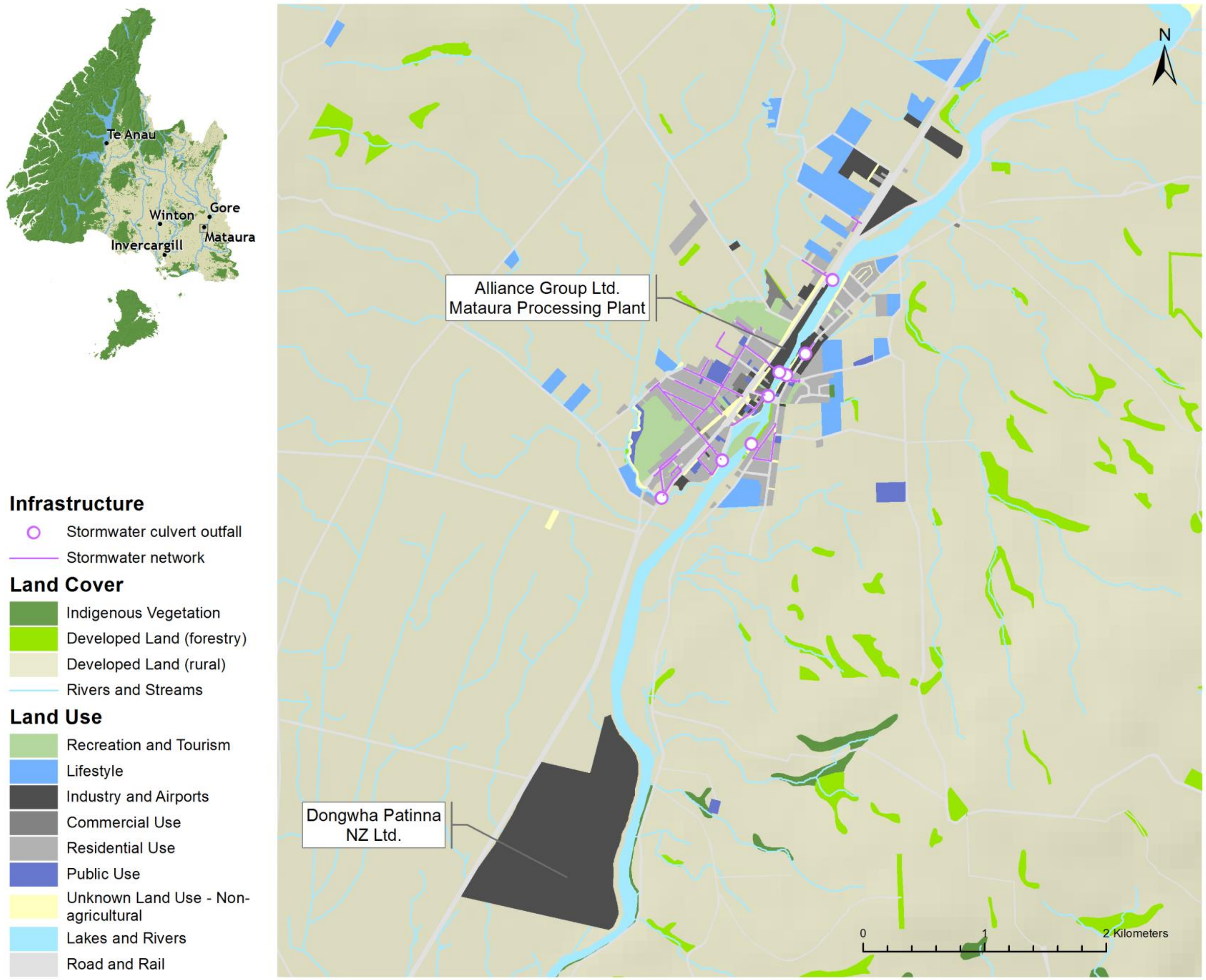
**Image C4: Looking west over the Matāura oxidation pond and wetland, Tuturau**
Source Emma Moran
Note The Matāura River runs parallel to the pond between the pond and Wyndham Road (at the end of the private road).

The total annual wastewater inflow into the Matāura treatment system is estimated at around 193,100 $m^3$, with the daily flow ranging between 450 $m^3$ and 605 $m^3$. This flow rate is dependent on wet weather. Discharge from the wastewater treatment system is directly to the Matāura River from a steep bank at the oxidation pond. The discharge quality is monitored in compliance with discharge consent conditions. There is no electricity at the site, so monitoring equipment is powered by solar energy.

The current resource consent for the wastewater discharge was granted in December 2006 and will expire in May 2021. The requirements of the consent for managing river flow conditions are simpler than the Gore consent. Higher flows from the site are consented during wet weather conditions; a weir on the oxidation pond allows higher wet weather discharge volumes to occur. The existing treatment system for Matāura does not have the capabilities that the Gore system does because of it being a wholly natural treatment system. The Matāura site's process relies on bacteria, sunlight, wind, time and temperature to achieve optimum treatment of the wastewater.

The following two maps show the Matāura wastewater and stormwater schemes.


Te Anau
Winton
Gore
Mataura
Invercargill
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
N
Alliance Group Ltd.
Mataura Processing Plant
Mataura Wastewater
Treatment Plant
Dongwha Patinna
NZ Ltd.
0
1
2 Kilometers


Te Anau
Winton
Gore
Mataura
Invercargill
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
Alliance Group Ltd.
Mataura Processing Plant
Dongwha Patinna
NZ Ltd.
N
0
1
2 Kilometers

## 3.2. Baseline Results

This section describes the baseline results for Matāura (i.e. what is actually occurring). The total annual inflow of wastewater into the Matāura treatment system is estimated at around 193,100 $m^3$, with the daily flow ranging between 450 $m^3$ and 605 $m^3$. Table C13 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C14 gives information on the average quality of the treated wastewater discharged to the Matāura River.

**Table C13: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2013-2016 | Total SS (tonnes) | BOD (tonnes) | Total N (tonnes) | Total P (tonnes) | *E. coli* (cfu/100ml) |
|---|---|---|---|---|---|
| Concentration (4 years) | 43.3 | 46.9 | 7.7 | 1.1 | ~9,999,100 |

**Table C14: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **(g/m$^3$)** | **(g/m$^3$)** | **(g/m$^3$)** | **(g/m$^3$)** | **(cfu/100ml)** |
| Average (5 years) | 25.7 | 7.1 | 10.3 | 1.4 | 880 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (4 years) | 1.7 to 5.7 | 1.1 to 1.7 | 2.0 to 2.5 | 0.2 to 0.4 | N.A. |
| Estimated loads | 4.9 | 1.4 | 2.0 | 0.3 | N.A. |

Source: Environment Southland consent monitoring data

The total replacement value (2016 valuation) of all the assets in the wastewater scheme is $7.2 million (around $8,900 per household). The largest contributor is the gravity mains in the pipe network, which accounts for roughly 68 percent of the replacement value. The treatment system is valued at $773,000. The rest of the scheme's value is made up of assets such as manholes and pump stations.

The annual depreciated value of the wastewater scheme is $115,000 and the annual operating cost is $243,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C15 using the methodology described in Section C1.5.

Figure C16 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[9] before being plotted to make it possible to include all five different contaminants on the same graph.

[9] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

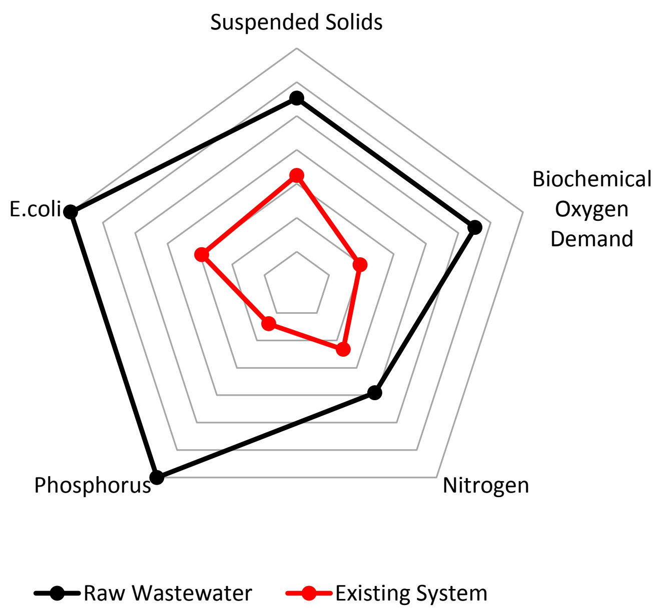



**Figure C16: Matāura baseline scenario (existing system)**

## 3.3. Modelling Scenarios

Four scenarios were developed for the Matāura wastewater system (the scenarios and treatment processes as listed below with more details are in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Further work is needed to determine whether any scenario is technically feasible. Table C15 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 823 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

| Scenario | Treatment Process (new units in bold) |
|---|---|
| Existing System | Liquid: oxidation pond, wetland |
| | Solid: storage in pond |
| 1. Nutrient reduction | Liquid: as existing, **enhancements to wetland, including plant thinning and improve gradient / flow depth** |
| | Solid: as existing |
| 2. Pathogen reduction | Liquid: as existing **UV disinfection, new** |
| | Solid: storage in pond |
| 3. Rapid infiltration | Existing process **+ high rate infiltration (rapid infiltration basins etc.)** |
| 4. Slow infiltration | Existing process **+ slow rate infiltration (spray irrigation etc.)** |

**Table C15: Matāura Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| **Existing scheme** | $14,969,000 | $606 |
| **1. Nutrient reduction** | $15,834,000 | +$35 |
| **2. Pathogen reduction** | $16,575,000 | +$65 |
| **3. Rapid infiltration (includes partial cost of land purchase)** | $20,520,000 | +$225 |
| **4. Slow infiltration (includes partial cost of land purchase)** | $22,289,000 | +$296 |

Figure C17 and Figure C18 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C16 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater. Except for phosphorus, the concentrations of the contaminants were transformed[10] before being plotted to make it possible to include all five different contaminants on the same graph.

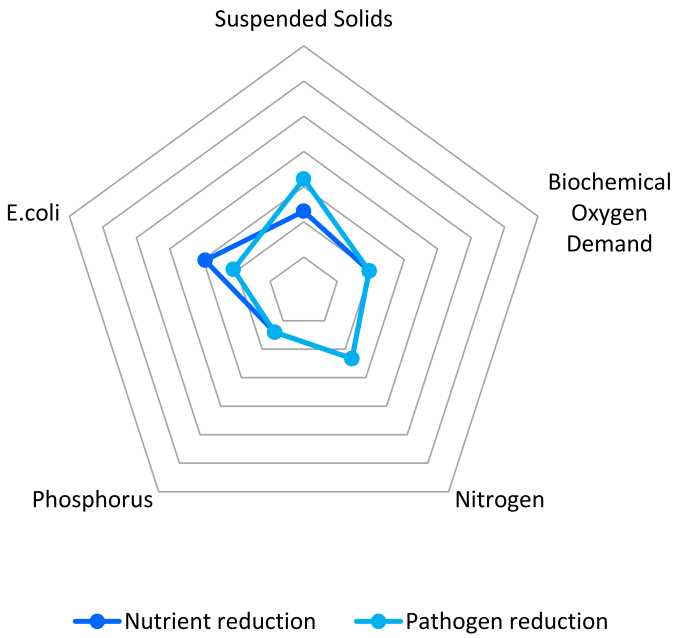



**Figure C17: Matāura 'discharge to water' scenarios**

[10] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

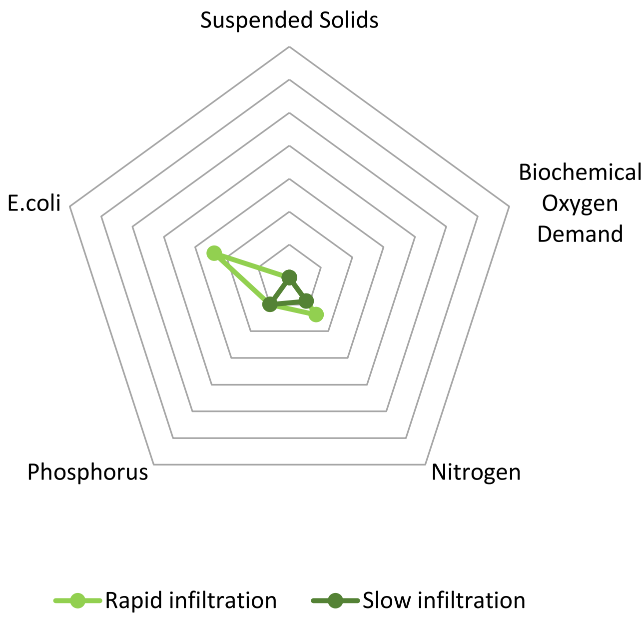



**Figure C18: Matāura 'discharge to land' scenarios**

## 3.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*Two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot** for the existing level of treatment (i.e. the base);*
- ***blue dots** for modelling scenarios representing discharges to water; and*
- ***green dots** for modelling scenarios representing discharges to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have **a clear black dot**, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 3.4.1. Total Suspended Solids

The existing system (the base) removes a substantial amount of suspended solids from the inflow of raw wastewater through its different treatment processes. The ponds remove suspended solids via bacteria and settlement. Overall, the existing treatment system removes 90 percent of the total suspended solids in the wastewater inflow. The Matāura system receives a base inflow load of 48.28 tonnes of solids annually, of which 43.31 tonnes are removed through treatment, and 4.96 tonnes are discharged to surface water.

Of the four scenarios modelled for Matāura, Scenario 3: *Rapid infiltration*, Scenario 4: *Slow infiltration* and Scenario 1: *Nutrient reduction* are likely to be the most effective for total suspended solids. Scenarios 3 and 4 use additional filtration through the soil to remove suspended solids over and above the existing system. Scenario 1: *Nutrient reduction,* which involves wetland enhancements, is also likely to be effective. The least effective scenario is Scenario 2: *Ultraviolet disinfection*, which is technology designed for treating *E. coli* rather than solids reduction. Table C16 summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). It also gives the discharge for the base and all scenarios.

**Table C16: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 53 | 89.7% | N.A. | 6 | 10.3% |
| 1. Nutrients | 56 | 96.0% | 7.0% | 2 | 4.0% |
| 2. Pathogens | 53 | 90.0% | 0.3% | 6 | 10.0% |
| 3. Rapid infiltration | 58 | 99.6% | 11.0% | 0 | 0.4% |
| 4. Slow infiltration | 58 | 99.6% | 11.0% | 0 | 0.4% |

The three most effective scenarios (Scenarios 3, 4 and 1) have an additional annual cost for wastewater treatment of between $35 and $296 per household. The results show a maximum of an 11 percent improvement in discharge quality. Scenario 1: *Nutrient reduction* is likely to deliver improvements at the lowest additional cost. Figure C19 shows the relationship between the treatment system's improvement in removing total suspended solids and the possible increase in annual cost per household. Scenario 2: *Ultraviolet disinfection* will have little improvement because it is not designed for this contaminant, yet it has a capital cost. Scenarios 3 and 4 (the two land-based technologies) can deliver the highest improvements and have a marked difference in costs.

Figure C20 shows the relationship between the annual discharge of suspended solids and annual cost per household. The two land-based scenarios, Scenario 3: *Rapid infiltration*, and Scenario 4: *Slow infiltration*, are each likely to achieve the best reduction in suspended solids loading, but have the highest cost. The results for these scenarios may increase once the full cost of land purchase is included and so the cost per household is likely to be much greater. Scenario 1: *Nutrient reduction* could give a small improvement but is dependent on the wetlands being well maintained.

**The key and explanation for these graphs is included at the start of the modelling results section.**

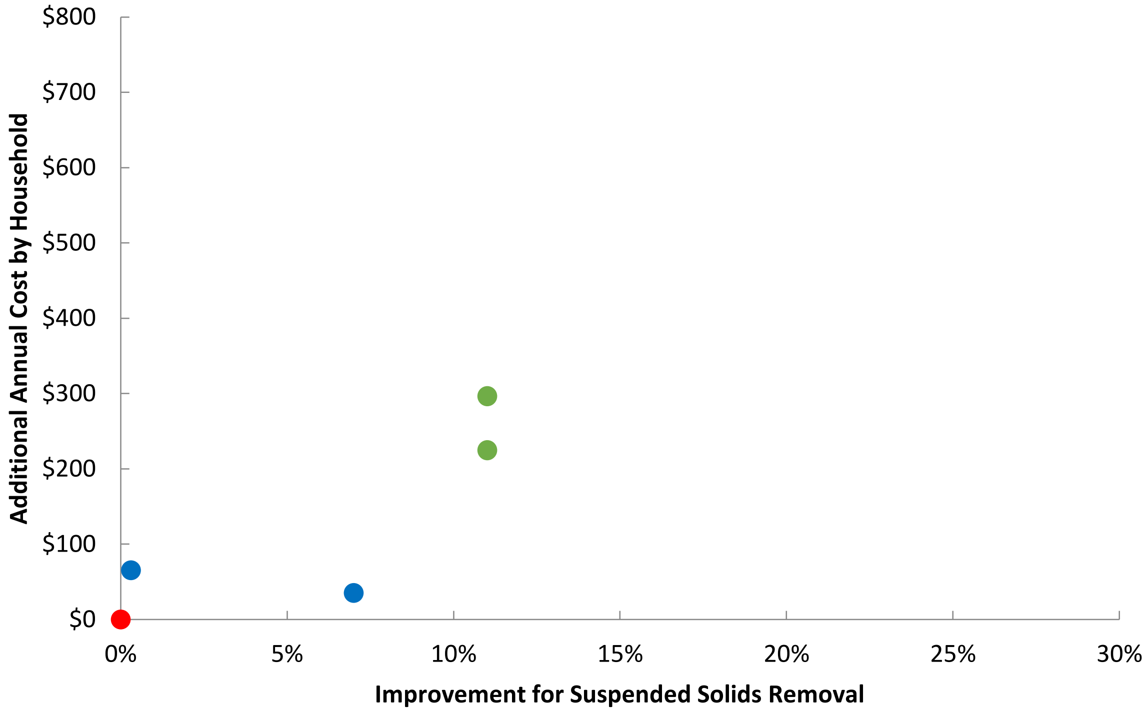



**Figure C19: Matāura improvement in treatment for suspended solids**

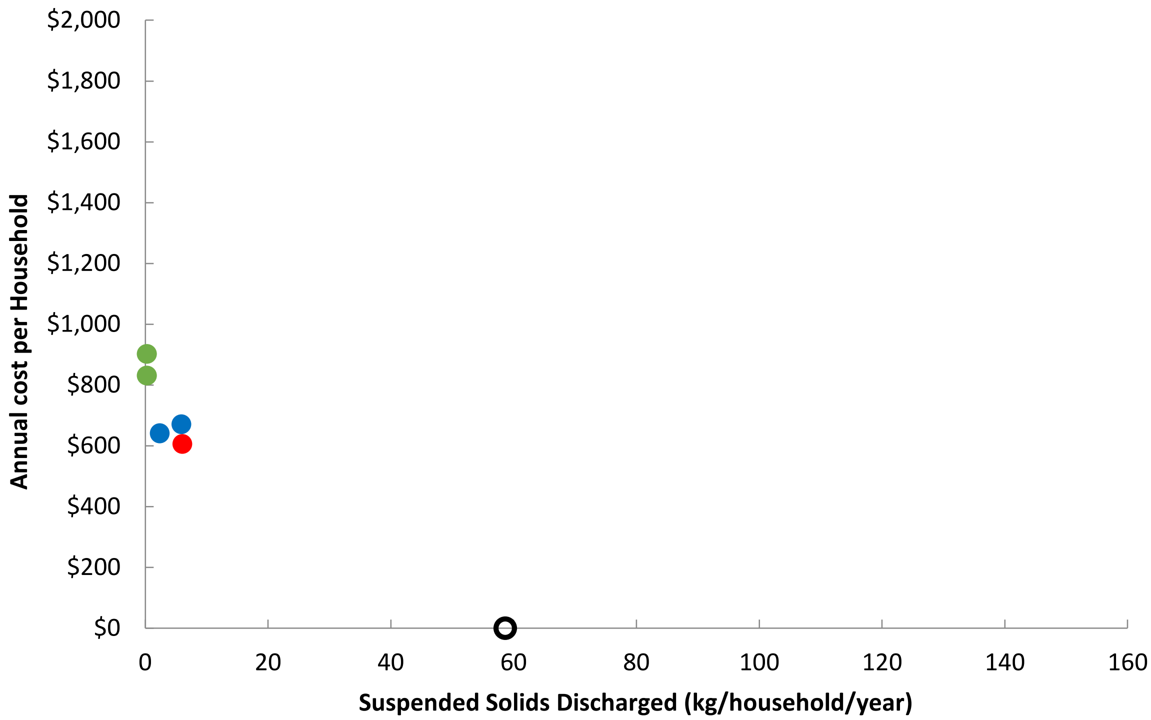



**Figure C20: Matāura discharge of suspended solids**

### 3.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing treatment system via the primary oxidation pond. The existing treatment system reduces 96.9 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Matāura system receives a base inflow load of 48.28 tonnes annually, of which 46.90 tonnes are reduced through treatment, and 1.37 tonnes are discharged to surface water.

Of the four scenarios modelled, Scenario 3: *Rapid infiltration* and Scenario 4: *Slow infiltration* are likely to be the most effective for further reducing biochemical oxygen demand, but any improvements are small. They were also the better performing scenarios for suspended solids. Two scenarios, Scenario 1: *Nutrient reduction* and Scenario 2: *Pathogen reduction* are less effective for this contaminant because their scenarios treatment capabilities are not designed for reducing biochemical oxygen demand. Table C17 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both the wastewater inflow and the base reduction (existing system). It also gives the resulting discharge for the base and all scenarios. Overall, the different scenarios make relatively small improvements because the existing system performs particularly well for this contaminant.

**Table C17: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 57 | 97.2% | 0.0% | 2 | 2.8% |
| 1. Nutrients | 57 | 97.2% | 0.0% | 2 | 2.8% |
| 2. Pathogens | 57 | 97.2% | 0.0% | 2 | 2.8% |
| 3. Rapid infiltration | 58 | 99.6% | 2.5% | 0 | 0.4% |
| 4. Slow infiltration | 58 | 99.6% | 2.5% | 0 | 0.4% |

The two most effective scenarios (Scenario 3 and 4) have additional annual costs of $225 and $296 per household for wastewater treatment. Of these two scenarios, Scenario 3: *Rapid infiltration* is likely to deliver improvements at the lowest additional cost. Figure C21 shows the relationship between the treatment system's improvement in reducing biochemical oxygen demand and the possible increase in annual cost per household. Figure C22 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household. The relatively small improvements in treatment and discharge that can be made for this contaminant are likely to increase the annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

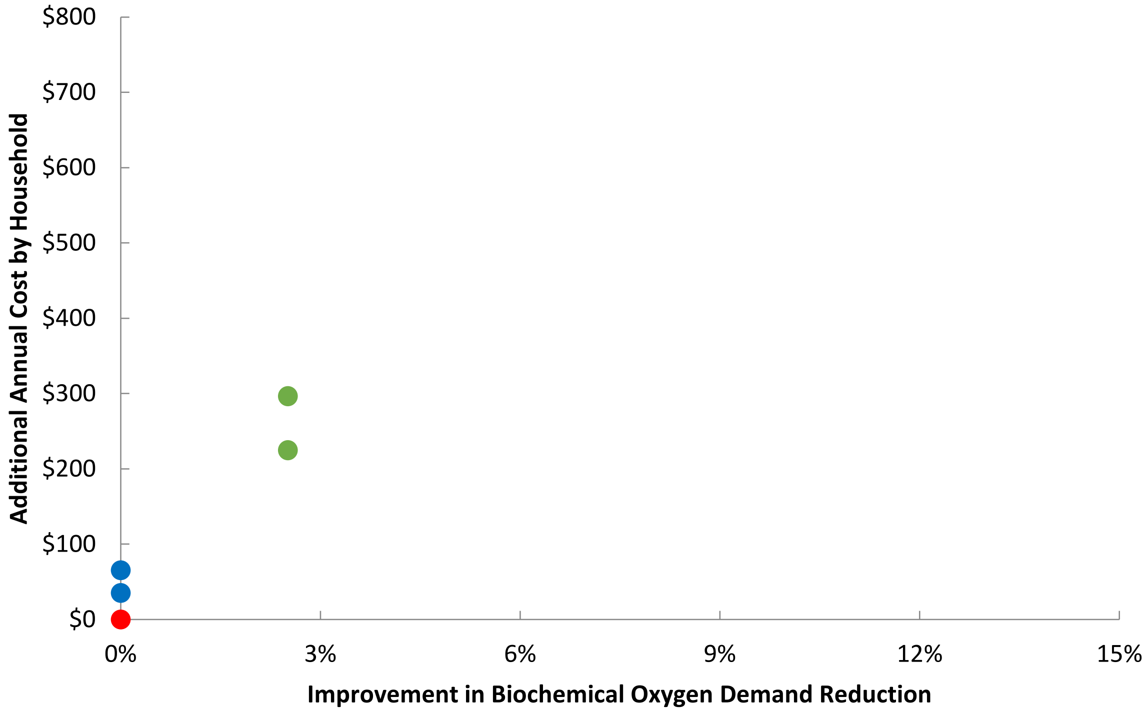



**Figure C21: Matāura improvement in treatment for biochemical oxygen demand (BOD)**

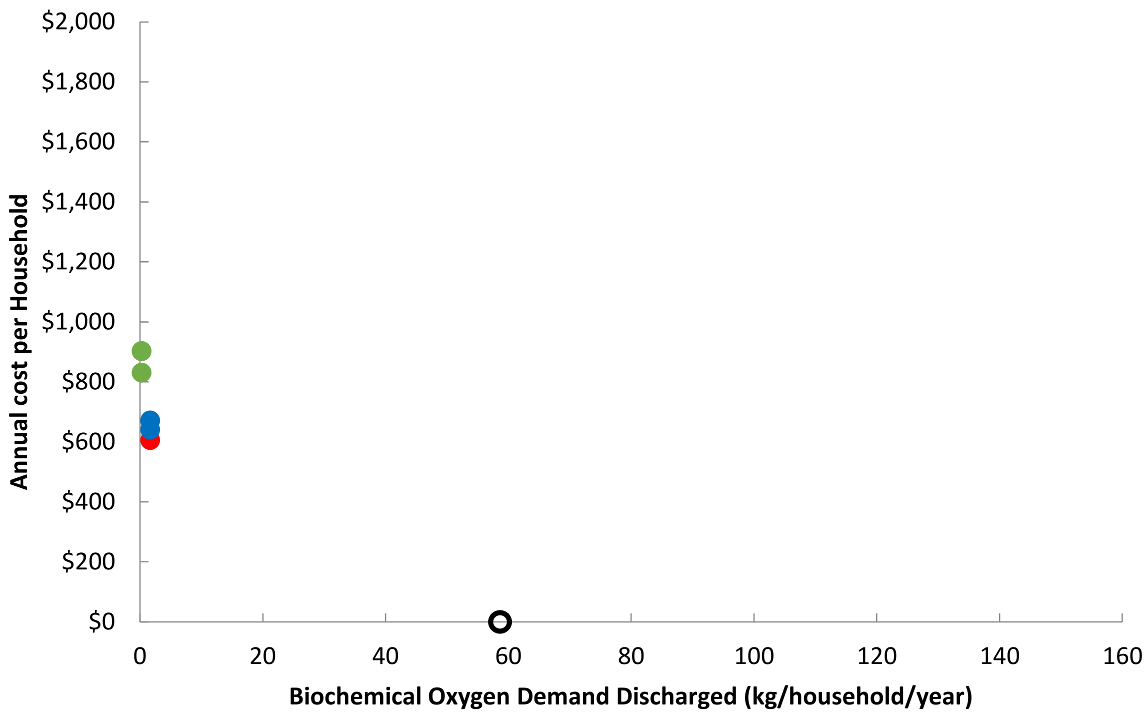



**Figure C22: Matāura discharge of biochemical oxygen demand (BOD)**

### 3.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and total phosphorus) from the inflow raw wastewater via bacteria in the primary pond and uptake by the plants in the wetlands. The existing system removes 77.8 percent of total nitrogen from the wastewater inflow, which although still considerable, is a lower proportion than its removal of suspended solids (90%) and biochemical oxygen demand (97%). The Matāura system receives a base inflow load of 9.66 tonnes of total nitrogen annually, of which 7.67 tonnes are removed through treatment, and 1.99 tonnes are discharged to the surface water.

The most effective scenario for removing nitrogen is likely to be Scenario 4: *Slow infiltration* followed by Scenario 3: *Rapid infiltration*. These two scenarios could remove over 90 percent of total nitrogen in the wastewater discharge (up to 2 kg per household per year). Scenario 1: *Nutrient reduction* and Scenario 2: *Pathogen reduction* are less effective for total nitrogen. Of the two land-based technologies, total nitrogen is the only case where slow infiltration is likely to be more effective than rapid infiltration. Table C18 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives resulting discharge for the base and all scenarios.

**Table C18: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing System | 9 | 79.4% | 0.0% | 2 | 20.6% |
| 1. Nutrients | 9 | 79.4% | 0.0% | 2 | 20.6% |
| 2. Pathogens | 9 | 79.4% | 0.0% | 2 | 20.6% |
| 3. Rapid infiltration | 11 | 92.0% | 15.9% | 1 | 8.0% |
| 4. Slow infiltration | 11 | 95.2% | 19.9% | 1 | 4.8% |

The two most effective scenarios for total nitrogen (Scenario 3 and 4) have the highest additional annual costs for wastewater treatment per household. Unlike the results for suspended solids and biochemical oxygen demand, the two land-based scenarios do not stand out as being relatively cost-effective. Figure C23 shows the relationship between the treatment system's improvement in removing total nitrogen and the increase in the annual cost per household. Figure C24 shows the relationship between the annual discharge of total nitrogen and annual cost per household.

Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost.

**The key and explanation for these graphs is included at the start of the modelling results section.**

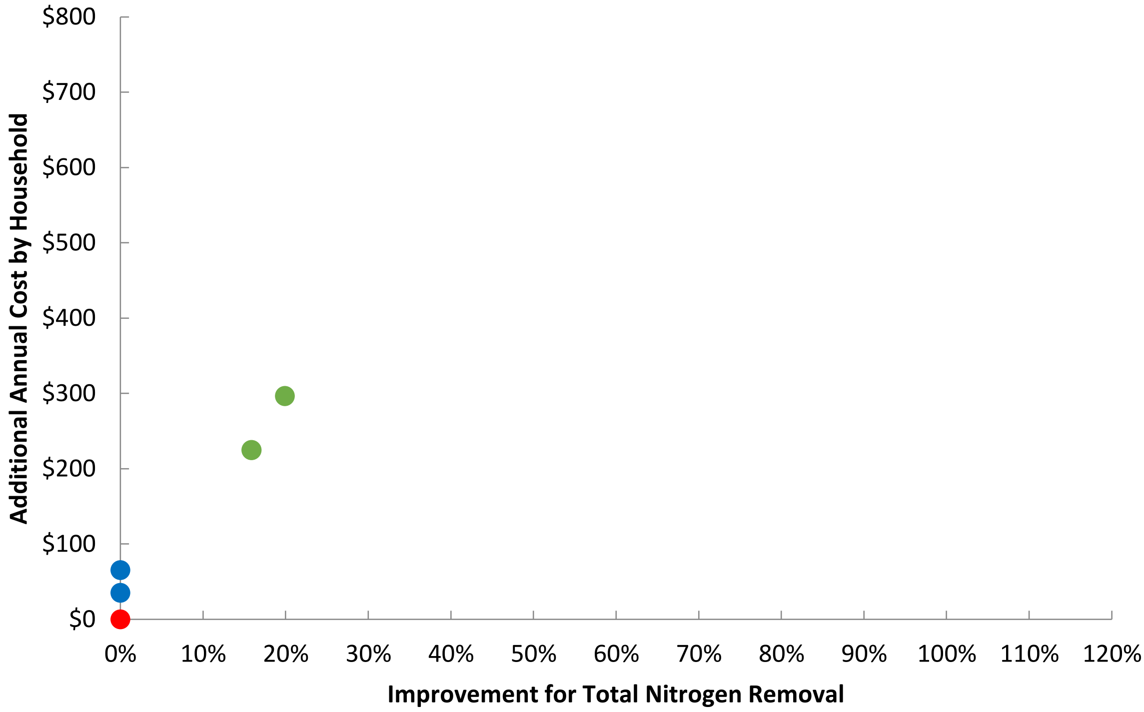



**Figure C23: Matāura improvement in treatment for total nitrogen**

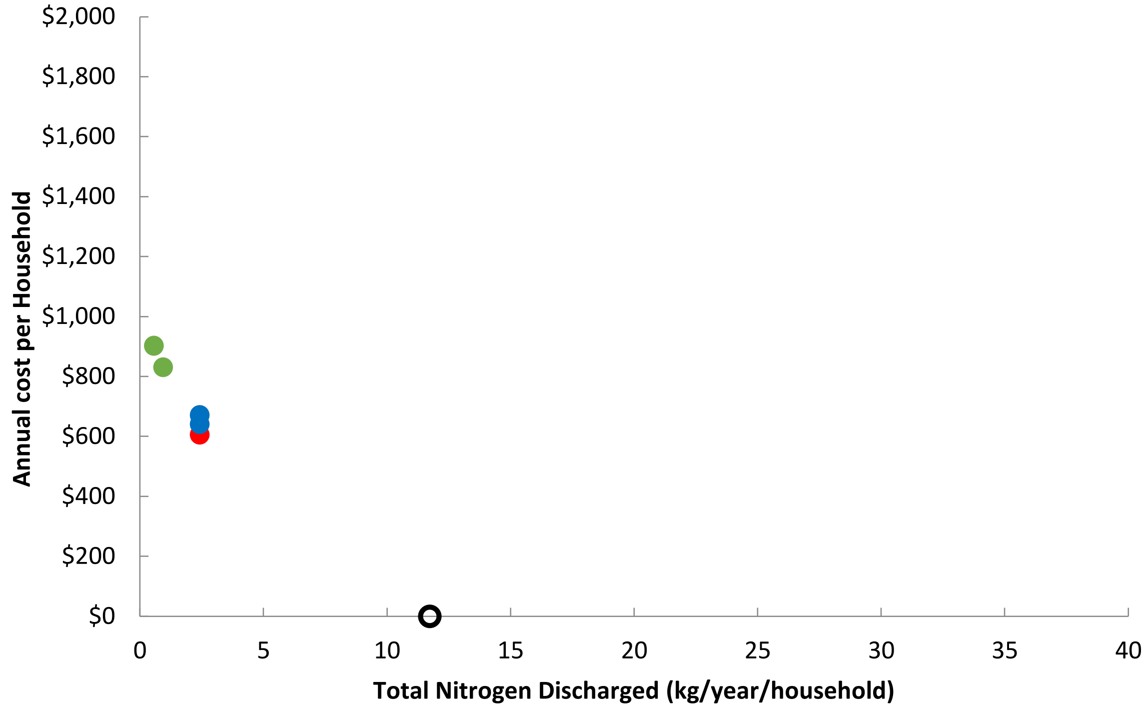



**Figure C24: Matāura discharge of total nitrogen**

### 3.4.4. Total Phosphorus

In addition to total nitrogen, the existing system also removes total phosphorus from the inflow of raw wastewater. Overall, 80.9 percent of the total phosphorus from the wastewater inflow is removed, which is close to the proportion of total nitrogen removal (78%). The Matāura system receives a base inflow load of 1.35 tonnes of total phosphorus annually, of which 1.08 tonnes are removed through treatment, and 0.27 tonnes are discharged to surface water.

As with previous contaminants, the two land-based scenarios, Scenario 3: *Rapid infiltration* and Scenario 4: *Slow infiltration* are likely to be the most effective for total phosphorus of the scenarios modelled. The remaining two scenarios are less effective for total phosphorus. Table C19 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

The scenarios that are relatively effective for total phosphorus (Scenario 3 and 4) have additional annual costs of $225 and $296 per household for wastewater treatment. It is evident that Scenario 3 is likely to deliver improvements at the lowest additional cost. Figure C25 shows the relationship between the treatment system's improvement in removing total phosphorus and the possible increase in annual cost per household. Figure C26 shows the relationship between the annual discharge of total phosphorus and annual cost per household.

**Table C19: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 1.3 | 80.0% | 0.0% | 0.3 | 20.0% |
| 1. Nutrients | 1.3 | 80.0% | 0.0% | 0.3 | 20.0% |
| 2. Pathogens | 1.3 | 80.0% | 0.0% | 0.3 | 20.0% |
| 3. Rapid infiltration | 1.4 | 85.7% | 7.1% | 0.2 | 14.3% |
| 4. Slow infiltration | 1.4 | 85.7% | 7.1% | 0.2 | 14.3% |

**The key and explanation for these graphs is included at the start of the modelling results section.**

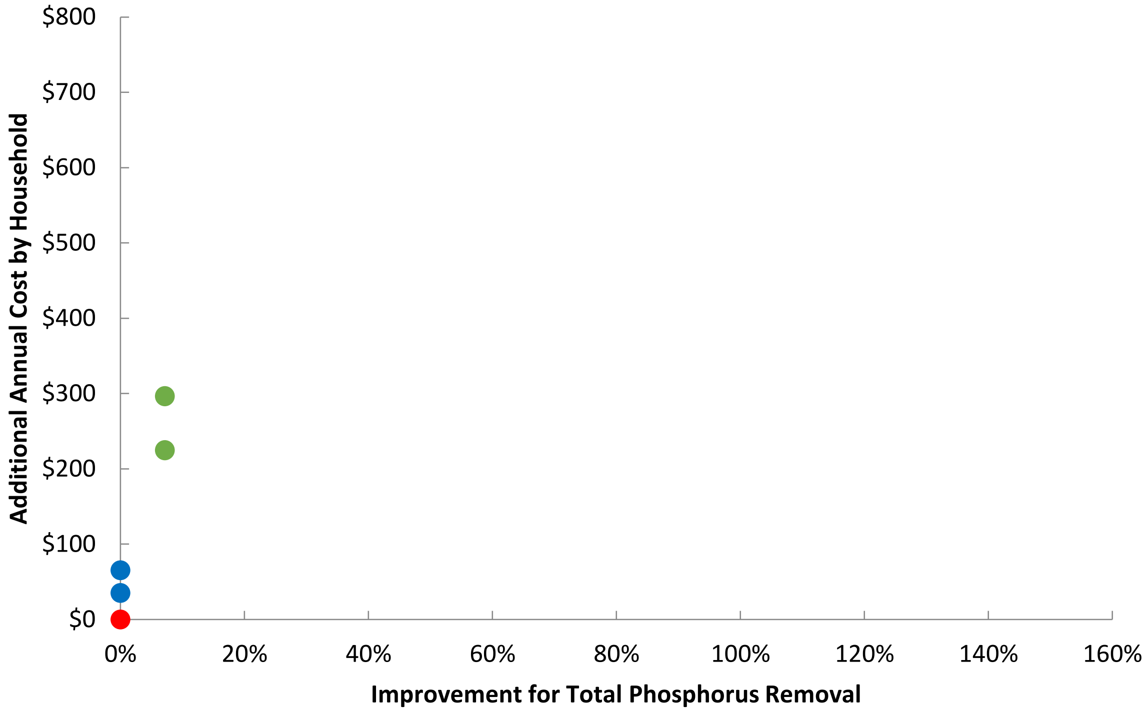



**Figure C25: Matāura improvement in treatment for total phosphorus**

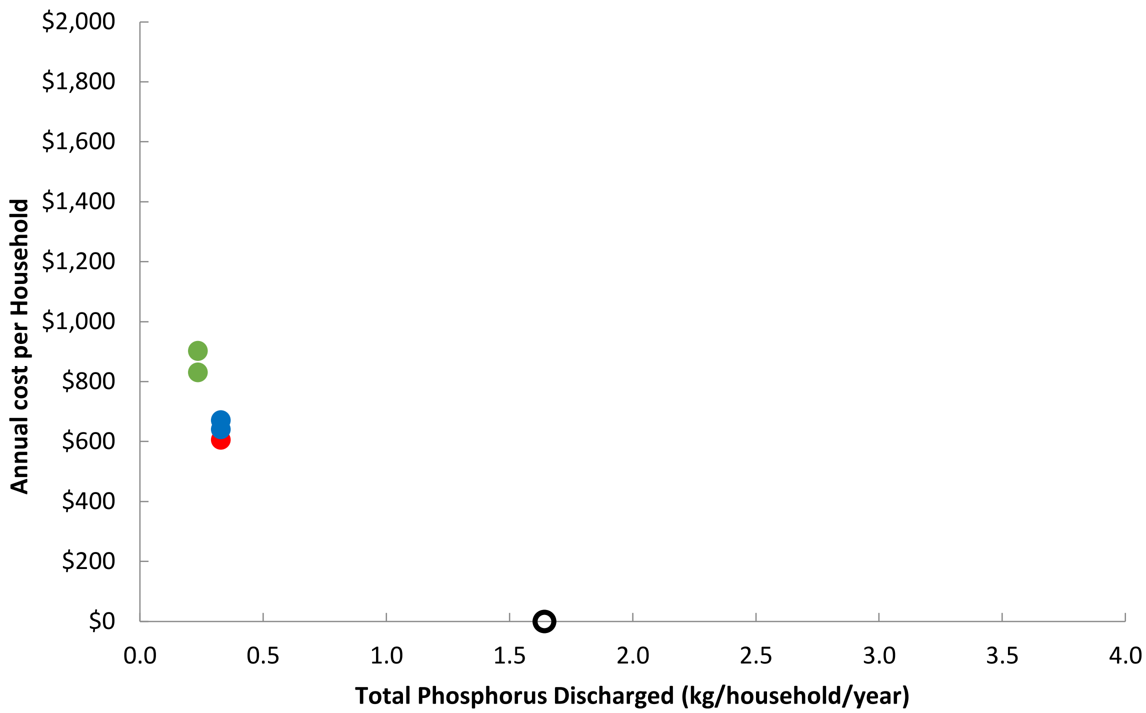



**Figure C26: Matāura discharge of total phosphorus**

### 3.4.5. *E. coli*

The existing treatment plant has substantial capability to remove *E. coli* from the raw wastewater inflow through its treatment in its oxidation ponds. On the whole, the existing system removes 99.87 percent of *E. coli*, which is a greater proportion than any other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Mataura system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,999,100 cfu/100mL through treatment, so that a concentration of 900 cfu/100mL is discharged to surface water.

The most effective for further removal of *E. coli* are likely to be Scenario 4: *Slow infiltration*, followed by Scenario 2: *Pathogen reduction* and Scenario 3: *Rapid infiltration.* Scenarios 3 and 4 include land-based technologies. Scenario 1: *Nutrient reduction* is likely to be ineffective for *E. coli* because the treatment principle for this scenario is not suitable for this contaminant. Table C20 summarises the scenario treatment capabilities for *E. coli* compared to wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

The three scenarios that could deliver additional capability for *E. coli* (Scenarios 2, 3 and 4) have additional annual costs for wastewater treatment ranging from $65 to $296. Scenario 2: *Pathogen reduction* is likely to deliver improvements at the lowest additional cost but is less effective for other contaminants, as it is specifically targeted at reducing pathogens. Figure C27 shows the relationship between the treatment system's improvement in removing *E. coli* and the possible increase in annual cost per household. Figure C28 shows the relationship between the annual discharge of *E. coli* and annual cost per household.

**Table C20: Annual Loads – *E. coli* (treatment removal and discharge)**

| Scenario | Conc removed (cfu/100mL) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge conc (cfu/100mL) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9,999,121 | 99.991% | 0.000% | 879 | 0.0088% |
| 1. Nutrients | 9,999,121 | 99.991% | 0.000% | 879 | 0.0088% |
| 2. Pathogens | 9,999,874 | 99.999% | 0.008% | 126 | 0.0013% |
| 3. Rapid infiltration | 9,999,755 | 99.998% | 0.006% | 245 | 0.0025% |
| 4. Slow infiltration | 9,999,999 | 99.99999% | 0.009% | 1 | 0.00001% |

**The key and explanation for these graphs is included at the start of the modelling results section.**

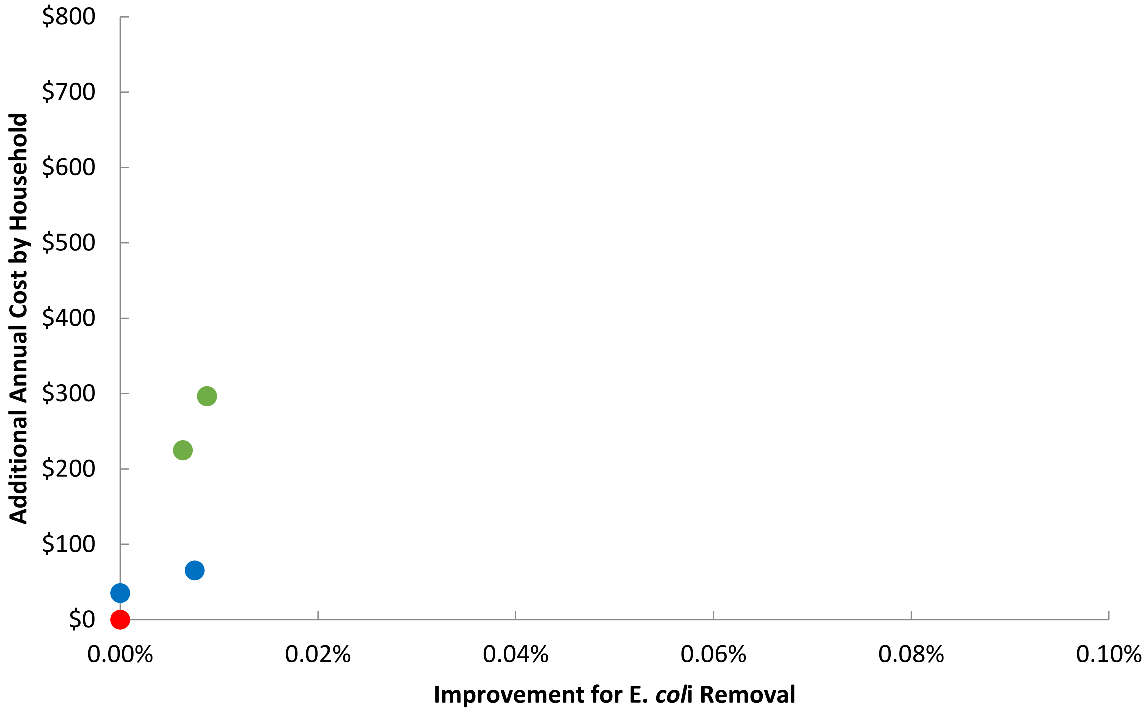



**Figure C27: Matāura improvement in treatment for *E. coli***

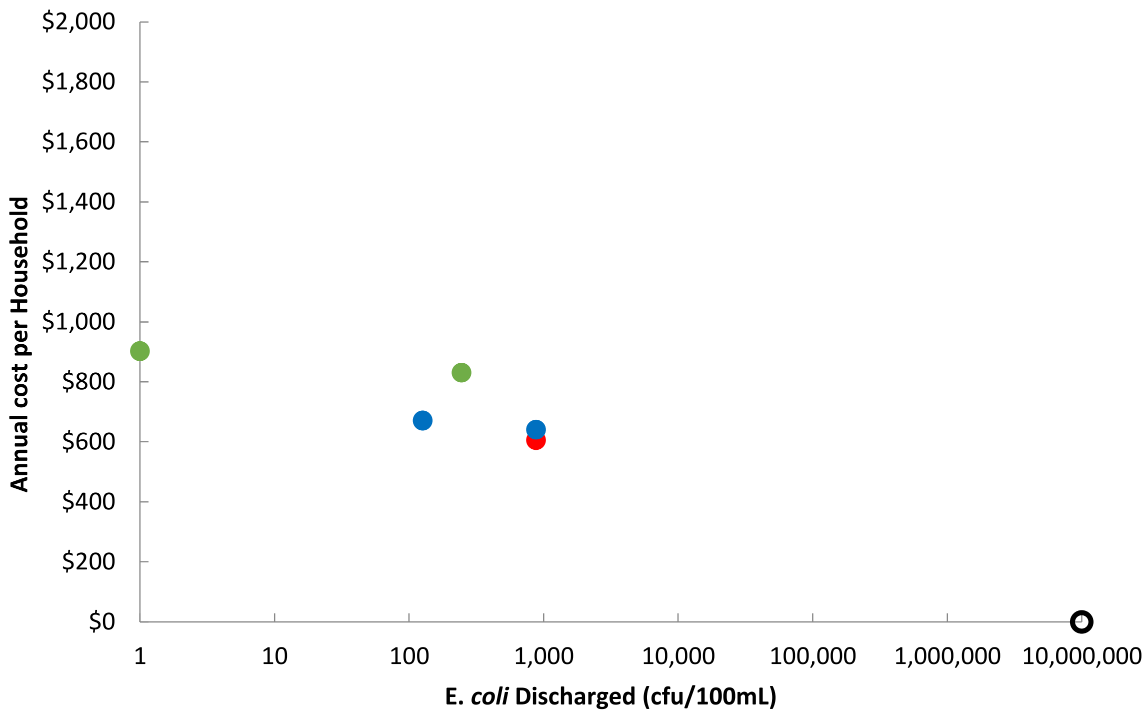



**Figure C28: Matāura discharge of *E. coli***

## 3.5. Matāura Summary

Matāura was established because of the prospects the Matāura Falls presented for hydro-power generation and industry. Industry drove Matāura's prosperity up until the 1990s, and many people moved to the town for employment opportunities. With changes in the agricultural sector and meat processing, and the closure of the paper mill, the town has had changing fortunes. Its close proximity to Gore gives Matāura's residents access to a wider set of services and facilities. With relatively low incomes and an older population, the affordability of essential services is a challenge for Matāura residents. The wastewater rate is currently an urban uniform annual charge; it is the same value as Gore's.

Matāura's wastewater scheme was established with the help of Government subsidies to improve public health and the health of the Matāura River. The existing wastewater treatment facility relies on natural processes to remove contaminants from the wastewater. Wastewater is treated by an oxidation pond and wetlands then discharged to the Matāura River.

Four scenarios were modelled for Matāura. Each scenario has strengths and weaknesses in its cost or treatment capabilities for each contaminant. The scenarios were all processes that are additional or complementary to the base system. Using the base system requires the existing processes to also be optimised and managed as effectively as possible. Most of the scenarios were not all that effective in further reducing the amount of *E. coli* in the discharge, as the existing system performs well for this contaminant. The land-based discharge scenarios (Scenarios 3 and 4) gave the widest range of improvements for the contaminants. These two scenarios are also the most expensive even before the full costs of purchasing suitable land are included.

## 3.6. Limitations and Constraints

The pathogen reduction scenario is not designed to reduce biochemical oxygen demand, total nitrogen and total phosphorus and so do not show up in the abatement curves for those contaminants.

Treatment options listed in the Resource Consent Application and Supporting Information (AEE) (November 2005) for Matāura WWTP, include treatment by Actiflo plant and treatment by 'slag bed'. Neither option was evaluated for this project.

Low population growth is limiting the Council's ability to raise rates in order to pay for infrastructure upgrades, such as improving the wastewater treatment system.

There are questions around the suitability and availability of land for 'discharge to land' scenarios. In the case of biochemical oxygen demand, total nitrogen and total phosphorus, where no alternatives to land discharge scenarios were proposed, more work needs to be done if there is a requirement by authorities for improving the discharge.

# 4. Winton

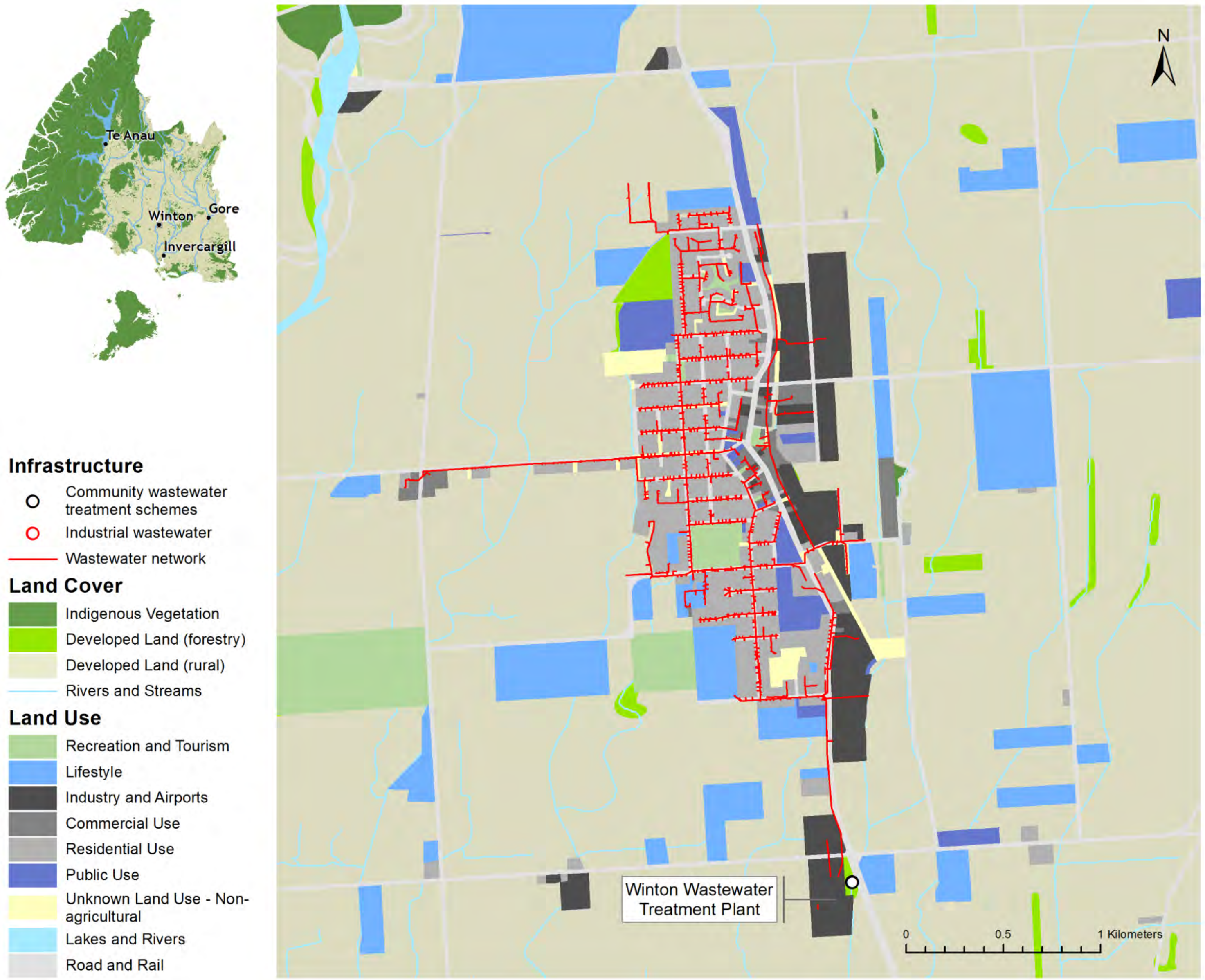
## 4.1. Winton Wastewater Scheme

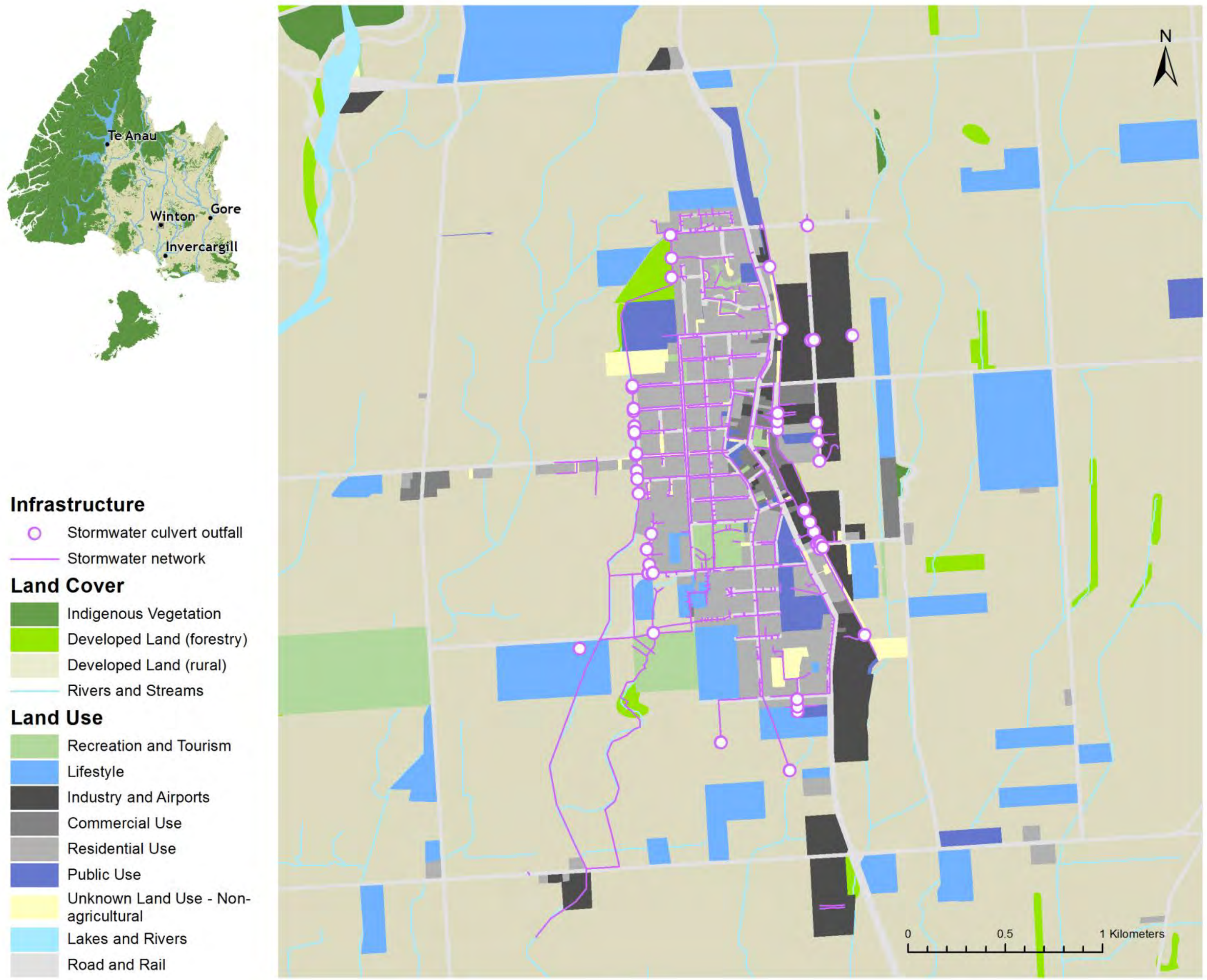
The Winton wastewater scheme has 1,233 total equivalent connections. The wastewater is generally domestic although there are a number of industrial discharges that may contribute to the overall flow and load. Wastewater flows under gravity from localised catchments to three minor pump stations and on to the main station at Dejoux Road from where it is pumped to the wastewater treatment system. Wastewater treatment consists of an oxidation pond (with two aerators) and a wetland before discharge to the Winton Stream. There is also an emergency overflow to the Winton Stream via a weeded ditch. The oxidation pond is thought to be lined with local low permeability clays.

**Image C5: Winton oxidation pond with aerator**

The wetland covers an area of 13.4 hectares divided into six operating cells. To improve performance, a fine screen was built at the inlet, the pond was desludged, and additional aerators installed. The wastewater treatment system's performance is consistent with other similar oxidation pond systems across the country. Non-compliances can occur when there are low flows in the Winton Stream.

<u>The following two maps show the Winton wastewater and stormwater schemes.</u>


Te Anau
Winton
Gore
Invercargill
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
N
Winton Wastewater Treatment Plant
0
0.5
1 Kilometers


Te Anau
Winton
Gore
Invercargill
N
0
0.5
1 Kilometers
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail

The current resource consent was granted in 2002 to discharge an average flow of 750 $m^3$/day of treated wastewater into the Winton Stream, and expires in December 2023. If additional improvements are required then a trickling filter is an option to be considered in the future.

## 4.2. Baseline Results

This section describes the baseline results for Winton (i.e. what is actually occurring). The total annual inflow of wastewater into the Winton treatment system is estimated at around 256,900 $m^3$, with the daily flow ranging from 685 $m^3$ to 710 $m^3$. Table C21 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C22 gives information on the quality of the treated wastewater discharged to the Ōreti River.

**Table C21: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2013-2016 | Total SS (tonnes) | BOD (tonnes) | Total N (tonnes) | Total P (tonnes) | *E. coli* (cfu/100ml) |
|---|---|---|---|---|---|
| Average (4 years) | 54.8 | 60.1 | 7.3 | 0.8 | ~9,996,000 |

**Table C22: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **(cfu/100ml)** |
| Average (5 years) | 36.7 | 16 | 21.8 | 3.8 | 3,800 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (4 years) | 7.5 to 9.4 | 4.1 to 4.7 | 5.6 to 6.7 | 1.0 to 1.0 | N.A. |
| Estimated loads | 9.4 | 4.1 | 5.6 | 1.0 | N.A. |

Source: Environment Southland consent monitoring data

Based on the 2017 annual valuation, the total replacement value of all the assets in the wastewater scheme is $12.3 million (around $11,000 per household). The largest contributor is the gravity mains in the pipe network, which accounts for roughly 84 percent of the replacement value. The treatment system is valued at $2.1 million. The rest of the scheme's value is made up of assets such as manholes and pump stations. The annual depreciated value of the wastewater scheme is $174,000 and the annual operating cost is $310,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C23 using the methodology described in Section C1.5. Figure C29 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[11] before being plotted to make it possible to include all five different contaminants on the same graph.

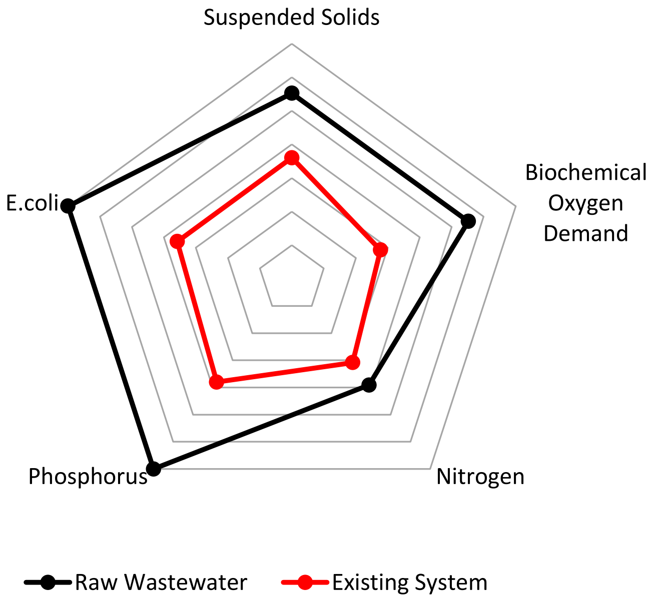



**Figure C29: Winton baseline scenario (existing system)**

**Image C6: Winton desludging geobag with oxidation pond in background**

[11] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

## 4.3. Modelling Scenarios

Seven scenarios were developed for the Winton wastewater system (the scenarios and treatment processes as listed below with more details are in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Further work is needed to determine whether any scenario is technically feasible, especially those relating to land-based disposal. Table C23 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 1,287 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

| **Scenario** | **Treatment Process (new units in bold)** |
|---|---|
| Existing System | Liquid: 3 mm screen, oxidation pond, wetland, |
| | Solid: storage in pond |
| 1. Phosphorus reduction | Liquid: 3 mm screen, oxidation pond, **chemical dosing, wetland (enhanced)** |
| | Solid: as existing |
| 2. Pathogen reduction | Liquid: 3 mm screen, oxidation pond, **wetland (enhanced), UV disinfection** |
| | Solid: as existing |
| 3. Rapid infiltration | Existing process **+ high rate infiltration (rapid infiltration basins etc.)** |
| 4. Nutrient reduction | Liquid: 3 mm screen, **trickling filter, clarifier,** oxidation pond, **wetland (enhanced)** |
| | Solid: as existing |
| 5. Slow infiltration | Existing process **+ slow rate infiltration (spray irrigation etc.)** |
| 6. Nutrient and solids reduction | Liquid: 3 mm screen, **trickling filter, clarifier,** oxidation pond, **wetland (enhanced), cloth/disc filter** |
| | Solid: as existing |
| 7. Enhanced treatment | Liquid: 3 mm screen, **fine screen, membrane bioreactor** |
| | Solid: as existing |

**Table C23: Winton Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| Existing scheme | $20,265,000 | $663 |
| 1. Phosphorus reduction | $21,769,000 | +$39 |
| 2. Pathogen reduction | $22,485,000 | +$58 |
| 3. Rapid infiltration (includes partial cost of land purchase) | $26,195,000 | +$154 |
| 4. Nutrient reduction | $28,086,000 | +$203 |
| 5. Slow infiltration (includes partial cost of land purchase) | $29,776,000 | +$246 |
| 6. Nutrient and solids reduction | $30,928,000 | +$276 |
| 7. Enhanced treatment | $40,401,000 | +$522 |

Figures C30 to C32 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C29 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater. Except for phosphorus, the concentrations of the contaminants were transformed[12] before being plotted to make it possible to include all five different contaminants on the same graph.

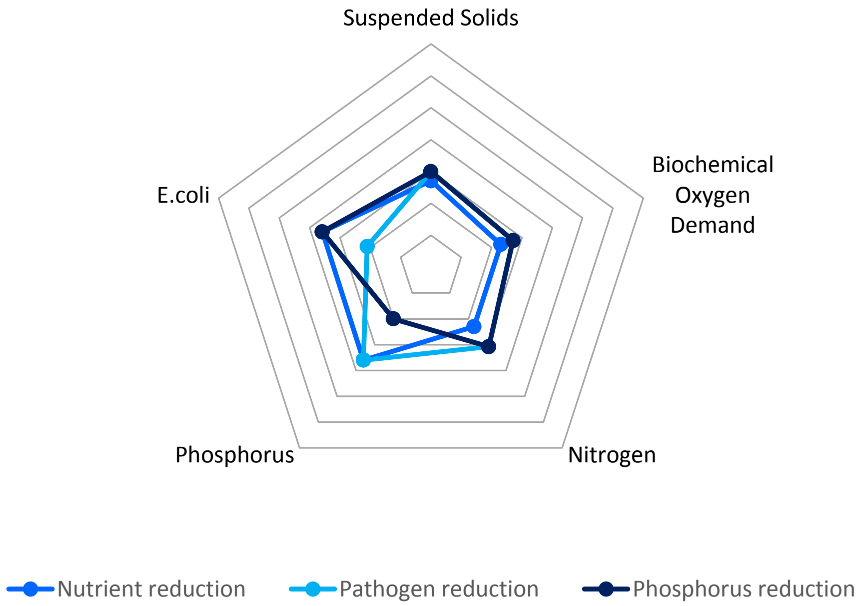



**Figure C30: Winton 'discharge to water' scenarios**

[12] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

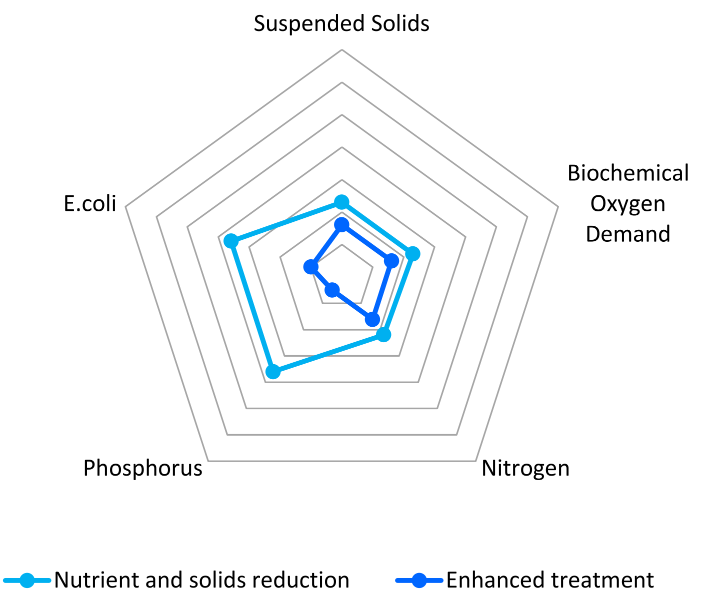



**Figure C31: Winton 'discharge to water' scenarios (continued)**

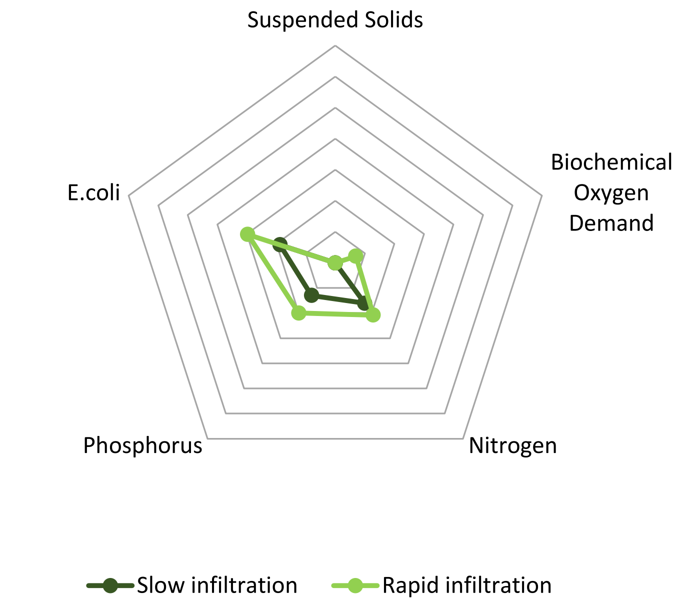



**Figure C32: Winton 'discharge to land' scenarios**

## 4.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*Two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot*** *for the existing level of treatment (i.e. the base);*
- ***blue dots*** *for modelling scenarios representing discharges to water; and*
- ***green dots*** *for modelling scenarios representing discharges to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have* ***a clear black dot****, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 4.4.1. Total Suspended Solids

The existing system (the base) removes a substantial proportion of total suspended solids from the inflow of raw wastewater through its different treatment processes. The bar screens at the main pump station removes large solids, with the majority of solids removed through settling out in the oxidation pond and will periodically be removed as sludge. Overall, the existing treatment system removes 91 percent of the total suspended solids in the wastewater inflow. The Winton system receives the base inflow load of 64.25 tonnes of solids annually, of which 54.82 tonnes are removed through treatment, and 9.43 tonnes are discharges to surface water.

Of the seven scenarios modelled in Winton, Scenario 3: *Rapid infiltration* and Scenario 5: *Slow infiltration* are expected to be the most effective at removing suspended solids because of filtration through the soil before discharge to groundwater. Scenario 7*: Enhanced treatment* offers an effective means of solids removal but typically involves abandoning ponds and constructing a completely new plant. Scenario 6: *Nutrients & solids* could also be an effective option at removing this contaminant.

The least effective scenarios appear to be Scenario 1: *Phosphorus reduction* and Scenario 2: *Pathogen reduction* – chemical dosing can be an effective way of removing solids but it depends on the chemical dosed, and this scenario is focused on phosphorus reduction rather than solids reduction. Table C24 summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C24: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 43 | 85.3% | 0.0% | 7 | 14.7% |
| 1. Phosphorus | 46 | 92.0% | 7.8% | 4 | 8.0% |
| 2. Pathogens | 46 | 92.0% | 7.8% | 4 | 8.0% |
| 3. Rapid infiltration | 50 | 99.6% | 16.7% | 0 | 0.4% |
| 4. Nutrients | 47 | 94.0% | 10.2% | 3 | 6.0% |
| 5. Slow infiltration | 50 | 99.6% | 16.7% | 0 | 0.4% |
| 6. Nutrients & solids | 48 | 96.0% | 12.5% | 2 | 4.0% |
| 7. Enhanced | 49 | 98.0% | 14.9% | 1 | 2.0% |

The four most effective scenarios (Scenarios 3, 5, 6 and 7) have additional annual costs for wastewater treatment of between $154 and $522 per household. Of these scenarios, Scenario 3: *Rapid infiltration* could deliver improvements at the lowest additional cost if it could be used in isolation, without further treatment upgrades before discharge to land. Scenarios 3 and 5 (the two land-based technologies) could deliver similar improvements for total suspended solids but have a marked difference in cost. Figure C33 shows the relationship between the treatment system's improvement in removing total suspended solids and the increase in annual cost per household. Figure C34 shows the relationship between the annual discharge of suspended solids and annual cost per household.

The key and explanation for these graphs is included at the start of the modelling results section.

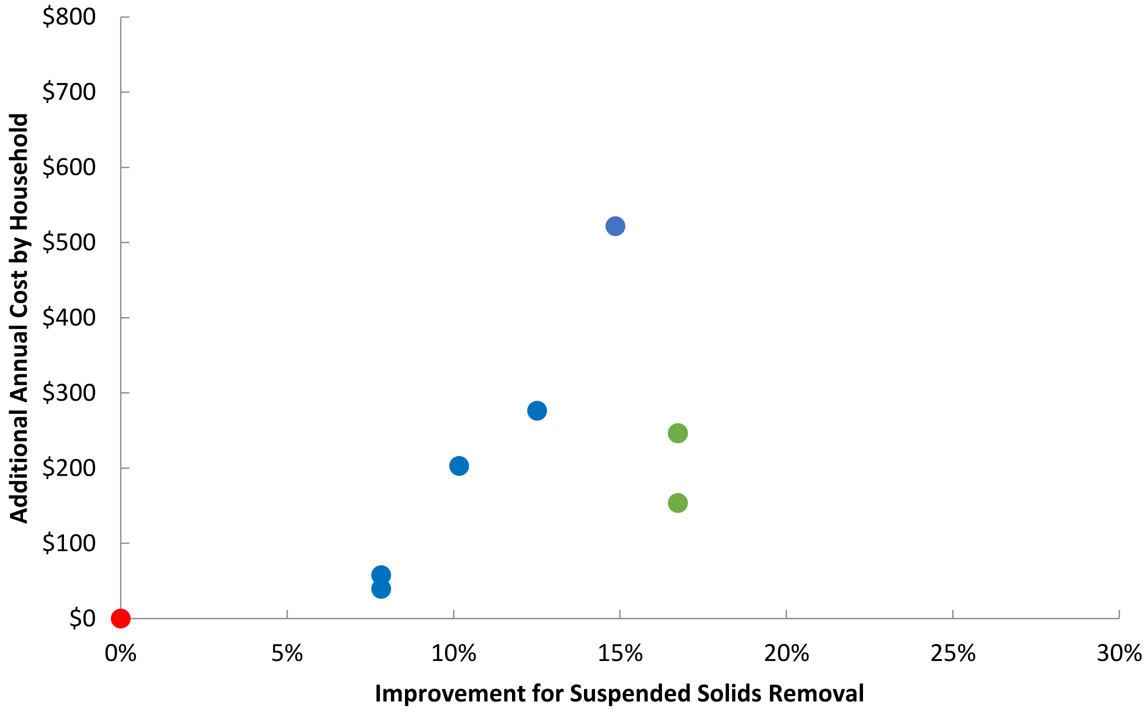



**Figure C33: Winton improvement in treatment for suspended solids**

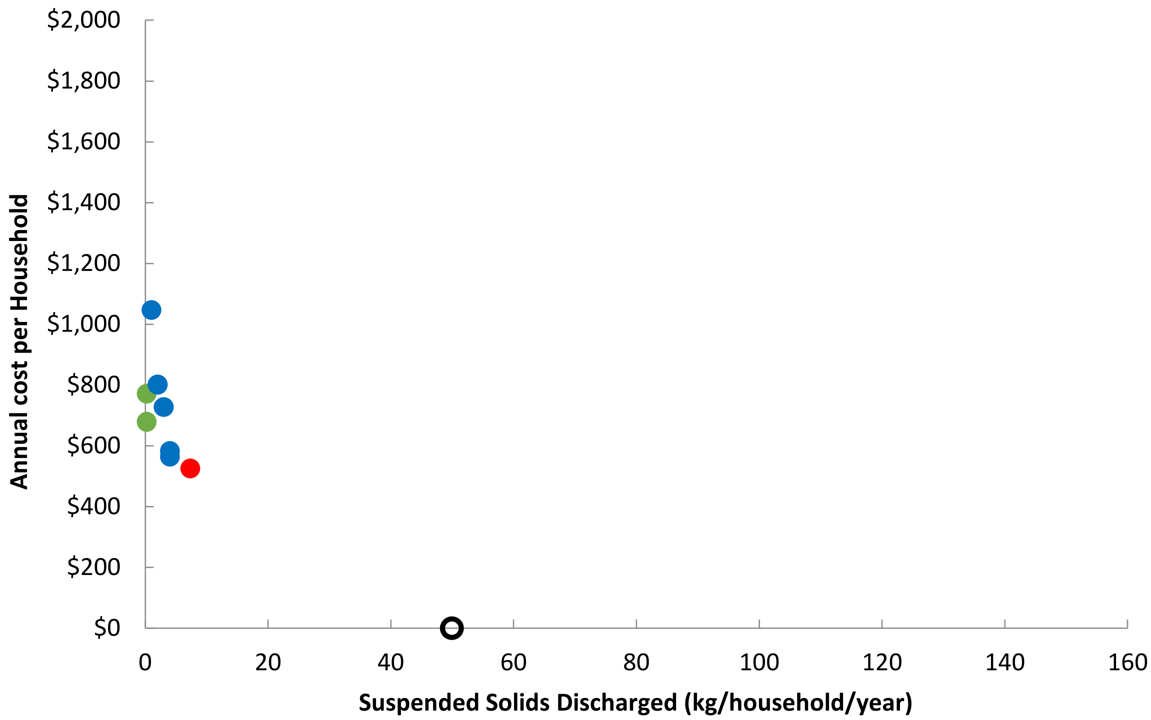



**Figure C34: Winton discharge of suspended solids**

### 4.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing system via an oxidation pond. The existing treatment system reduces 95.7 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Winton system receives a base inflow load of 64.25 tonnes annually, of which 60.14 tonnes are reduced through treatment, and 4.11 tonnes are discharged to surface water.

Of the seven scenarios modelled, Scenario 5: *Slow infiltration* and Scenario 3: *Rapid infiltration* are likely to be the most effective for further reducing biochemical oxygen demand because of reduction through the soil before discharge to groundwater. They were also the best performing scenarios for suspended solids for the same reason. Scenario 7: *Enhanced treatment* could also deliver relatively effective improvements for this contaminant. Scenario 1: *Phosphorus reduction* and Scenario 2: *Pathogen reduction* appear to be the least effective for this contaminant, as they are focused on reduction of other contaminants. Table C25 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both wastewater inflow and the base reduction (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C25: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 47 | 93.6% | 0.0% | 3 | 6.4% |
| 1. Phosphorus | 47 | 94.0% | 0.4% | 3 | 6.0% |
| 2. Pathogens | 47 | 94.0% | 0.4% | 3 | 6.0% |
| 3. Rapid infiltration | 50 | 99.2% | 6.0% | 0 | 0.8% |
| 4. Nutrients | 48 | 96.0% | 2.6% | 2 | 4.0% |
| 5. Slow infiltration | 50 | 99.6% | 6.4% | 0 | 0.4% |
| 6. Nutrients & solids | 48 | 96.0% | 2.6% | 2 | 4.0% |
| 7. Enhanced | 49 | 98.0% | 4.7% | 1 | 2.0% |

The three most effective scenarios (Scenarios 3, 5 and 7) have additional annual costs for wastewater treatment per household of between $154 and $522. Of these scenarios, Scenario 3: *Rapid infiltration* is likely to deliver improvements at the lowest additional cost. Figure C35 shows the relationship between the treatment system's improvement in reducing biochemical oxygen demand and the increasing annual cost per household. Figure C36 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household. The relatively small improvements in treatment and discharge that can be made for this contaminant are likely to increase the annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

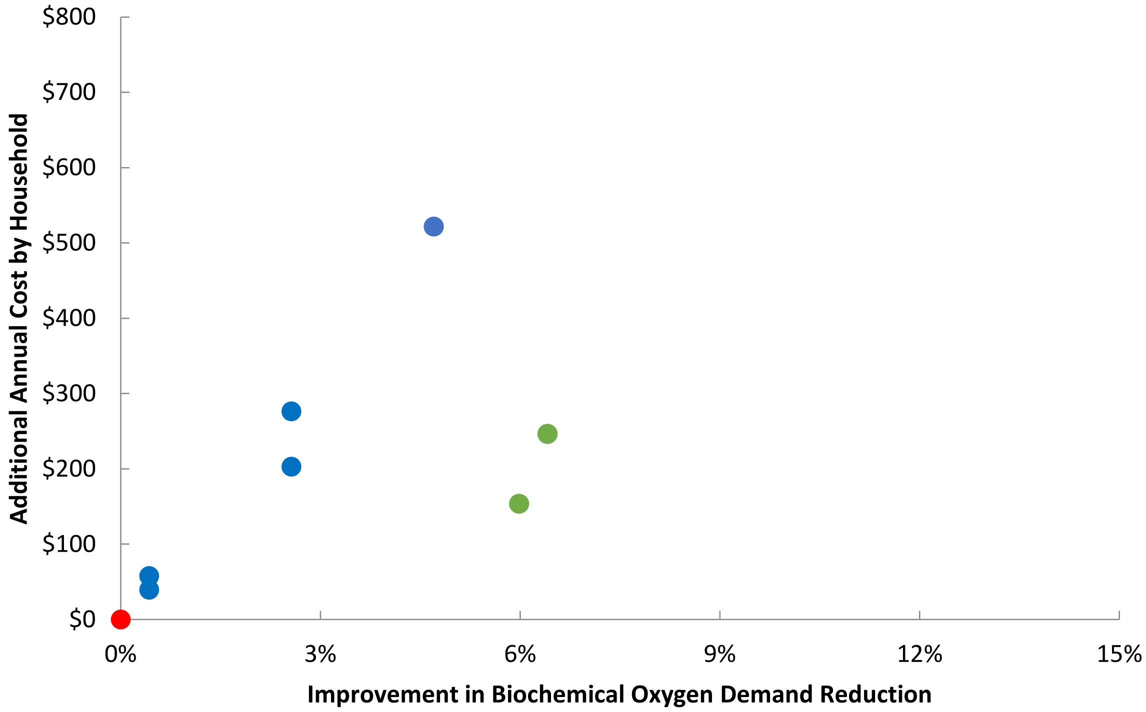



**Figure C35: Winton improvement in treatment for biochemical oxygen demand (BOD)**

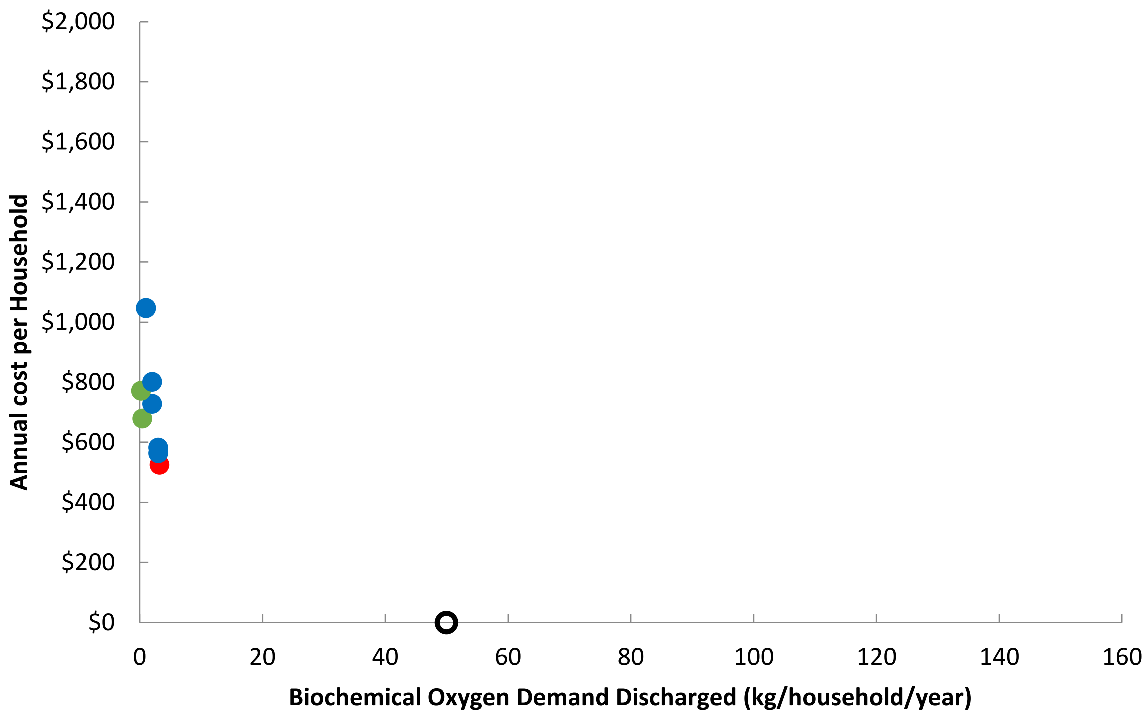



**Figure C36: Winton discharge of biochemical oxygen demand (BOD)**

### 4.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and phosphorus) from the inflow of raw wastewater though to a lesser degree as pond based systems have not been specifically designed with nutrient removal in mind. The existing system removes 70.5 percent of total nitrogen from the wastewater inflow, which although still considerable, is a lower proportion than its removal of suspended solids (91%) and biochemical oxygen demand (96%). The Winton system receives a base inflow load of 12.85 tonnes of total nitrogen annually, of which 7.25 tonnes are removed through treatment, and 5.60 tonnes are discharged to surface water.

The most effective scenarios for removing total nitrogen are Scenario 5: *Slow infiltration* and Scenario 7: *Enhanced treatment*. These two scenarios could remove 90 percent of total nitrogen in the wastewater discharge (up to 3 kg per household per year). Scenario 3: *Rapid infiltration,* Scenario 4: *Nutrients reduction* and Scenario 6: *Nutrients & solids* are moderately effective for total nitrogen. Of the two land-based technologies, slow rate infiltration will be a much more effective choice for dealing with effects of total nitrogen as the nutrients will get taken up by plants as the wastewater infiltrates through the soil. Table C26 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C26: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 6 | 56.4% | 0.0% | 4 | 43.6% |
| 1. Phosphorus | 6 | 56.4% | 0.0% | 4 | 43.6% |
| 2. Pathogens | 6 | 56.4% | 0.0% | 4 | 43.6% |
| 3. Rapid infiltration | 8 | 84.0% | 48.9% | 2 | 16.0% |
| 4. Nutrients | 8 | 80.0% | 41.8% | 2 | 20.0% |
| 5. Slow infiltration | 9 | 90.0% | 59.6% | 1 | 10.0% |
| 6. Nutrients & solids | 8 | 82.0% | 45.4% | 2 | 18.0% |
| 7. Enhanced | 9 | 90.0% | 59.6% | 1 | 10.0% |

The two most effective scenarios (Scenarios 5 and 7) for total nitrogen have relatively high additional annual costs for wastewater treatment per household. The additional annual cost per household of Scenario 5 is $246 and Scenario 7 is $522. Unlike the results for suspended solids and biochemical oxygen demand, the two land-based scenarios do not stand out as being relatively cost-effective. Scenario 4: *Nutrients reduction* could deliver considerable improvements at the lower additional costs than Scenarios 5 and 7. Figure C37 shows the relationship between the treatment system's improvement in removing total nitrogen and the possible increase in annual cost per household. Figure C38 shows the relationship between the annual discharge of total nitrogen and annual cost per household. Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost.

**The key and explanation for these graphs is included at the start of the modelling results section.**

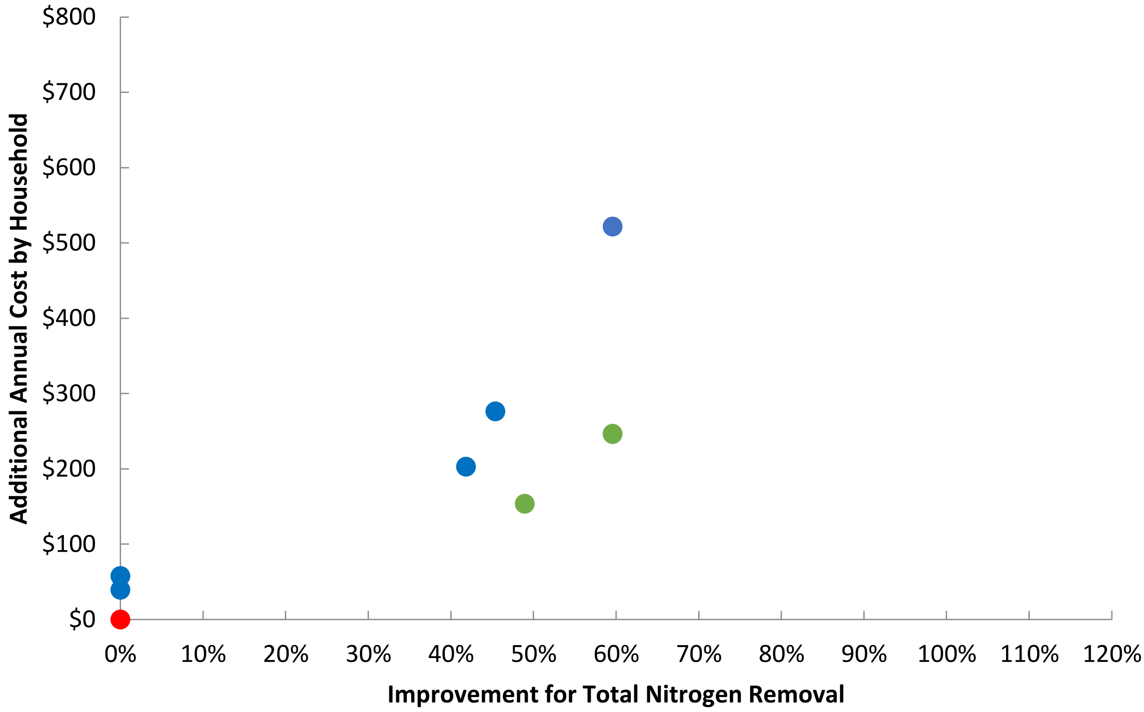



**Figure C37: Winton improvement in treatment for total nitrogen**

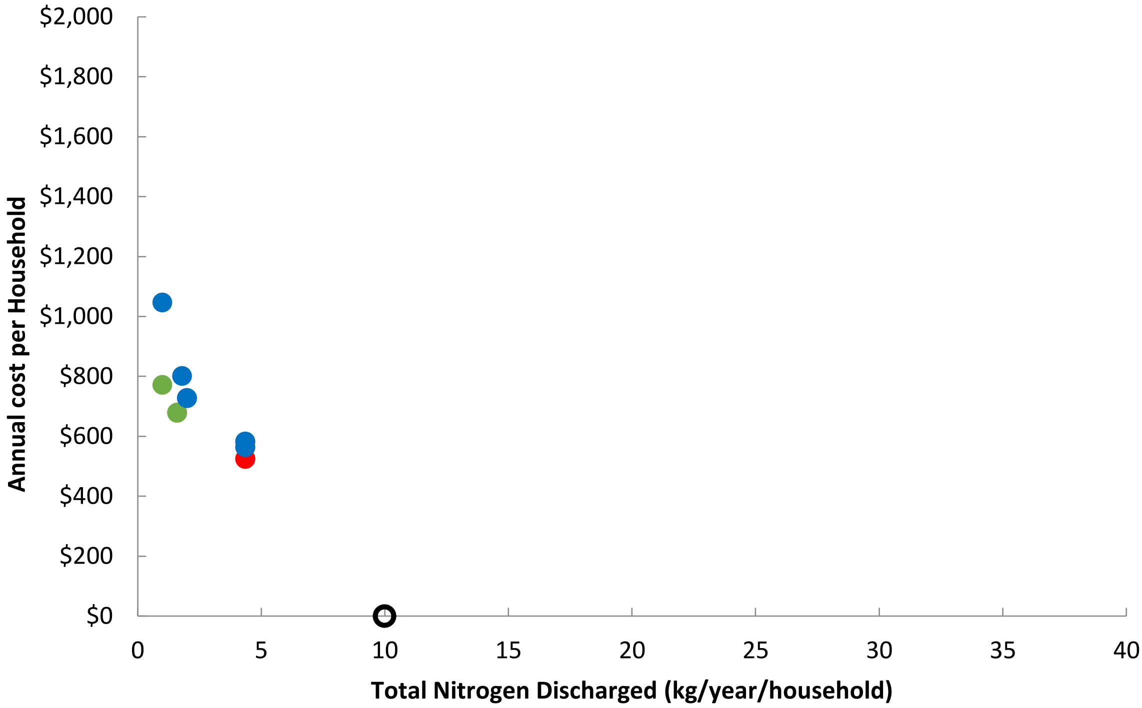



**Figure C38: Winton discharge of total nitrogen**

#### 4.4.4. Total Phosphorus

In addition to total nitrogen, the existing system also removes total phosphorus from the inflow of raw wastewater. Overall, 70.3 percent of the total phosphorus from the wastewater inflow is removed, which is a similar proportion to total nitrogen removal (70.5%). The Winton system receives a base inflow load of 1.80 tonnes of total phosphorus annually, of which 0.82 tonnes are removed through treatment, and 0.98 tonnes are discharged to surface water.

Of all the scenarios modelled, Scenario 7: *Enhanced treatment* is likely to be the most effective for further removal of total phosphorus. Scenario 5: *Slow infiltration* could also deliver effective removal as phosphorous attaches to soil particles as it passes through the soil. Scenario 1: *Phosphorus reduction* is also effective as it encourages particulate to settle out in the system. Scenarios 3 and 5 are the two land-based discharge scenarios, of which Scenario 3: *Rapid infiltration* is less effective for this contaminant because there is less opportunity for the nutrient to be absorbed within the soil. Table C27 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C27: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 0.6 | 45.7% | 0.0% | 0.8 | 54.3% |
| 1. Phosphorus | 1.0 | 71.4% | 56.3% | 0.4 | 28.6% |
| 2. Pathogens | 0.7 | 48.6% | 6.2% | 0.7 | 51.4% |
| 3. Rapid infiltration | 1.0 | 71.4% | 56.3% | 0.4 | 28.6% |
| 4. Nutrients | 0.7 | 48.6% | 6.2% | 0.7 | 51.4% |
| 5. Slow infiltration | 1.1 | 81.4% | 78.1% | 0.3 | 18.6% |
| 6. Nutrients & solids | 0.7 | 48.6% | 6.2% | 0.7 | 51.4% |
| 7. Enhanced | 1.3 | 92.9% | 103.1% | 0.1 | 7.1% |

The scenarios that are relatively effective for total phosphorus (Scenarios 1, 3, 5 and 7) have a wide range of additional annual costs for wastewater treatment, ranging from $39 to $522 per household. Of these scenarios, Scenario 1: *Phosphorus reduction* could deliver improvements at the lowest additional cost, although it is likely to be less effective for other contaminants, as it is not targeted at these other contaminants. Figure C39 shows the relationship between the treatment system's improvement in removing total phosphorus and the possible increase in annual cost per household. Figure C40 shows the relationship between the annual discharge of total phosphorus and annual cost per household.

The key and explanation for these graphs is included at the start of the modelling results section.

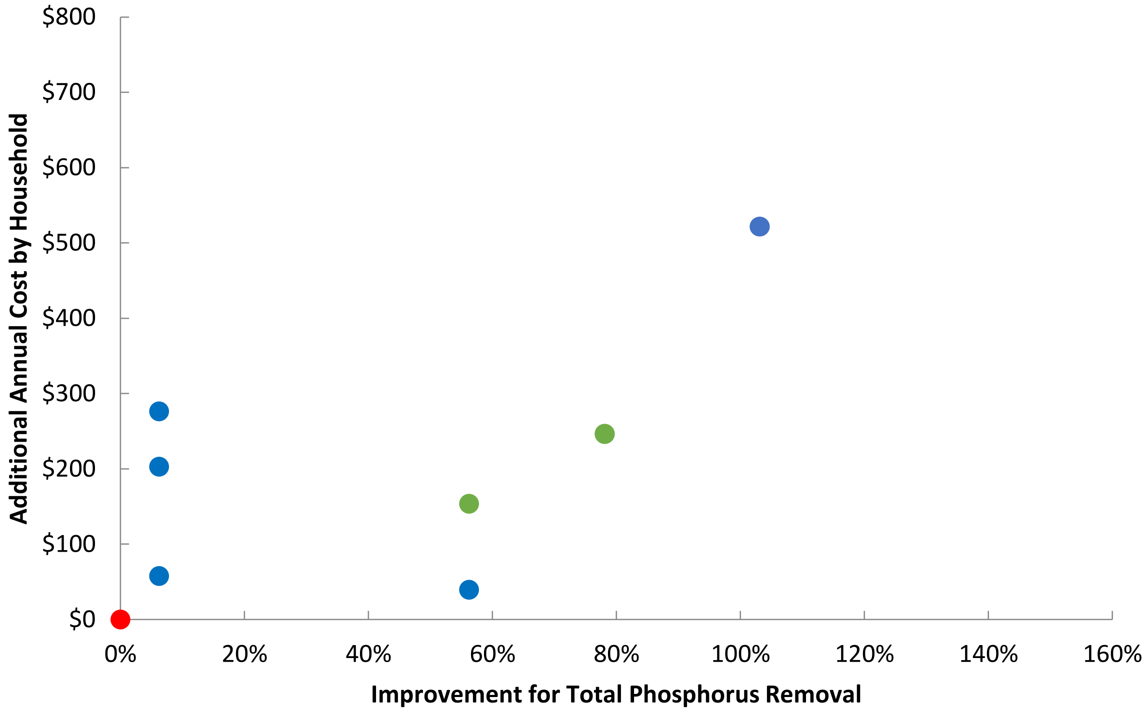



**Figure C39: Winton improvement in treatment for total phosphorus**

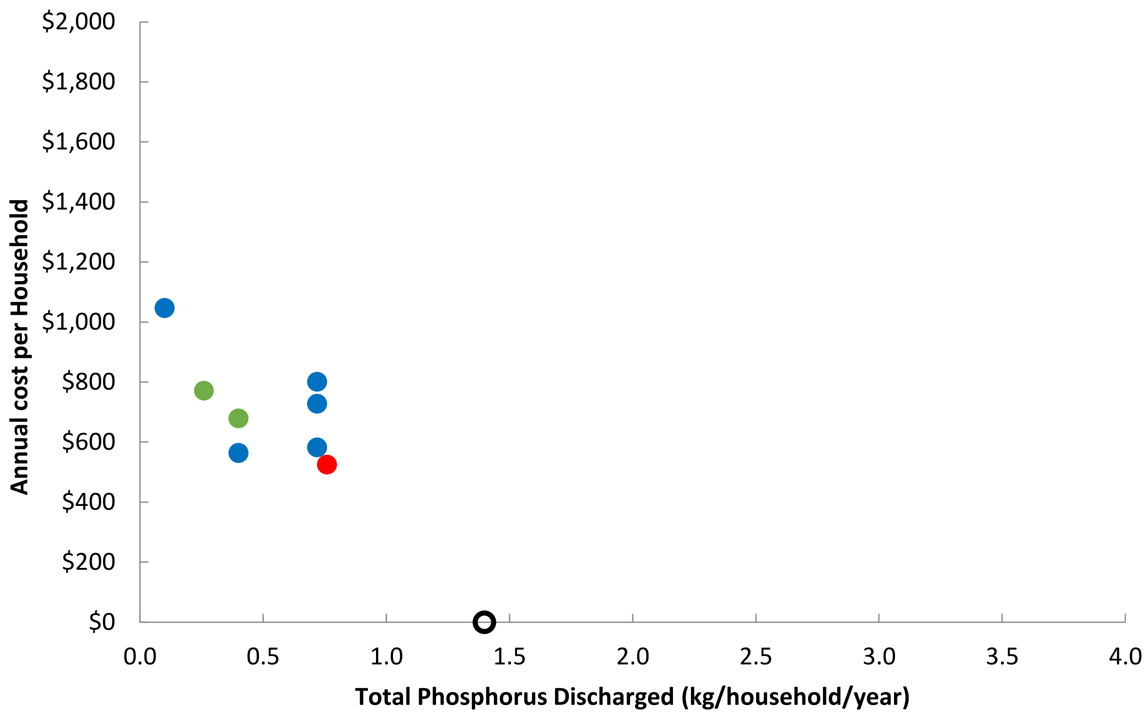



**Figure C40: Winton discharge of total phosphorus**

### 4.4.5. *E. coli*

The existing treatment plant has substantial capability to remove *E. coli* from the raw wastewater inflow through ultraviolet in natural sunlight, natural die off and being consumed by other bacteria and as a food source for other bacteria and algae. On the whole, the existing system removes 99.64 percent of *E. coli*, which is greater proportion than for any other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Winton system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,996,200 cfu/100mL through treatment, so that a concentration of 3,800 cfu/100mL is discharged to surface water.

Of the scenarios modelled, Scenario 5: *Slow infiltration*, Scenario 7: *Enhanced treatment* and Scenario 2: *Pathogen reduction* are likely to be the most effective for further removal of *E. coli*. Scenario 3: *Rapid infiltration* is also likely to deliver improvements in *E. coli* removal. Table C28 summarises the scenario treatment capabilities for *E. coli* compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C28: Annual Loads – *E. coli* (treatment removal and discharge)**

| Scenario | Conc removed (cfu/100mL) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge conc (cfu/100mL) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9,996,190 | 99.96% | 0.000% | 3,810 | 0.038% |
| 1. Phosphorus | 9,996,190 | 99.96% | 0.000% | 3,810 | 0.038% |
| 2. Pathogens | 9,999,874 | 99.999% | 0.037% | 126 | 0.0013% |
| 3. Rapid infiltration | 9,999,076 | 99.991% | 0.029% | 924 | 0.0092% |
| 4. Nutrients | 9,996,190 | 99.96% | 0.000% | 3,810 | 0.038% |
| 5. Slow infiltration | 9,999,925 | 99.999% | 0.037% | 75 | 0.0008% |
| 6. Nutrients & solids | 9,996,190 | 99.96% | 0.000% | 3,810 | 0.038% |
| 7. Enhanced | 9,999,990 | 99.9999% | 0.038% | 10 | 0.0001% |

The four scenarios that could deliver additional capability for *E. coli* (Scenarios 2, 3, 5 and 7) have additional annual costs for wastewater treatment, ranging from $58 to $522 per household. Scenario 2: *Pathogen reduction* is likely to deliver improvements at the lowest additional costs but is less effective for other contaminants, as it does not target these other contaminants. Figure C41 shows the relationship between the treatment system's improvement in removing *E. coli* and the possible increase in annual cost per household. Figure C42 shows the relationship between the annual discharge of *E. coli* and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

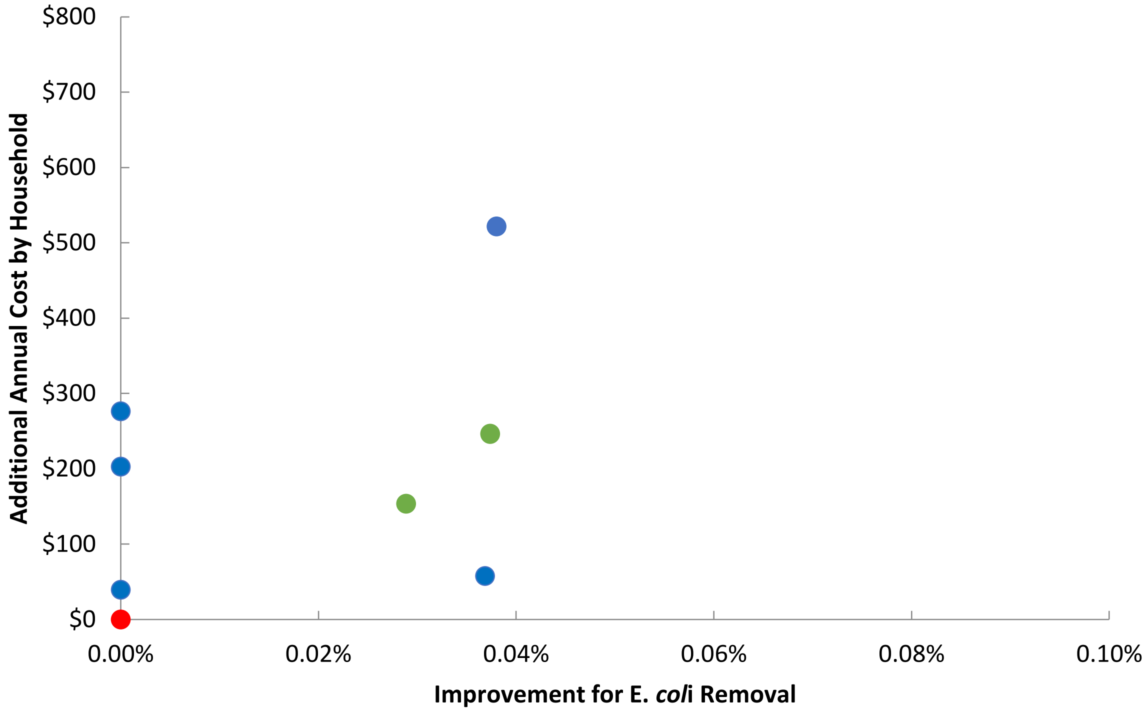



**Figure C41: Winton improvement in treatment for *E. coli***

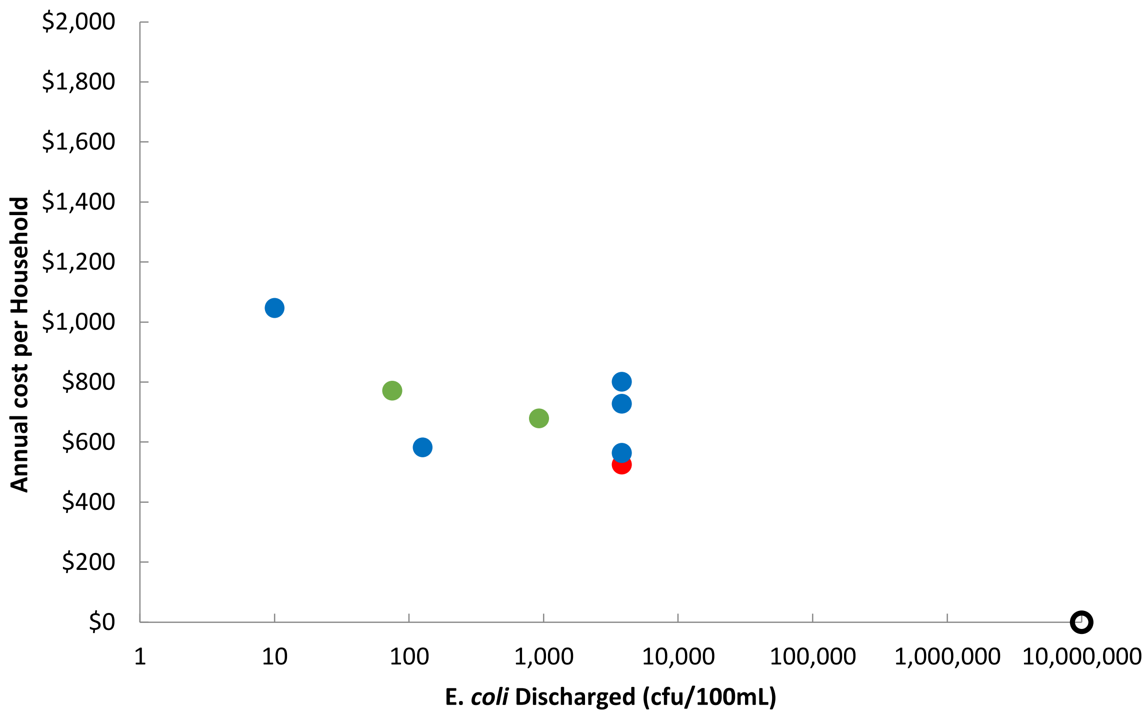



**Figure C42: Winton discharge of *E. coli***

## 4.5. Winton Summary

The current wastewater system is a three millimetre fine screen with oxidation pond with wetland that discharges to the Winton Stream. The oxidation pond was desludged in 2015 with the sludge currently drying on site in a geobag. One of the challenges with this system is that it discharges to a small stream which can have low flows and low dilution at certain times of the year, particularly summer months.

The Winton wastewater scheme receives residential, commercial and light industrial wastewater with limited inflows of trade waste. The existing wastewater treatment capabilities deliver a considerable level of contaminant reduction, especially for biochemical oxygen demand and *E. coli*.

Seven scenarios were modelled for Winton. Each scenario has strengths and weaknesses in its cost or treatment capabilities for each contaminant. The scenarios include options that are either additional to the existing system or replace the existing base system. The capability of the base system means that the scenarios generally give a relatively small percentage improvement in contaminant reduction. The scenarios have a wide range of annual costs per household and these costs may not relate to each scenario's capability to treat particular contaminants.

## 4.6. Limitations and Constraints

There are a number of important limitations to the scenarios modelled. Across the scenarios, redundancy in mechanical plant may be needed, additional sludge production from some scenarios will increase lifecycle costs, and the likelihood of finding appropriate soils near Winton to receive any land disposal discharge is remote.

Occasional failures of mechanical plant can compromise compliance increasing the risk of breaching the discharge consent. Likewise low flow in the receiving waters may also compromise compliance though this is largely beyond Council control. Complex mechanical plants, such as bioreactors, require specialist operator knowledge and input. Additional sludge production for many of the scenarios modelled will require pond desludging projects to occur more often, which increases lifecycle operational costs.

The two land-based scenarios are dependent on the availability of suitable land (either owned by the Council or able to be purchased). At present, Southland District Council does not own any neighbouring land to the wastewater treatment system. Indicative reviews of soils and soil moisture indicate that land disposal around Winton may not be feasible for parts of the year, meaning that a discharge to water will also have to be retained. Having any discharge to water in the future is likely to trigger a requirement to move towards upgrades involving more complex mechanical plants, with increased risk of failure and operating costs.

# 5. Nightcaps

## 5.1. Nightcaps Wastewater Scheme

The Nightcaps wastewater scheme was built in 1988, and upgraded in 1995 when a weeded drain was added. The scheme has 196 total equivalent connections (including schools and businesses) and receives largely domestic wastewater. Total annual wastewater inflow into the plant is estimated at around 35,000 $m^3$ with the daily flow ranging between 85 $m^3$ and 105 $m^3$. The scheme currently consists of standard reticulation and the treatment system is a single stage oxidation pond with a concrete wave band, rock bed filters, and a weeded drain. The treated wastewater is discharged into the Wairio Stream about 300 metres downstream of the oxidation pond. The wastewater treatment system is on Leithen Street, south of High Street and west of Nightcaps golf course.

Southland District Council holds two resource consents to discharge treated wastewater to land (via the base of the rock filter beds and weeded drain) and then to water (Wairio Stream) from the Nightcaps wastewater treatment system. This current resource consent will expire in July 2027. During the consent term the oxidation pond will be desludged to improve performance.

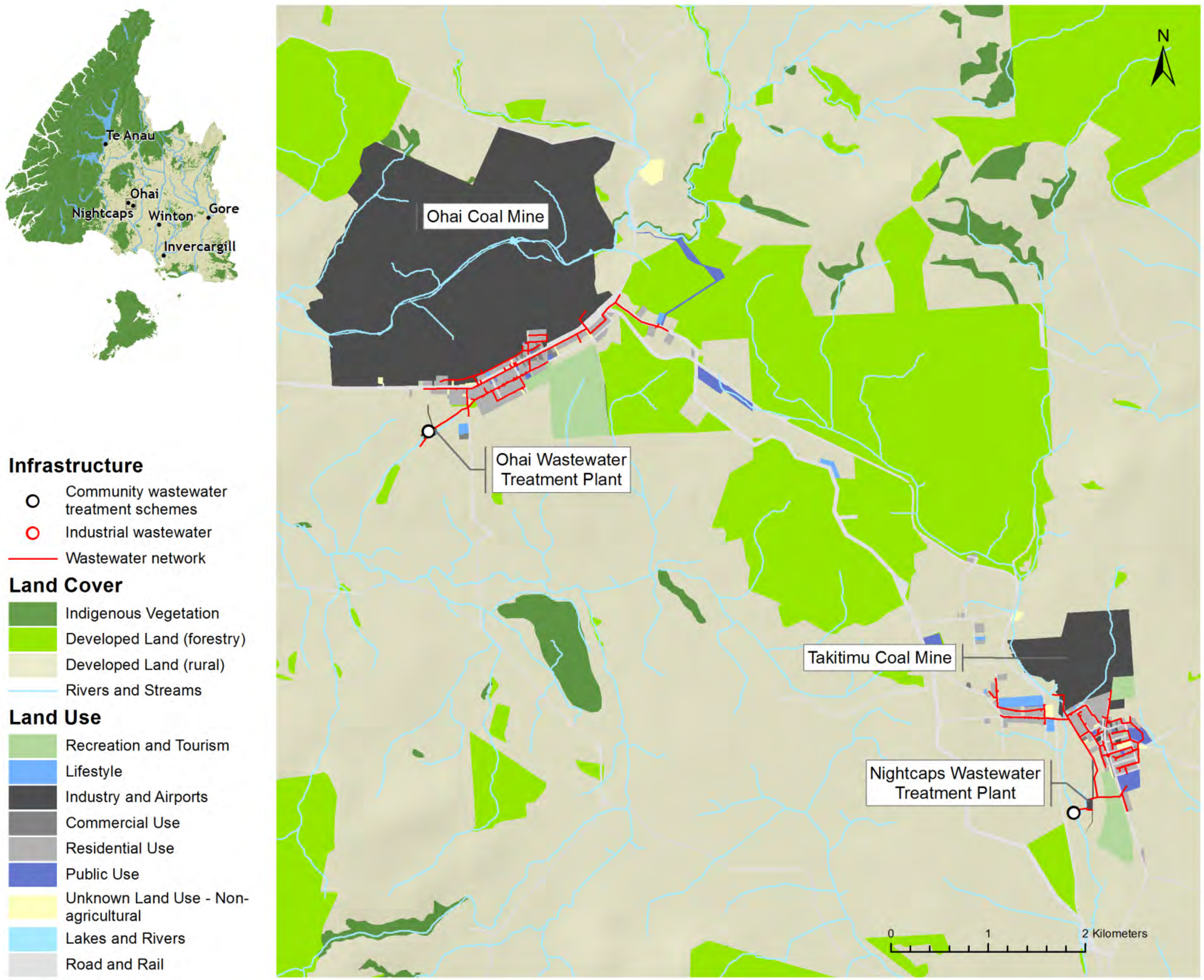
**Image C7: Nightcaps oxidation pond July 2014**

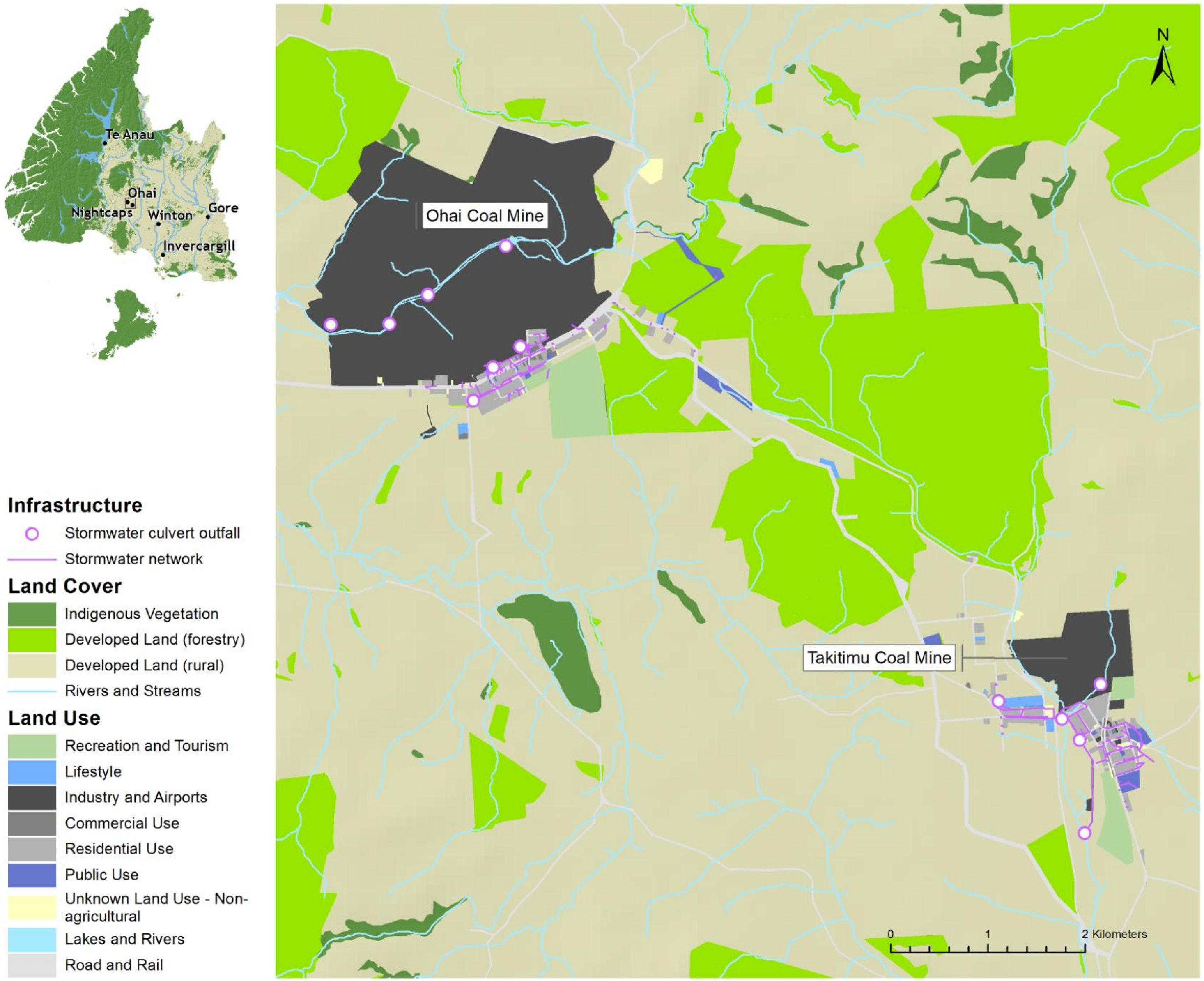
At the wastewater treatment system, the oxidation pond gives solids removal and secondary treatment[13] – while there is some reduction in nitrogen, phosphorus and other organic pollutants at this stage it is not the primary function of the pond. The rock filter beds (50 m x 1.5 m) are designed for polishing[14] – they filter algae and suspended solids as the treated wastewater percolates through into the weeded drain. The treated wastewater flows through a 1.3 kilometre long vegetated ditch with natural weeds that are managed for additional polishing before being discharged into the Wairio Stream. There are few recorded bores nearby. Water quality in the Wairio Stream above the wastewater discharge is reduced by other activities in the catchment and the discharge is likely to be contributing to elevated nutrients and micro-organisms downstream.

The following two maps show the Nightcaps (and Ohai) wastewater and stormwater schemes.

[13] Micro-organisms present within the upper levels of the pond break down organic matter in aerobic conditions and reduce the biological oxygen demand of the wastewater. Facultative and anaerobic micro-organisms breakdown the settled solids.

[14] By 2016 the rock filter beds had become overgrown and silted, and now likely function as an extension of the weeded drain. Some nutrient removal is possible in the drain through plant uptake, as well as reduction in bacteriological contaminants through exposure to sunlight.


Te Anau
Ohai
Nightcaps
Winton
Gore
Invercargill
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
N
Ohai Coal Mine
Ohai Wastewater Treatment Plant
Takitimu Coal Mine
Nightcaps Wastewater Treatment Plant
0
1
2 Kilometers


Te Anau
Ohai
Nightcaps
Winton
Gore
Invercargill
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
N
Ohai Coal Mine
Takitimu Coal Mine
0
1
2 Kilometers

## 5.2. Baseline Results

This section describes the baseline results for Nightcaps (i.e. what is actually occurring). The total annual inflow of wastewater into the Nightcaps treatment plant is estimated at around 34,900 $m^3$ with the daily flow ranging between 85 $m^3$ and 105 $m^3$. Table C29 identifies the quantity of contaminants (total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli)* removed annually from the raw wastewater by the existing treatment process. Table C30 gives information on the average quality of the treated wastewater discharged to the Wairio Stream.

**Table C29: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2013-2016 | Total SS (tonnes) | BOD (tonnes) | Total N (tonnes) | Total P (tonnes) | *E. coli* (cfu/100ml) |
|---|---|---|---|---|---|
| Average (4 years) | 7.7 | 8.5 | 1.4 | 0.2 | ~9,991,000 |

**Table C30: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **(g/m³)** | **(g/m³)** | **(g/m³)** | **(g/m³)** | **(cfu/100ml)** |
| Average (5 years) | 28.6 | 7.4 | 10.1 | 1.7 | 8,600 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (4 years) | 0.6 to 1.6 | 0.3 to 0.3 | 0.3 to 0.7 | 0.0 to 0.1 | N.A. |
| Estimated loads | 1.0 | 0.3 | 0.4 | 0.1 | N.A. |

Source: Environment Southland consent monitoring data

Based on the June 2017 valuation, the total replacement value of all the assets of wastewater scheme is $3 million (around $18,000 per household). As with all of the schemes, the largest contributor is the reticulated pipe network, which accounts for roughly 85 percent of the replacement value. The oxidation pond itself has a replacement cost of $413,600. The rest of the scheme's value is made up of assets such as manholes, sewer laterals and a single pump station.

The annual depreciated value of the wastewater scheme is $40,000 and the annual operating cost is $50,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C31 using the methodology described in Section C1.5.

Figure C43 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[15] before being plotted to make it possible to include all five different contaminants on the same graph.

[15] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

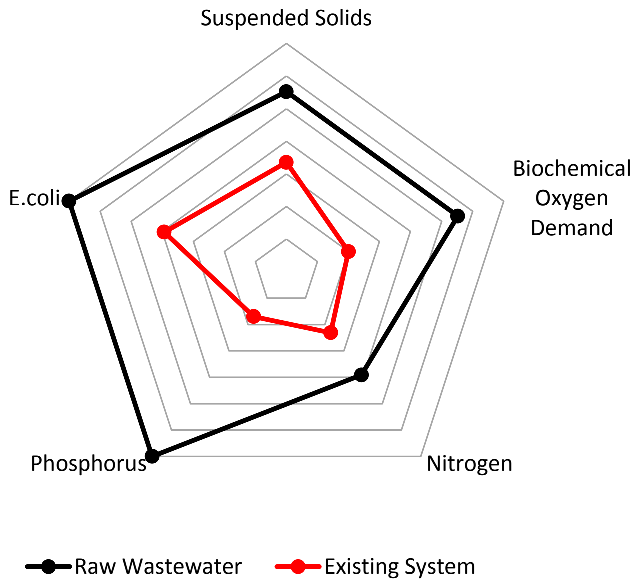



**Figure C43: Nightcaps baseline scenario (existing system)**

## 5.3. Modelling Scenarios

Five scenarios were developed for the Nightcaps wastewater system (the scenarios and treatment processes as listed below with more details are in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Further work is needed to determine whether any scenario is technically feasible, especially those where part of the solution includes land-based treatment and disposal. Table C31 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 161 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

The two discharge to land scenarios are also likely to be used together with other treatment processes. For example, a rapid infiltration discharge route may require further solids removal. Likewise, an ultraviolet plant may also require an initial solids removal step to increase its efficiency.

| **Scenario** | **Treatment Process (new units in bold)** |
|---|---|
| Existing System | Liquid: oxidation pond, rock filter beds, |
| | Solid: storage in pond |
| 1. Phosphorus reduction | Liquid: oxidation pond, rock filter beds, **chemical dosing** |
| | Solid: as existing |
| 2. Nutrient reduction | Liquid: oxidation pond, rock filter beds, **wetland** |
| | Solid: as existing |

| Scenario | Treatment Process (new units in bold) |
|---|---|
| 3. Pathogen reduction | Liquid: oxidation pond, rock filter beds, **UV disinfection** |
| | Solid: as existing |
| 4. Rapid infiltration | Existing process **+ high rate infiltration (rapid infiltration basins etc.)** |
| 5. Slow infiltration | Existing process **+ slow rate infiltration (spray irrigation etc.)** |

**Table C31: Nightcaps Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| **Existing scheme** | $3,773,000 | $781 |
| **1. Phosphorus reduction** | $4,359,000 | +$121 |
| **2. Nutrient reduction** | $4,378,000 | +$125 |
| **3. Pathogen reduction** | $4,777,000 | +$208 |
| **4. Rapid infiltration (includes partial cost of land purchase)** | $6,292,000 | +$521 |
| **5. Slow infiltration (includes partial cost of land purchase)** | $6,733,000 | +$613 |

Figures C44 and Figure C45 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C43 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater. Except for phosphorus, the concentrations of the contaminants were transformed[16] before being plotted to make it possible to include all five different contaminants on the same graph.

[16] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

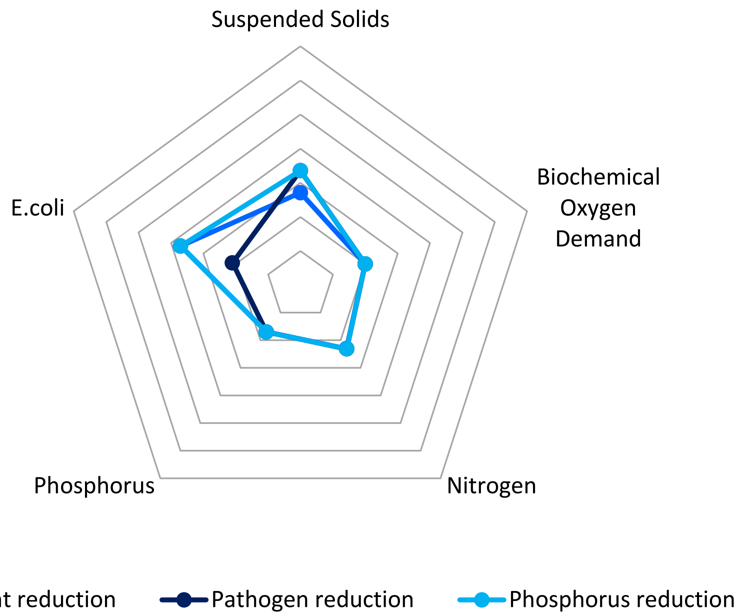



**Figure C44: Nightcaps 'discharge to water' scenarios**

Note: The scenarios achieve similar performance for some contaminants so the results overlap on the graph

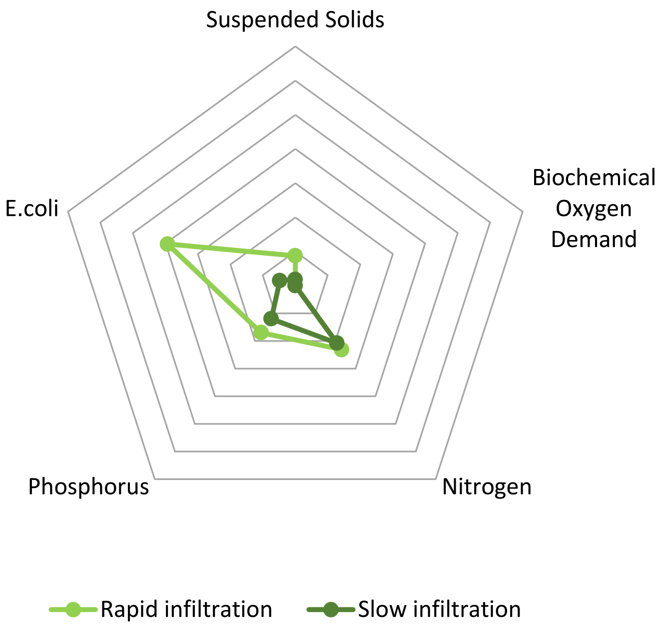



**Figure C45: Nightcaps 'discharge to land' scenarios**

Note: The scenarios achieve similar performance for some contaminants so the results overlap on the graph

## 5.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*Two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot*** *for the existing level of treatment (i.e. the base);*
- ***blue dots*** *for modelling scenarios representing discharges to water; and*
- ***green dots*** *for modelling scenarios representing discharges to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have* ***a clear black dot****, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 5.4.1. Total Suspended Solids

The existing system (the base) removes a substantial proportion of total suspended solids from the inflow of raw wastewater through its different treatment processes. The screen removes large solids, the oxidation pond adds some removal of bacteria and solids via settlement. Overall, the existing treatment system removes 88.6 percent of total suspended solids in the wastewater inflow. The Nightcaps system receives a base inflow load of 8.73 tonnes of solids annually, of which 7.7 tonnes are removed through treatment, and 1.0 tonne is discharged to surface water (roughly 2.5 kg per day).

Of the five scenarios modelled for Nightcaps, Scenario 5: *Slow infiltration* and Scenario 4: *Rapid infiltration* are likely to be the most effective at removing total suspended solids because of filtration through the soil before discharge to groundwater. Scenario 2: *Nutrient reduction* could also be an effective option for this contaminant. Scenario 1: *Phosphorus reduction* and Scenario 3: *Pathogen reduction* appear to be less effective for this contaminant – chemical dosing can be an effective process for solids removal but depends on the chemical dosed This scenario is focused on phosphorus reduction rather than solids reduction. Table C32 summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C32: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 48 | 88.6% | 0.0% | 6 | 11.4% |
| 1. Phosphorus | 48 | 88.6% | 0.0% | 6 | 11.4% |
| 2. Nutrients | 51 | 94.0% | 6.1% | 3 | 6.0% |
| 3. Pathogens | 148 | 88.6% | 0.0% | 6 | 11.4% |
| 4. Rapid infiltration | 54 | 99.0% | 11.8% | 1 | 1.0% |
| 5. Slow infiltration | 54 | 99.5% | 12.4% | 0 | 0.5% |

The three most effective scenarios (Scenarios 2, 4 and 5) have additional annual costs for wastewater treatment of between $125 and $613 per household. Of these scenarios, Scenario 2: *Nutrient reduction* could deliver improvements at the lowest additional cost. Figure C46 shows the relationship between the treatment system's improvement in removing total suspended solids and the possible increase in annual cost per household. Scenario 1: *Phosphorus reduction* and Scenario 3: *Pathogen reduction* have little improvement for removal of total suspended solids and could increase costs to the household. Figure C47 shows the relationship between the annual discharge of suspended solids and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

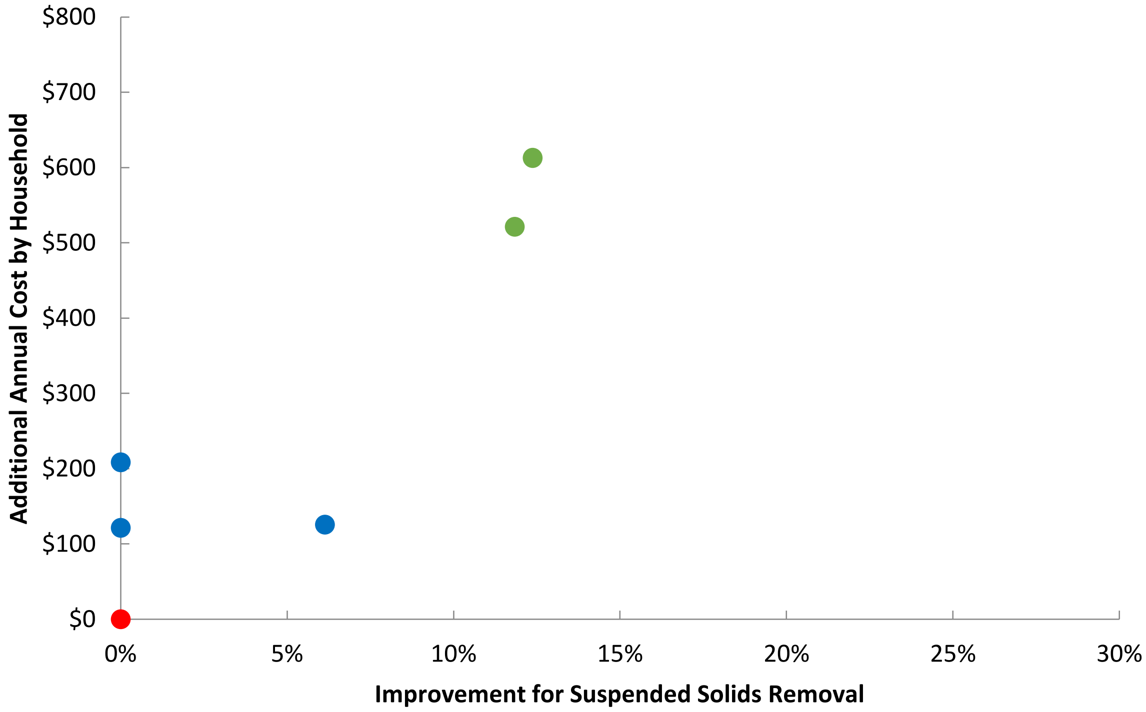



**Figure C46: Nightcaps improvement in treatment for suspended solids**

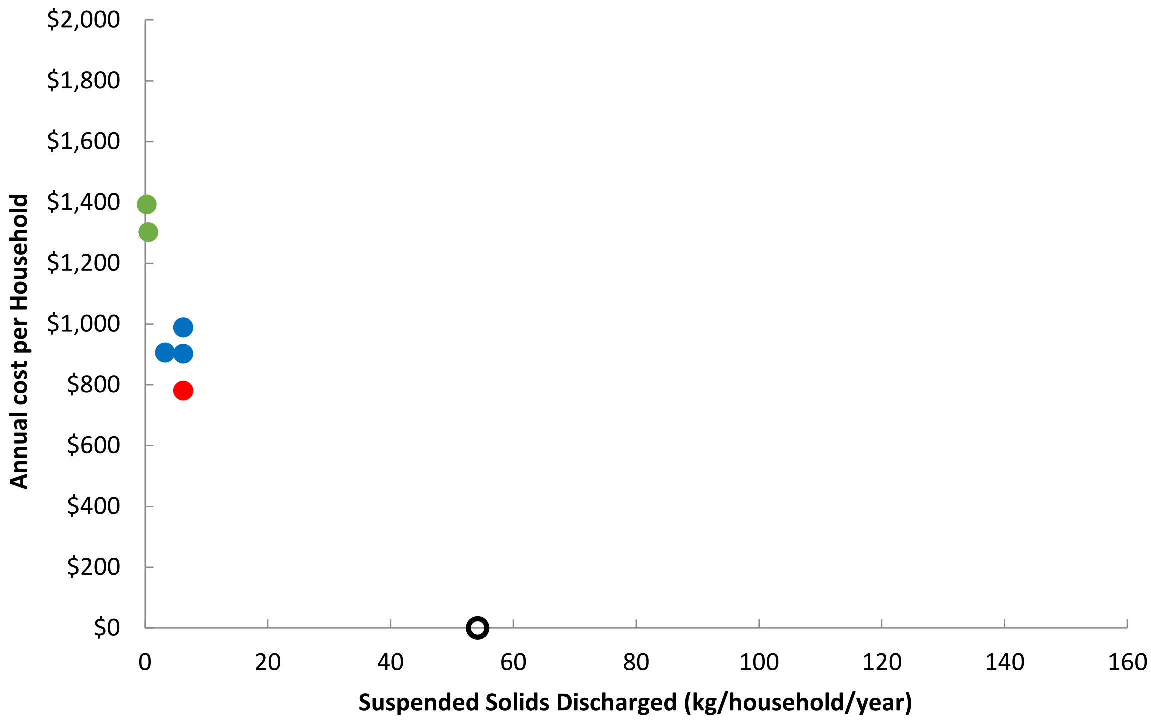



**Figure C47: Nightcaps discharge of suspended solids**

### 5.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing treatment system via the single oxidation pond. The existing treatment system reduces 97 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Nightcaps system receives a base inflow load of 8.7 tonnes annually, of which 8.47 tonnes are reduced through treatment, and 0.2 tonne is discharged to surface water (roughly 0.6 kg per day).

Of the five scenarios modelled, Scenario 4: *Rapid infiltration* and Scenario 5: *Slow infiltration* are likely to be the most effective for further reducing biochemical oxygen demand. They were also the better performing scenarios for suspended solids. All of the other scenarios, Scenario 1: *Phosphorus reduction*, Scenario 2: *Nutrient reduction* and Scenario 3: *Pathogen reduction* are less effective in delivering improvements for this contaminant. Table C33 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both the wastewater inflow and the base reduction (the existing system). It also gives the resulting discharge for the base and all scenarios. Overall, the different scenarios are likely to deliver relatively small improvements because the existing treatment system performs particularly well for this contaminant.

**Table C33: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 53 | 97.0% | 0.0% | 2 | 3.0% |
| 1. Phosphorus | 53 | 97.0% | 0.0% | 2 | 3.0% |
| 2. Nutrients | 53 | 97.0% | 0.0% | 2 | 3.0% |
| 3. Pathogens | 53 | 97.0% | 0.0% | 2 | 3.0% |
| 4. Rapid infiltration | 54 | 99.6% | 2.6% | 0 | 0.4% |
| 5. Slow infiltration | 54 | 99.6% | 2.6% | 0 | 0.4% |

The two most effective scenarios (Scenarios 4 and 5) have an additional annual cost for wastewater treatment per household of $521 and $613. Of these scenarios, Scenario 4: *Rapid infiltration* is likely to deliver improvements at the lowest additional cost. Figure C48 shows the relationship between the treatment system's improvement in reducing biochemical oxygen demand and the possible increase in annual cost per household. Figure C49 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household. The relatively small improvements in treatment and discharge that can be made for this contaminant are likely to increase the annual cost per household.

The key and explanation for these graphs is included at the start of the modelling results section.

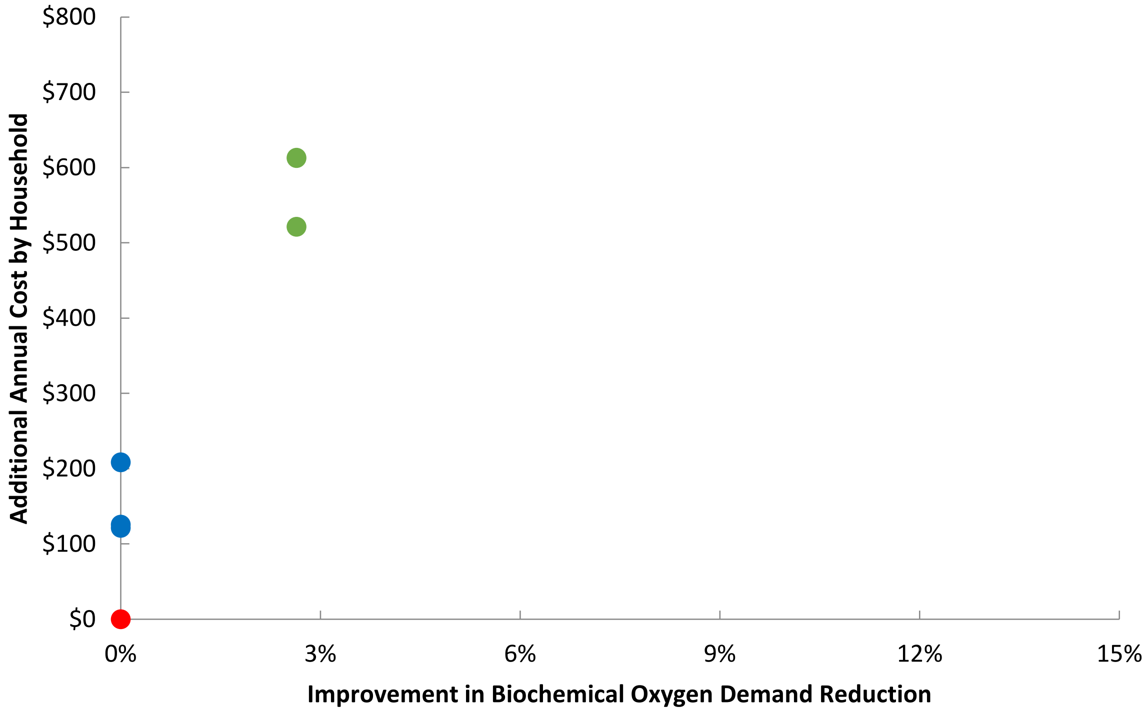



**Figure C48: Nightcaps improvement in treatment for biochemical oxygen demand (BOD)**

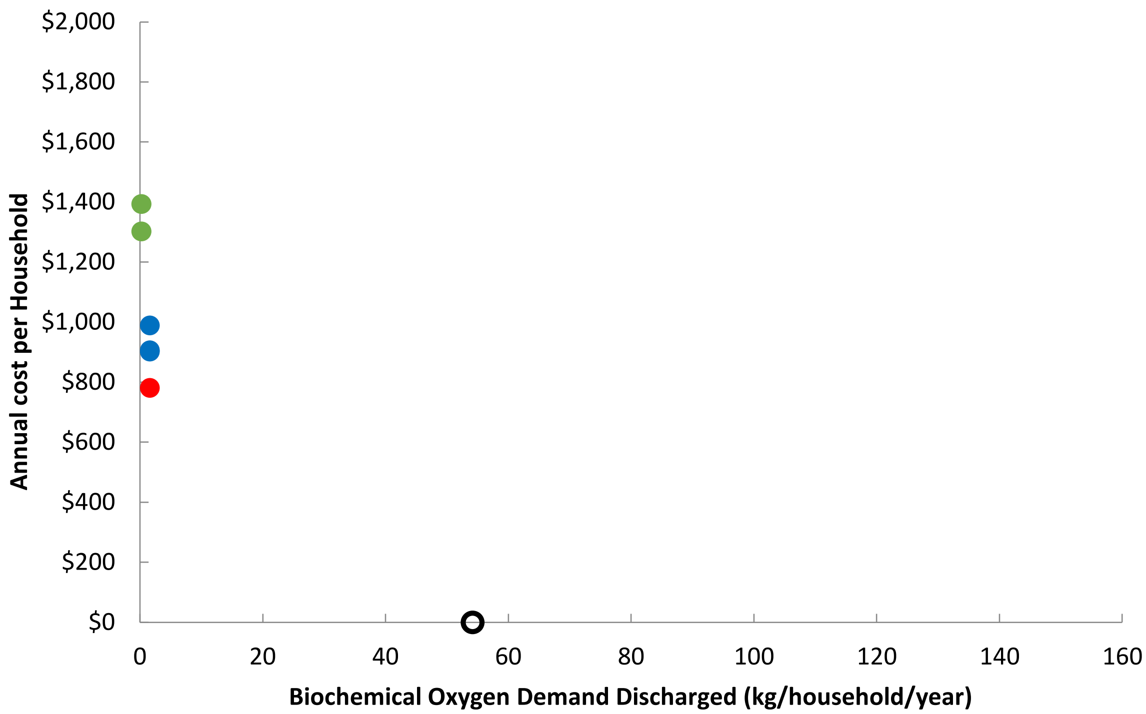



**Figure C49: Nightcaps discharge of biochemical oxygen demand (BOD)**

### 5.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and total phosphorus) from the inflow of raw wastewater via its oxidation pond, rock filter beds and vegetation ditch. The existing system removes 79.8 percent of total nitrogen from the wastewater inflow, which is, although still considerable, a lower proportion than its removal of suspended solids (89%) and biochemical oxygen demand (97%). The Nightcaps system receives a base inflow load of 2.21 tonnes of total nitrogen annually, of which 1.75 tonnes are removed through treatment, and 0.35 tonne is discharged to surface water (roughly 0.9 kg per day).

No scenario achieved a marked reduction in nitrogen when compared to the assumed performance of the existing system, which achieves 80 per cent reduction. The most effective scenario for removing total nitrogen could be Scenario 5: *Slow infiltration*, which increases reduction to 84 percent of the total nitrogen in the wastewater discharge (up to 0.5 kg per household per year). Scenario 2: *Nutrient reduction*, results in a more consistent reduction in nitrogen in comparison to the existing system but given the assumptions made in the analysis, its improvement is largely indiscernible. The remaining scenarios appear to be less effective for this contaminant as they are not typically designed or installed with nitrogen removal in mind. Of the two land-based scenarios, total nitrogen is the only case where Scenario 4: *Rapid infiltration* is likely to be less effective and in this case study did not achieve any nitrogen reduction. Table C34 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C34: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9 | 79.8% | 0.0% | 2 | 20.2% |
| 1. Phosphorus | 9 | 79.8% | 0.0% | 2 | 20.2% |
| 2. Nutrients | 9 | 80.0% | 0.3% | 2 | 20.0% |
| 3. Pathogens | 9 | 79.8% | 0.0% | 2 | 20.2% |
| 4. Rapid infiltration | 9 | 79.8% | 0.0% | 2 | 20.2% |
| 5. Slow infiltration | 9 | 84.0% | 5.3% | 2 | 16.0% |

Of the two scenarios that achieve some additional nitrogen reduction over the existing system (Scenarios 2 and 5), Scenario 2: *Nutrient reduction* has the lowest additional cost for wastewater treatment per household. The cost of Scenario 2 is $125. Similar to suspended solids, the land-based technologies (Scenarios 4 and 5) do not stand out as being cost-effective by comparison. Figure C50 shows the relationship between the treatment system's improvement in removing total nitrogen and the possible increase in annual cost per household. Figure C51 shows the relationship between the annual discharge for total nitrogen and annual cost per household. Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost. This effect is less than for the other case studies.

**The key and explanation for these graphs is included at the start of the modelling results section.**

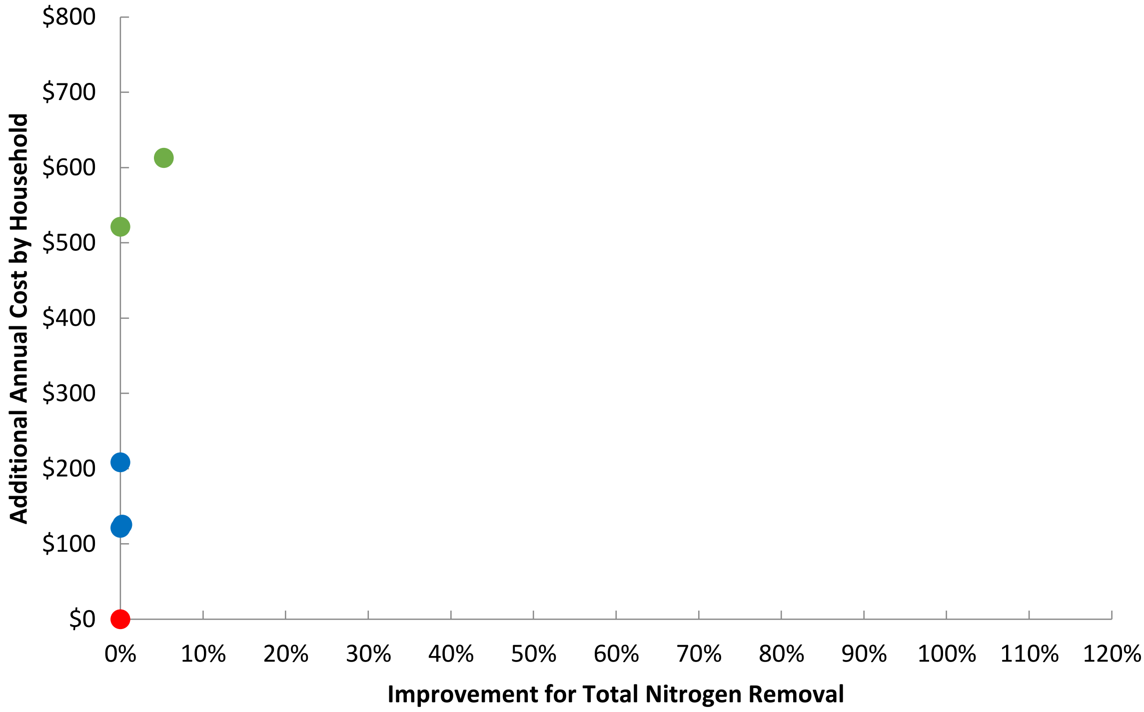



**Figure C50: Nightcaps improvement in treatment for total nitrogen**

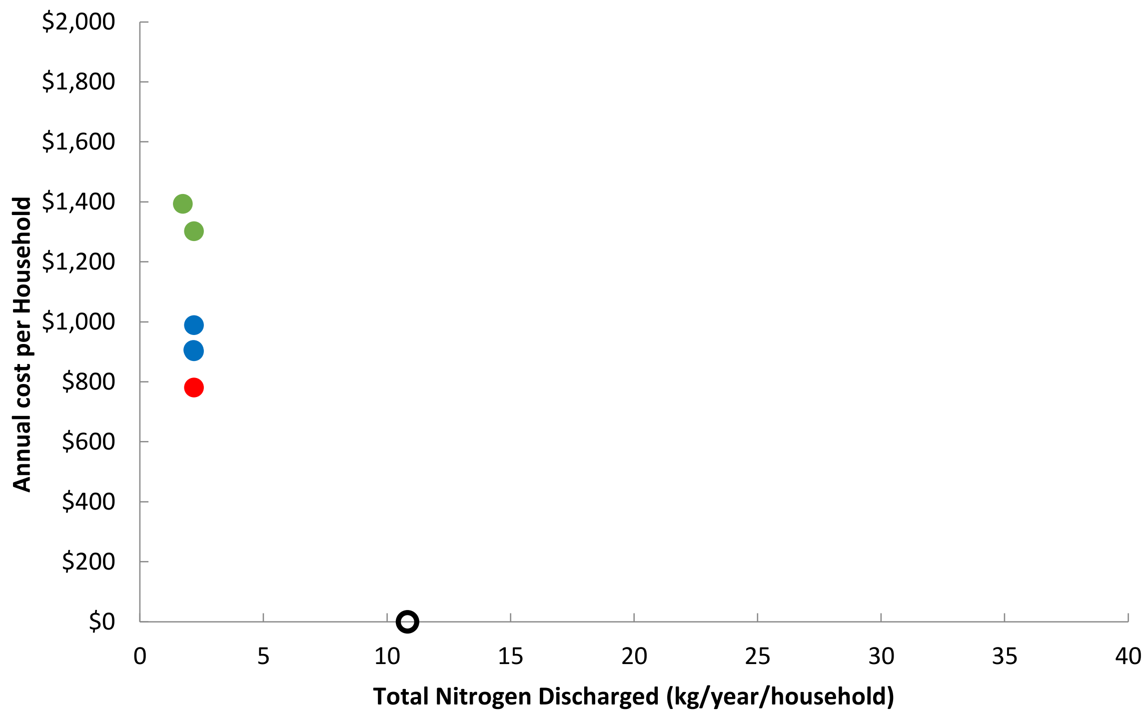



**Figure C51: Nightcaps discharge of total nitrogen**

### 5.4.4. Total Phosphorus

In addition to total nitrogen, the existing system removes phosphorus from the inflow of raw wastewater. Overall, 75.7 percent of the total phosphorus from the wastewater inflow is removed, which is close to the proportion of total nitrogen removal (79.8%). The Nightcaps system receives a base inflow load of 0.24 tonne of total phosphorus annually, of which 0.18 tonne is removed through treatment, and 0.06 tonne is discharged to surface water.

Scenario 1: *Phosphorus reduction* results in a more consistent reduction in phosphorus in comparison to the existing system, as it specifically targets phosphorus reduction through chemical addition but given the assumptions made in the analysis, its improvement is largely indiscernible. Scenario 5: *Slow infiltration* could also deliver improvements for this contaminant as the phosphorus will bind to soil particles. All the other scenarios appear to be less effective for this contaminant. Table C35 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C35: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 1.1 | 75.7% | 0.0% | 0.4 | 24.3% |
| 1. Phosphorus | 1.1 | 75.7% | 0.0% | 0.4 | 24.3% |
| 2. Nutrients | 1.1 | 75.7% | 0.0% | 0.4 | 24.3% |
| 3. Pathogens | 1.1 | 75.7% | 0.0% | 0.4 | 24.3% |
| 4. Rapid infiltration | 1.1 | 75.7% | 0.0% | 0.4 | 24.3% |
| 5. Slow infiltration | 1.3 | 82.9% | 9.4% | 0.3 | 17.1% |

The two scenarios that are relatively effective for total phosphorus (Scenarios 1 and 5) have additional annual costs of $121 and $613 per household. Of these scenarios, Scenario 1: *Phosphorus reduction* is likely to deliver the most consistent improvements at the lowest additional cost. Figure C52 shows the relationship between the treatment system's improvement in total phosphorus removal and the possible increase in annual cost per household. Figure C53 shows the relationship between the annual discharge of total phosphorus and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

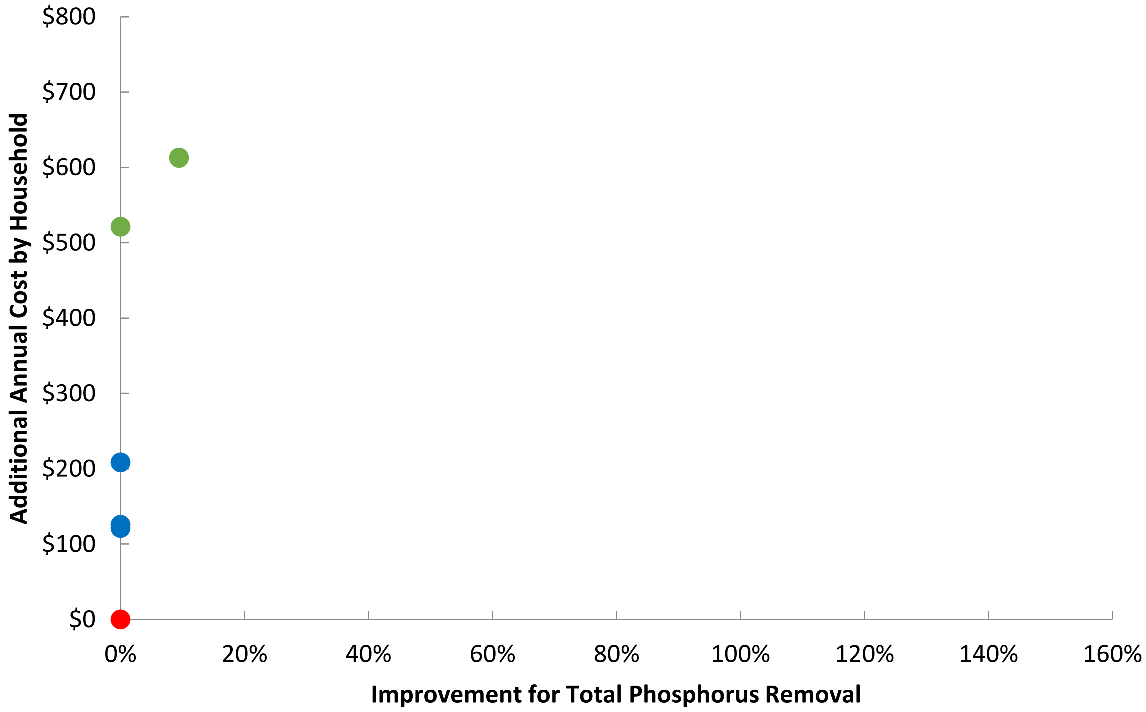



**Figure C52: Nightcaps improvement in treatment for total phosphorus**

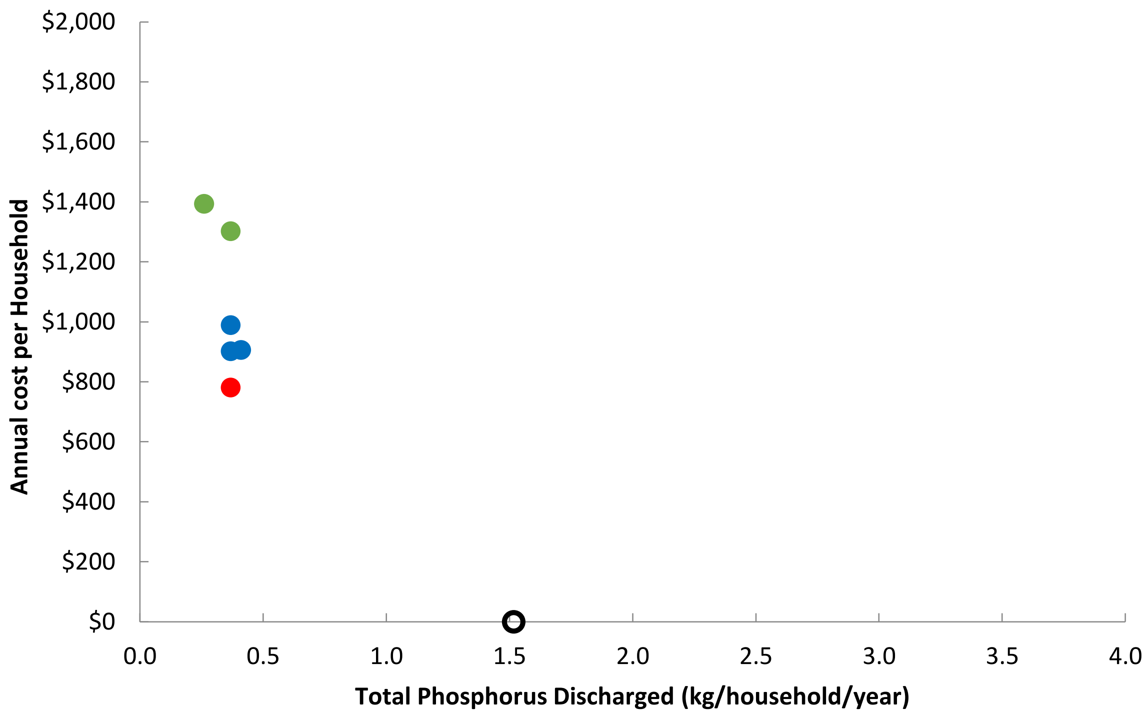



**Figure C53: Nightcaps discharge of total phosphorus**

### 5.4.5. *E. coli*

As with other wastewater treatment systems, the existing oxidation pond has substantial capability to remove *E. coli* from the wastewater inflow through die off from natural ultraviolet disinfection (sunlight) and as a food source for other biological process within the pond. The system removes 99.91 percent of *E. coli*, which is a greater proportion than any of the other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Nightcaps system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,991,400 cfu/100mL through treatment, so that a concentration of 8,600 cfu/100mL is discharged to surface water.

Of the scenarios modelled, Scenario 3: *Pathogen reduction* and Scenario 5: *Slow infiltration* are likely to be the most effective for further removal of *E. coli*, although ultraviolet disinfection may need some form of additional solids removal to improve its efficiency, which is not included in the scenario as modelled. Scenarios 3 and 5 could deliver 0.085 percent and 0.86 percent additional removal. Scenario 1: *Phosphorus reduction* and Scenario 2: *Nutrient reduction* could also deliver improvements for this contaminant. Scenario 4: *Rapid infiltration* on its own is less effective, but if used together with a treatment process, such as chemically assisted settlement and ultraviolet disinfection, it may be a suitable means of disposal. Table C36 summarises the scenario treatment capabilities for *E. coli* compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharges for the base and all scenarios.

**Table C36: Annual Loads – *E. coli* (treatment removal and discharge)**

| Scenario | Conc removed (cfu/100mL) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge conc (cfu/100mL) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9,991,388 | 99.91% | 0.000% | 8,612 | 0.086% |
| 1. Phosphorus | 9,995,000 | 99.95% | 0.036% | 5,000 | 0.050% |
| 2. Nutrients | 9,995,000 | 99.95% | 0.036% | 5,000 | 0.050% |
| 3. Pathogens | 9,999,874 | 99.999% | 0.085% | 126 | 0.0013% |
| 4. Rapid infiltration | 9,991,388 | 99.91% | 0.000% | 8,612 | 0.086% |
| 5. Slow infiltration | 9,999,997 | 99.99997% | 0.086% | 3 | 0.00003% |

The four scenarios that could deliver additional capability for *E. coli* (Scenarios 1, 2, 3 and 5) have a wide range of additional annual costs for wastewater treatment. *Scenario 3: Pathogen reduction* could deliver most improvements for least additional cost although it is likely to be less effective for other contaminants. Figure C54 shows the relationship between the treatment system's improvement in removing *E. coli* and the possible increase in annual cost per household. Figure C55 shows the relationship between the annual discharge of *E. coli* and annual cost per household. Overall, the improvement from these scenarios is minimal because of the effectiveness of the existing pond at removing *E. coli*.

**The key and explanation for these graphs is included at the start of the modelling results section.**

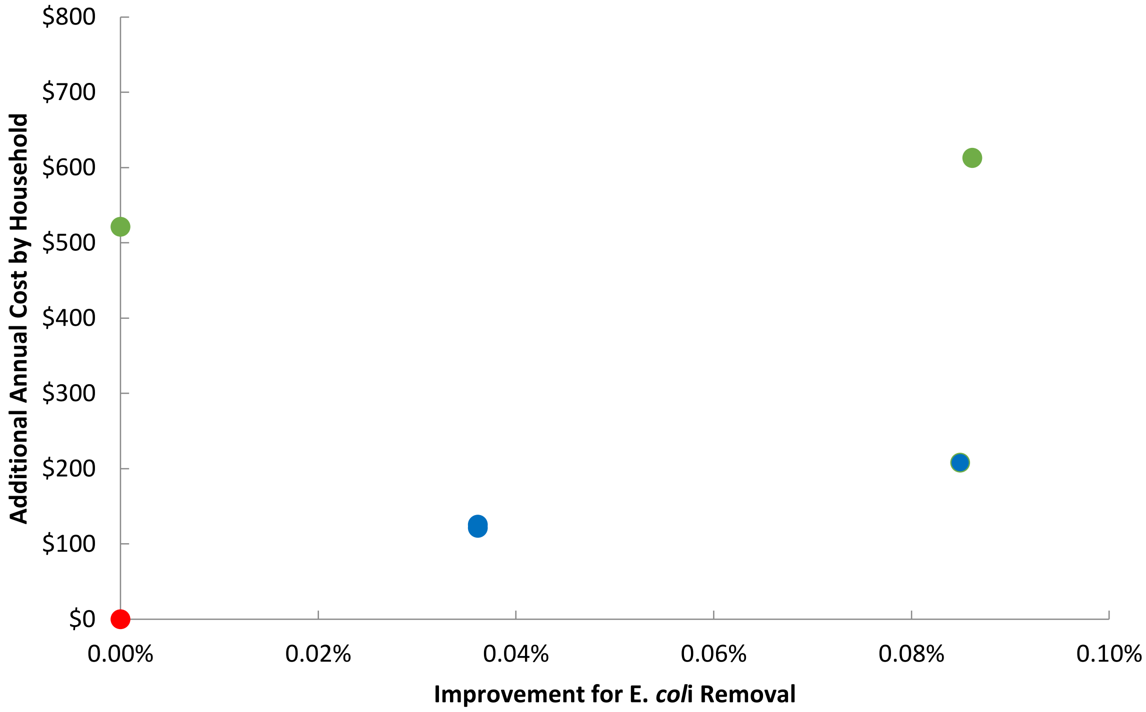



**Figure C54: Nightcaps improvement in treatment for *E. coli***

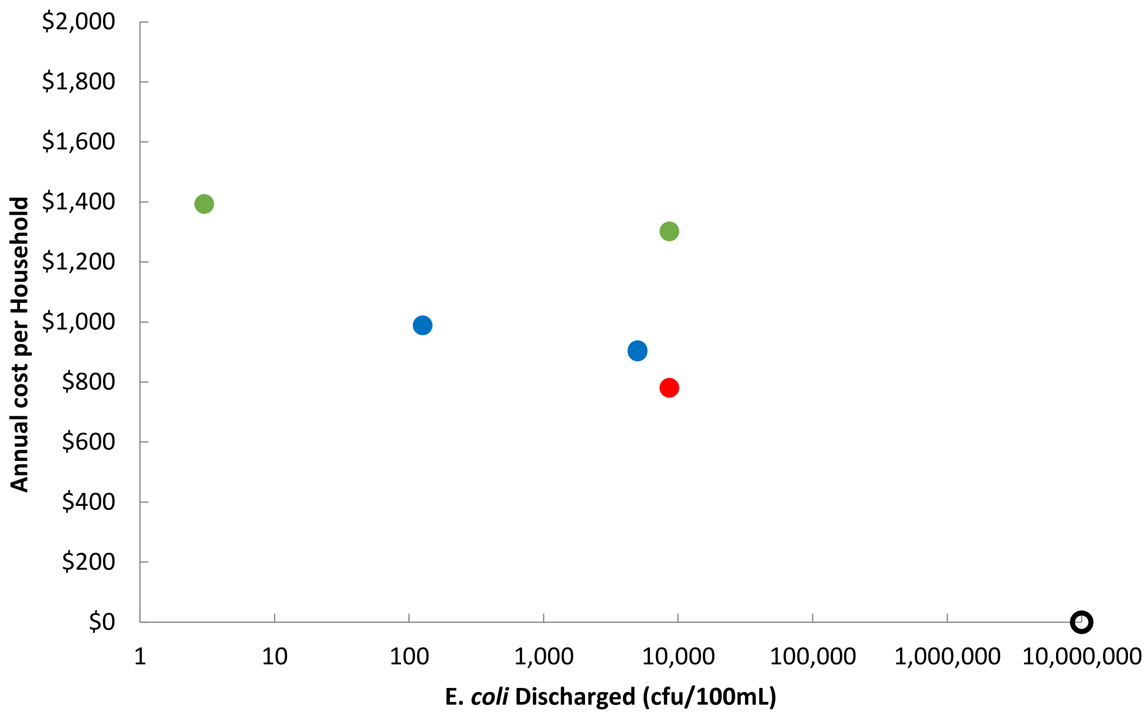



**Figure C55: Nightcaps discharge of *E. coli***

## 5.5. Nightcaps Summary

The Nightcaps wastewater scheme was established in 1988 and currently has 196 total equivalent connections. It receives residential and some commercial and light industrial wastewater for treatment at the town's oxidation pond. The town's relatively small ratepayer base makes funding maintenance and upgrades difficult. The existing wastewater treatment system delivers a relatively high level of contaminant reduction, especially for biochemical oxygen demand and *E. coli*. The existing system's lowest proportion of contaminant reduction is for nutrients (total nitrogen and total phosphorus). The quality of water in the Wairio upstream is reduced by other activities in the catchment and the discharge is likely to be contributing to elevated nutrients and micro-organisms downstream.

Five alternative treatment and/or discharge scenarios were modelled for Nightcaps. Each scenario has strengths and weaknesses in its cost or treatment capabilities for each contaminant. All of the scenarios are pre-feasibility options that are additional to the existing system. No scenario considered abandoning the current pond and constructing a highly technical mechanical plant. The cost-effectiveness of such a scenario meant it was not considered to be a realistic option. The capability of the existing system means that the scenarios generally deliver a relatively small percentage of improvement in contaminant reduction. The scenarios have a wide range of annual costs per household and these costs may not relate to each scenario's capability to treat particular contaminants.

## 5.6. Limitations and Constraints

There are a number of important limitations to the scenarios modelled for Nightcaps. Across the scenarios, redundancy in mechanical plant may be needed, additional sludge production from some scenarios will increase lifecycle costs, and the likelihood of finding appropriate soils near the town to receive any land-based disposal discharge is remote.

The limited monitoring data set for the existing system means that in comparison with other case studies, there is more uncertainty in the performance of the existing system. Although the upgrade scenarios do not appear to provide much improvement, in practice, they are likely to be more reliable and so provide more certainty in the contaminant reduction achieved, as compared to the existing system.

An important limitation is the use of an ultraviolet plant without also including treatment for additional suspended solids removal. Although the existing treatment system is effective for solids removal, additional removal may be necessary for an ultraviolet plant to work effectively. Additional sludge production may arise as a result of chemical dosing. It could require pond desludging projects to occur more often, which increases lifecycle operational costs.

The land-based scenarios are dependent on the availability of suitable land, either already owned by the Council or able to be purchased. At present, Southland District Council does not own any neighbouring land to the Nightcaps wastewater treatment system. Indicative reviews of soils and soil moisture indicate that land disposal around the town may not be feasible for parts of the year, meaning that a discharge to water will also have to be retained. As community expectations change, having any discharge to water in the future is likely to mean a requirement to move towards upgrades involving highly complex mechanical plants such as membrane bioreactors.

# 6. Ohai

## 6.1. Ohai Wastewater Scheme

The Ohai wastewater scheme was built in 1953 – the oldest in the Southland District – and was upgraded in 2004 with ultraviolet disinfection. The scheme has 233 total equivalent connections and receives largely domestic wastewater. Total annual wastewater inflow into the plant is estimated at around 43,000 $m^3$ with the average daily flow ranging between 85 $m^3$ and 125 $m^3$. The scheme currently consists of standard reticulation and the treatment system is a conventional biological filter (screening, digestion, trickling filters and clarifiers) and ultraviolet disinfection. This system is a mechanical plant that is designed to enhance wastewater stabilisation over a smaller land area[17]. It differs from oxidation pond-based systems used in many Southland towns and typically produces a much higher quality of discharge than an oxidation pond. The treated wastewater is discharged into a small stream, which is a tributary of the Orauea Stream. The treatment system is located at the western end of the town, south of Birchwood Road (the Ohai-Clifden Highway).

The Ohai wastewater network consists of service connections, gravity mains, rising mains, manholes and cleaning eyes. Inflow from the reticulation network gravitates to a single pump station, which pumps directly to the wastewater treatment system. The small stream receives some stormwater inflow from the town at a point just upstream of the wastewater discharge.

[17] The site is 1.5 hectares and roughly 55 percent is taken up by access and the treatment system – the remainder is a steep sided gully with a stream and areas of wetland in the base.

**Image C8: Ohai biological trickling filter with tributary of Orauea Stream between pine trees**

As wastewater arrives at the wastewater treatment system it passes through a coarse screen. It then flows into two Imhoff tanks for solids removal and sludge digestion. The digestion process breaks down and stabilises the sludge, which will eventually end up in landfill. After the Imhoff tanks remove solids and sludge, the wastewater then passes through two stone media trickling filters for secondary treatment[18]. Next, the wastewater passes through two humus tanks (secondary clarifiers) to remove more solids, which is mostly biomass from the secondary treatment. The solids are recirculated back to the Imhoff tanks. The ultraviolet disinfection reactor was installed to "polish" the treated wastewater[19] before it is discharged into the stream. Water quality issues are usually related to low flows at the point of discharge into the source of the unnamed tributary, which joins the Orauea Stream roughly 1.5 kilometres away.

[18] The biological film that grows in the filter helps the breakdown of organic matter in aerobic conditions and reduces the biochemical oxygen demand of the wastewater. There is some reduction in the concentration of nitrogen, phosphorus and other organic substances including bacteria, but it is limited and not the primary role of a trickling filter.

[19] In this case the polishing is to reduce bacteria concentration to a low level. The process aims to reduce bacteria concentration from millions of organisms per 100 millilitres to tens of organisms per 100 millilitres.

**Image C9: Ohai ultraviolet disinfection reactor**

Southland District Council holds a resource consents to discharge treated wastewater to water in the tributary of the Orauea Stream from the Ohai wastewater treatment system. Environment Southland is currently processing a new discharge consent application.

The Ohai wastewater and stormwater schemes are shown in the previous section on Nightcaps.

## 6.2. Baseline Results

This section describes the baseline results for Ohai (i.e. what is actually occurring). The total annual inflow of wastewater into Ohai treatment system is estimated at 80,000 $m^3$ and the daily average flow at 230 $m^3$. Table C37 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C38 gives information on the average quality of the treated wastewater discharged to the tributary of the Orauea River.

**Table C37: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2013-2015 | Total SS (tonnes) | BOD (tonnes) | Ammoniacal N[20] (tonnes) | Total P (tonnes) | Faecal coliforms[21] (cfu/100ml) |
|---|---|---|---|---|---|
| Average (3 years) | 10.4 | 10.5 | 2.1 | 0.2 | 9,999,906 |

**Table C38: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Ammoniacal N | Total P | Faecal coliforms |
|---|---|---|---|---|---|
| **Concentrations** | **(g/m$^3$)** | **(g/m$^3$)** | **(g/m$^3$)** | **(g/m$^3$)** | **(cfu/100ml)** |
| Average (3 years) | 9.8 | 9.0 | 3.5 | 2.0 | 74 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Estimated loads | 0.4 | 0.4 | 0.2 | 0.09 | N.A. |

Source: Environment Southland consent monitoring data

Based on the 2017 annual valuation, the total replacement value of all the assets in the wastewater scheme is $3.95 million (or roughly $23,000 per household). The largest contributor is the pipe network, which accounts for roughly 75 percent of the replacement value. The treatment system is valued at $1.01 million. The rest of the scheme's value is made up of assets such as manholes and pump stations.

The annual depreciated value of the wastewater scheme is $54,000 and the annual operating cost is $33,000.

Figure C56 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[22] before being plotted to make it possible to include all five different contaminants on the same graph.

[20] Monitoring data was only available for ammoniacal nitrogen which is a portion of the total nitrogen.
[21] Monitoring data was only available for faecal coliforms, which includes *E. coli*, and is generally in a similar range of concentration as *E. coli*
[22] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

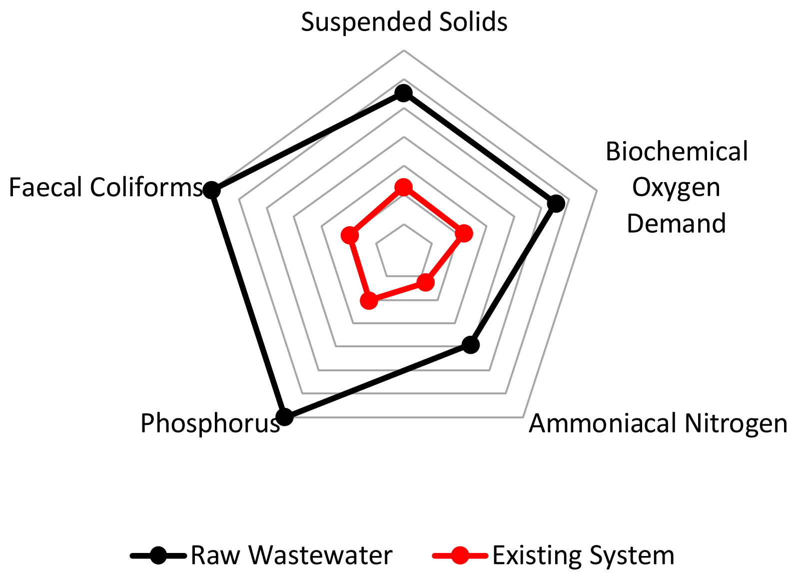



**Figure C56: Ohai baseline scenario (existing system)**

As explained at the beginning of Part C, no scenarios were modelled for the Ohai wastewater system. The system typically produces the quality of wastewater that the alternative treatment scenarios modelled for the other case studies are designed to produce (with the exception of membrane bioreactor and tertiary treatment type plants). Ohai is a similar size to Nightcaps so the costs of either a rapid infiltration or a slow rate infiltration land-based disposal system are likely to be roughly equivalent between the two towns.

**Image C10: SDC Strategic Manager Water and Waste, Ian Evans, at the Ohai 'office'**

# 7. Te Anau

## 7.1. Te Anau Wastewater Scheme

The oldest part of the Te Anau wastewater scheme was built in 1967 and the scheme has expanded as the town has developed. The wastewater treatment system of two small oxidation ponds was upgraded in 1984, with the addition of a large oxidation pond (now the primary oxidation pond), in 2004 with a screen, aerators, and wetland, and again in 2015. The scheme has 2,621 total equivalent connections and receives domestic, commercial and light industrial waste. Subdivision development has been occurring in Te Anau creating new residential lots. Although many of these properties are yet to be built on, these half connections are included in the scheme's total equivalent connections. The Southland District Council is developing a long term strategy for future wastewater management in Te Anau.

**Image C11: Te Anau primary oxidation pond**

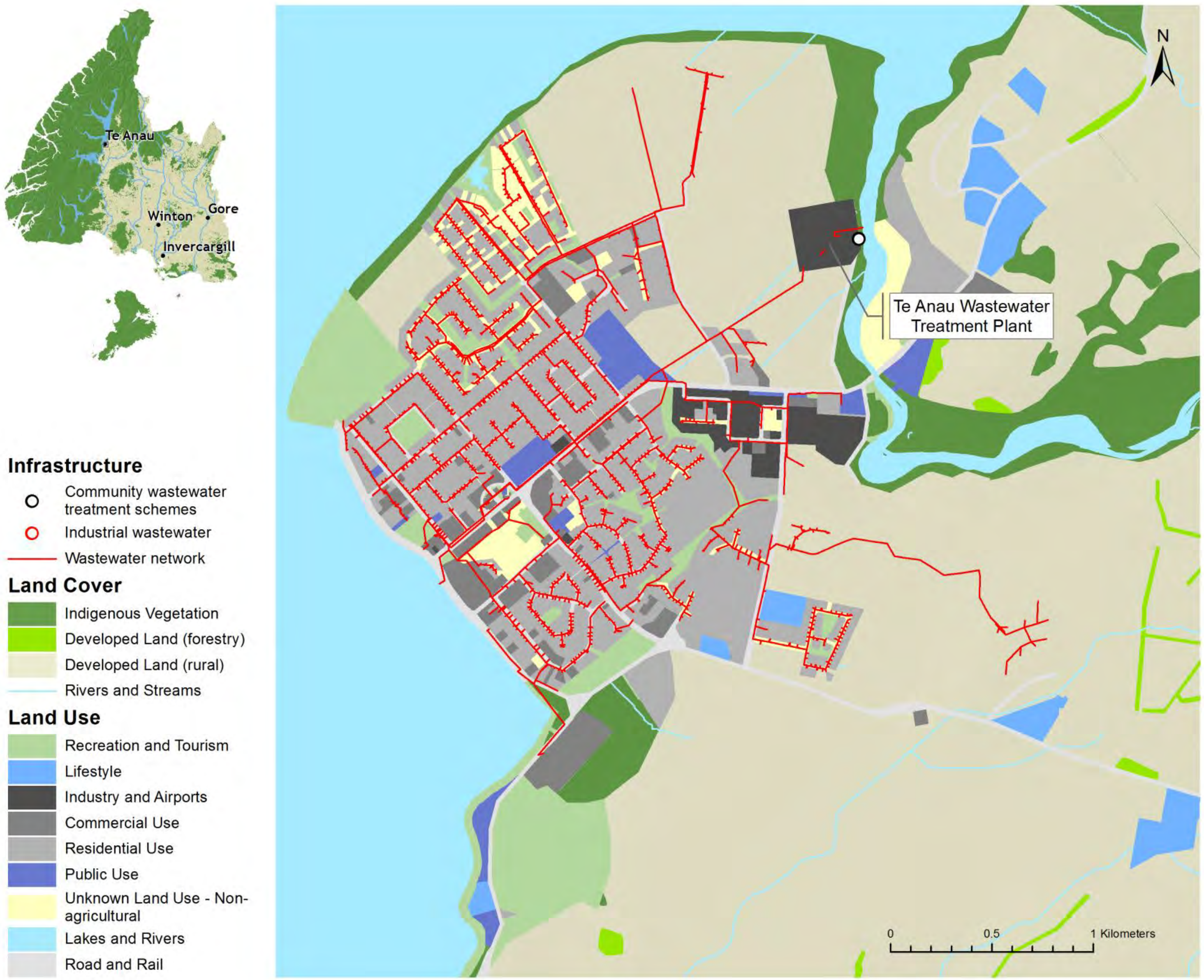
Inflow from the reticulation gravitates to minor pump stations delivering to one of three main stations and on to the wastewater treatment system. The wastewater treatment system is a series of three oxidation ponds that discharge via a wetland into the Upukerora River, near its mouth into Lake Te Anau. The two smaller ponds (1.4 ha in total) were built in 1966 as part of the initial wastewater scheme. The larger pond (3.3 ha) was built in 1984 to meet increased demand. The ponds operate in series with the large pond initially receiving wastewater through a bar screen and then flow through the two smaller ponds to the wetland. Aerators were installed in the large pond together with a wetland to improve performance. The wastewater discharges from the wetlands, through a piped outlet, to the Upukerora River.

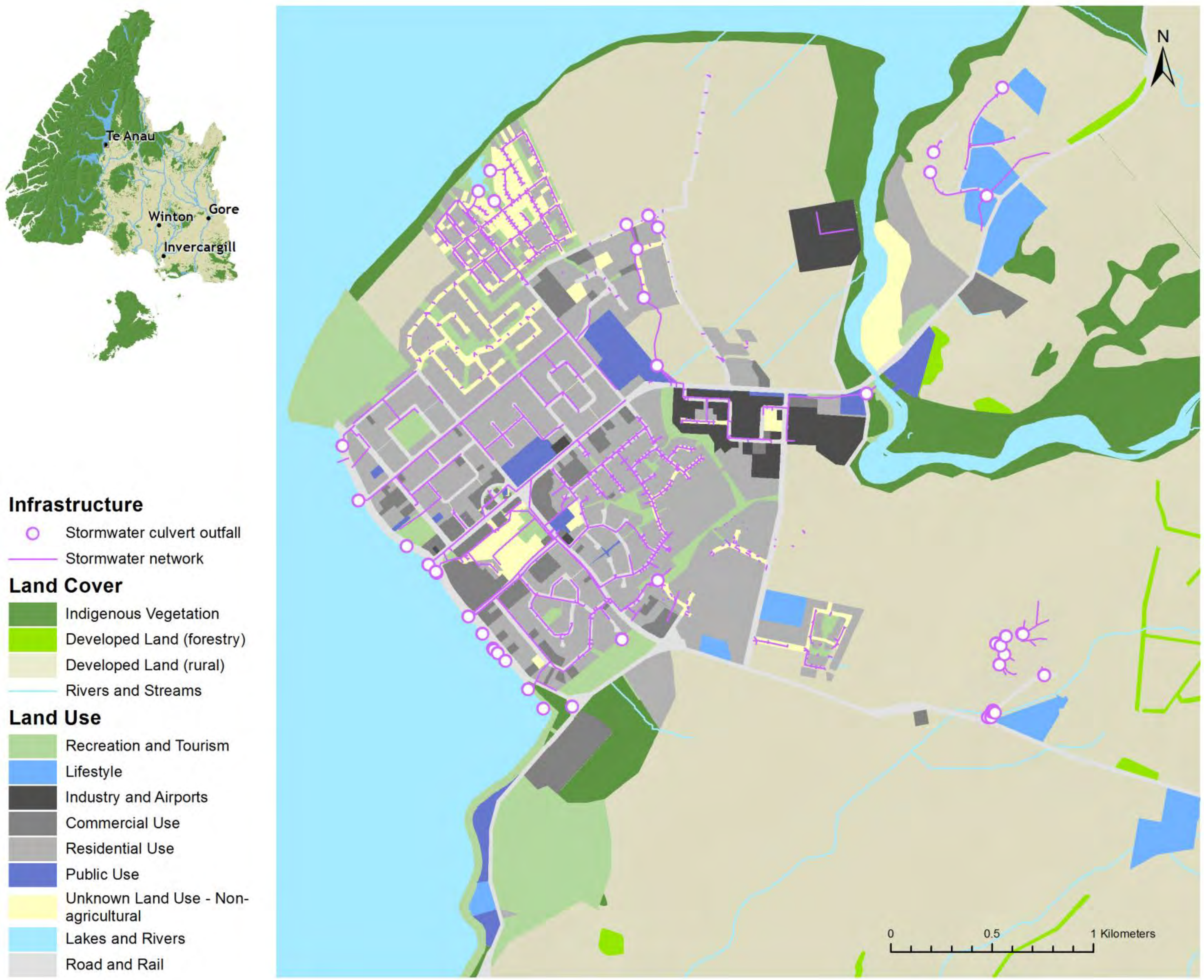
The current location of the wastewater discharge is not considered sustainable as it constitutes a continued discharge to water and is contrary to stakeholder expectations. While the site of the plant is on the river delta and at risk of flooding it is considered that further work to existing flood protection infrastructure will provide sufficient long term security for the site. From 2006 a working party investigated a number of options for treatment and disposal before developing the current preferred option of improved treatment at the current site before disposal to land around Kepler Farm by centre pivot irrigators. The proposal involves a pond upgrade (an inlet screen, additional aeration and desludging), a 19 kilometre pipeline laid in the road reserve, and centre pivot irrigation of the treated wastewater at Kepler farm (north of Te Anau airport at Manapouri). A final decision on the scope of the upgrade is expected in 2018.

A resource consent for the discharge into the Upukerora River expired in 2014. In 2015, a new long-term consent was granted for irrigation at Kepler Block and a short-term consent (expiring in 2020) was granted to continue the discharge to the Upukerora River.  The three ponds were desludged and the new inlet screen was constructed.  The long-term consent for the Kepler Block proposal was appealed to the Environment Court by the community group Fiordland Sewage Options.  All appeals were settled in December 2017.  Work is currently under way on detailed design of the pipeline to Kepler while an option of irrigation by sub surface driplines is being evaluated against the consented centre pivot option.


**Image C12: Te Anau inlet screen**

<u>The following two maps show the Te Anau wastewater and stormwater schemes.</u>


Te Anau
Winton
Gore
Invercargill
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
N
Te Anau Wastewater Treatment Plant
0
0.5
1 Kilometers


Te Anau
Winton
Gore
Invercargill
N
0
0.5
1 Kilometers
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail

## 7.2. Baseline Results

This section describes the baseline results for Te Anau (i.e. what is actually occurring). The total annual inflow of wastewater into the Te Anau treatment system is estimated at 301,300 $m^3$, with the daily flow ranging between 800 $m^3$ and 850 $m^3$. This volume can be considerably higher during peak visitor season over summer months. Table C39 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C40 gives information on the average quality of the treated wastewater discharged into the Upukerora River near its outflow into Lake Te Anau.

**Image C13: Upukerora River near Lake Te Anau**

**Table C39: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2013-2016 | Total SS (tonnes) | BOD (tonnes) | Total N (tonnes) | Total P (tonnes) | *E. coli* (cfu/100ml) |
|---|---|---|---|---|---|
| Average (4 years) | 59.2 | 69.2 | 7.7 | 0.1 | ~9,998,500 |

**Table C40: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **(cfu/100ml)** |
| Average (5 years) | 53.5 | 20.5 | 24.4 | 6.7 | 1,200 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (4 years) | 10.5 to 16.1 | 4.9 to 8.3 | 5.4 to 8.3 | 1.6 to 2.0 | N.A. |
| Estimated loads | 16.1 | 6.2 | 7.3 | 2.0 | N.A. |

Source: Environment Southland consent monitoring data

Figure C57 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[23] before being plotted to make it possible to include all five different contaminants on the same graph.

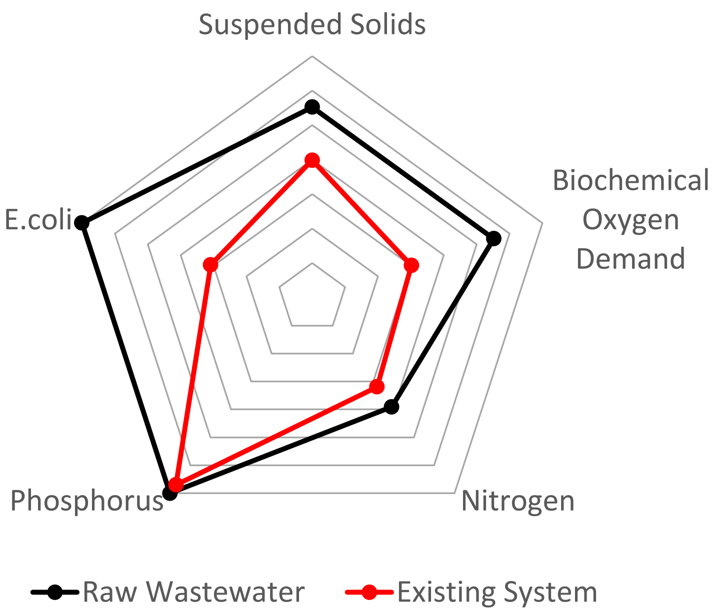



**Figure C57: Te Anau baseline scenario (existing system)**

Based on the 2017 annual valuation, the total replacement value of all assets in the wastewater scheme is $27.5 million (around $28,500 per household). As with the other schemes, the largest contributor is the reticulated pipe network, which accounts for roughly 80 percent of the replacement value. The treatment system is valued at $4.85 million.

[23] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

The annual depreciated value of the wastewater scheme is $374,000 and the annual operating cost is $140,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C41 using the methodology in Section C1.5.

**Image C14: Te Anau aerator**
Source Emma Moran

## 7.3. Modelling Scenarios

Two scenarios were developed for the Te Anau wastewater system (the scenarios and treatment processes as listed below with more details in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Scenario 1: *Nutrient reduction* is designed as an upgrade to the existing treatment plant with a continued discharge to water. Scenario 2: *Slow infiltration* is similar to the consented upgrade for the Kepler block of land. Table C41 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 1,022 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

| Scenario | Treatment Process (new units in bold) |
|---|---|
| Existing system | Liquid: bar screen, primary oxidation pond (with aerators), secondary oxidation ponds, wetland<br>Solid: storage in pond |

| Scenario | Treatment Process (new units in bold) |
|---|---|
| 1. Nutrient reduction | Liquid: as existing, **trickling filter**<br>Solid: as existing |
| 2. Slow infiltration | Existing process + **pond waveband + pump station + transfer pipeline + recirculation pump station + odour control + treated wastewater disposal**<br>Solid: as existing |

**Table C41: Te Anau Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| **Existing scheme** | $21,576,000 | $703 |
| **1. Nutrient reduction** | $25,996,000 | +$144 |
| **2. Slow infiltration (includes partial cost of land)** | $53,575,000 | +$1,043 |

Figures C58 and C59 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C57 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater. Except for phosphorus, the concentrations of the contaminants were transformed[24] before being plotted to make it possible to include all five different contaminants on the same graph.

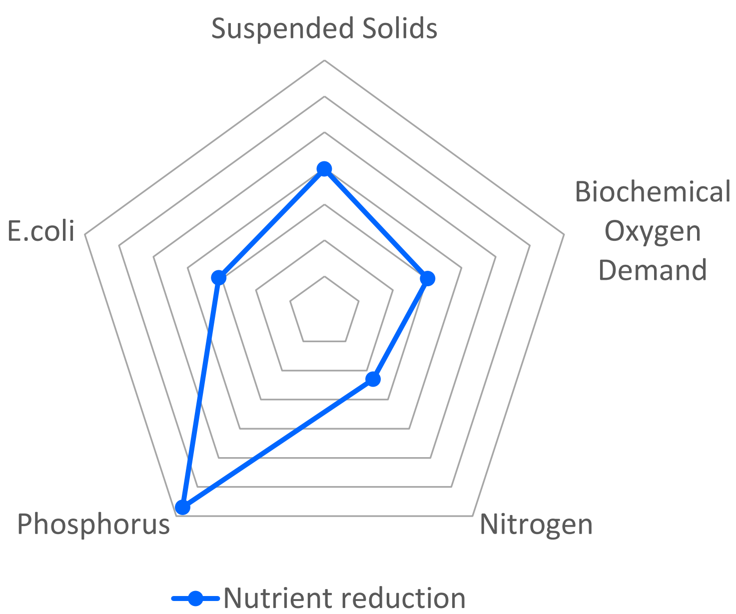



**Figure C58: Te Anau 'discharge to water' scenario**

[24] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

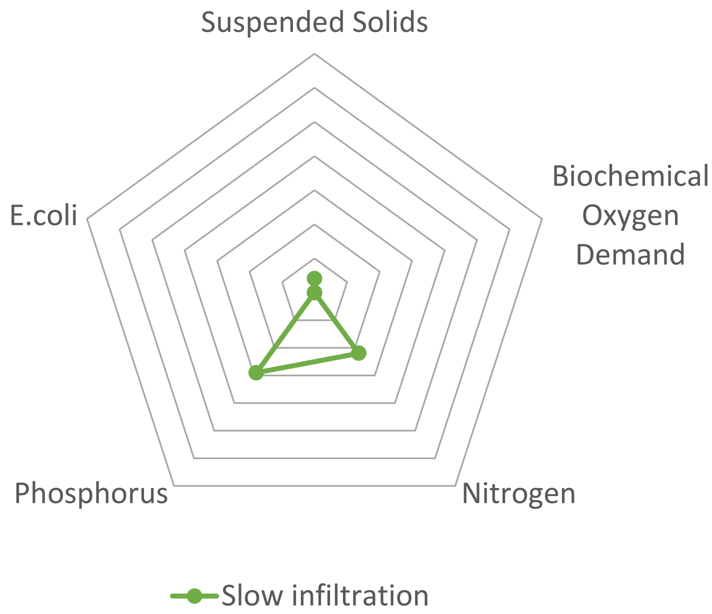



**Figure C59 Te Anau 'discharge to land' scenario**

## 7.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*There are two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot** for the existing level of treatment (i.e. the base);*
- ***a blue dot** for the modelling scenario representing discharge to water; and*
- ***a green dot** for the modelling scenario representing discharge to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have **a clear black dot**, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 7.4.1. Total Suspended Solids

The existing wastewater system (the base) removes a substantial proportion of total suspended solids largely through settlement in the ponds. The screen removes large solids, and the oxidation ponds add to some removal via bacteria and settlement. Overall, the existing treatment system removes 78.6 percent of the total suspended solids from the wastewater inflow. The Te Anau system receives a base inflow load of 75.3 tonnes of solids annually, of which 59.2 tonnes are removed through treatment, and 16.1 tonnes are discharged to surface water (roughly 41 kg per day).

Of the two scenarios modelled for Te Anau, Scenario 2: *Slow infiltration* is considered a more effective means of solids removal because it takes a direct discharge of the flow away from a surface water body, and solids are removed by filtration through the soil before discharge to the aquifer. Scenario 1: *Nutrient reduction* is less effective because the process is primarily designed to treat contaminants such as biochemical oxygen demand and nitrogen. Table C42 – summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). It also gives the resulting discharge for the base and both scenarios.

**Table C42: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 58 | 78.6% | 0.0% | 16 | 21.4% |
| 1. Nutrient reduction | 58 | 78.6% | 0.0% | 16 | 21.4% |
| 2. Slow infiltration | 73 | 99.4% | 26.5% | 0 | 0.6% |

Of the options considered here, Scenario 2: *Slow infiltration* is more effective and has an additional annual cost for wastewater treatment of $1,043 per household. Scenario 1: *Nutrient reduction* has little or no improvement yet it is likely to have an annual cost of $144 per household. It also relies on being able to gain resource consent to continue with a discharge to water (which is highly unlikely). Figure C60 shows the relationship between the treatment system's improvement in removing total suspended solids and the possible increase in annual cost per household. Figure C61 shows the relationship between the annual discharge of suspended solids and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

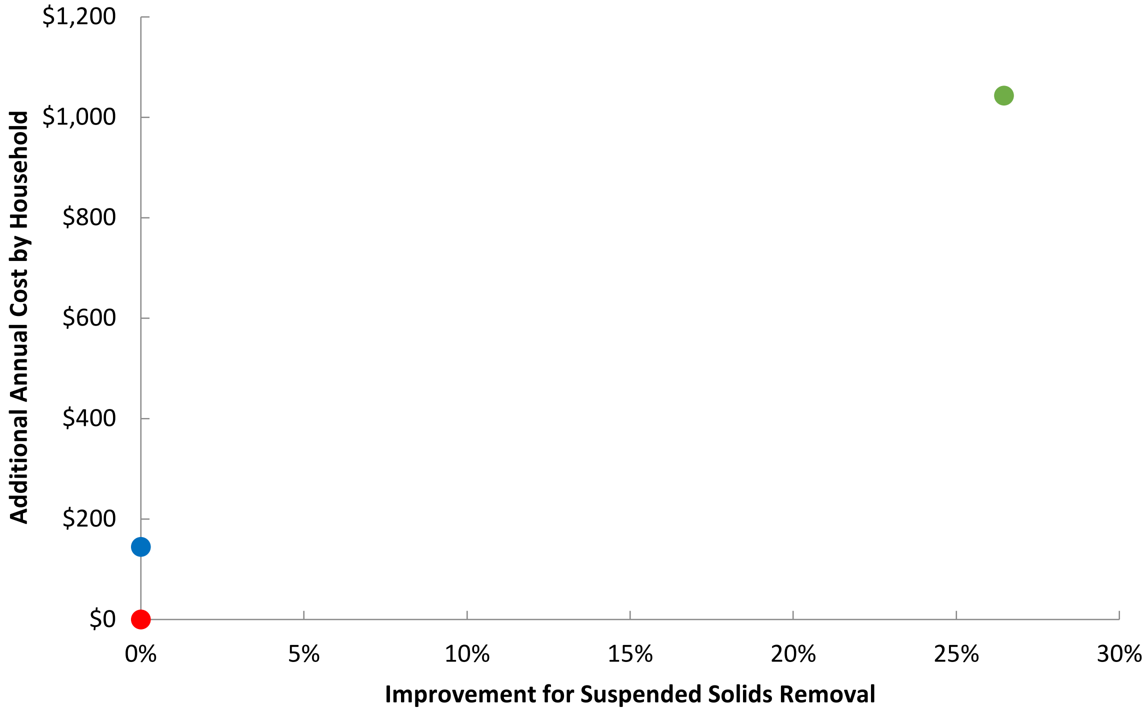



**Figure C60: Te Anau improvement in treatment for suspended solids**

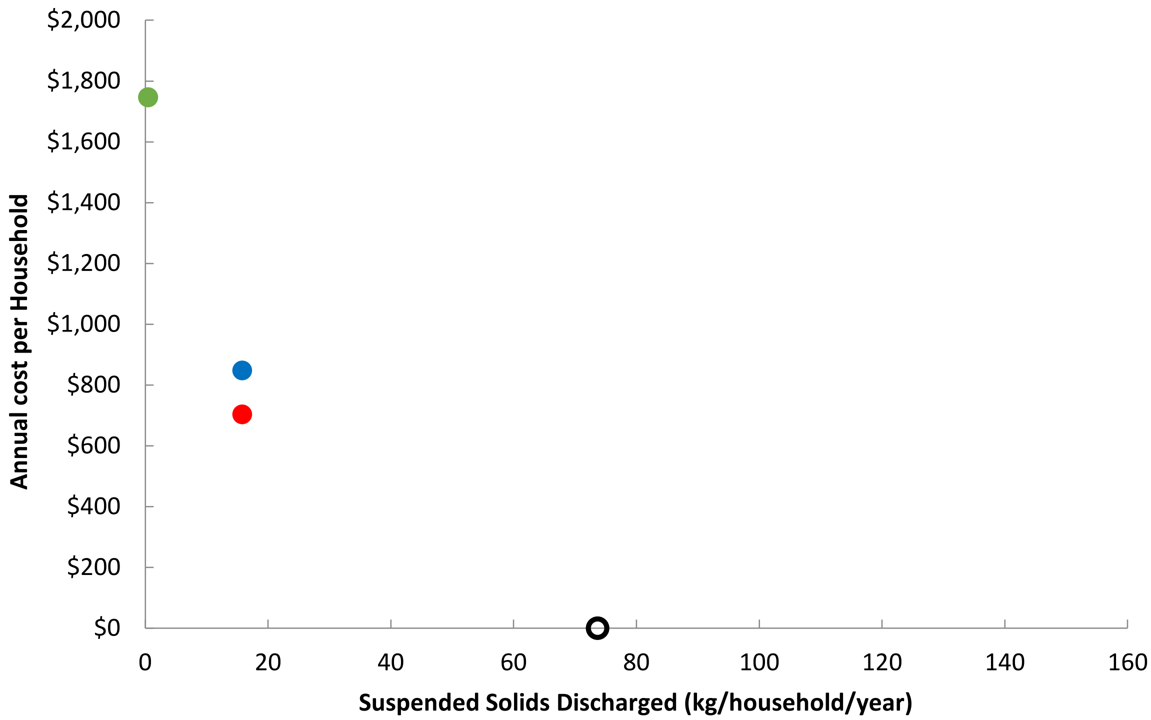



**Figure C61: Te Anau discharge of suspended solids**

### 7.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing treatment system via the oxidation ponds. The existing treatment system reduces 92 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Te Anau system receives a base inflow load of 75.3 tonnes annually, of which 69.1 tonnes are reduced through treatment, and 6.2 tonnes are discharged to surface water.

Taking a range of other factors into account, Scenario 2: *Slow infiltration* is likely to be the most effective for further reducing biochemical oxygen demand (it is also the most effective scenario for suspended solids). Scenario 1: *Nutrient reduction* is not effective for this contaminant. Table C43 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both the wastewater inflow and the base reduction (existing system). It also gives resulting discharge for the base and both scenarios.

**Table C43: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 68 | 91.8% | 0.0% | 6 | 8.2% |
| 1. Nutrient reduction | 68 | 91.8% | 0.0% | 6 | 8.2% |
| 2. Slow infiltration | 73 | 99.6% | 8.5% | 0 | 0.4% |

Scenario 2: *Slow infiltration*, the more effective scenario for biochemical oxygen demand, has an additional annual cost for wastewater treatment of $1,043 per household. Scenario 1: *Nutrient reduction* is less effective and has an additional annual cost of $144 per household. Figure C62 shows the relationship between the treatment system's improvement in reducing biochemical oxygen demand and the possible increase in annual cost per household. Figure C63 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

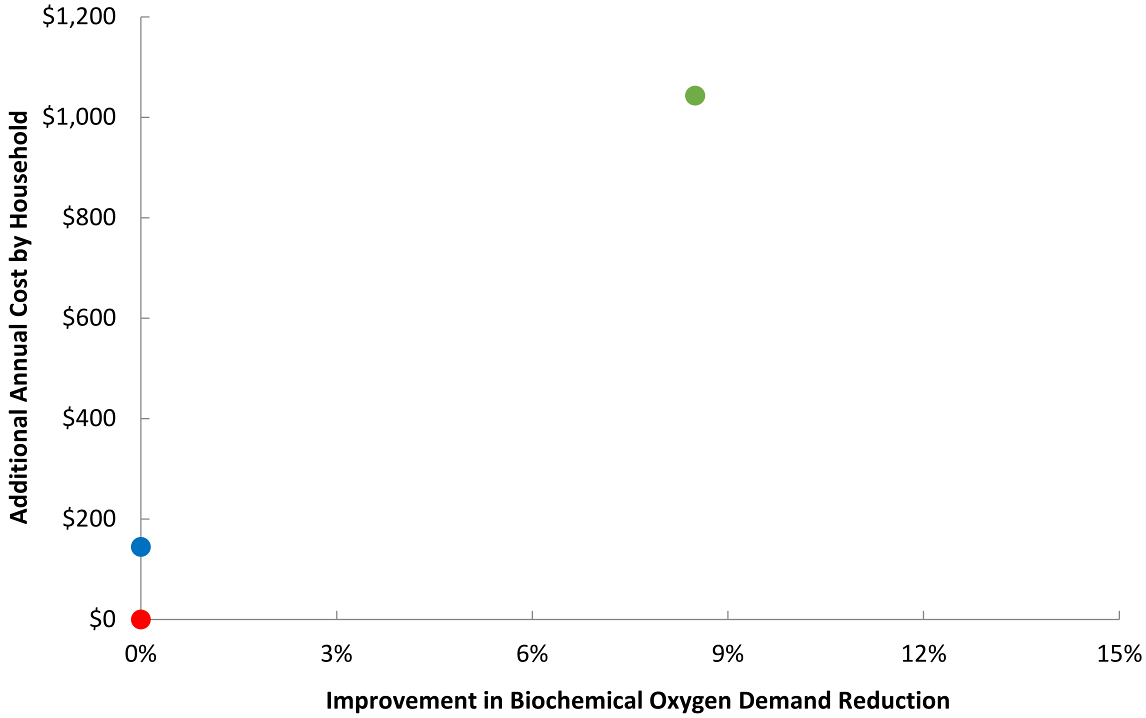



**Figure C62: Te Anau improvement in treatment for biochemical oxygen demand (BOD)**

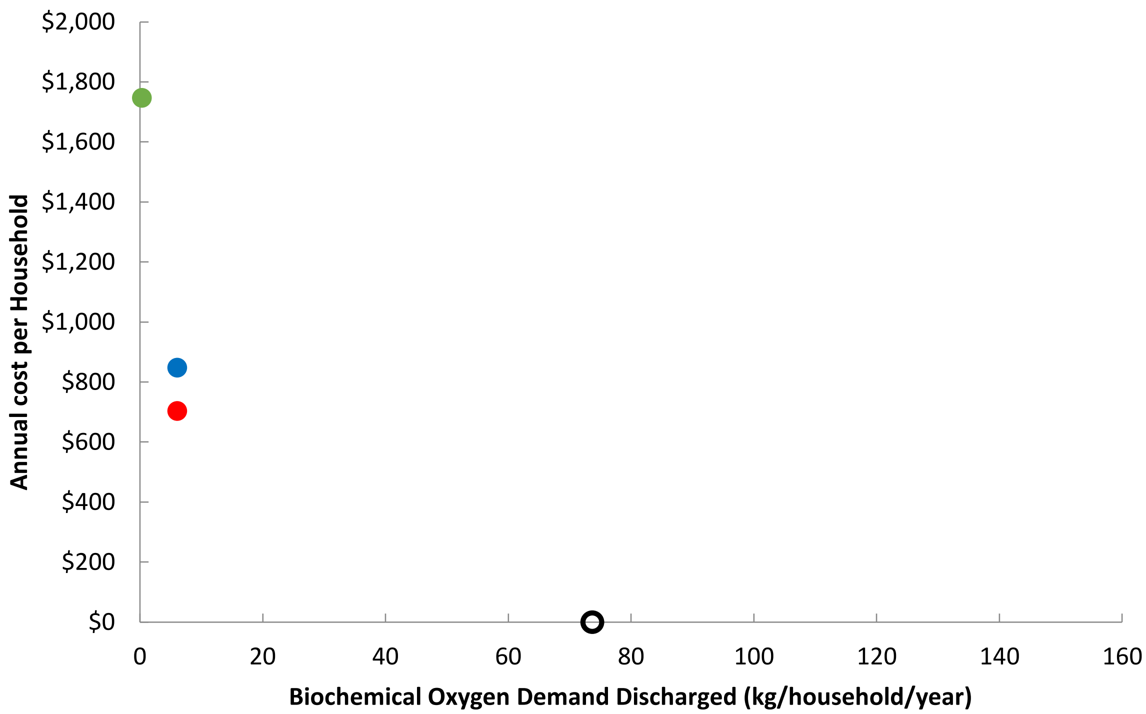



**Figure C63: Te Anau discharge of biochemical oxygen demand (BOD)**

### 7.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and total phosphorus) from the inflow of raw wastewater, though to a lesser extent than the other contaminants considered in this research. The existing system removes 51 percent of total nitrogen from the wastewater inflow, which although considerable, is a lower proportion than its removal of suspended solids (79%) and biochemical oxygen demand (92%). The Te Anau system receives a base inflow load of 15.1 tonnes of total nitrogen annually, of which 7.7 tonnes are removed through treatment, and 7.4 tonnes are discharged to surface water.

Both scenarios show a considerable improvement in nitrogen removal when compared to the baseline (the existing system) - Scenario 2: *Slow infiltration* being slightly more effective. This scenario removes 82 percent of nitrogen, which is far above the existing system's base removal. Scenario 1: *Nutrient reduction* is also likely to be relatively effective for total nitrogen. Table C44 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and both scenarios.

Scenario 2: *Slow infiltration*, the most effective scenario for total nitrogen, has the highest additional annual cost for wastewater treatment per household. By comparison, Scenario 1: *Nutrient reduction* is a relatively cost-effective option for Total Nitrogen. These results do not take into account the other factors that are relevant when proposing a land-based discharge. Figure C64 shows the relationship between the treatment system's improvement in removing total nitrogen and increase in annual cost per household. Figure C65 shows the relationship between the annual discharge of total nitrogen and annual cost per household.

Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost.

**Table C44: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 8 | 51.2% | 0.0% | 7 | 48.8% |
| 1. Nutrient reduction | 12 | 80.0% | 56.3% | 3 | 20.0% |
| 2. Slow infiltration | 12 | 82.0% | 60.2% | 3 | 18.0% |

**The key and explanation for these graphs is included at the start of the modelling results section.**

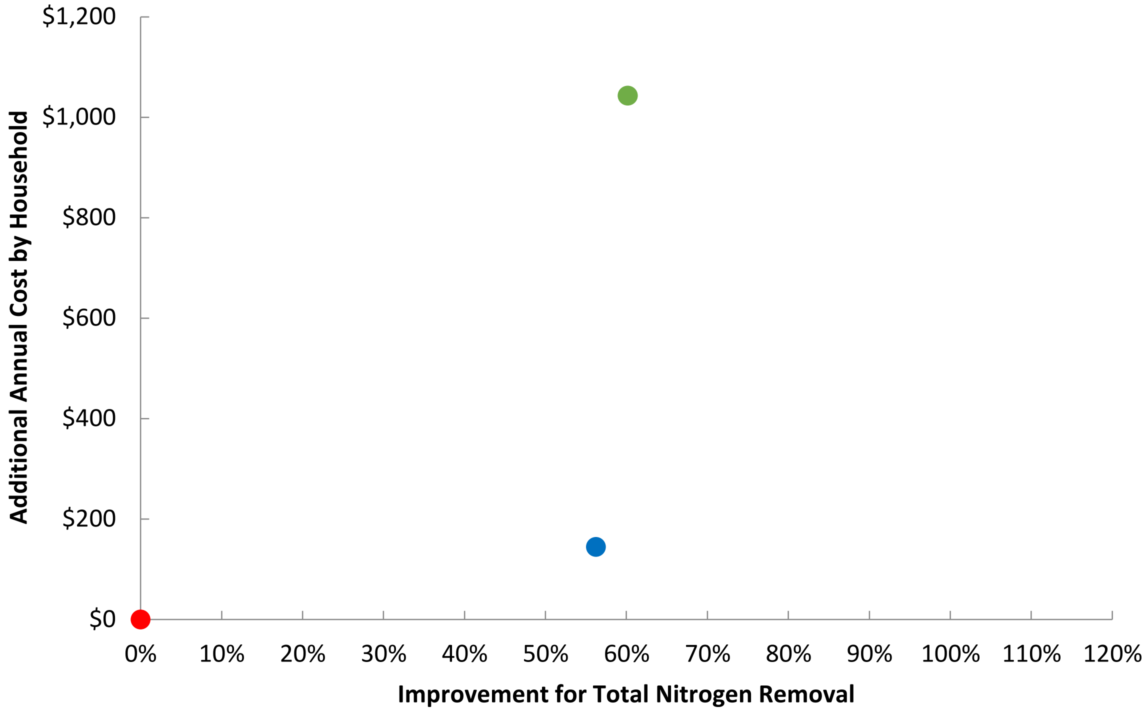



**Figure C64: Te Anau improvement in treatment for total nitrogen**

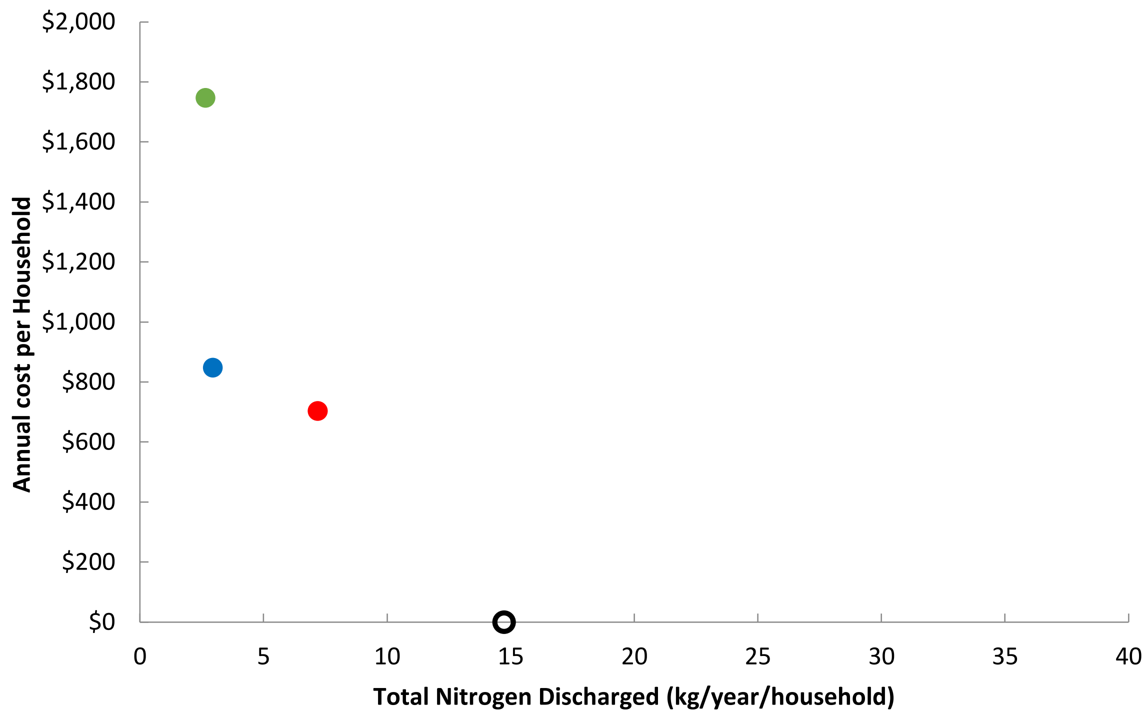



**Figure C65: Te Anau discharge of total nitrogen**

### 7.4.4. Total Phosphorus

In addition to total nitrogen, the existing system also removes total phosphorus from the inflow of raw wastewater. Overall, 4.3 percent of total phosphorus from the wastewater inflow is removed, which is far less than that for any of the four other contaminants being considered. This low removal rate may result from the "typical" concentrations assumed for the incoming wastewater and the limited monitoring data of the discharge quality. The actual wastewater inflow may have higher phosphorus concentrations than assumed. The Te Anau system has been assumed to receive a base inflow load of 2.1 tonnes of total phosphorus annually, of which 0.1 tonnes are removed through treatment, and 2.0 tonnes are discharged.

As with the previous contaminants, Scenario 2: *Slow infiltration* is the most effective for total phosphorus of the two scenarios modelled because it is land-based discharge. Scenario 1: *Nutrient reduction* is not designed with phosphorous removal in mind and offers no additional improvement for this contaminant. Table C45 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and both scenarios.

**Table C45: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 0.1 | 4.3% | 0.0% | 2.0 | 95.7% |
| 1. Nutrient reduction | 0.1 | 4.3% | 0.0% | 2.0 | 95.7% |
| 2. Slow infiltration | 1.2 | 58.6% | 1266.7% | 0.9 | 41.4% |

Scenario 2: *Slow infiltration*, which was relatively effective for total phosphorus, has the highest additional annual cost for wastewater treatment of $1,043 per household. Scenario 1: *Nutrient reduction* delivers no improvements in removing this contaminant and has an additional annual cost of $144 per household. Figure C66 shows the relationship between the treatment system's improvement in removing total phosphorus and the possible increase in annual cost per household. Figure C67 shows the relationship between the annual discharge of total phosphorus and annual cost per household. This graph uses a different scale on the x-axis in comparison with other case studies because the minimal phosphorus reduction assumed for the existing system results in a high % improvement for the effective upgrade scenario.

**The key and explanation for these graphs is included at the start of the modelling results section.**

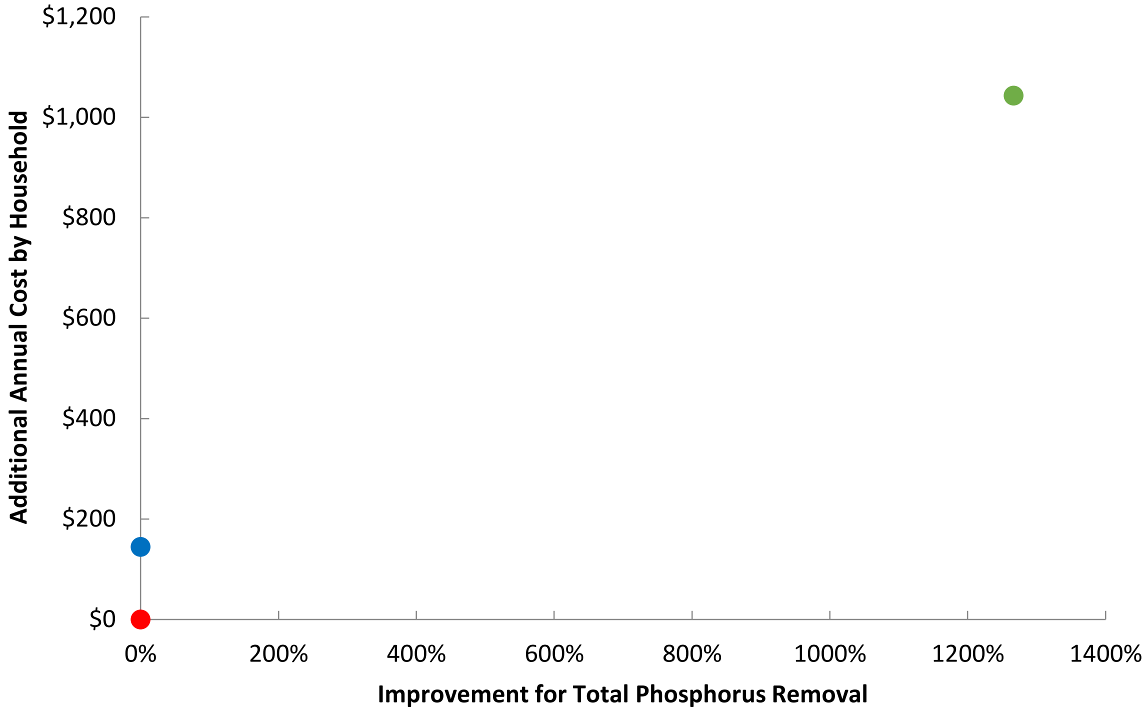



**Figure C66: Te Anau improvement in treatment of total phosphorus**

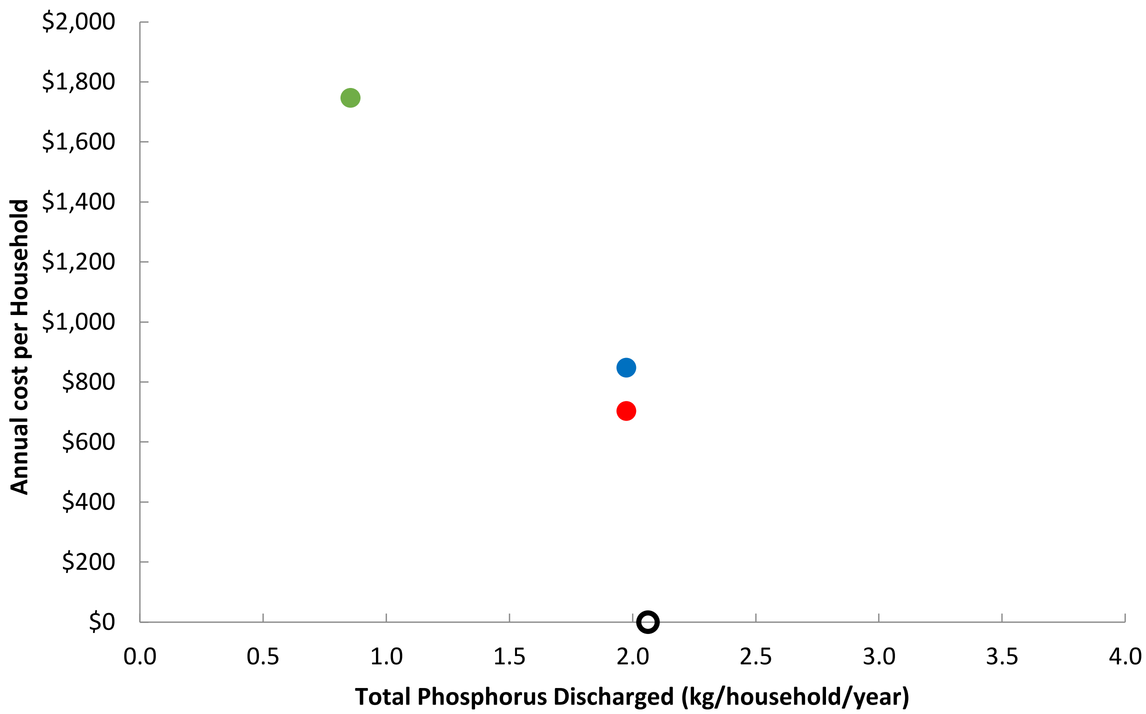



**Figure C67: Te Anau discharge of total phosphorus**

### 7.4.5. *E. coli*

The existing system has substantial capability to remove *E. coli* from the raw wastewater inflow through natural ultraviolet from sunlight, die off of bacteria and as a food source for other algae formed as part of the treatment process. On the whole, the existing system removes 99.88 percent of *E. coli*, which is a greater proportion than for any of the other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Te Anau system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,998,800 cfu/100mL through treatment, so that a concentration of 1,200 cfu/100mL is discharged to surface water.

Of the two scenarios modelled, Scenario 2: *Slow infiltration* is effective for removal of *E. coli*. Scenario 1: *Nutrient reduction* is not designed with *E. coli* removal in mind and offers no additional improvement. Table C46 summarises the scenario treatment capabilities for *E. coli* compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and both scenarios.

**Table C46: Annual Loads – *E. coli* (treatment removal and discharge)**

| Scenario | Conc removed (cfu/100mL) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge conc (cfu/100mL) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9,998,780 | 99.99% | 0.000% | 1,220 | 0.012% |
| 1. Nutrient reduction | 9,998,780 | 99.99% | 0.000% | 1,220 | 0.012% |
| 2. Slow infiltration | 9,999,999 | 99.99999% | 0.012% | 1 | 0.00001% |

The scenario that offers additional capability for *E. coli* (Scenario 2) has an additional annual cost of $1,043 per household for wastewater treatment. Scenario 1: *Nutrient reduction* is likely to deliver little improvement for an additional annual cost of $144 per household. Figure C68 shows the relationship between the treatment system's improvement in removing *E. coli* and the increase in additional annual cost per household. Figure C69 shows the relationship between the annual discharge of *E. coli* and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

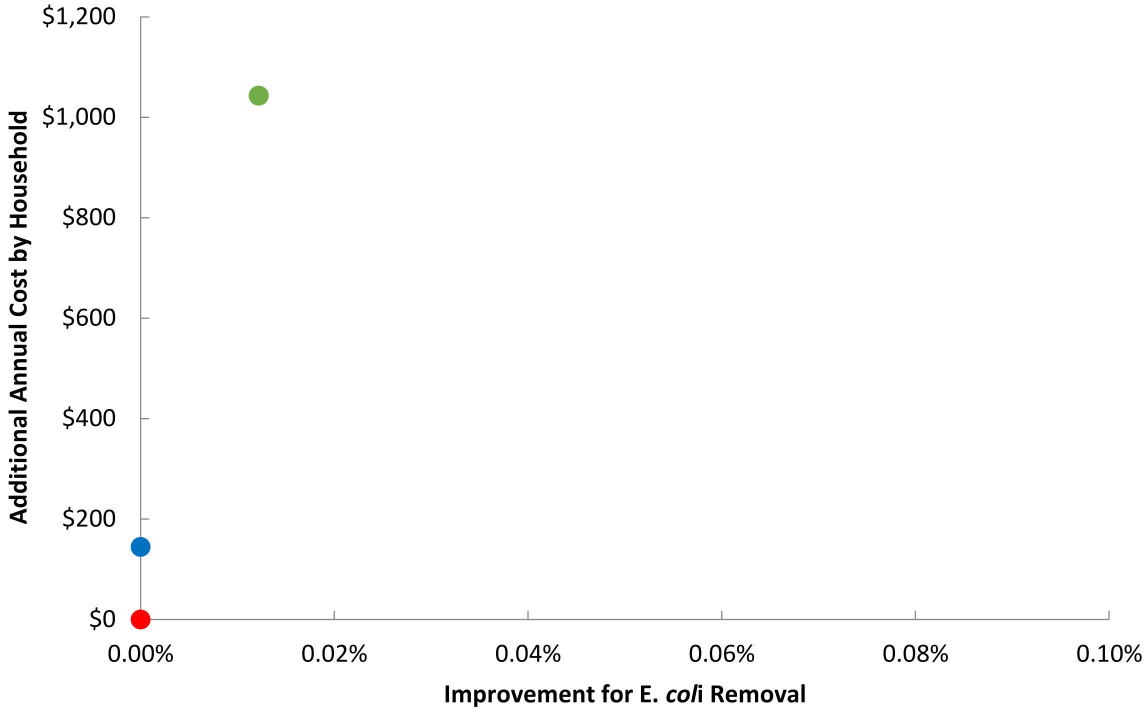



**Figure C68: Te Anau improvement in treatment for *E. coli***

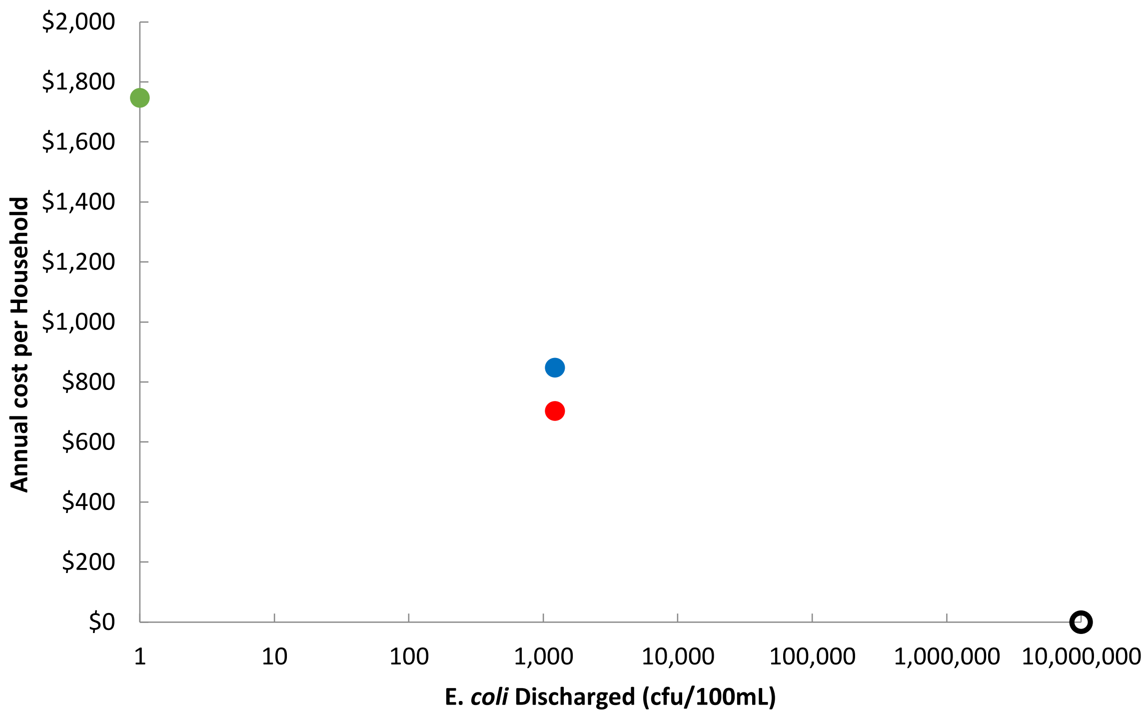



**Figure C69: Te Anau discharge of *E. coli***

## 7.5. Te Anau Summary

The Te Anau wastewater treatment system is based around oxidation ponds, and it has developed over time as the town has continued to grow. The current set up uses a mechanical fine screen, facultative oxidation pond, two maturation ponds and a wetland before discharging to the Upukerora River. The discharge point is about 800 metres upstream of Lake Te Anau, near the mouth of the Upukerora River. The river's ability to assimilate the wastewater discharge varies depending on what is happening upstream of the discharge. For example, high rainfall events have the potential to flush sediments and nutrients down through the catchment upstream of the discharge, but also can increase river flow and dilution.

Te Anau's wastewater scheme receives residential as well as commercial/light industrial wastewater for treatment. The treatment system gives a relatively high level of contaminant removal, especially for biochemical oxygen demand and *E. coli*. As with other similar pond based systems, Te Anau's is less efficient at removing nutrients, with low reduction rates for total phosphorus and total nitrogen.

The existing system's performance may be explained by the use of 'typical Southland' concentrations for the incoming wastewater. As well, there is limited monitoring data of the quality of the discharge and the system is likely to be influenced by population fluctuations through the year. The actual wastewater inflow may have higher phosphorus concentrations than assumed, which can be confirmed by sampling of inflow into the pond. If this is the case then the existing system may be achieving better rates of reduction, particularly for phosphorus than those estimated in this case study.

Two scenarios were modelled for Te Anau: one based on the consented Kepler land discharge, and one assuming a continued discharge to water is possible and achieves improvements in total nitrogen reduction, and makes reductions in phosphorous more reliable. Each scenario has strengths and weaknesses in its cost or treatment performance for each contaminant.

The capability of the base system means that the scenarios generally deliver a relatively small percentage improvement in contaminant reduction, especially for biochemical oxygen demand and *E. coli*. The scenarios have a range of annual costs per household and these costs may not relate to each scenario's capability to treat particular contaminants. The modelling exercise does not include the range of factors that are taken into account when determining a preferred outcome – these include views of stakeholders including iwi to whom a continued discharge to water is unacceptable.

## 7.6. Limitations and Constraints

The discharge to land scenario depends on the availability of suitable land (either owned by the Council or able to be purchased). Southland District Council owns land suitable for the discharge and has undertaken extensive investigations in support of upgrading by slow rate infiltration of treated wastewater.

The limited monitoring data set for the existing system means that, in comparison with other case studies, there is more uncertainty in the performance of the existing system. Although the nutrient reduction scenario does not appear to provide much improvement, in practice, it is likely to be more reliable. It provides more certainty in the contaminant reduction achieved, as compared to the existing system.

# 8. Invercargill

## 8.1. Invercargill Wastewater Scheme

The Invercargill wastewater scheme was built in 1910. The urban area has separate stormwater and wastewater schemes, over an area of 3,000 hectares. Around 19,300 residential, commercial and industrial properties are connected to the wastewater network. The treatment system includes tertiary treatment.

The Clifton wastewater treatment system is located in Lake Street, at the south end of Invercargill. The primary treatment process includes screening, pre-aeration, grit removal and sedimentation. Secondary treatment is carried out by trickling filters and clarification. The tertiary process provides ultraviolet disinfection from natural sunlight in facultative ponds, followed by final disinfection and polishing in constructed wetlands. Treated wastewater is discharged into the New River Estuary for three or four hours on the outgoing tide. Sludge's from the primary sedimentation and secondary clarification processes are digested, dewatered in sludge lagoons, dried in windrows, and then applied to land as biosolids. The quality of the treated wastewater is generally high and fully meets the resource consent conditions, although the plant is a major source of nutrients (nitrogen and phosphorus) in the estuary. The discharge consent was granted in 2004 and will expire in 2029.

**Image C15: Clifton wastewater clarifier**

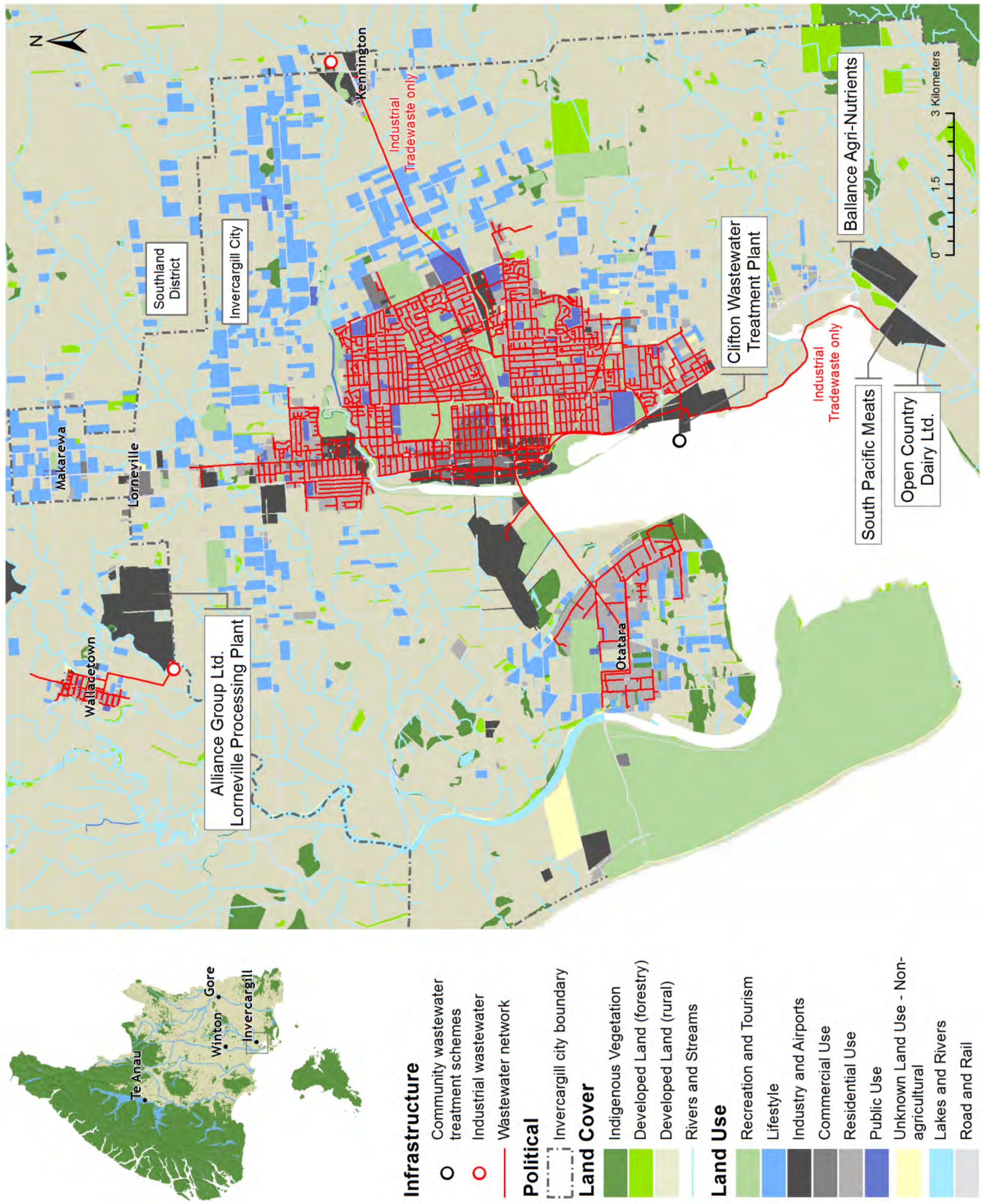
There are 15 constructed overflows from the wastewater network to the stormwater network which operate when the wastewater network is overloaded with stormwater, or as a result of blockage. These overflows have been monitored since 2013, and three have operated in that time. Stormwater can enter the wastewater network after intense rainfall ponding on properties resulting in inflow into gulley traps, through leaky pipes, and where drainage systems have been mistakenly or deliberately interconnected on properties. The wastewater network can become overloaded with stormwater, resulting in overflows to the stormwater network. Wet weather wastewater flows at the Clifton wastewater treatment system can be up to six times the dry weather flows.

**Image C16: Clifton wastewater trickling filter**

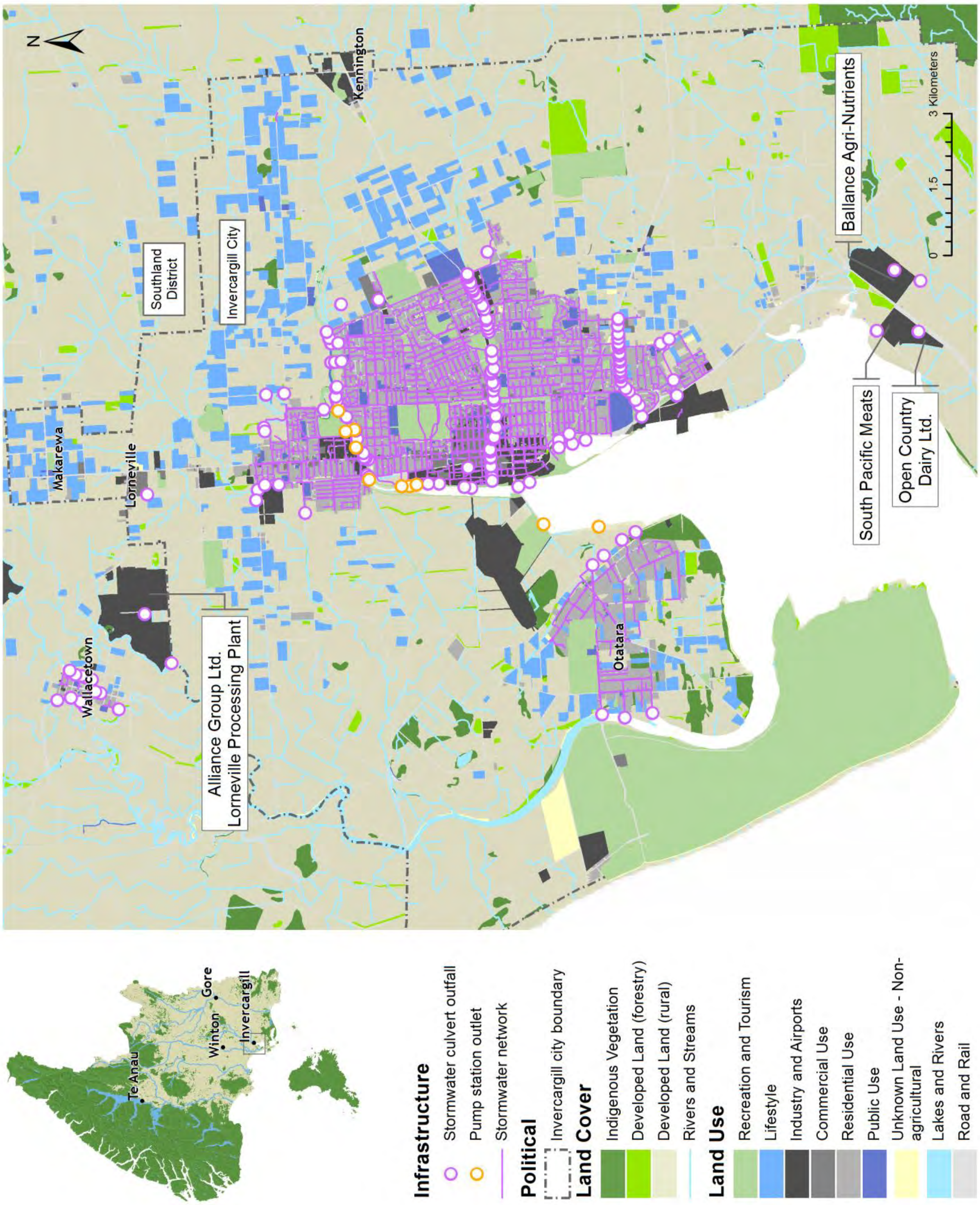
The major contributors to trade waste in Invercargill are South Pacific Meats and Open Country Dairy at Awarua, Silver Fern Farms at Kennington, Prime Range Meats at West Plains, and Alsco and McCallums Laundry/Dry Cleaning, Quality Food, and Bowmont Meats in Invercargill City. These contributors combined account for 20 percent of Clifton Treatment Plant wastewater inflow volume. The loading on the Clifton plant is minimal because the large processors pre-treat their wastewater to a good standard (M. Loan, pers. comm. 2018). A total of 25 dischargers whose loading or volumes exceed the permitted categories of the trade waste bylaw hold trade waste consents.

**Image C17: Clifton wetlands**

The following two maps show the Invercargill wastewater and stormwater schemes.



Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Political
Invercargill city boundary
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
Te Anau
Winton
Gore
Invercargill
N
Kennington
Industrial Tradewaste only
Southland District
Invercargill City
Makarewa
Lorneville
Wallacetown
Alliance Group Ltd. Lorneville Processing Plant
Otatara
Clifton Wastewater Treatment Plant
Industrial Tradewaste only
Ballance Agri-Nutrients
South Pacific Meats
Open Country Dairy Ltd.
0 1.5 3 Kilometers



N
Kennington
Southland District
Invercargill City
Makarewa
Lorneville
Wallacetown
Alliance Group Ltd. Lorneville Processing Plant
Otatara
Ballance Agri-Nutrients
South Pacific Meats
Open Country Dairy Ltd.
0
1.5
3 Kilometers
Te Anau
Winton
Gore
Invercargill
Infrastructure
Stormwater culvert outfall
Pump station outlet
Stormwater network
Political
Invercargill city boundary
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail

## 8.2. Baseline Results

This section describes the baseline results for Invercargill (i.e. what is actually occurring). The total annual inflow of wastewater into the Invercargill treatment system at Clifton is estimated at 9,052,300 $m^3$ with the daily flow varying between 25,100 $m^3$ and 25,300 $m^3$. Table C47 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C48 gives information on the average quality of the treated wastewater discharged into New River Estuary.

**Image C18: Clifton wetlands with treatment plant in background**

**Table C47: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant<br>2013-2016 | Total SS<br>(tonnes) | BOD<br>(tonnes) | Total N<br>(tonnes) | Total P<br>(tonnes) | *E. coli*<br>(cfu/100ml) |
|---|---|---|---|---|---|
| Average (4 years) | 2,087 | 2,189 | 192.8 | 21.7 | ~9,998,500 |

**Table C48: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **(cfu/100ml)** |
| Average (5 years) | 19.4 | 8.2 | 28.7 | 4.6 | 1,300 |

| Loads | (tonnes) | (tonnes) | (tonnes) | (tonnes) | |
|---|---|---|---|---|---|
| Range (4 years) | 146.0 to 196.8 | 56.2 to 92.5 | 186.5 to 349.1 | 37.1 to 45.5 | N.A. |
| Estimated loads | 175.6 | 74.2 | 259.8 | 41.6 | N.A. |

Source: Environment Southland consent monitoring data

The total optimised[25] replacement value of all the assets in the wastewater network (including Bluff) is $274.8 million (around $12,500 per household). The largest contributor to value is the pipe network, which accounts for roughly 79 percent of the optimised replacement value. The Clifton treatment plant has an optimised replacement value of $45 million.

The annual depreciated value of the wastewater scheme is $2,174,000 and the annual operating cost is $3,154,000. These 2016 figures were used to determine the total 30 year cost of the existing system in Table C49 using the methodology in Section C1.5.

Figure C70 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[26] before being plotted to make it possible to include all five different contaminants on the same graph.

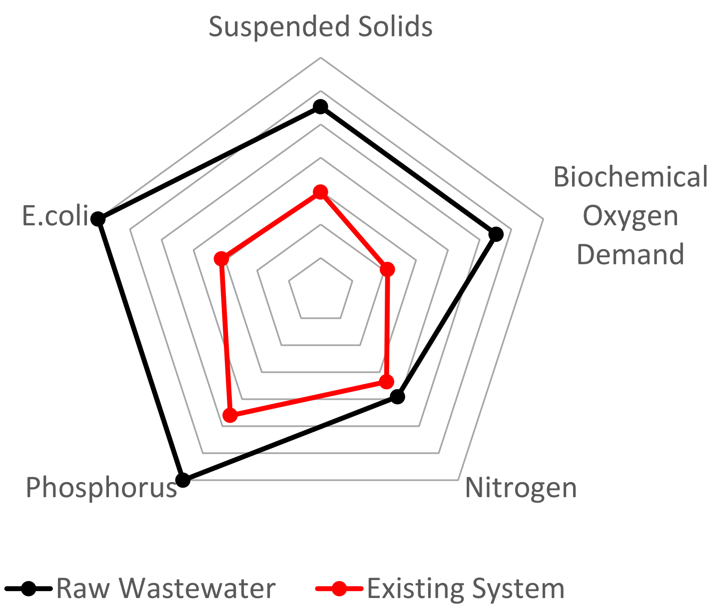



**Figure C70: Invercargill baseline scenario (existing system)**

[25] The Council prefer 'optimised replacement cost' over 'replacement cost', and it is used in the Invercargill asset management plans (Malcolm Loan, pers. comm., 2018). 'Replacement cost' implies that an asset will be replaced with a like asset, while 'optimised replacement cost' will consider new technology, and improved performance and economics. For example, earthenware pipes which account for 65% of the pipe asset will be replaced in other materials which provide better performance and lower cost. Similarly, electrical, mechanical and electronic plant replacements will take advantage of new technology and methodology to gain performance and economic improvements.

[26] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

**Image C19: Looking from Clifton's wetlands across to New River Estuary**

## 8.3. Modelling Scenarios

Seven scenarios were developed for the Invercargill wastewater system (the scenarios and treatment processes as listed below with more details are in Appendix 2). The scenarios are ordered by their total cost (lowest to highest). Further work is needed to determine whether any scenario is technically feasible. Table C49 gives the scheme's total cost for the capital investment and annual operating costs over 30 years. The additional annual cost per household is based on 20,904 households and the same 30 year time period (the annual average number of households forecast between 2016 and 2046).

| Scenario | Treatment Process (new units in bold) |
| --- | --- |
| Existing System | Liquid: screen, pre-aeration, sedimentation tanks, trickling filter, secondary clarifier, facultative ponds, wetland |
| | Solid: digester, sludge lagoons |
| 1. Phosphorus reduction | Liquid: screen, pre-aeration, **chemical dosing,** sedimentation tanks, trickling filter, secondary clarifier, facultative ponds, wetland |
| | Solid: as existing |
| 2. Pathogen reduction | Liquid: screen, pre-aeration, sedimentation tanks, trickling filter, secondary clarifier, facultative ponds, wetland, **UV disinfection** |
| | Solid: as existing |
| 3. Rapid infiltration | Existing process **+ high rate infiltration (rapid infiltration basins etc.)** |

| Scenario | Treatment Process (new units in bold) |
|---|---|
| 4. Nutrient reduction | Liquid: screen, pre-aeration, sedimentation tanks, trickling filter, secondary clarifier, **bioreactors,** facultative ponds, wetland<br>Solid: as existing |
| 5. Nutrient and solids reduction | Liquid: Screen, Pre-aeration, Sedimentation tanks, Trickling filter, Secondary clarifier, **Bioreactors, new,** Facultative ponds, Wetland, **Cloth/disc filter, new**<br>Solid: as existing |
| 6. Slow infiltration | Existing process **+ slow rate infiltration (spray irrigation etc.)** |
| 7. Enhanced treatment | Liquid: 3mm screen, **fine screen, membrane bioreactor**<br>Solid: as existing |

**Table C49: Invercargill Wastewater Scenarios**

| Scenario | Total 30 year cost | Additional annual cost per household |
|---|---|---|
| **Existing scheme** | $223,039,000 | $356 |
| **1. Phosphorus reduction** | $241,126,000 | +$29 |
| **2. Pathogen reduction** | $242,282,000 | +$31 |
| **3. Rapid infiltration (includes partial cost of land purchase)** | $282,256,000 | +$94 |
| **4. Nutrient reduction** | $287,868,000 | +$103 |
| **5. Nutrient and solids reduction** | $294,900,000 | +$115 |
| **6. Slow infiltration (includes partial cost of land purchase)** | $354,330,000 | +$209 |
| **7. Enhanced treatment** | $354,564,000 | +$210 |

Figures C71 to C73 show the target treated wastewater concentrations which were used to design the upgrade scenarios. The same axes have been used as in Figure C70 so the performance of the upgrade scenarios can be compared to that achieved by the existing treatment system. The concentrations used for the discharge to land scenarios are at the point of discharge to groundwater, and are based on the stated assumptions for soil type and depth to groundwater. Except for phosphorus, the concentrations of the contaminants were transformed[27] before being plotted to make it possible to include all five different contaminants on the same graph.

[27] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

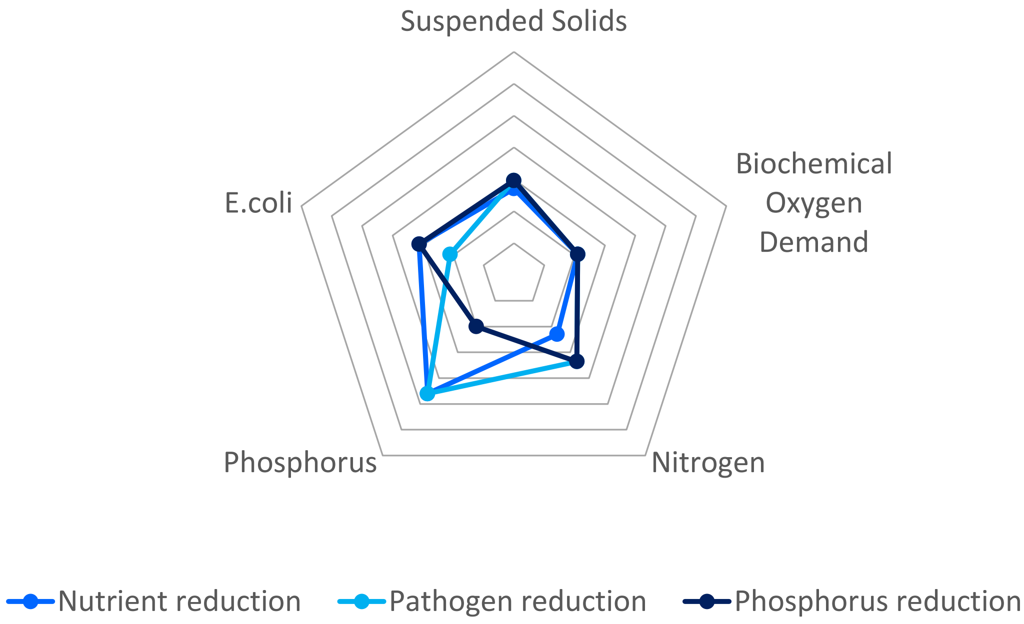



**Figure C71: Invercargill 'discharge to water' scenarios**

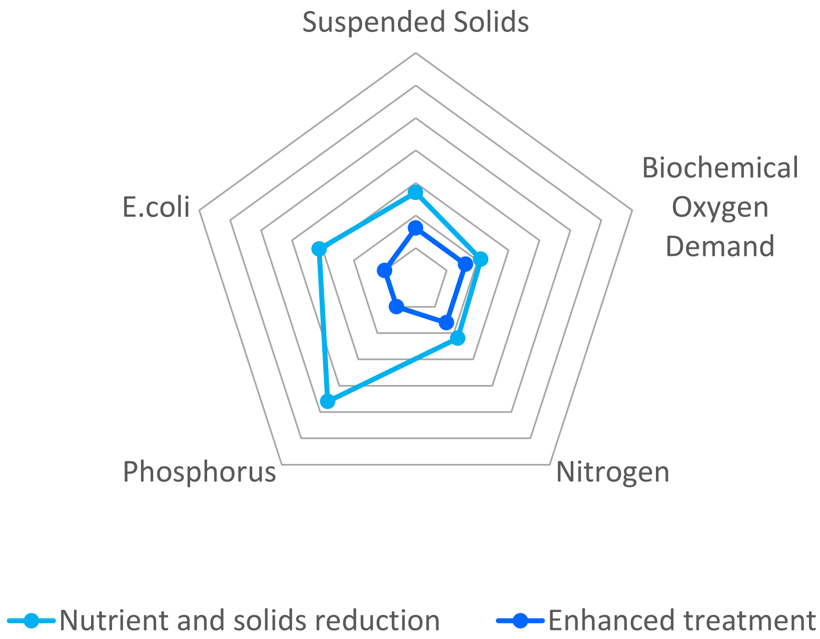



**Figure C72: Invercargill 'discharge to water' scenarios (continued)**

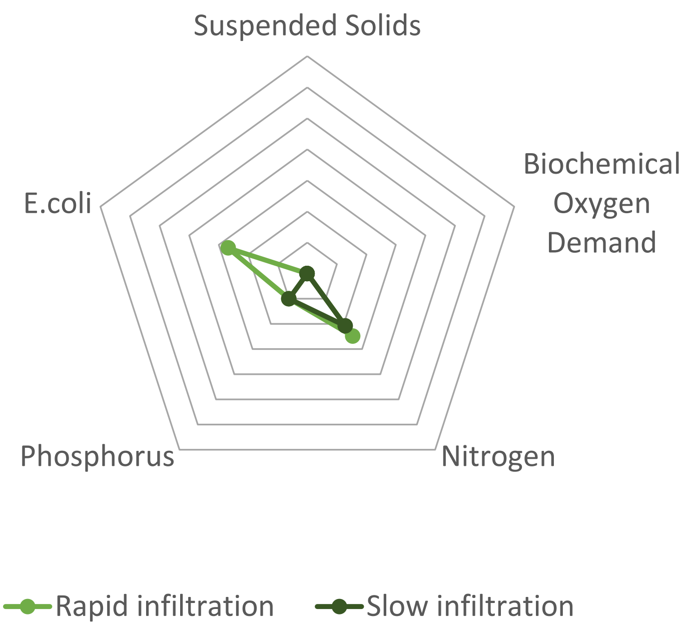



**Figure C73: Invercargill 'discharge to land' scenarios**

## 8.4. Modelling Results

*The scenarios are standard pre-feasibility options and all results are estimates only.*

*Two types of graphs are used in this section: wastewater treatment graphs and wastewater discharge graphs. All of the graphs have:*

- ***a red dot** for the existing level of treatment (i.e. the base);*
- ***blue dots** for modelling scenarios representing discharges to water; and*
- ***green dots** for modelling scenarios representing discharges to land.*

*The modelling scenarios (blue and green dots) are not numbered on the graphs but it is possible to identify each scenario by noting its position on the vertical 'cost' axis and referring to the scenario costs table above. For example, the least expensive scenario will be the lowest blue or green dot and the most expensive scenario will be the highest blue or green dot.*

*The wastewater discharge graphs also have **a clear black dot**, representing the wastewater inflow (i.e. pre-treatment) for the town. The black dot gives a useful reference point for the reduction in contaminants achieved by both the base scenario (existing level of treatment) and the modelling scenarios. The distance between the black dot and the red dot indicates the effectiveness of the existing treatment system.*

*The scale of the axes on the graphs was determined by the full set of results for all six case studies with alternate scenarios. Making the scale consistent across the graphs means that the results are comparable between graphs.*

### 8.4.1. Total Suspended Solids

The existing system (the base) removes a substantial proportion of total suspended solids from the inflow of raw wastewater through its different treatment processes. The screen removes large solids, the ponds add some removal via bacteria and settlement. Overall the existing treatment system removes 92.2 percent of the total suspended solids in the wastewater inflow. The Invercargill system receives a base inflow load of 2,263 tonnes of solids, of which 2,087 tonnes are removed through treatment, and 176 tonnes are discharged.

Of the seven scenarios modelled for Invercargill, Scenario 3: *Rapid infiltration* and Scenario 6: *Slow infiltration* could be the most effective at removing total suspended solids. These scenarios use additional filtration through the soil to remove suspended solids before discharge to the aquifer. Scenario 7: *Enhanced treatment* could also be relatively effective for this contaminant. Scenario 1: *Phosphorus reduction* and Scenario 2: *Pathogen reduction* are likely to be less effective for treating suspended solids these treatments do not typically reduce suspended solids. Table C50 summarises the scenario treatment capabilities for total suspended solids (kilograms per household per year – kg/hh/year) in comparison to the wastewater inflow and the base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C50: Annual Loads – Suspended Solids (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 100 | 92.2% | 0.0% | 8 | 7.8% |
| 1. Phosphorus | 100 | 92.2% | 0.0% | 8 | 7.8% |
| 2. Pathogens | 100 | 92.2% | 0.0% | 8 | 7.8% |
| 3. Rapid infiltration | 108 | 99.6% | 8.0% | 0 | 0.4% |
| 4. Nutrients | 102 | 94.0% | 1.9% | 6 | 6.0% |
| 5. Nutrients & solids | 102 | 94.0% | 1.9% | 6 | 6.0% |
| 6. Slow infiltration | 108 | 99.6% | 8.0% | 0 | 0.4% |
| 7. Enhanced | 106 | 98.0% | 6.2% | 2 | 2.0% |

The three most effective scenarios for suspended solids (Scenarios 3, 6 and 7) have additional annual costs for wastewater treatment of between $94 and $210 per household. Scenarios 3 and 6 (the two land-based technologies) are likely to deliver similar improvements for total suspended solids but have a marked difference in cost. Of these scenarios, Scenario 3: *Rapid infiltration* is expected to deliver improvements at the lowest additional cost. Figure C74 shows the relationship between the treatment system's improvement in removing total suspended solids and the possible increase in annual cost per household. Scenario 1: *Phosphorus reduction* and Scenario 2: *Pathogen reduction* have no improvements for removal of total suspended solids yet could increase costs to the household. Figure C75 shows the relationship between the annual discharge of suspended solids and annual cost per household.

The key and explanation for these graphs is included at the start of the modelling results section.

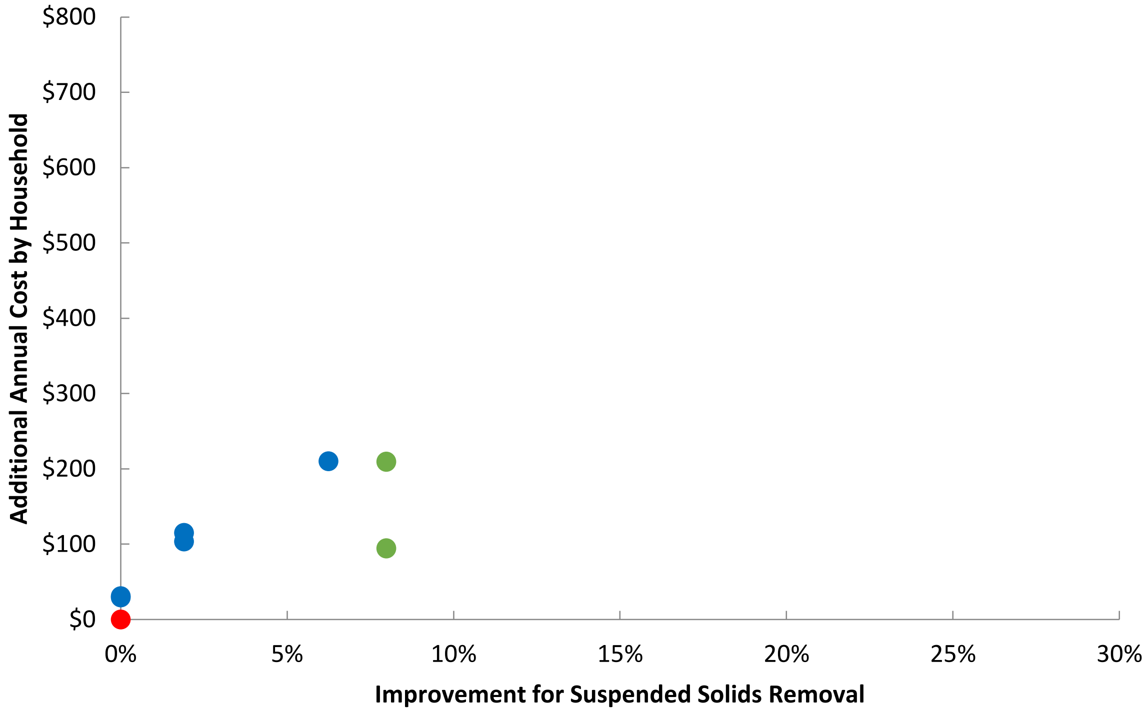



**Figure C74: Invercargill improvement in treatment for suspended solids**

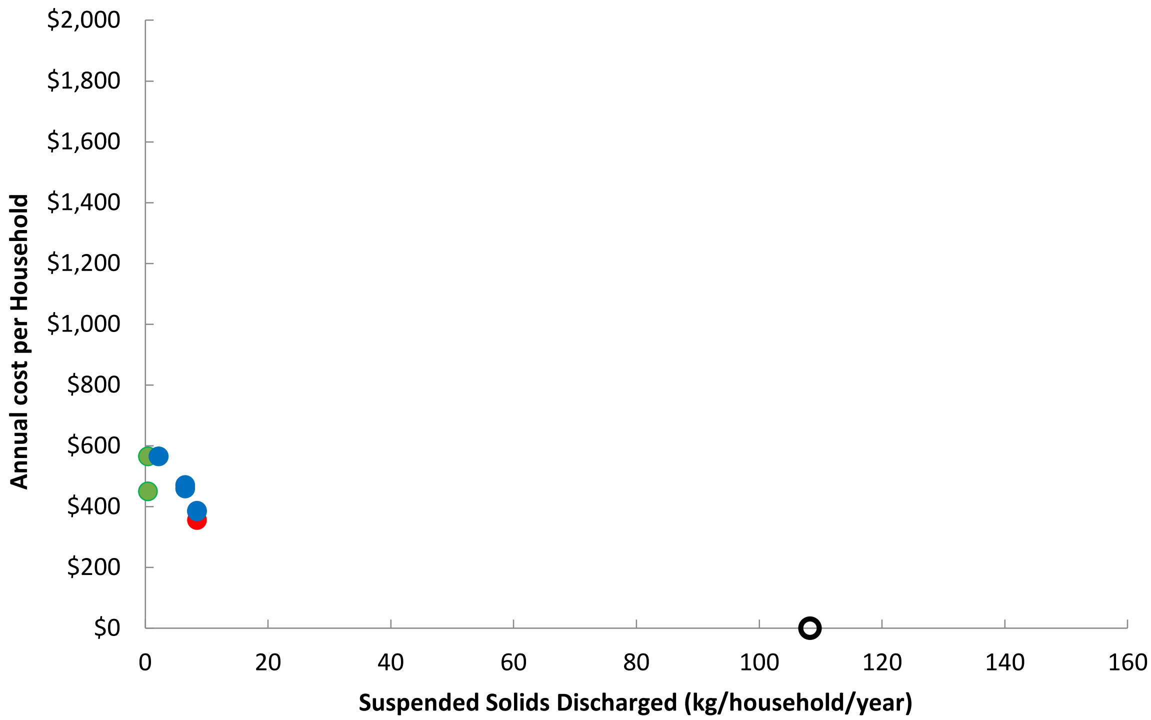



**Figure C75: Invercargill discharge of suspended solids**

### 8.4.2. Biochemical Oxygen Demand

Biochemical oxygen demand is treated within the existing treatment system via the primary and secondary ponds. The existing treatment system reduces 97 percent of biochemical oxygen demand, which as with the total suspended solids, is a considerable proportion of the raw wastewater inflow. For biochemical oxygen demand, the Invercargill system receives a base inflow load of 2,263 tonnes annually, of which 2189 tonnes are reduced through the treatment process, and 74 tonnes are discharged to surface water.

There is minimal improvement from any of the upgrade scenarios because the existing system is highly effective in reducing biochemical oxygen demand. Of seven scenarios modelled, Scenario 3: *Rapid infiltration* and Scenario 6: *Slow infiltration* are likely to be the most effective for further reducing biochemical oxygen demand. They were also the better performing scenarios for suspended solids. Scenario 7: *Enhanced treatment* is also likely to be effective for reduction of this contaminant. The remaining scenarios are less effective for this contaminant because these treatments do not typically reduce biological oxygen demand. Table C51 summarises the scenario treatment capabilities for biochemical oxygen demand in comparison to both the wastewater inflow and the base reduction (existing system). It also gives the resulting discharge for the base and all scenarios. Overall, the different scenarios modelled are likely to deliver relatively small improvements because the existing treatment system performs particularly well for this contaminant.

**Table C51: Annual Loads - BOD (treatment reduction and discharge)**

| Scenario | Load reduction (kg/hh/year) | Treatment reduction as % of inflow | Improvement as % of base reduction | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Base reduction | 105 | 96.7% | 0.0% | 4 | 3.3% |
| 1. Phosphorus | 105 | 96.7% | 0.0% | 4 | 3.3% |
| 2. Pathogens | 105 | 96.7% | 0.0% | 4 | 3.3% |
| 3. Rapid infiltration | 108 | 99.6% | 3.0% | 0 | 0.4% |
| 4. Nutrients | 105 | 96.7% | 0.0% | 4 | 3.3% |
| 5. Nutrients & solids | 105 | 96.7% | 0.0% | 4 | 3.3% |
| 6. Slow infiltration | 108 | 99.6% | 3.0% | 0 | 0.4% |
| 7. Enhanced | 106 | 98.0% | 1.3% | 2 | 2.0% |

The three most effective scenarios for biochemical oxygen demand (Scenarios 3, 6 and 7) have an additional annual cost for wastewater treatment per household of between $94 and $210. Of these scenarios, Scenario 3: *Rapid infiltration* is likely to deliver improvements at the lowest additional cost. Figure C76 shows the relationship between the treatment system's improvement in reducing biochemical oxygen demand and the possible increase in annual cost per household. Figure C77 shows the relationship between the annual discharge of biochemical oxygen demand and annual cost per household. The relatively small improvements in treatment and discharge that can be made for this contaminant are likely to increase the annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

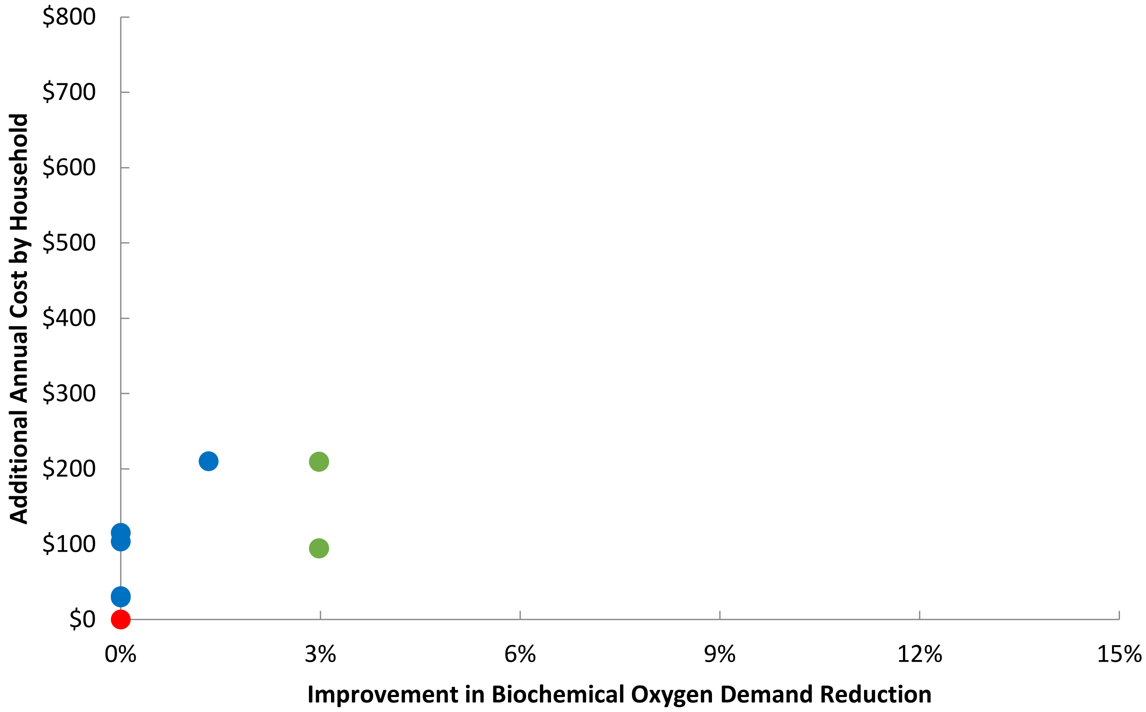



**Figure C76: Invercargill improvement in treatment for biochemical oxygen demand (BOD)**

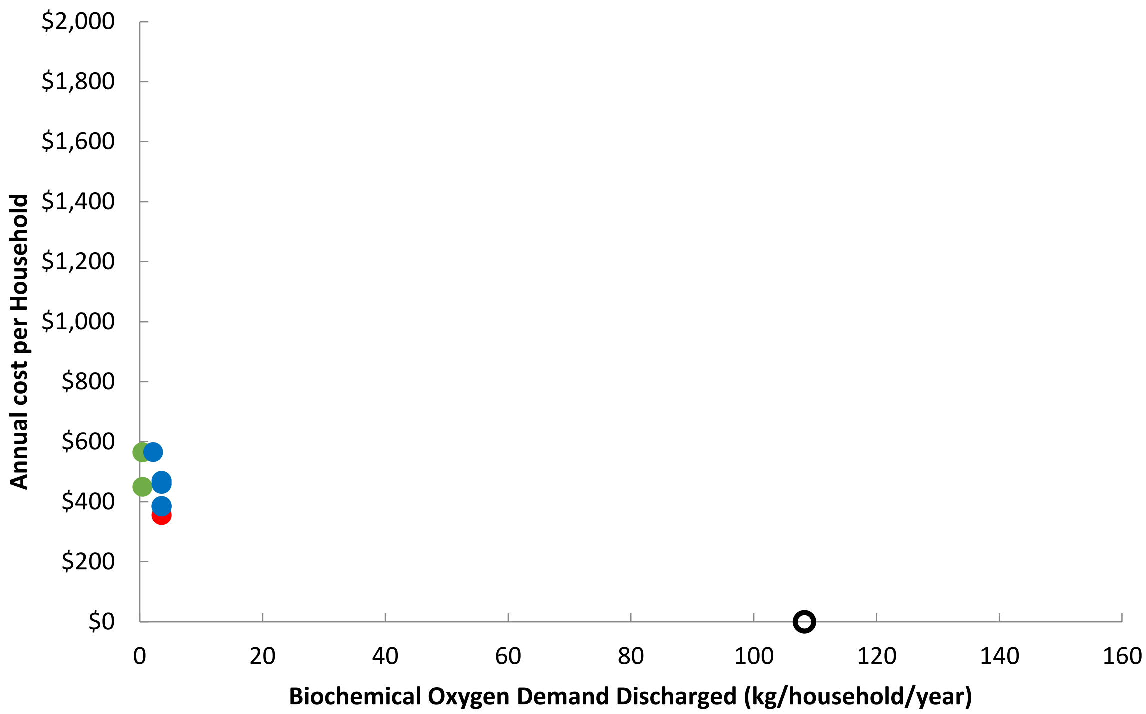



**Figure C77: Invercargill discharge of biochemical oxygen demand (BOD)**

### 8.4.3. Total Nitrogen

In addition to suspended solids and biochemical oxygen demand, the existing system also removes nutrients (total nitrogen and phosphorus) from the inflow of raw wastewater within the sedimentation and trickling filter processes. The existing system removes 56 percent of total nitrogen from the wastewater inflow, which is a lower proportion than its removal of suspended solids (92%) and biochemical oxygen demand (97%). The Invercargill system receives a base inflow load of 453 tonnes of total nitrogen annually, of which 193 tonnes are removed through treatment, and 260 tonnes are discharged.

The most effective scenario is Scenario 7: *Enhanced treatment*, which could remove 90 percent of the total nitrogen in the wastewater discharge (19.5 kg per household per year). Scenario 6: *Slow infiltration* could also remove over 80 percent of the total nitrogen in the wastewater discharge. Scenario 5: *Nutrients & solids*, Scenario 4: *Nutrient reduction* and Scenario 3: *Rapid infiltration* could be considerably effective for this contaminant. Table C52 summarises the scenario treatment capabilities for total nitrogen compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C52: Annual Loads – Total Nitrogen (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9 | 42.6% | 0.0% | 12 | 57.4% |
| 1. Phosphorus | 9 | 42.6% | 0.0% | 12 | 57.4% |
| 2. Pathogens | 9 | 42.6% | 0.0% | 12 | 57.4% |
| 3. Rapid infiltration | 16 | 76.0% | 78.4% | 5 | 24.0% |
| 4. Nutrients | 17 | 80.0% | 87.8% | 4 | 20.0% |
| 5. Nutrients & solids | 18 | 82.0% | 92.5% | 4 | 18.0% |
| 6. Slow infiltration | 18 | 84.0% | 97.2% | 3 | 16.0% |
| 7. Enhanced | 19 | 90.0% | 111.3% | 2 | 10.0% |

Of the five scenarios that are relatively effective for total nitrogen (Scenarios 3, 4, 5, 6 and 7), Scenario 3: *Rapid infiltration* has the lowest additional cost. The two most effective scenarios (Scenarios 6 and 7) for total nitrogen have the highest additional annual cost for wastewater treatment per household. Figure C78 shows the relationship between the treatment system's improvement in removing total nitrogen and the possible increase in annual cost per household. Figure C79 shows the relationship between the annual discharge of total nitrogen and annual cost per household.

Overall, the increasing costs of treatment across the different scenarios are reflected in an increasing reduction in nitrogen, indicating an improvement for this contaminant at a cost.

**The key and explanation for these graphs is included at the start of the modelling results section.**

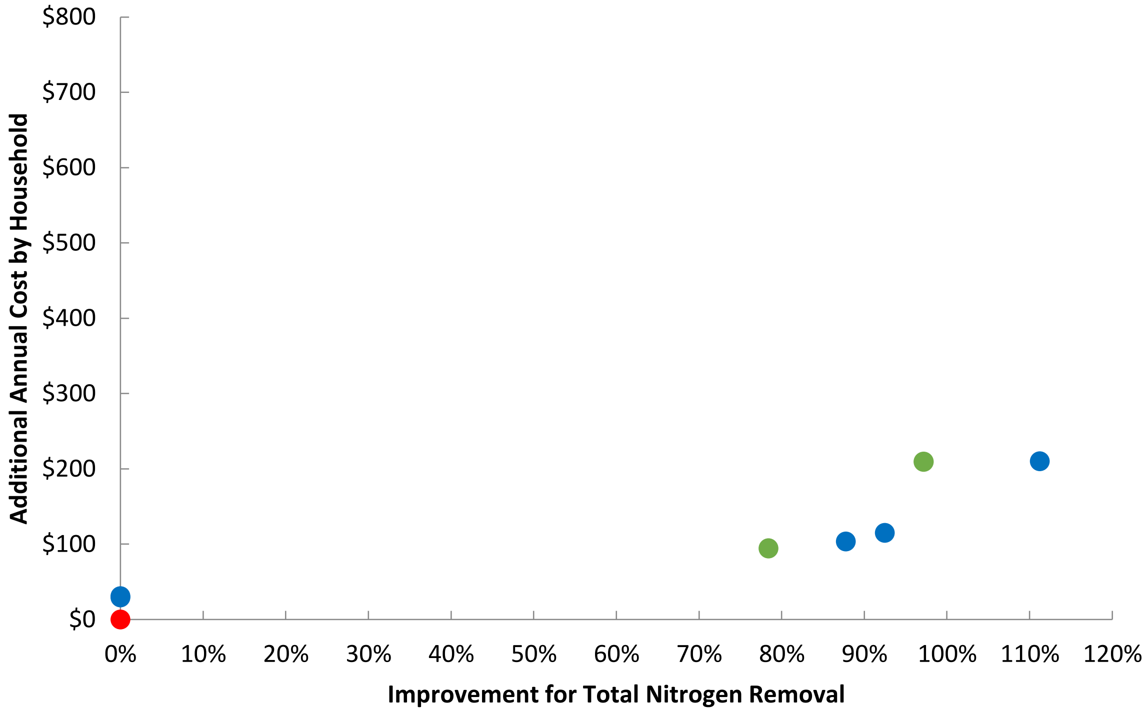



**Figure C78: Invercargill improvement in treatment for total nitrogen**

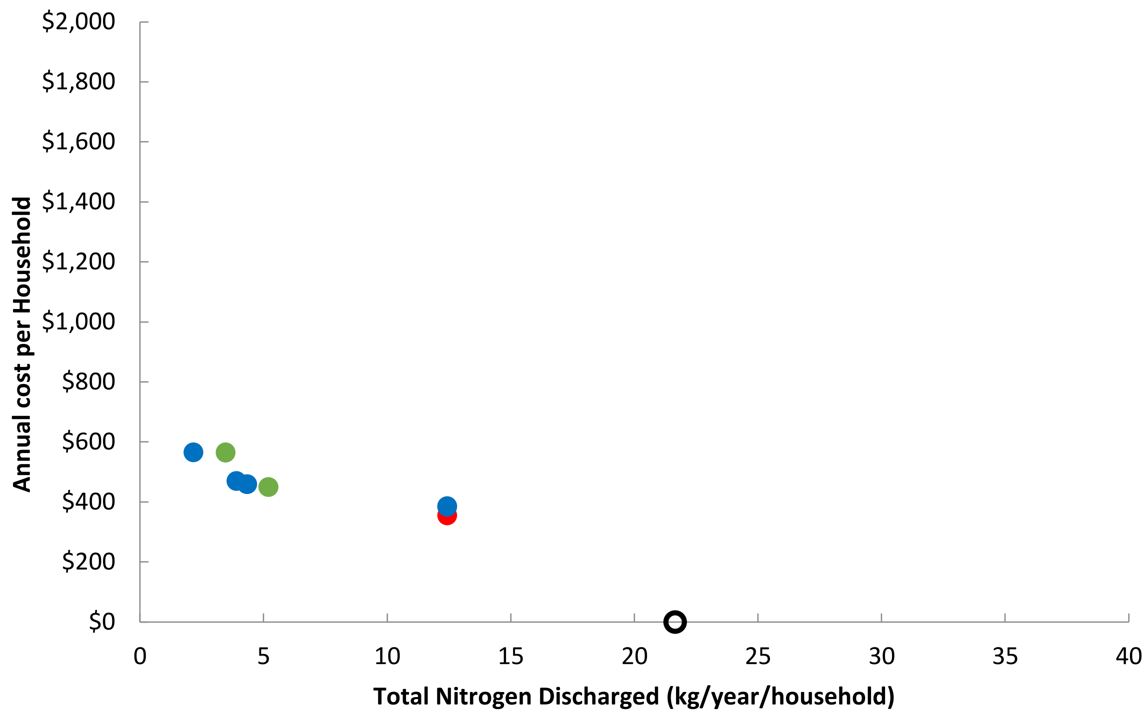



**Figure C79: Invercargill discharge of total nitrogen**

### 8.4.4. Total Phosphorus

In addition to total nitrogen, the existing system also removes phosphorus from the inflow of raw wastewater. Overall, 34 percent of total phosphorus from the wastewater inflow is removed, which is slightly lower than the proportion of total nitrogen removal (42%). The Invercargill system receives a base inflow load of 63 tonnes of total phosphorus annually, of which 22 tonnes are removed through treatment, and 42 tonnes are discharged to surface water.

As with total nitrogen, Scenario 7: *Enhanced treatment* could be the most effective for total phosphorus of the scenarios modelled. The two land-based scenarios could also be effective for total phosphorus removal. Scenario 1: *Phosphorus reduction* is also likely to be considerably effective for this contaminant. Scenario 2: *Pathogen reduction*, Scenario 4: *Nutrient reduction* and Scenario 5: *Nutrients & solids* are less effective for this contaminant because these treatments do not typically remove phosphorus. Table C53 summarises the scenario treatment capabilities for total phosphorus compared to the wastewater inflow and base removal (existing system). It also gives resulting discharge for the base and all scenarios.

**Table C53: Annual Loads – Total Phosphorus (treatment removal and discharge)**

| Scenario | Load removed (kg/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge load (kg/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 1.0 | 34.3% | 0.0% | 2.0 | 65.7% |
| 1. Phosphorus | 2.2 | 71.4% | 108.3% | 0.9 | 28.6% |
| 2. Pathogens | 1.0 | 34.3% | 0.0% | 2.0 | 65.7% |
| 3. Rapid infiltration | 2.6 | 85.7% | 150.0% | 0.4 | 14.3% |
| 4. Nutrients | 1.0 | 34.3% | 0.0% | 2.0 | 65.7% |
| 5. Nutrients & solids | 1.0 | 34.3% | 0.0% | 2.0 | 65.7% |
| 6. Slow infiltration | 2.6 | 85.7% | 150.0% | 0.4 | 14.3% |
| 7. Enhanced | 2.6 | 85.7% | 150.0% | 0.4 | 14.3% |

The scenarios that are relatively effective for total phosphorus (Scenarios 1, 3, 6, and 7) have additional annual costs for wastewater treatment ranging from $29 to $210 per household. Of these scenarios, Scenario 1: *Phosphorus reduction* is likely to deliver improvements at the lowest additional annual cost per household, with the cost being $29. In comparison with other case studies, the additional cost per household for Invercargill is lower, reflecting the potential economies of scale. Figure C80 shows the relationship between the treatment system's improvement in removing total phosphorus and the possible increase in annual cost per household. Figure C81 shows the relationship between the annual discharge of total phosphorus and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

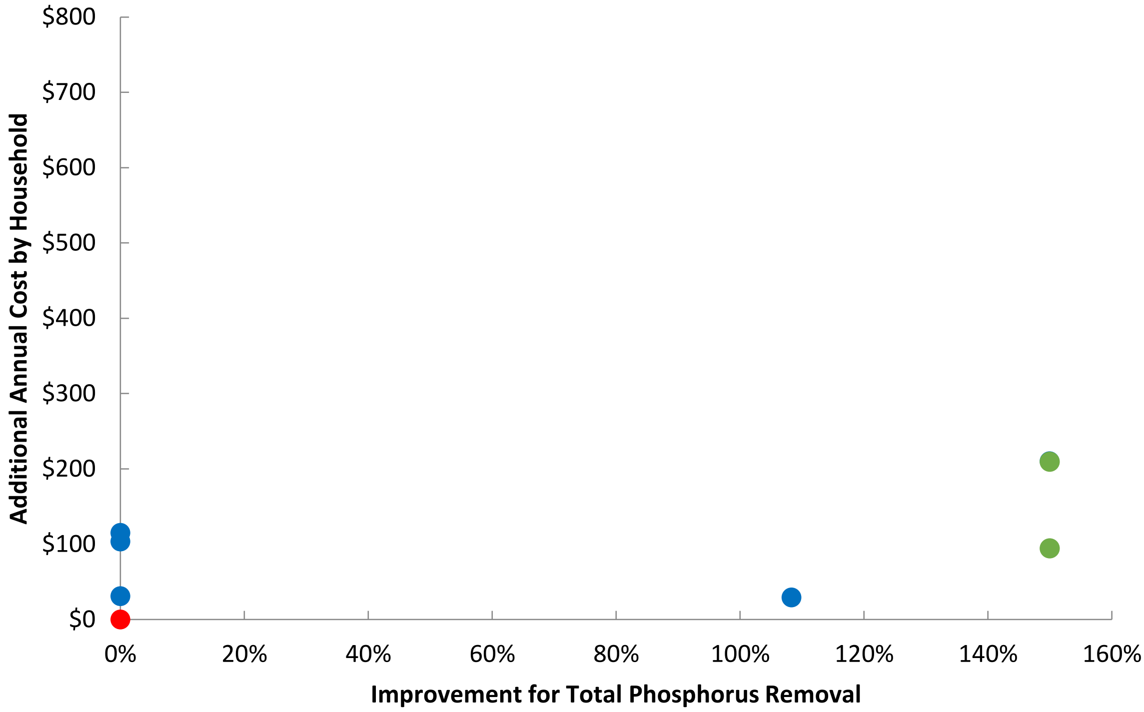



**Figure C80: Invercargill improvement in treatment for total phosphorus**

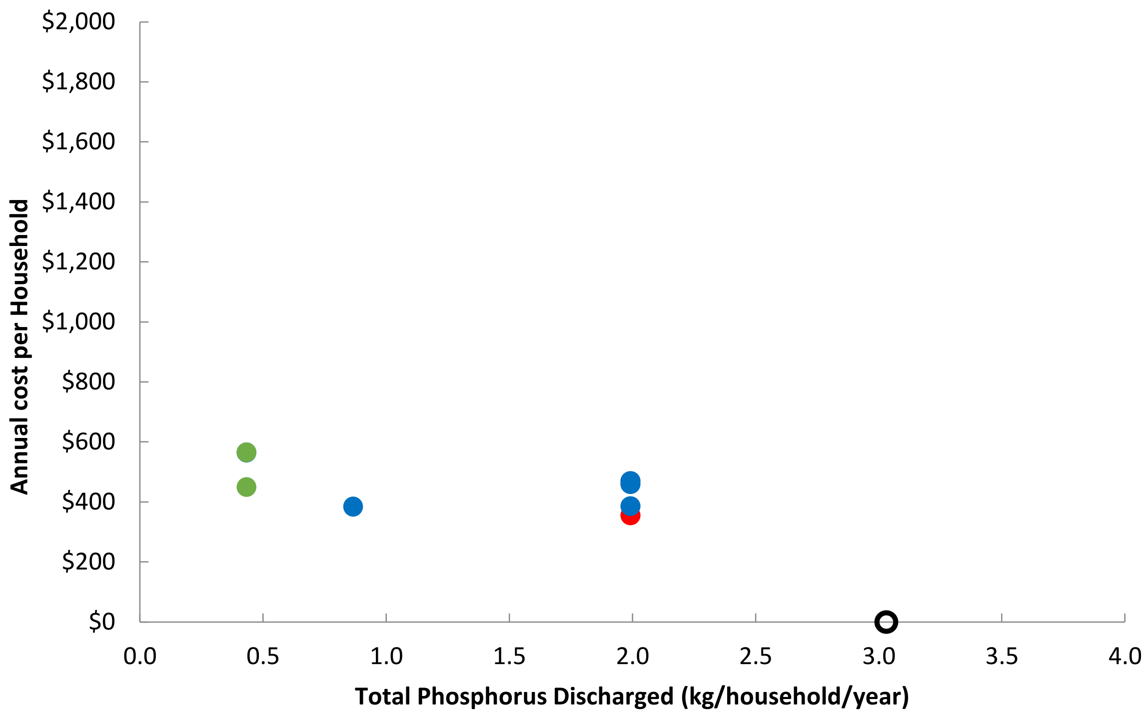



**Figure C81: Invercargill discharge of total phosphorus**

### 8.4.5. *E. coli*

The existing treatment plant has substantial capability to remove *E. coli* from the raw wastewater inflow within the facultative ponds (a type of waste stabilisation pond used for biological treatment). On the whole, the existing system removes 99.99 percent of *E. coli*, which is a greater proportion than for any of the other four contaminants. Yet even very small residual amounts of *E. coli* can still pose a risk to human health. For *E. coli*, the Invercargill system receives base inflow concentrations of 10 million cfu/100mL, which is reduced by 9,998,700 cfu/100mL through treatment, so that a concentration of 1,300 cfu/100mL is discharged to surface water.

Of the scenarios modelled, Scenario 2: *Pathogen reduction*, Scenario 6: *Slow infiltration* and Scenario 7: *Enhanced treatment*, could be the most effective for further removal of *E. coli*. These scenarios could deliver between 0.012% and 0.013% additional removal and include a land-based technology. Scenario 3: *Rapid infiltration* is another land-based technology, which is less effective relative to other scenarios. Table C54 summarises the scenario treatment capabilities for *E. coli* compared to the wastewater inflow and base removal (existing system). It also gives the resulting discharge for the base and all scenarios.

**Table C54: Annual Loads – *E. coli* (treatment removal and discharge)**

| Scenario | Load removed (bn cfu/hh/year) | Treatment removal as % of inflow | Improvement as % of base removal | Discharge concentration (bn cfu/hh/year) | Discharge as % of inflow |
|---|---|---|---|---|---|
| Existing system | 9,998,677 | 99.99% | 0.000% | 1,323 | 0.013% |
| 1. Phosphorus | 9,998,677 | 99.99% | 0.000% | 1,323 | 0.013% |
| 2. Pathogens | 9,999,874 | 99.999% | 0.012% | 126 | 0.0013% |
| 3. Rapid infiltration | 9,999,527 | 99.995% | 0.009% | 473 | 0.0047% |
| 4. Nutrients | 9,998,677 | 99.99% | 0.000% | 1,323 | 0.013% |
| 5. Nutrients & solids | 9,998,677 | 99.99% | 0.000% | 1,323 | 0.013% |
| 6. Slow infiltration | 9,999,999 | 99.99999% | 0.013% | 1 | 0.00001% |
| 7. Enhanced | 9,999,990 | 99.9999% | 0.013% | 10 | 0.0001% |

The four scenarios that offer additional capability for *E. coli* (Scenarios 2, 3, 6 and 7) have a wide range of additional annual costs for wastewater treatment. Scenario 2: *Pathogen reduction* is likely to deliver improvements at the lowest additional cost per household. Figure C82 shows the relationship between the treatment system's improvement in removing *E. coli* and the possible increase in annual cost per household. Figure C83 shows the relationship between the annual discharge of *E. coli* and annual cost per household.

**The key and explanation for these graphs is included at the start of the modelling results section.**

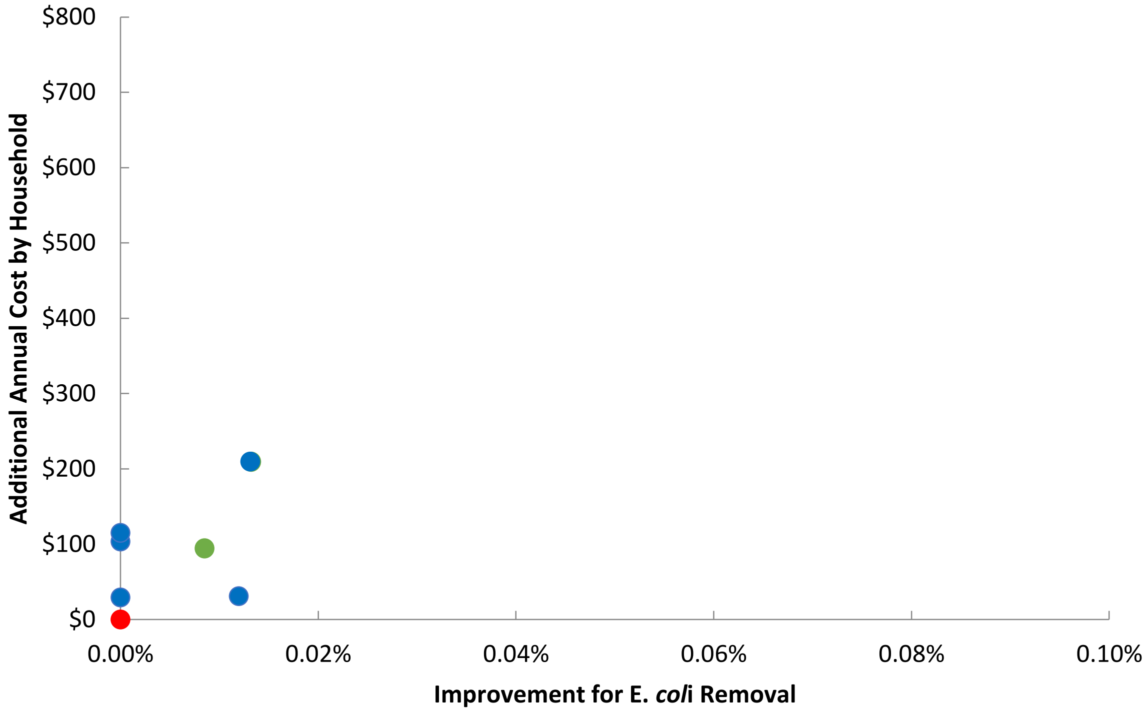



**Figure C82: Invercargill improvement in treatment for *E. coli***

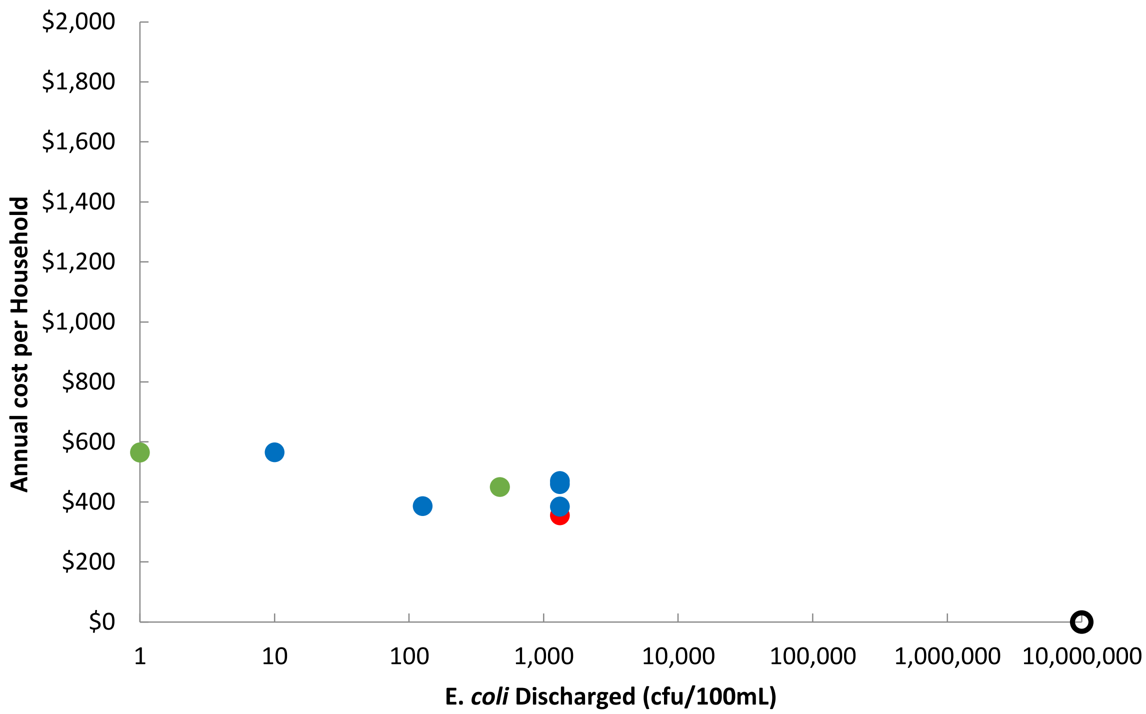



**Figure C83: Invercargill discharge of *E. coli***

## 8.5. Invercargill Summary

The existing treatment system includes pre-screening and pre-aeration, primary sedimentation, secondary trickling filter, clarification and facultative ponds and wetlands. The primary treatment system was built in 1969, the secondary system added in 1993, and the facultative ponds in 2004.

The discharge is timed for a four hour period following each high tide to enable flushing through New River Estuary to the coast. The city and the treatment plant are protected by stop banks and are susceptible to expected sea level rise into the future. Depending on the extent of sea level rise, Invercargill may be forced to retreat or enhance current levels of protection, illustrating the importance of a town's location in relation to water.

Seven options for upgrade were modelled with variable results depending on the contaminant. The land-based scenarios (rapid infiltration and slow infiltration) and the enhanced treatment (nutrient removal) offer the most improvement across the contaminants. Suitable sites for land-based treatment and discharge may not be found within the Invercargill District and the costs are likely to be much higher than the results shown.

The existing treatment plant already achieves high reductions in suspended solids and biochemical oxygen demand, and *E. coli*. Most of the scenarios considered only achieved minimal further improvements for these contaminants. The upgrades achieve considerable reductions in nitrogen and phosphorus. The costs per household for the Invercargill upgrades were generally less than the other case study towns, possibly reflecting the benefits of economies of scale.

## 8.6. Limitations and Constraints

The performance of the wastewater treatment system at Clifton is well monitored, in comparison to the other case studies in this research, because of its size and location beside New River Estuary. There is a high degree of certainty in performance of the current system, and more certainty that the predicted improvements of the upgrade scenarios can be achieved if they prove to be feasible during detailed design.

Implementation of the upgrade scenarios may require additional redundancy in mechanical plant, and the impact of additional sludge production was not included in the predicted costs. These issues could be considerable for some scenarios and will increase costs. The land-based scenarios depend on the availability of suitable land and the sensitivity of the receiving environments, which influences the area required.

At present, Invercargill City Council has not identified sufficient land close to Clifton. Indicative reviews of soil types and soil moisture suggest that a year round discharge to land is unlikely to be feasible. As a result, it is likely wastewater will need to be pumped some distance to a suitable site, or a discharge to water retained. The cost of discharge to land is particularly sensitive to the distance it needs to be pumped. As community expectations change, having any discharge to water in the future is likely to involve considering an upgrade to a more complex mechanical treatment system to improve performance for nutrient (nitrogen and/or phosphorus) reduction.

# 9. Bluff

## 9.1. Bluff Wastewater Scheme

Bluff domestic wastewater and trade waste is collected through a wastewater pipe network, and pumped to a treatment plant at the Ocean Beach end of Bluff Hill. Approximately 1085 residential, commercial, and industrial properties are connected to the Bluff sewerage network. The main contributors to trade waste are the fishing industry, and South Port, together accounting for around 56 percent of biological loading to treatment plant wastewater inflow.

**Image C20: View from Bluff Hill looking west towards Ocean Beach**
Source Emma Moran

The treatment plant consists of a screen, followed by an aerated lagoon, clarification, and ultraviolet radiation. The treated wastewater is discharged through a 50 metre long discharge pipe into Foveaux Strait at Ocean Beach. Sludge removed in the clarifier is returned to the aerated lagoon to provide biomass, and, from time to time, excess sludge is transported by tanker to the Clifton plant for further processing and discharge to land as biosolids. A unique feature of the treatment system is the high sea water component from the fishing industry. The treated wastewater is generally of high quality. Receiving water is sampled at 10 metres from the point of discharge, with water quality seldom being less than the background water quality, and no apparent negative environmental effects are observed.

**Image C21: Bluff aerated lagoon**

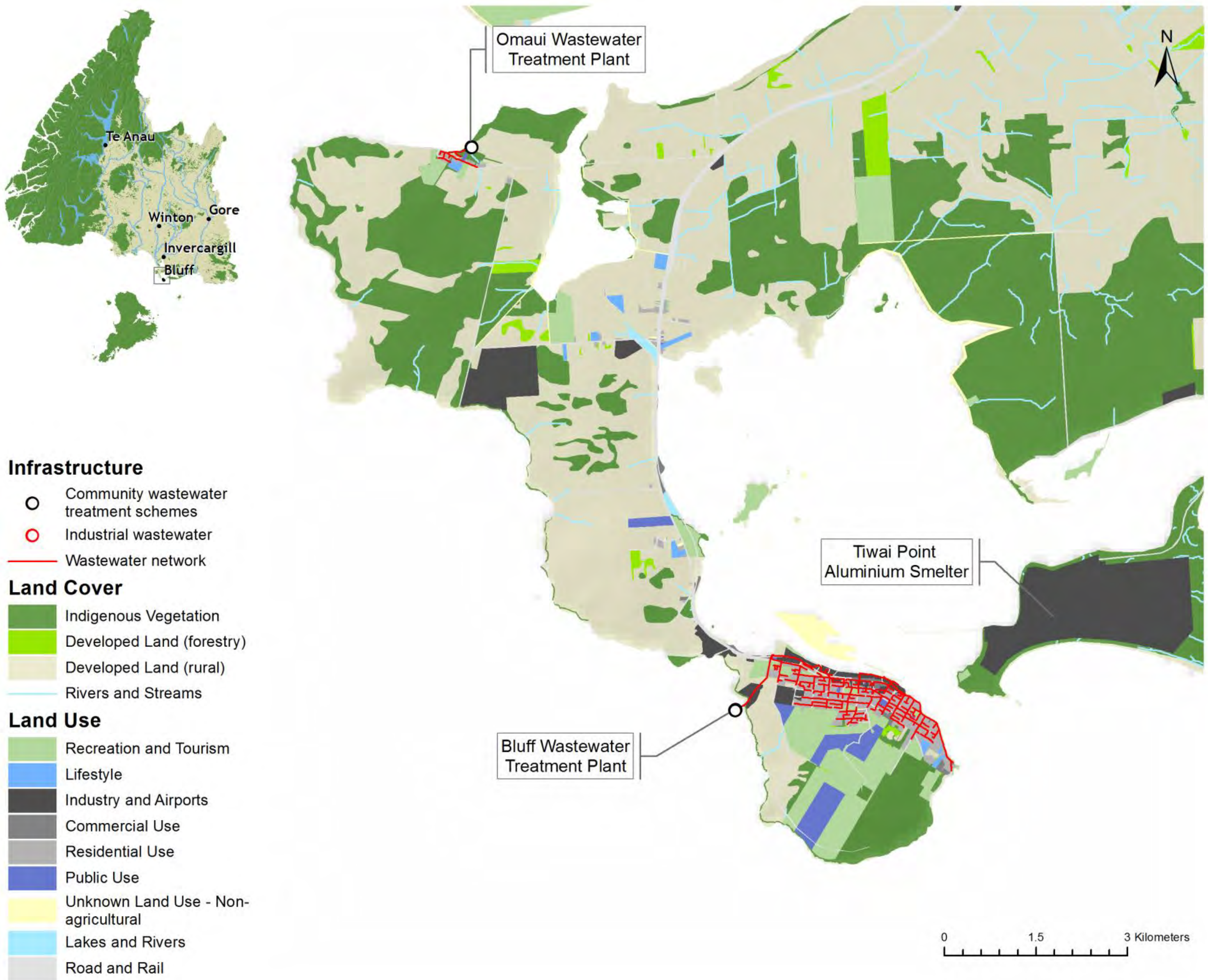
**Image C22: wastewater clarifier (the wastewater outflow pipe extends from the shoreline to the rocks on the right)**

Stormwater from the residential area of Bluff is collected through a stormwater pipe network separate to the wastewater network, and discharges through multiple outlets into Bluff harbour. The stormwater catchment includes the residential and commercial areas of Bluff and direct surface water intakes from Bluff Hill catchments above the urban area. Stormwater from Island Harbour and the foreshore port facilities is separately drained and managed by the port operator, South Port. The Bluff stormwater network suffers contamination from occasional wastewater system overflows caused by wastewater blockage. Some cross connections of wastewater pipes to stormwater on properties have been identified and corrected.

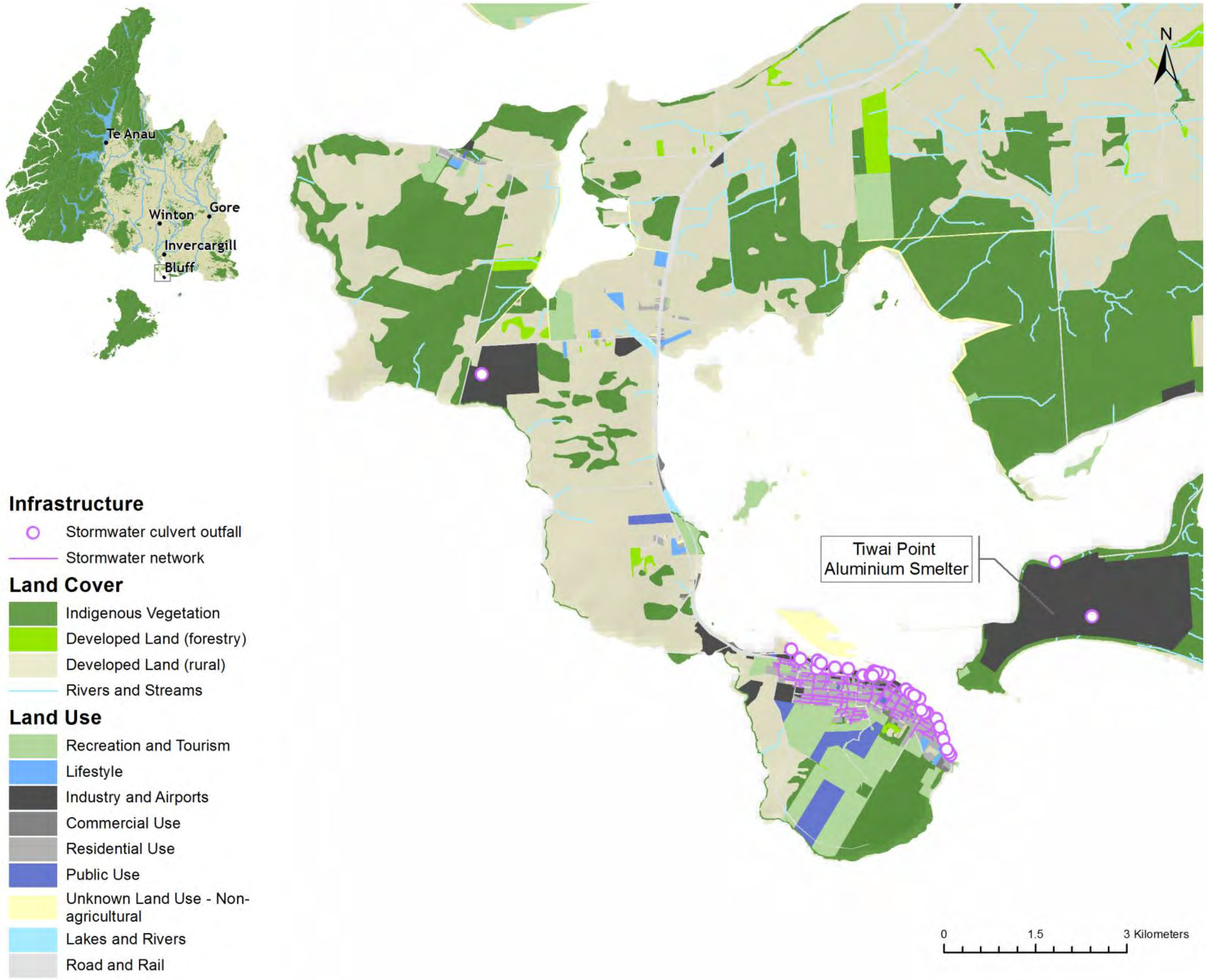
The major contributors to trade waste in Bluff are Sanford, Riverton Fish, Ngai Tahu, Wilbur Ellis, Bluff Protein, Polar Processing and Cando Fishing, which combined, account for 65 percent of the Bluff Treatment Plant loading. A total of seven dischargers whose loading or volumes exceed the permitted categories of the trade waste bylaw hold trade waste consents.

**Image C23: Bluff screen at start of treatment process**

<u>The following two maps show the Bluff wastewater and stormwater schemes.</u>



Te Anau
Winton
Gore
Invercargill
Bluff
Omaui Wastewater Treatment Plant
Bluff Wastewater Treatment Plant
Tiwai Point Aluminium Smelter
N
0
1.5
3 Kilometers
Infrastructure
Community wastewater treatment schemes
Industrial wastewater
Wastewater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail


Te Anau
Winton
Gore
Invercargill
Bluff
Infrastructure
Stormwater culvert outfall
Stormwater network
Land Cover
Indigenous Vegetation
Developed Land (forestry)
Developed Land (rural)
Rivers and Streams
Land Use
Recreation and Tourism
Lifestyle
Industry and Airports
Commercial Use
Residential Use
Public Use
Unknown Land Use - Non-agricultural
Lakes and Rivers
Road and Rail
Tiwai Point Aluminium Smelter
N
0
1.5
3 Kilometers

## 9.2. Baseline Results

This section describes the baseline results for Bluff (i.e. what is actually occurring). The total annual inflow of wastewater into the Bluff treatment system is estimated at 383,250 $m^3$, with the daily flow ranging between 600 $m^3$ and 3,600 $m^3$. Table C55 identifies the quantity of contaminants removed annually from the raw wastewater by the existing treatment process: total suspended solids, biochemical oxygen demand, total nitrogen, total phosphorus, and *E. coli*. Table C56 gives information on the average quality of the treated wastewater discharged into the coastal marine area in Foveaux Strait near Ocean Beach.

**Table C55: Annual contaminant loads and concentration (*E. coli*) removed from wastewater**

| Contaminant 2014-2018 | Total SS (tonnes) | BOD (tonnes) | Total N (tonnes) | Total P (tonnes) | *E. coli* (cfu/100ml) |
|---|---|---|---|---|---|
| Average (5 years) | 78.0 | 88.7 | 6.9 | 1.2 | ~9,999,500 |

**Table C56: Annual contaminant concentrations and loads in wastewater discharge**

| Contaminant 2013-2018 | Total SS | BOD | Total N | Total P | *E. coli* |
|---|---|---|---|---|---|
| **Concentrations** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **($g/m^3$)** | **(cfu/100ml)** |
| Average (5 years) | 46.5 | 18.5 | 31.9 | 3.8 | 300 |
| **Loads** | **(tonnes)** | **(tonnes)** | **(tonnes)** | **(tonnes)** | |
| Range (5 years) | 18.0 to 23.6 | 7.3 to 9.4 | 12.9 to 16.9 | 1.7 to 2.0 | N.A. |
| Estimated loads | 17.8 | 7.1 | 12.2 | 1.5 | N.A. |

Source: Environment Southland consent monitoring data

The Bluff pipe network optimised replacement value is included within the Invercargill pipe asset database, and is not valued separately. The Bluff treatment plant has an optimised replacement value of $2.95 million.

The annual depreciated value of the wastewater scheme is $91,000 and the annual operating cost is $131,000.

Figure C84 shows the relative performance of the existing system for each of the five contaminants considered (red) compared to the assumed concentrations of the inflow of wastewater to the treatment system (black). Except for phosphorus, the concentrations of the contaminants were transformed[28] before being plotted to make it possible to include all five different contaminants on the same graph.

[28] The *E. coli* concentration was log transformed and those for BOD, SS and TN were ln transformed.

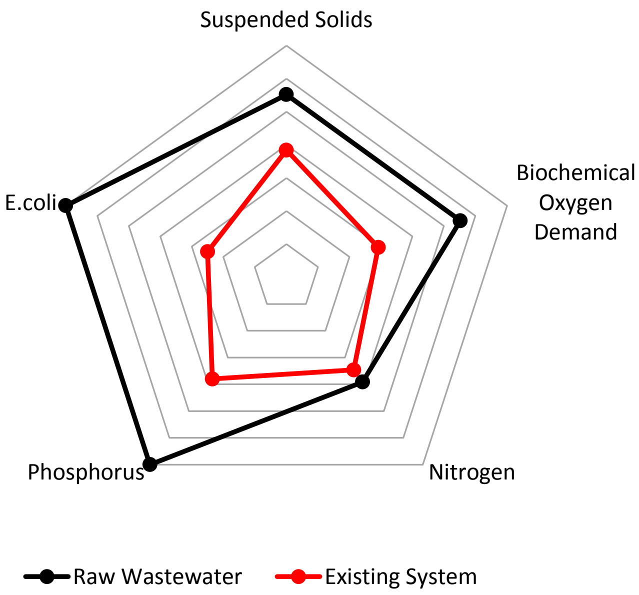



**Figure C84: Bluff baseline scenario (existing system)**

**Image 24: The launders at Bluff Wastewater Treatment System**
Source: Adrian Cocker, Invercargill City Council

As explained at the beginning of Part C, no scenarios were modelled for the Bluff wastewater system. In 2014 Invercargill City Council commissioned a review of Bluff wastewater treatment and disposal options, as part of the requirements of its discharge consent. This review concluded that the plant currently produces high quality treated wastewater, with no detrimental effects on microbiological water quality recorded in routine monitoring. It also concluded that few alternative treatment systems are viable because of the high saline content of Bluff wastewater, and variable strength because of fishing industry trade waste. If Bluff's existing wastewater discharge cannot be reconsented in its current form then it is more likely that the Council will pipe Bluff's wastewater to Invercargill's Clifton treatment system for further treatment (and discharge to New River Estuary) then upgrade the treatment system. This review was provided to Environment Southland.

# 10. The Southland Economic Model for Fresh Water

This report has presented research on municipal wastewater that Southland's four councils (Gore District Council, Invercargill City Council, Southland District Council, and Environment Southland) have done as part of The Southland Economic Project. Through this research, a set of eight case studies have been produced on wastewater treatment for the municipal sector. This dataset for wastewater will be used in The Southland Economic Model for Fresh Water, which was also developed within The Southland Economic Project. The dataset and the model will be used from 2019 onwards to understand some of the possible economic impacts of setting limits for water quality in Southland.

The Southland Economic Model is a representation of the regional economy. The model contains 19 sectors (e.g. government, households, utilities, agriculture[29]). It traces flows of capital and labour between these sectors within Southland, and also between Southland and the rest of New Zealand. In tracing resources within (and to and from) the regional economy, the model will be able to report on both direct impacts (as felt by the business owners) and wider impacts (those that flow-on through value chains, consumer spending and pricing).

The model will be used to build understanding of possible economic impacts by testing a range of 'what if' scenarios and comparing these results to a baseline scenario, which describes what is reasonable to assume will have happened otherwise. The results will be produced at a number of different scales, including: sectors, territorial areas, the region and the rest of New Zealand. These results will be reported using several economic measures to give a more complete picture. Key measures will be changes in employment, household income, and economic growth. The model will also include the ability to change certain external factors, such as commodity prices, to see how they may influence the results.

Importantly, The Southland Economic Model for Fresh Water is 'dynamic', which means that it traces resources through time, as the economy moves from its start year in 2016 out 30 years to 2046. This 30-year timeframe fits with those used for council infrastructure and financial strategies. The model

[29] Agriculture is separated out into specific industries and major geographic areas to give more resolution.

is calibrated using a full set of economic accounts from Statistics New Zealand for 2007 and 2013 and data from other sources. Because it is dynamic, the model will show how Southland's economy is likely to transition from the current situation to a new water and land management system under each different scenario. The shape of these 'transition pathways' will allow people to see the possible economic impacts of different rates of change, both in policy implementation and the response (i.e. the actions taken to change water use). The model's start year is 2016 because this is the year that implementation of the National Policy Statement of Fresh Water started in Southland.

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## Appendix 1: Industrial wastewater discharges to water and land (excluding sludge, whey, solid waste, herbicide and water)

| ID | Title | Abstract | Owner | |
|---|---|---|---|---|
| AUTH-20158595-01 | 20158595-01 Discharge to Water | AUTH-20158595-01 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Limited \| 30/11/2016 | Alliance Group Ltd | To discharge treated meat processing wastewater and sewage from the township of Wallacetown, to water at Lorneville |
| AUTH-20169983-01-V1 | 20169983-01-V1 - Discharge to Water | AUTH-20169983-01-V1 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Limited \| 16/02/2017 | Alliance Group Ltd | To discharge treated meat processing wastewater to the Makarewa River at Makarewa Junction, approx. 750 metres downstream of Branxholme - Makarewa Road |
| AUTH-202327 | 202327 - Discharge to Water | AUTH-202327 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Ltd - Mataura \| 06/12/2004 | Alliance Group Ltd | To discharge up to 14,400 cubic metres per day of treated meat works wastewater to the Mataura River at Mataura |
| AUTH-204125 | 204125 - Discharge to Water | AUTH-204125 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Ltd - Mataura \| 19/12/2006 | Alliance Group Ltd | To discharge up to 21,200 cubic metres of cooling water per day from the Mataura meat processing plant into a water race which discharges to the Mataura River |
| AUTH-206299 | 206299 - Discharge to Water | AUTH-206299 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Lorneville \| 30/04/2013 | Alliance Group Ltd | To discharge stormwater to an open drain, a tributary of the Makarewa River, at Lorneville Riverton Highway, Lorneville |
| AUTH-206300-V2 | 206300-V2 - Discharge to Water | AUTH-206300-V2 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group | Alliance Group Ltd | To discharge stormwater to the Makarewa River, at Branxholme Makarewa Road, Makarewa |

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|---|---|---|---|---|
| | | Makarewa \| 11/04/2013 | | |
| AUTH-206301 | 206301 - Discharge to Water | AUTH-206301 \| Resource Consent \| Discharge Permit (To Water) \| Alliance Group Ltd - Mataura \| 30/04/2013 | Alliance Group Ltd | To discharge stormwater to the Mataura River, at McQueen Avenue, Mataura |
| AUTH-200971-V1 | 200971-V1 - Discharge to Land | AUTH-200971-V1 \| Resource Consent \| Discharge Permit (To Land) \| Alliance Group - Makarewa \| 04/10/2002 | Alliance Group Ltd | To discharge leachate to land from a closed refuse disposal site at Makarewa |
| AUTH-20158595-03 | 20158595-03 - Discharge to Land | AUTH-20158595-03 \| Resource Consent \| Discharge Permit (To Land) \| Alliance Group Limited \| 30/11/2016 | Alliance Group Ltd | To discharge up to 3000 cubic metres of treated wastewater to land via irrigation at Crowe Road, Lorneville |
| AUTH-20158595-04 | 20158595-04 - Discharge to Land | AUTH-20158595-04 \| Resource Consent \| Discharge Permit (To Land) \| Alliance Group Limited \| 30/11/2016 | Alliance Group Ltd | To discharge treated wastewater to land in circumstances that may result in contaminants entering water, from a contingency short term storage area, at Crowe Road, Lorneville |
| AUTH-20169983-02-V1 | 20169983-02-V1 - Discharge to Land | AUTH-20169983-02-V1 \| Resource Consent \| Discharge Permit (To Land) \| Alliance Group Limited \| 16/02/2017 | Alliance Group Ltd | To discharge meat processing wastewater through the base of a treatment pond to groundwater where it will enter the Makarewa River at Makarewa Junction, approx. 750 metres downstream of Branxholme - Makarewa Road |
| AUTH-94468 | 94468 - Discharge to Land | AUTH-94468 \| Resource Consent \| Discharge Permit (To Land) \| Alliance Group Lorneville \| 05/06/1998 | Alliance Group Ltd | To discharge leachate into the ground, in circumstances where it may enter water, from a closed landfill at Lorneville |

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|---|---|---|---|---|
| AUTH-95498 | 95498 - Discharge to Land | AUTH-95498 \| Resource Consent \| Discharge Permit (To Land) \| Silver Fern Farms Management Limited - Group Environmental \| 17/03/1999 | Silver Fern Farms Ltd | To discharge up to 1400 cubic metres of primary treated wastewater per week to land, from a venison abattoir at Mossburn |
| AUTH-201191 | 201191 - Discharge to Land | AUTH-201191 \| Resource Consent \| Discharge Permit (To Land) \| Blue Sky Meats (NZ) Ltd \| 03/12/2002 | Blue Sky Meats Ltd | To discharge up to 1000 cubic metres of meat processing and rendering plant wastewater to land at Morton Mains via a spray irrigator |
| AUTH-20147510 | 20147510 - Discharge to Water | AUTH-20147510 \| Resource Consent \| Discharge Permit (To Water) \| South Pacific Meats Ltd \| 15/05/2015 | South Pacific Meats Ltd | To discharge stormwater to an open drain at New River Estuary |
| AUTH-202727 | 202727 - Discharge to Land | AUTH-202727 \| Resource Consent \| Discharge Permit (To Land) \| New Zealand Aluminium Smelters \| 08/10/2004 | New Zealand Aluminium Smelters Ltd | To discharge stormwater and process water onto land and into the ground at Tiwai Point, in circumstances where they may enter water |
| AUTH-203373 | 203373 - Dishcarge to Land | AUTH-203373 \| Resource Consent \| Discharge Permit (To Land) \| New Zealand Aluminium Smelters \| 06/06/2006 | New Zealand Aluminium Smelters Ltd | To discharge contaminants onto land including circumstances where they may enter water and to discharge water including contaminants to the coastal marine area includes surface and cooling and flushing waters at Tiwai Point Bluff Harbour |
| AUTH-203376 | 203376 - Discharge to Land | AUTH-203376 \| Resource Consent \| Discharge Permit (To Land) \| New Zealand Aluminium Smelters \| 06/06/2006 | New Zealand Aluminium Smelters Ltd | To discharge up to 295 cubic metres per day of treated sewage onto and into land at Tiwai Point |
| AUTH-203379 | 203379 - Discharge to coastal water | AUTH-203379 \| Resource Consent \| Coastal Permit (Discharge to Water CMA) \| New Zealand Aluminium | New Zealand Aluminium Smelters Ltd | To discharge up to 140 cubic metres per day of treated effluent into Foveaux Strait at Tiwai Point |

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|---|---|---|---|---|
| | | Smelters \| 06/06/2006 | | |
| AUTH-205500 | 205500 - Discharge to Land | AUTH-205500 \| Resource Consent \| Discharge Permit (To Water) \| Fonterra Limited \| 04/11/2008 | Fonterra Ltd | To discharge up to 9,300m3 per day of treated dairy process wastewater and up to 20,700m3 per day of condensate, cooling water, stormwater, denitrification water and demineralisation water from the Edendale dairy factory to the Mataura River |
| AUTH-20158423 | 20158423 - Discharge to Land | AUTH-20158423 \| Resource Consent \| Discharge Permit (To Land) \| Fonterra Limited \| 21/04/2017 | Fonterra Ltd | To discharge dairy factory wastewater to land at Mararua Farm, State Highway 1, Edendale |
| AUTH-20171236 | AUTH-20171236 - Discharge to Land | AUTH-20171236 \| Resource Consent \| Discharge Permit (To Land) \| Fonterra Limited \| 13/07/2017 | Fonterra Ltd | To discharge dairy factory wastewater to land and aerosols and odours into the air at Dobbie Road, Edendale |
| AUTH-204524-V1 | 204524-V1 - Discharge to Water | AUTH-204524-V1 \| Resource Consent \| Discharge Permit (To Water) \| Open Country Dairy Ltd \| 23/10/2007 | Open Country Dairy Ltd | To discharge condensate and stormwater from a milk processing plant to a farm drain at Awarua |
| AUTH-300569-V2 | 300569-V2 - Discharge to Water | AUTH-300569-V2 \| Resource Consent \| Discharge Permit (To Water) \| Waikaia Gold Ltd \| 01/02/2012 | Waikaia Gold Ltd | To discharge water and contaminants from a gold mining operation to the Waikaia River and to the Garvie Burn at Freshford |
| AUTH-207232 | 207232 - Discharge to Water | AUTH-207232 \| Resource Consent \| Discharge Permit (To Water) \| Bathurst Coal Limited \| 24/03/2010 | Bathurst Coal Ltd | To discharge treated stormwater to a tributary of the Wairio Stream at Company Road, Nightcaps from a coal mining operation |

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|---|---|---|---|---|
| AUTH-300661-V2 | 300661-V2 - Discharge to Water | AUTH-300661-V2 \| Resource Consent \| Discharge Permit (To Water) \| Bathurst Coal Limited \| 18/07/2011 | Bathurst Coal Ltd | To discharge treated site water to the Wairio Stream at the Coaldale Mine Site, Company Road, Nightcaps |
| AUTH-206094 | 206094 - Discharge to Land | AUTH-206094 \| Resource Consent \| Discharge Permit (To Land) \| Bathurst Coal Limited \| 24/03/2010 | Bathurst Coal Ltd | To discharge mine water, stormwater and coal-wash process water to a soakage pit at Company Road, Nightcaps |
| AUTH-20158148-01 | 20158148-01 - Discharge to Water | AUTH-20158148-01 \| Resource Consent \| Discharge Permit (To Water) \| Greenbriar Limited \| 01/12/2015 | Greenbriar Ltd | To discharge treated mine water from New Vale mine to an unnamed tributary of the Hedgehope Stream at Waimumu |
| AUTH-20158148-02 | 20158148-02 - Discharge to Water | AUTH-20158148-02 \| Resource Consent \| Discharge Permit (To Water) \| Greenbriar Limited \| 01/12/2015 | Greenbriar Ltd | To discharge treated surface runoff and groundwater from Goodwin Coal Mine to the Hedgehope Stream at Waimumu |
| AUTH-201973 | 201973 - Discharge to Water | AUTH-201973 \| Resource Consent \| Discharge Permit (To Water) \| Greenbriar Limited \| 04/08/2003 | Greenbriar Ltd | To discharge treated minewater and stormwater to Morley Stream at Ohai from a coal mining operation |
| AUTH-207359 | 207359 - Discharge to Water | AUTH-207359 \| Resource Consent \| Discharge Permit (To Water) \| Greenbriar Limited \| 28/09/2010 | Greenbriar Ltd | To discharge up to 12,000 cubic metres of untreated water per day to Morley Stream near Ohai |
| AUTH-301848 | 301848 - Discharge to Water | AUTH-301848 \| Resource Consent \| Discharge Permit (To Water) \| Greenbriar Limited \| 02/12/2013 | Greenbriar Ltd | To discharge surface water and groundwater from the Wairaki No. 1 Opencast Mine pit to the Morely Stream |

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|---|---|---|---|---|
| AUTH-200989 | 200989 - Discharge to Water | AUTH-200989 \| Resource Consent \| Discharge Permit (To Water) \| Ravensdown Fertiliser Co-op Ltd \| 23/05/2002 | Ravensdown Fertiliser Co-op Ltd | To discharge stormwater to a tributary of the Dipton Stream at the Dipton Limeworks, Gerrard Road |
| AUTH-96448 | 96448 - Discharge to Water | AUTH-96448 \| Resource Consent \| Discharge Permit (To Water) \| Ravensdown Fertiliser Co-op Ltd - Balfour (Balfour Lime Division) \| 21/10/2000 | Ravensdown Fertiliser Co-op Ltd | To discharge stormwater from a limestone quarry to a tributary of the Longridge Stream at Kingston Crossing Road, Balfour |
| AUTH-202170 | 202170 - Discharge to Water | AUTH-202170 \| Resource Consent \| Discharge Permit (To Water) \| Fernhill Limeworks Ltd ( ) \| 26/08/2003 | Fernhill Limeworks Ltd | To discharge stormwater to a tributary of the Winton Stream from a limeworks at Kauana, Winton |
| AUTH-203820 | 203820 - Discharge to Water | AUTH-203820 \| Resource Consent \| Discharge Permit (To Water) \| Ballance Agri-Nutrients Ltd \| 05/06/2007 | Ballance Agri-Nutrients Ltd | To discharge treated and untreated stormwater from a fertiliser manufacturing, storage and dispatch facility, via an unnamed drain to the Mokotua Stream at Bluff Road, Awarua |
| AUTH-96033 | 96033 - Discharge to Water | AUTH-96033 \| Resource Consent \| Discharge Permit (To Water) \| Southern Aggregates Ltd \| 29/11/2000 | Southern Aggregates Lt | To discharge stormwater and cooling water from a quarry at Greenhills |
| AUTH-20169941-02 | 20169941-02 - Discharge to Water | AUTH-20169941-02 \| Resource Consent \| Discharge Permit (To Water) \| International Specialty Aggregates Limited \| 16/01/2017 | International Specialty Aggregates Ltd | To discharge water back to an existing excavated pond for gravel washing at 419 Cross Road, Pebbly Hill, Dacre |

<table>
<tr><td>AUTH-207367-V1</td><td>207367-V1 - Discharge to Land</td><td>AUTH-207367-V1 | Resource Consent | Discharge Permit (To Water) | International Specialty Aggregates Limited | 12/07/2010</td><td>International Specialty Aggregates Ltd</td><td>To discharge gravel washwater to water for aggregate cleaning at Pitt Road, Otatara</td></tr>
<tr><td>AUTH-96287</td><td>96287 - Discharge to Land</td><td>AUTH-96287 | Resource Consent | Discharge Permit (To Land) | International Specialty Aggregates Ltd | 07/11/1997</td><td>International Specialty Aggregates Ltd</td><td>To discharge stormwater onto or into land from a quarry and to discharge treated stormwater from a quarry into water an unnamed tributary of Awarua Bay, at Awarua Bay Road</td></tr>
<tr><td>AUTH-20147508-01</td><td>20147508-01 - Discharge to Land</td><td>AUTH-20147508-01 | Resource Consent | Discharge Permit (To Land) | Fulton Hogan Southland Ltd | 10/04/2015</td><td>Fulton Hogan Southland Ltd</td><td>To discharge up to 800,000 litres of gravel washwater to land in circumstances where contaminants may enter water</td></tr>
<tr><td>AUTH-20157783-01</td><td>20157783-01 - Discharge to Land</td><td>AUTH-20157783-01 | Resource Consent | Discharge Permit (To Land) | Mr Alister MacDonald | 30/04/2015</td><td>Mr Alister MacDonald</td><td>To take groundwater and to discharge washwater from gravel washing into a pond near the Oreti River about 450 metres below the Mossburn Bridge</td></tr>
<tr><td>AUTH-205360</td><td>205360 - Discharge to Land</td><td>AUTH-205360 | Resource Consent | Discharge Permit (To Land) | Southern Stone & Timber Ltd | 28/04/2008</td><td>Southern Stone & Timber Ltd</td><td>To discharge gravel washwater into the ground via seepage through the base of the settling/storage ponds at Tokonui-Gorge Road Highway, Gorge Road</td></tr>
<tr><td>AUTH-205660-V1</td><td>205660-V1 - Discharge to Land</td><td>AUTH-205660-V1 | Resource Consent | Discharge Permit (To Land) | Pyper's Produce Ltd | 18/05/2009</td><td>Pyper's Produce Ltd</td><td>To discharge washwater from vegetable cleaning to land using a sprinkler irrigation system at Branxholme Road Invercargill</td></tr>
<tr><td>AUTH-302648-02</td><td>302648-02 - Discharge to Land</td><td>AUTH-302648-02 | Resource Consent | Discharge Permit (To</td><td>AG & GJ Whyte Ltd</td><td>To discharge gravel washwater to land at Oporo Flat Road Waianiwa</td></tr>
</table>

<table>
<tr><td></td><td></td><td>Land) | AG & GJ Whyte Ltd | 14/01/2014</td><td></td><td></td></tr>
<tr><td>AUTH-205270</td><td>205270 - Discharge to Water</td><td>AUTH-205270 | Resource Consent | Discharge Permit (To Water) | Network Electrical Servicing Ltd | 02/07/2008</td><td>Network Electrical Servicing Ltd</td><td>To discharge washwater from a truckwash into the Waihopai Arm of the New River Estuary via the Invercargill City Council stormwater system</td></tr>
<tr><td>AUTH-20169938-02</td><td>20169938-02 - Discharge to Water</td><td>AUTH-20169938-02 | Resource Consent | Discharge Permit (To Water) | Southern Stone & Timber Limited | 31/01/2017</td><td>Southern Stone & Timber Limited</td><td>To discharge aggregate wash water through the base of water storage ponds to groundwater</td></tr>
<tr><td>AUTH-300378-V2</td><td>300378-V2 - Discharge to Water</td><td>AUTH-300378-V2 | Resource Consent | Discharge Permit (To Water) | Resolution Developments Limited | 27/07/2011</td><td>Resolution Developments Limite</td><td>To discharge wash water and boiler blow-down water to a former mine pit near Craig Road, Mataura</td></tr>
<tr><td>AUTH-301935</td><td>301935 - Discharge to Water</td><td>AUTH-301935 | Resource Consent | Discharge Permit (To Water) | Crawford Enterprises Ltd | 03/02/2013</td><td>Crawford Enterprises Ltd</td><td>To discharge gravel wash water to a tributary of Ota creek</td></tr>
<tr><td>AUTH-302438-03</td><td>302438-03 - Discharge to Water</td><td>AUTH-302438-03 | Resource Consent | Discharge Permit (To Water) | J Baynes | 18/04/2014</td><td>J Baynes</td><td>To discharge wash water containing sediments to the extraction pond</td></tr>
<tr><td>AUTH-20147304</td><td>20147304 - Discharge to Land</td><td>AUTH-20147304 | Resource Consent | Discharge Permit (To Land) | D T King Ltd | 14/10/2015</td><td>D T King Ltd</td><td>To discharge truck wash water and stock truck effluent to land, at Otautau Wreys Bush Road, Otautau</td></tr>
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|---|---|---|---|---|
| AUTH-20157914-01 | 20157914-01 - Discharge to Land | AUTH-20157914-01 \| Resource Consent \| Discharge Permit (To Land) \| Patrice Downs Ltd \| 01/10/2015 | Patrice Downs Ltd | To discharge truck wash waste water (and dairy shed effluent and wintering shed effluent and dairy farm effluent sludge) to land at Gap Road West, Winton |
| AUTH-20158427-02 | 20158427-02 - Discharge to Land | AUTH-20158427-02 \| Resource Consent \| Discharge Permit (To Land) \| McGregor Concrete Ltd - Winton \| 13/01/2016 | McGregor Concrete Ltd | To discharge up to 100,000 litres per day of gravel wash water to land, in circumstances where it may enter water, near the Oreti River, about 1.5km below the Winton Bridge |
| AUTH-205992 | 205992 - Discharge to Land | AUTH-205992 \| Resource Consent \| Discharge Permit (To Land) \| McGregor Group Ltd \| 05/06/2009 | McGregor Concrete Ltd | To discharge up to 100,000 litres of gravel wash water to land per day at the Oreti River some 600 metres above Dipton Stream confluence |
| AUTH-20169440-01 | 20169440-01 - Discharge to Land | AUTH-20169440-01 \| Resource Consent \| Discharge Permit (To Land) \| McClintock Contracting Limited \| 13/09/2016 | McClintock Contracting Limited | To discharge up to 100 cubic metres of gravel wash water per day to land at Riversdale-Waikaia Road, Riversdale |
| AUTH-20169960-02 | 20169960-02 - Discharge to Land | AUTH-20169960-02 \| Resource Consent \| Discharge Permit (To Land) \| Ryal Bush Transport Limited \| 14/02/2017 | Ryal Bush Transport Limited | To discharge gravel wash water to land at Viner Road, Branxholme |
| AUTH-205922 | 205922 - Discharge to Land | AUTH-205922 \| Resource Consent \| Discharge Permit (To Land) \| Wreys Bush Concrete Products Ltd \| 26/05/2010 | Wreys Bush Concrete Products Ltd | To discharge up to 250 cubic metres of gravel wash water per day to land and to dispose of sludge from a settling pond to land at Wreys Bush |
| AUTH-301570 | 301570 - Discharge to Land | AUTH-301570 \| Resource Consent \| Discharge Permit (To Land) \| Kapuka | Kapuka Transport Ltd | To discharge truck wash water to land at Kapuka South Road, Kapuka |

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| | | Transport Ltd \| 21/09/2012 | | |
| AUTH-302064-02 | 302064-02 - Discharge to Land | AUTH-302064-02 \| Resource Consent \| Discharge Permit (To Land) \| Golden Bush Mining Ltd \| 31/08/2016 | Golden Bush Mining Ltd | To discharge wash water to land, involving open cast gold mining near Round Hill, Southland |
| AUTH-205318 | 205318 - Discharge to Land | AUTH-205318 \| Resource Consent \| Discharge Permit (To Land) \| Andrews Transport (1993) Limited \| 30/10/2008 | Andrews Transport (1993) Limited | To discharge wastewater to land via a soakhole and via a trailer tanker, from a truckwash at Riversdale |
| AUTH-205960-V1 | 205960-V1 - Discharge to Land | AUTH-205960-V1 \| Resource Consent \| Discharge Permit (To Land) \| Nightcaps Contracting Ltd \| 20/05/2009 | Nightcaps Contracting Ltd | To discharge truckwash and stock truck effluent to land via a K-line system at Tinkertown Road, Nightcaps |
| AUTH-206984 | 206984 - Discharge to Land | AUTH-206984 \| Resource Consent \| Discharge Permit (To Land) \| Winton Park Investments Ltd \| 16/11/2009 | Winton Park Investments Ltd | To discharge wastewater from a truckwash to land, at Winton-Lorneville Highway, Winton |
| AUTH-300549-V1 | 300549-V1 - Discharge to Land | AUTH-300549-V1 \| Resource Consent \| Discharge Permit (To Land) \| Niagara Sawmilling Co Ltd \| 17/08/2011 | Niagara Sawmilling Co Ltd | To discharge wastewater from a truckwash to land at Niagara Sawmilling at Clapham Road, Kennington |
| AUTH-300758 | 300758 - Discharge to Land | AUTH-300758 \| Resource Consent \| Discharge Permit (To Land) \| McDowall Rural Services Limited \| 14/12/2011 | McDowall Rural Services Ltd | To discharge truckwash effluent to land at Limehills - Browns Road, Browns |

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| AUTH-302581 | 302581 - Discharge to Land | AUTH-302581 \| Resource Consent \| Discharge Permit (To Land) \| Booth AG (2008) Ltd \| 22/10/2013 | Booth AG (2008) Ltd | To discharge truckwash effluent to land via low rate irrigation at Bayswater Road Otautau |
| AUTH-97021 | 97021 - Discharge to Land | AUTH-97021 \| Resource Consent \| Discharge Permit (To Land) \| Northern Southland Transport Holdings Ltd \| 05/08/1998 | Northern Southland Transport Holdings Ltd | To discharge treated truckwash water to land via a soak hole at Te Anau |
| AUTH-205536 | 205536 - Discharge to Water | AUTH-205536 \| Resource Consent \| Discharge Permit (To Water) \| Sinclair Contracting Ltd \| 29/06/2009 | Sinclair Contracting Ltd | To discharge up to 1 cubic metre per week of truckwash wastewater to land where it may enter water, at Cardigan Road, Wyndham |
| AUTH-97150 | 97150 - Discharge to Water | AUTH-97150 \| Resource Consent \| Discharge Permit (To Water) \| Scullys Transport Ltd \| 07/11/1997 | Scullys Transport Ltd | To discharge stormwater and treated truckwash effluent of up to 1 cubic meter per day to a tributary of the Oreti River at Lady Barkley, Winton |
| AUTH-301146 | 301146 - Discharge to Water | AUTH-301146 \| Resource Consent \| Discharge Permit (To Water) \| D L Dumbleton \| 01/05/2012 | D L Dumbleton | To discharge waste water to water from a gravel pit at Coal Pit Road, Edendale |
| AUTH-301940 | 301940 - Discharge to Land | AUTH-301940 \| Resource Consent \| Discharge Permit (To Land) \| Scullys Transport Ltd \| 15/03/2013 | Scullys Transport Ltd | To discharge truck wash waste to land via travelling irrigator at Dipton Winton Highway, Limehills/Centre Bush |
| AUTH-201094 | 201094 - Discharge to Water | AUTH-201094 \| Resource Consent \| Discharge Permit (To Water) \| Pioneer Generation Ltd \| 18/03/2002 | Pioneer Generation Ltd | to discharge oil and grease from the powerhouse machinery to the Waiau River via the tailrace of the powerhouse |

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| AUTH-201095 | 201095 - Discharge to Water | AUTH-201095 \| Resource Consent \| Discharge Permit (To Water) \| Pioneer Generation Ltd \| 18/03/2002 | Pioneer Generation Ltd | to discharge contaminants into water as a result of maintenance works at the existing Monowai Hydro Electric Power Scheme canal |
| AUTH-201096 | 201096 - Discharge to Water | AUTH-201096 \| Resource Consent \| Discharge Permit (To Water) \| Pioneer Generation Ltd \| 18/03/2002 | Pioneer Generation Ltd | to discharge cooling water from the Monowai Hydro Electric Power Scheme powerhouse turbines to the Waiau River via the tailrace of the powerhouse |
| AUTH-201097 | 201097 - Discharge to Water' | AUTH-201097 \| Resource Consent \| Discharge Permit (To Water) \| Pioneer Generation Ltd \| 18/03/2002 | Pioneer Generation Ltd | to discharge contaminants into water as a result of maintenance works at the existing tailrace of the Monowai Hydro Electric Power Scheme powerhouse |
| AUTH-202854 | 202854 - Discharge to Land | AUTH-202854 \| Resource Consent \| Discharge Permit (To Land) \| Pioneer Generation Ltd \| 29/08/2005 | Pioneer Generation Ltd | To discharge herbicide to land in circumstances where it may enter water for willow control by ground-based applicators |
| AUTH-97076-V1 | 97076-V1 - Discharge to Land | AUTH-97076-V1 \| Resource Consent \| Discharge Permit (To Land) \| Slinkskins Ltd \| 03/08/2001 | Slinkskins Ltd | To discharge pre-treated tannery and fellmongery wastewater onto land at Thornbury |
| AUTH-200815 | 200815 - Discharge to Water | AUTH-200815 \| Resource Consent \| Discharge Permit (To Water) \| Craigpine Timber Ltd \| 08/03/2002 | Craigpine Timber Ltd | To discharge timber yard storm water and condensate into the Winton Stream and Marshall Creek |
| AUTH-300549-V1 | 300549-V1 - Discharge to Land | AUTH-300549-V1 \| Resource Consent \| Discharge Permit (To Land) \| Niagara Sawmilling Co Ltd \| 17/08/2011 | Niagara Sawmilling Co Ltd | To discharge wastewater from a truckwash to land at Niagara Sawmilling at Clapham Road, Kennington |

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|---|---|---|---|---|
| AUTH-301704 | 301704 - Discharge to Land | AUTH-301704 \| Resource Consent \| Discharge Permit (To Land) \| Findlater Sawmilling Ltd \| 14/11/2012 | Findlater Sawmilling Ltd | To discharge stormwater to a wetland from a sawmilling operation at Wilson Crossing Road, Ryal Bush |
| AUTH-20146797 | 20146797 - Discharge to Water | AUTH-20146797 \| Resource Consent \| Discharge Permit (To Water) \| Brightwood Sawmill \| 10/07/2014 | Brightwood Sawmil | To discharge treated stormwater to an unnamed tributary of the Aparima River at Otautau |
| AUTH-203262 | 203262 - Discharge to Water | AUTH-203262 \| Resource Consent \| Discharge Permit (To Water) \| Dongwha Patinna NZ Ltd \| 01/02/2006 | Dongwha Patinna NZ Ltd | To discharge up to 7700 cubic metres of untreated stormwater per day and up to 811 cubic metres of treated wastewater per day to the Mataura River |
| AUTH-203265 | 203265 - Discharge to Water | AUTH-203265 \| Resource Consent \| Discharge Permit (To Water) \| Dongwha Patinna NZ Ltd \| 01/02/2006 | Dongwha Patinna NZ Ltd | To discharge tile drainage to the Hudson Stream |
| AUTH-203260 | 203260 - Discharge to Land | AUTH-203260 \| Resource Consent \| Discharge Permit (To Land) \| Dongwha Patinna NZ Ltd \| 01/02/2006 | Dongwha Patinna NZ Ltd | To discharge up to 811 cubic metres of effluent to land per day and to discharge treatment pond seepage, at Mataura |
| AUTH-203264 | 203264 - Discharge to Land | AUTH-203264 \| Resource Consent \| Discharge Permit (To Land) \| Dongwha Patinna NZ Ltd \| 01/02/2006 | Dongwha Patinna NZ Ltd | To discharge stormwater to land at Mataura |

# Appendix 2: Scenarios and treatment processes

## Gore Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 2,198,600$m^3$<br>(6024$m^3$/d) | 2013 census 12,033 people | Mataura River<br><br>2 outfalls | <25 $m^3$/s in river Rolling 80%ile<br>BOD ≤20mg/L<br>TSS ≤20mg/L<br>DP ≤0.5mg/L<br>Amm-N ≤30mg/L<br>E.coli ≤1,000MPN/100mL<br>25-60 $m^3$/s in river Rolling 80%ile<br>BOD ≤30mg/L<br>TSS ≤50mg/L<br>DP ≤1mg/L<br>Amm-N ≤30mg/L<br>E.coli ≤2,500MPN/100mL<br>>60 $m^3$/s in river Rolling 80%ile<br>BOD ≤30mg/L<br>TSS ≤70mg/L<br>DP ≤4.9mg/L<br>Amm-N ≤30mg/L<br>E.coli ≤5,000MPN/100mL |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Gore<br>Existing WWTP | | Liquid:<br>• 3mm screen<br>• Primary Pond<br>• Secondary Pond<br>• Actiflo (operational during low river flows)<br>Solid:<br>• Storage in pond | Based on historic performance:<br>- with Actiflo (as long term annual medians)<br>TSS < 30 mg/L<br>BOD < 10 mg/L<br>NH4N < 20 mg/L<br>TN < 25 mg/L<br>DRP < 0.2 mg/L<br>TP < 1.0 mg/L<br>E.coli: 3000 cfu/100 mL<br>- without Actiflo (as long term annual medians)<br>TSS < 50 mg/L<br>BOD < 25 mg/L<br>NH4N < 10 mg/L<br>TN < 20 mg/L<br>DRP < 2.0 mg/L<br>TP < 3.0 mg/L<br>E.coli: 1500 cfu/100 mL | N/A | N/A | Assuming entire population is connected, the per capita flow rate equates to 500l/hd/d. Suggests significant infiltration, stormwater inflow or industrial contribution.<br><br>Large seasonal load from Waitane Meats (existing additional aeration provided when in operation) |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 1a - Discharge to Water - nutrient reduction* | ***BOD, TSS, TN, TP Removal (year round)***<br><br>***>50% TN reduction***<br>***>65% TP removal*** | Liquid:<br>• 3mm screen<br>• Primary pond<br>• Secondary Pond<br>• **Trickling Filter, new**<br>• **MBBR, new**<br>• Actiflo **(operating 365d/yr)**<br>Solid: as existing | <u>Likely quality</u><br>TSS < 20mg/L<br>BOD < 10mg/L<br>TN < 10mg/L<br>TP < 1.0mg/L<br>E.coli <3000MPN/100mL | \$3.7M | \$0.5M | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge discharged to pond, so desludging frequency will need to be increased. |
| *Option 1b – Discharge to Water - Pathogen reduction* | ***E.coli Removal*** | Liquid<br>• 3mm screen<br>• Primary Pond<br>• Secondary Pond<br>• Actiflo (operational during low river flows)<br>• **UV Disinfection, new**<br>Solid: as existing | <u>Likely quality</u><br>TSS < 30-50mg/L<br>BOD < 10-25mg/L<br>TN <25mg/L<br>TP < 1.0-3.0mg/L<br>E.coli 126MPN/100mL | \$1.0M | \$0.05M | • Robust and proven technology<br>• Minimal operator input required |
| *Option 1c – Discharge to Water - Phosphorus reduction* | ***TP Removal (year round)***<br><br>***>65% TP removal*** | Liquid;<br>• 3mm screen<br>• Primary pond<br>• Secondary Pond<br>• Actiflo **(operating 365d/yr)**<br>Solid: as existing | <u>Likely quality</u><br>TSS < 30mg/L<br>BOD < 25mg/L<br>TN < 25mg/L<br>TP < 1.0mg/L<br>E.coli <3000MPN/100mL | N/A | \$0.1M | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge production, which will require more frequent pond desludging.<br>• No redundancy in Actiflo |
| *Option 1d – Discharge to Water - Nutrient reduction incl solids reduction* | ***BOD, TSS, TN Removal***<br><br>***>55% TN reduction***<br>***>65% TP removal*** | Liquid:<br>• 3mm screen<br>• Primary pond<br>• Secondary Pond<br>• **Trickling Filter, new**<br>• **MBBR, new**<br>• Actiflo **(operating 365d/yr)**<br>• **Cloth/disc filter, new**<br>Solid: as existing | <u>Likely quality</u><br>TSS < 15mg/L<br>BOD < 10mg/L<br>TN < 9mg/L<br>TP < 1.0mg/L<br>E.coli <3000MPN/100mL | \$4.9M | \$0.6M | • Robust and proven technology<br>• Minimal additional contaminant reduction<br>• Minimal operator input required, as no wetland to influence the filter<br>• Additional sludge production (similar to Option 1a), which will require more frequent pond desludging.<br>• Disc filter includes allowance for concrete tank. |
| *Option 1e- Discharge to Water - membrane bioreactor* | ***BOD, TSS, TN, TP, E.coli Removal***<br><br>***75% TN & TP reduction*** | Liquid<br>• 3mm screen<br>• **Fine screen, new**<br>• **Membrane Bioreactor (MBR), new**<br>Solid: as existing | <u>Likely quality</u><br>TSS 5mg/L<br>BOD 5mg/L<br>E.coli 10MPN/100mL<br>TN 5mg/L<br>TP 0.5mg/L | \$19M | \$0.8M | • Proven technology<br>• Higher level of operator knowledge and skill required than Options 1a to 1d<br>• Dedicated operator required for site<br>• Higher energy requirement than other options<br>• Power supply to site may require upgrading<br>• Additional sludge production (more than Options 1c and 1d), which will require more frequent pond desludging. |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 1f- Discharge to Water*<br>*- Tertiary Treatment* | ***BOD, TSS, TN, TP, E.coli Removal***<br><br>***99% TN & TP reduction***<br><br>***Note: RO reject stream treated then discharged to water*** | Liquid:<br>• 3mm screen<br>• Primary Pond<br>• Secondary Pond<br>• **Trickling Filter, new**<br>• **Ultrafiltration (UF) , new**<br>• **Reverse Osmosis (RO), new**<br>Solid: as existing<br>RO Reject Stream Treatment:<br>• **MBBR, new**<br>• **Wetland, new**<br>• **UV, new** | Likely quality of blended discharge of RO permeate and RO reject streams:<br>TSS 1mg/L<br>BOD 1mg/L<br>E.coli <126MPN/100mL<br>TN 5mg/L<br>TP 0.5mg/L | $43M | $2M | • RO treated wastewater could be beneficially reused with additional treatment (eg stabilisation, chlorine dosing) but option assumes discharge to the Mataura River<br>• UF/RO technology is proven for producing high quality treated wastewater discharge.<br>• Typically the RO reject stream is discharged to sea or to evaporation ponds. Neither is feasible for Gore.<br>• The proposed RO reject stream treatment is unproven and would require further investigation to confirm the feasibility to ensure removal of TN. After blending the RO permeate and the RO reject, there is minimal improvement over Option 1e<br>• RO reject stream could be discharged to land, however this would require blending for the sodium adsorption ratio to be less than guideline values to protect soil structure.<br>• Additional sludge production (more than Options 1c and 1d), which will require more frequent pond desludging. |
| *Option 2 a -Discharge to Land*<br>*- rapid rate* | | *Existing process* ***+ high rate infiltration (rapid infiltration basins etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli 509MPN/100mL<br>TN 9mg/L<br>TP <1mg/L | $7.7M | $0.13M | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round.<br>• Southland Region has high ground water tables and so subsurface drainage likely to be required to mitigate groundwater mounding.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Gore may not be feasible for some of the time |
| *Option 2 b -Discharge to Land*<br>*- slow rate* | | *Existing process* ***+ slow rate infiltration (spray irrigation etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli <1MPN/100mL<br>TN 6mg/L<br>TP <1mg/L | $23.9M | $0.14M | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Gore may not be feasible for some of the time |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data as given for the existing system has been processed by Market Economics. It is not known whether the seasonal load from Waitane Meats has been included within the data. Review of monitoring data has been undertaken for design of Option 1e and 1f.
4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard(s). Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Site Specific Factors identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.

7. Two land application mechanisms are outlined; high rate infiltration (HRI) and slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area, and annual profile of field moisture content. Two soil types have been considered to represent the range of soil types across Southland that could be considered for land application. These soil types are rapidly drained alluvial gravels and imperfectly drained clay loams, which are better suited to HRI and SRI, respectively. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the use of very low loading rates, greater areas of land or storage. This study assumes that there is a suitable parcel of land within 4km and that no storage is required (eg irrigation is not stopped during periods of saturated soils or wet weather.
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices, indicative prices from suppliers, or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. An qualitative assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.
9. No allowance for handling additional sludge quantities, either treatment or disposal
10. No allowance for upgrading power supply to site.
11. Operating costs are associated with new treatment costs only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – assumes trickling filter cover not included, assumes existing actiflo pumpset is suitable for reuse as trickling filter feed pumps, allowed for 1new pumping station to lift flow into MBBR then gravitate through actiflo, assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
b. Option 1b - assumes no requirement for UV feed pumping station, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
c. Option1c – assumes high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river). Increased desludging frequency but not considered in this study. No redundancy in Actiflo.
d. Option1d – assumes filter sized for 3x average daily flow. Flows above this would be bypassed.
e. Option1e – assumes typical average winter and summer influent concentrations based on monitoring data provided by GDC.
f. Option 1f – assumes UF backwash discharged to pond. Assumes single stage RO with 70% recovery (ie RO reject is 30% of influent flow). Assume fully nitrified wastewater passes through UF/RO. Assume blend RO permeate (treated wastewater) and treated RO reject stream are blended prior to discharge. The proposed RO reject stream treatment is unproven and would require further investigation to confirm the feasibility to ensure removal of TN.
g. Option 2a – Land cost $40k/ha, RIB rising main assumed 4km length with 40m static pumping head, Single stage pumping, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river), no allowance for subsurface drainage.
h. Option 2b – Land cost $40k/ha, SRI rising main assumed 4km length with 40m static pumping head, Single stage pumping, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).

## Matāura Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 220,800$m^3$<br>(605$m^3$/d) | 1,509 people<br>From 2013 census | Mataura River | Current consent to discharge ADWF of 2000$m^3$/d into Mataura River expires in 2021<br>TSS < 60 mg/L<br>BOD < 20 mg/L<br>DRP < 1.5kg/day<br>Ammonia-N 15kg/day<br>E.coli: 5000 cfu/100 mL<br><br>Trigger values:<br>DRP 1kg/day<br>Ammonia-N 10kg/day |

| Case Study Option | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Mataura Existing WWTP | | Liquid:<br>• Oxidation pond<br>• Wetland<br>Solid<br>• Storage in pond | Actual mean 2013 – 2015<br>BOD 7.8, 4.9, 7.5mg/L<br>TSS 16.0, 7.5, 23.8mg/L<br>E.coli 921.3, 240.8, 2645MPN/100mL<br>TN 10.9, 9.3, 10.0mg/L<br>TP 1.2, 1.0, 1.8mg/L | N/A | N/A | • Per capita flow rate equates to 401 l/hd/d. Suggests some infiltration.<br>• Existing quality from WWTP only marginaaly exceeds the treatment objectives set for addressing initial NPS-FM response. Therefore minimal additional options developed. |
| *Option 1a - Discharge to Water - solids reduction* | ***TSS Removal*** | Liquid:<br>• As existing<br>• **Enhancements to Wetland**<br>- **Plant thinning**<br>- **Improve gradient / flow depth**<br>Solid: as existing | Likely quality<br>BOD <10mg/L<br>TSS 10mg/L<br>E.coli 5000MPN/100mL<br>TN <11mg/L<br>TP <2mg/L | $0.34M | $7,000 | • Scope of wetland improvements to be confirmed if option is progressed<br>• Robust and proven technology<br>• Minimal operator input required |
| *Option 1b – Discharge to Water – pathogen reduction* | ***BOD, TSS, E.coli Removal*** | Liquid:<br>• As existing<br>• **UV, new**<br>Solid: as existing | Likely quality<br>BOD <10mg/L<br>TSS <25mg/L<br>E.coli 126MPN/100mL<br>TN <11mg/L<br>TP <2mg/L | $0.31M | $26,000 | • Robust and proven technology<br>• Minimal operator input required |
| *Option 2 a -Discharge to Land*<br>- *Rapid rate* | | Existing process **+ high rate infiltration (rapid infiltration basins etc)** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli 245MPN/100mL<br>TN 4mg/L<br>TP 1mg/L | $2.6M | $28,000 | • Assumes that suitable area of land available and suitable conditions for land application occur year round.<br>• Southland Region has high ground water tables and so subsurface drainage likely to be required to mitigate groundwater mounding.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Mataura may not be feasible |

| Case Study Option | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 2 b -Discharge to Land*<br>- *Slow rate* | | Existing process **+ slow rate infiltration (spray irrigation etc)** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli <1MPN/100mL<br>TN 2.4mg/L<br>TP <1mg/L | $3.6M | $30,000 | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff<br>• No allowance for odour control at disposal site<br>• Indicative review of soils and soil moisture indicate that land disposal around Mataura may not be feasible |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology. Also, the total capital cost of the identified upgrade option cannot be averaged to create a cost per kg removal of contaminants between the current baseline performance and future 'marker' targets, as there is an initial investment in plant and infrastructure that is not scalable across the entire range. i.e. the cost of a distributor for a BTF provided to achieve a TN target of 20mg/l will be the same as required for a target of 10mg/l.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of actual design.
4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard. Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Site Specific Factors identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.
7. Two land application mechanisms are outlined; high rate infiltration (HRI) and slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area and annual profile of field moisture content. Two soil types have been considered to represent the range of soil types across Southland that could be considered for land application. These soil types are rapidly drained alluvial gravels and imperfectly drained clay loams, which are better suited to HRI and SRI, respectively. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the use of very low loading rates, greater areas of land or storage. This study assumes that there is a suitable parcel of land within 4km and that no storage is required (eg irrigation does not stop during periods of saturated soils or wet weather.
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. An assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.
9. No allowance for handling sludge quantities, either treatment or disposal
10. No allowance for upgrading power supply to site.
11. Assume predominantly domestic catchment (ie no significant trade waste flow or load).
12. Operating costs are associated with new treatment processes only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – Wetland enhancements primarily associated with plant thinning, and improvements to the hydraulic gradient flow depth to provide HRT of 6 days. Wetland dimensions not known so scope uncertain.
b. Option 1b - assumes no requirement for UV feed pumping station, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
c. Option 2a – Land cost $40k/ha, RIB rising main assumed 4km length with 40m static pumping head, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river), no allowance for subsurface drainage.

Option 2b – Land cost $40k/ha, SRI rising main assumed 4km length with 40m static pumping head, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).

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## Winton Wastewater Treatment Plant

| **Total annual inflow:** | **Population:** | **Existing Discharge Route:** | **Existing Resource Consents** |
|---|---|---|---|
| 256,900$m^3$ ($704m^3/d$) | 1233 total equivalent connections<br>AMP records 2,436 people – (2013 census 2,211) | Winton Stream | Current consent to discharge $750m^3/d$ into Winton Stream expires in 2023.<br><br>Min. standards for Class D waters apply.<br>Total ammonia nitrogen limits apply beyond the mixing zone. |

| **Case Study** | **Objective of Option** | **Treatment Process (new units in bold)** | **Expected Wastewater Discharge Quality** | **Economic Considerations (+/-30%)** | | **Associated Issues** |
|---|---|---|---|---|---|---|
| | | | | **Indicative Capital Cost** | **Indicative Annual Operating Cost** | |
| Winton Existing WWTP | | Liquid:<br>• 3mm screen<br>• Oxidation pond<br>• Wetland<br>Solid<br>• Storage in pond | Actual mean 2013 – 2016<br>BOD 16.4mg/L<br>TSS 32.4mg/L<br>E.coli 4225MPN/100mL<br>TN 22.0mg/L<br>TP 3.6mg/L | N/A | N/A | • Majority of reticulation is asbestos cement.<br>• Reticulation inspection in 2004 and condition graded as moderate. No areas of significant concern.<br>• Rock filter beds silted and overgrown<br>• Robust and proven technology<br>• Minimal operator input required |
| *Option 1a - Discharge to Water - nutrient reduction* | ***BOD, TSS, TN Removal***<br><br>***50% TN reduction*** | Liquid<br>• 3mm screen<br>• **Trickling Filter, new**<br>• **Clarifier, new**<br>• Oxidation pond<br>• Wetland, **enhanced**<br>Solid: as existing | Likely quality<br>BOD 10mg/L<br>TSS 15mg/L<br>E.coli 5000MPN/100mL<br>TN 10mg/L<br>TP 3.6mg/L | $3.6M | $42,000 | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge discharged to pond, so desludging frequency will need to be increased. |
| *Option 1b – Discharge to Water –pathogen reduction* | ***BOD, TSS, E.coli Removal*** | Liquid:<br>• 3mm screen<br>• Oxidation pond<br>• Wetland, **enhanced**<br>• **UV disinfection, new**<br>Solid: as existing | Likely quality<br>BOD 15mg/L<br>TSS 20mg/L<br>E.coli 126MPN/100mL<br>TN 22mg/L<br>TP 3.6mg/L | $0.6M | $29,000 | • Robust and proven technology<br>• Minimal operator input required |
| *Option 1c – Discharge to Water - phosphorus reduction* | ***BOD, TSS, TP Removal***<br><br>***50% TP reduction*** | Liquid:<br>• 3mm screen<br>• Oxidation pond<br>• **Chemical dosing, new**<br>• Wetland, **enhanced**<br>Solid: as existing | Likely quality<br>BOD 15mg/L<br>TSS 20mg/L<br>E.coli 5000MPN/100mL<br>TN 22mg/L<br>TP 2mg/L | $0.2M | $28,000 | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge production, which will require more frequent pond desludging. |
| *Option 1d – Discharge to Water*<br>• *Nutrient reduction incl solids reduction* | ***BOD, TSS, TN Removal***<br><br>***55% TN reduction*** | Liquid:<br>• 3mm screen<br>• **Trickling Filter, new**<br>• **Clarifier, new**<br>• Oxidation pond<br>• Wetland, **enhanced**<br>• **Cloth/disc filter, new**<br>Solid: as existing | Likely quality<br>BOD 10mg/L<br>TSS 10mg/L<br>E.coli 5000MPN/100mL<br>TN 9mg/L<br>TP 3.6mg/L | $4.1M | $90,000 | • Robust and proven technology<br>• Minimal additional contaminant reduction<br>• Risk of filter blocking if solids carryover from wetland, which then requires additional operator attention<br>• Additional sludge production (similar to Option 1a), which will require more frequent pond desludging. |

| Case Study | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 1e- Discharge to Water*<br>• *Membrane bioreactor* | ***BOD, TSS, TN, TP, E.coli Removal***<br><br>• ***75% TN & TP reduction*** | Liquid:<br>• 3mm screen<br>• **Fine screen, new**<br>• **Membrane bioreactor, new**<br>Solid: as existing | Likely quality<br>BOD 5mg/L<br>TSS 5mg/L<br>E.coli 10MPN/100mL<br>TN 5mg/L<br>TP 0.5mg/L | $7M | $200,000 | • Proven technology<br>• Higher level of operator knowledge and skill required than Options 1a to 1d<br>• Dedicated operator required for site<br>• Higher energy requirement than other options<br>• Power supply to site may require upgrading<br>• Additional sludge production (more than Options 1c and 1d), which will require more frequent pond desludging. |
| *Option 2 a -Discharge to Land*<br>• *Rapid rate* | | *Existing process* ***+ high rate infiltration (rapid infiltration basins etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <2mg/L<br>TSS 1mg/L<br>E.coli 924MPN/100mL<br>TN 8mg/L<br>TP 2mg/L | $2.8M | $29,000 | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round.<br>• Southland Region has high ground water tables and so subsurface drainage likely to be required to mitigate groundwater mounding.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Winton would not be feasible |
| *Option 2 b -Discharge to Land*<br>• *Slow rate* | | *Existing process* ***+ slow rate infiltration (spray irrigation etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli 75MPN/100mL<br>TN 5mg/L<br>TP 1.3mg/L | $4.8M | $34,000 | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff<br>• No allowance for odour control at disposal site<br>• Indicative review of soils and soil moisture indicate that land disposal around Winton would not be feasible |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology. Also, the total capital cost of the identified upgrade option cannot be averaged to create a cost per kg removal of contaminants between the current baseline performance and future 'marker' targets, as there is an initial investment in plant and infrastructure that is not scalable across the entire range. i.e. the cost of a distributor for a BTF provided to achieve a TN target of 20mg/l will be the same as required for a target of 10mg/l.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data summarised for the existing system has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of actual design. Monitoring data has been reviewed for the development of Option 1e.
4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard(s). Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Associated Issues identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.
7. Two land application mechanisms are outlined; high rate infiltration (HRI) and slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area, and annual profile of field moisture content. Two soil types have been considered to represent the range of soil types across Southland that could be considered for land application. These soil types are rapidly drained alluvial gravels and imperfectly drained clay loams, which are better suited to HRI and SRI, respectively. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the used of very low loading rates, greater areas of land, or storage. This study assumes that there is a suitable parcel of land within 4km and that no storage is required (eg irrigation is not stopped during periods of saturated soils or wet weather.
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. An assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.

9. No allowance for handling additional sludge quantities, either treatment or disposal
10. No allowance for upgrading power supply to site.
11. Operating costs are associated with new treatment processes only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – Wetland enhancements primarily associated with desludging to provide HRT of 6 days. Wetland dimensions not known so scope uncertain. Cost allows for construction of new wetland (worst case) with additional land cost component of $40k/ha, assumes current wetland is fully planted, 5% plant mortality / 2years, trickling filter cover not included, trickling filter feed / recycle pump station included, clarifier sludge disposal recycled into pond (will increase desludging frequency but not considered in this study), assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
b. Option 1b - assumes no requirement for UV feed pumping station, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
c. Option1c – assumes alkalinity dosing is not required, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
d. Option1d – assumes filter sized for 3x average daily flow. Flows above this would be bypassed.
e. Option1e – assumes typical average influent concentrations based on per capita unit generation typical for domestic catchments in New Zealand. It assumes there is no significant trade waste flow or load
f. Option 2a – Land cost $40k/ha, RIB rising main assumed 4km length with 40m static pumping head, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river), no allowance for subsurface drainage.
g. Option 2b – Land cost $40k/ha, SRI rising main assumed 4km length with 40m static pumping head, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).

## Nightcaps Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 34,900m$^3$<br>(96m$^3$/d)<br><br>ADWF, ADF and PWWF not known.<br>Data derived from PS | 196.3 total equivalent connections<br>AMP records 294 people – (2013 census 306) | 300m long weeded drain into Wairio Stream | New consent currently being processed – 15 year status quo.<br>May not meet standards for E.coli under RWP. |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Nightcaps Existing WWTP | | Liquid:<br>• Oxidation pond<br>• Rock filter beds<br>Solid: stored in pond | Actual mean 2013 - 2015<br>BOD 9.3, 8.0, 9.8mg/L<br>TSS 53.0, 17.2, 79.3mg/L<br>E.coli 636.7, 35,213, 2093MPN/100mL<br>TN 19.2. 6.9, 9.1mg/L<br>TP 3.3, 0.9, 1.5mg/L | N/A | N/A | • Reticulation inspection in 2004 identified 48 faults.<br>• Rock filter beds silted and overgrown but weeds probably providing some filtration |
| *Option 1a - Discharge to Water- - nutrient reduction* | ***TSS, TN Removal***<br><br>***80% TSS reduction***<br>***50% TN reduction*** | Liquid:<br>• As existing<br>• **Wetland, new**<br>Solid: as existing | Likely quality<br>BOD <10mg/L<br>TSS 15mg/L<br>E.coli 5000MPN/100mL<br>TN <10mg/L<br>TP <4mg/L | $0.26M | $4,000 | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge production, which will require desludging of new wetland. |
| *Option 1b – Discharge to Water – pathogen reduction* | ***E.coli Removal*** | Liquid:<br>• As existing<br>• **UV, new**<br>Solid: as existing | Likely quality<br>BOD <10mg/L<br>TSS <80mg/L<br>E.coli 126MPN/100mL<br>TN <20mg/L<br>TP <4mg/L | $0.25M | $14,000 | • Robust and proven technology<br>• Minimal operator input required |
| *Option 1c – Discharge to Water - Phosphorus reduction* | ***TP Removal***<br><br>***50% TP reduction*** | Liquid:<br>• As existing<br>• **Chemical dosing, new**<br>Solid: as existing | Likely quality<br>BOD <10mg/L<br>TSS <80mg/L<br>E.coli 5000MPN/100mL<br>TN <20mg/L<br>TP <2mg/L | $0.15M | $8,000 | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge production, which will require more frequent pond desludging. |
| *Option 2 a -Discharge to Land*<br>*- Rapid rate* | | *Existing process **+ high rate infiltration (rapid infiltration basins etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS 2.4mg/L<br>E.coli 12,200MPN/100mL<br>TN 11mg/L<br>TP 1.8mg/L | $1.0M | $20,000 | • Assumes that suitable area of land available and suitable conditions for land application occur year round.<br>• Southland Region has high ground water tables and so subsurface drainage likely to be required to mitigate groundwater mounding.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Nightcaps would not be feasible |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 2 b -Discharge to Land*<br>- *Slow rate* | | *Existing process **+ slow rate infiltration (spray irrigation etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS 1.2mg/L<br>E.coli 3MPN/100mL<br>TN 8mg/L<br>TP 1.2mg/L | \$1.2M | \$22,500 | • Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff<br>• No allowance for odour control at disposal site<br>• Indicative review of soils and soil moisture indicate that land disposal around Nightcaps would not be feasible |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology. Also, the total capital cost of the identified upgrade option cannot be averaged to create a cost per kg removal of contaminants between the current baseline performance and future 'marker' targets, as there is an initial investment in plant and infrastructure that is not scalable across the entire range. i.e. the cost of a distributor for a BTF provided to achieve a TN target of 20mg/l will be the same as required for a target of 10mg/l.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of actual design.
4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard. Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Associated Issues identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.
7. Two land application mechanisms are outlined; high rate infiltration (HRI) and slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area, and annual profile of field moisture content. Two soil types have been considered to represent the range of soil types across Southland that could be considered for land application. These soil types are rapidly drained alluvial gravels and imperfectly drained clay loams, which are better suited to HRI and SRI, respectively. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the use of very low loading rates, greater areas of land or storage. This study assumes that there is a suitable parcel of land within 4km and that no storage is required (eg irrigation does not stop during periods of saturated soils or wet weather.
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. An assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.
9. No allowance for handling additional sludge quantities, either treatment or disposal.
10. No allowance for upgrading power supply to site.
11. Assumes predominantly domestic catchment (ie no significant trade waste flow or load).
12. Operating costs are associated with new treatment processes only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – cost allows for construction of new wetland with HRT 6 days min, 0.6-1.5m deep, used 0.6m (USEPA). Land cost component of \$40k/ha, assumes current wetland is fully planted, 5% plant mortality / 2years, assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
b. Option 1b - assumes no requirement for UV feed pumping station, Assume peak daily dry weather flows and wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
c. Option1c – assumes alkalinity dosing is not required, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).
d. Option 2a – Land cost \$40k/ha, RIB rising main assumed 4km length with 40m static pumping head, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river), no allowance for subsurface drainage.
e. Option 2b – Land cost \$40k/ha, SRI rising main assumed 4km length with 40m static pumping head, Assume peak daily dry weather flows and high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).

## Ohai Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 43,400$m^3$<br>(119$m^3$/d) | 233.5 total equivalent connections<br>AMP records 294 people – (2013 census 303) | Tributary to Orauea Stream to Waiau River | Current consent to discharge 120m3/d at ADWF and 480$m^3$/d at WWF.<br>TSS <30mg/l.<br>BOD <30mg/l.<br>Min. standards for Class D waters apply.<br>Total ammonia nitrogen limits apply beyond the mixing zone. |

| Case Study Option | Objective of Option | Treatment Process | Expected Wastewater Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Ohai Existing WWTP | | • Inlet Screen<br>• 2no. Imhoff Tanks<br>• 2no. Stone media filters<br>• 2no. rectangular humus tanks<br>• UV disinfection chamber | Actual mean 2013 - 2015<br>BOD 6.4, 10.0, 10.5mg/L<br>TSS 8.3, 9.7, 11.3mg/L<br>FC 94MPN/100mL*1<br>NH4N 2.5, 2.5, 5.6mg/L<br>TP 2.1, 1.8, 2.2mg/L<br><br>Notes<br>*1 – pre-2014 data. Thereafter values are elevated with average of 5091MPN/100mL. Discussed with SDC and most probable cause is bulb maintenance issues. | N/A | N/A | • Per capita flow rate equates to 404 l/hd/d. Suggests some infiltration.<br>• Reticulation inspection in 2012/13 and identified 174 faults. Overall pipe grading is moderate but lateral connections poor so likely source of infiltration.<br>• Rock filter beds silted and overgrown |

### NO WWTP UPGRADES REQUIRED TO ACHIEVE:

BOD <10mg/L
TSS <15mg/L
FC <126MPN/100mL (bulb maintenance required)
TN <10mg/L
TP 2mg/L

**Notes:**

1. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
2. The monitoring flow and load data has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of the final design. It is assumed that the catchment is predominantly domestic with no significant trade waste flow or load.
3. SDC have reported that the current UV is undersized and is proposed to be replaced. However, there does not appear to have been any change to the flow and loads since 2014, which would suggest that there is no requirement to upgrade if the UV plant is maintained.
4. There has been no allowance for population growth.

Assumes predominantly domestic catchment (ie no significant trade waste flows or loads).

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## Te Anau Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 301,257m$^3$<br>(825m$^3$/d) | 2,621 total equivalent connections<br>AMP records 2,628 people – (2013 census 1,911) | Upukerora River | Current short term consent to discharge 1,400 m$^3$/d (max. monthly average) into Upukerora River expires in 2020<br>Trigger values outside mixing zone:<br>SIN <0.295 mg/L<br>DRP <0.026 mg/L<br><br>Kepler block (from Commissioners' decision)<br>TN 27.1mg/L<br>TP 7.8mg/L<br>Microbial contaminants <126cfu/100mL<br>Max discharge rate 4,500m$^3$/d (Sept – March) and 2,000m$^3$/d (April – August) |

| Case Study | Objective of Option | Treatment Process | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Te Anau Existing WWTP | | Liquid:<br>• bar screen<br>• Primary oxidation pond (with aerators)<br>• Secondary oxidation ponds<br>• Wetland<br>Solid: stored in ponds | Actual mean 2013 – 2015<br>BOD 26.0, 17.9, 23.0mg/L<br>TSS 46.6, 40.6, 97.5mg/L<br>E.coli 945, 705, 2233MPN/100mL<br>$NH_4N$ 16.2, 10.2, 10.3mg/L<br>TN 26.6, 16.3, 19.5mg/L<br>TP 6.9, 5.5, 8.4mg/L | N/A | N/A | • Per capita flow rate equates to 314 L/hd.d<br>• Reticulation inspection in 2004 and condition graded as moderate. No areas of significant concern.<br>• Kepler Block selected for land disposal of treated wastewater and consents lodged in 2013 |
| *Option 1a - Discharge to Water - nutrient reduction* | ***TN Removal 50% reduction*** | Liquid: As existing + Trickling Filter<br>Solid: as existing | Likely quality<br>BOD <30mg/L<br>TSS <100mg/L<br>E.coli 2000MPN/100mL<br>TN 10mg/L<br>TP <8mg/L | $2.25M | $15,000 | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge discharged to pond, so desludging frequency will need to be increased. |
| *Option 2 b -Discharge to Land*<br>• *Slow rate* | | Liquid: As existing + pond waveband + pump station + transfer pipeline + recirculation pump station + odour control + treated wastewater disposal<br>Solid: as existing | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD 1mg/L<br>TSS 1.5mg/L<br>E.coli 1MPN/100mL<br>TN 9mg/L<br>TP 2.9mg/L | $12.8M | $0.25M | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Indicative review of soils and soil moisture indicate that land disposal around Te Anau may not be feasible |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology. Also, the total capital cost of the identified upgrade option cannot be averaged to create a cost per kg removal of contaminants between the current baseline performance and future 'marker' targets, as there is an initial investment in plant and infrastructure that is not scalable across the entire range. i.e. the cost of a distributor for a BTF provided to achieve a TN target of 20mg/l will be the same as required for a target of 10mg/l.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of actual design.

4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high-level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard(s). Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Site Specific Factors identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.
7. One land application mechanism is outlined; slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area, and annual profile of soil field moisture content. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the use of very low loading rates, greater areas of land or provision of storage. This study assumes that there is a suitable parcel of land within 18.3km and that no storage is required (eg irrigation is not stopped during periods of saturated soils or wet weather).
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. A qualitative assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.
9. No allowance for handling additional sludge quantities, either treatment or disposal.
10. No allowance for upgrading power supply to site.
11. Operating costs are associated with new treatment processes only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – Trickling filter cover not included. Additional sludge discharge to ponds, so desludging frequency will need to increase. No allowance for these costs. New filter feed / recycle pump station included in costs.
b. Option 2b – Assumes irrigation site is 18.3km to the south of Te Anau. Costs allow for an odour treatment facility at irrigation site. Assume high wet weather flows are balanced at Te Anau WWTP

## Invercargill Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 9,052,300m$^3$<br>(24,801m$^3$/d) | 50,000 people connected. | New River Estuary | 12month rolling medians<br>BOD – 20mg/l<br>TSS – 50mg/l<br>FC – 6000MPN/100mL<br><br>Expires 30 June 2029 |

| Case Study Option | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) Indicative Capital Cost | Economic Considerations (+/-30%) Indicative Annual Operating Cost | Associated Issues |
|---|---|---|---|---|---|---|
| Invercargill Existing WWTP | | Liquid:<br>• Screen<br>• Pre-aeration<br>• Sedimentation tanks<br>• Trickling filter<br>• Secondary clarifier<br>• Facultative ponds<br>• Wetland<br>Solid:<br>• Digester<br>• Sludge lagoons | <u>Actual mean/median 2013 – 2015</u><br>CBOD 6.1, 8.5, 9.0mg/L<br>TSS 16.1, 20.0, 20.0mg/L<br>E.coli 1,285, 1,161, 1,516MPN/100mL<br>TN 20.0, 29.6, 33.0mg/L<br>TP 4.0, 4.7, 4.5mg/L<br><br>FC values typ. 20% higher than E.coli values | N/A | N/A | • High stormwater infiltration<br>• Robust and proven technology<br>• Minimal operator input required<br>• Sludge produced continuously from sedimentation tanks and secondary clarifier. |
| *Option 1a - Discharge to Water - nutrient reduction* | ***BOD, TSS, TN Removal***<br><br>***65% TN reduction*** | Liquid:<br>• Screen<br>• Pre-aeration<br>• Sedimentation tanks<br>• Trickling filter<br>• Secondary clarifier<br>• **Bioreactors, new**<br>• Facultative ponds<br>• Wetland<br>Solid: as existing | <u>Likely quality</u><br>BOD 10mg/L<br>TSS 15mg/L<br>E.coli 2000MPN/100mL<br>TN 10mg/L<br>TP 5mg/L | $8.8M | $1.2M | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge discharged to pond, so desludging frequency will need to be increased. |
| *Option 1b – Discharge to Water – pathogen reduction* | ***BOD, TSS, E.coli Removal*** | Liquid:<br>• Screen<br>• Pre-aeration<br>• Sedimentation tanks<br>• Trickling filter<br>• Secondary clarifier<br>• Facultative ponds<br>• Wetland<br>• **UV disinfection, new**<br>Solid: as existing | <u>Likely quality</u><br>BOD 10mg/L<br>TSS 20mg/L<br>E.coli 126MPN/100mL<br>TN 30mg/L<br>TP 5mg/L | $4.0M | $0.3M | • Robust and proven technology<br>• Minimal operator input required |

| Case Study Option | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 1c – Discharge to Water – phosphorus reduction* | ***BOD, TSS, TP Removal***<br><br>***60% TP reduction*** | Liquid:<br>• Screen<br>• Pre-aeration<br>• **Chemical dosing, new**<br>• Sedimentation tanks<br>• Trickling filter<br>• Secondary clarifier<br>• Facultative ponds<br>• Wetland<br>Solid: as existing | Likely quality<br>BOD 10mg/L<br>TSS 20mg/L<br>E.coli 2000MPN/100mL<br>TN 30mg/L<br>TP 2mg/L | $0.35M | $0.42M | • Robust and proven technology<br>• Minimal operator input required<br>• Additional sludge production, which requires handling. Capacity and performance of existing digesters with alum-based sludge would need to be reviewed if this option progressed.<br>• Additional sludge production, which will require more frequent lagoon desludging |
| *Option 1d – Discharge to Water*<br>*- Nutrient reduction incl solids reduction* | ***BOD, TSS, TN Removal***<br><br>***70% TN reduction*** | Liquid<br>• Screen<br>• Pre-aeration<br>• Sedimentation tanks<br>• Trickling filter<br>• Secondary clarifier<br>• **Bioreactors, new**<br>• Facultative ponds<br>• Wetland<br>• **Cloth/disc filter, new**<br>Solid: as existing | Likely quality<br>BOD 10mg/L<br>TSS 15mg/L<br>E.coli 2000MPN/100mL<br>TN 9mg/L<br>TP 5mg/L | $10.5M | $1.3M | • Robust and proven technology<br>• Minimal additional contaminant reduction<br>• Risk of filter blocking if solids carryover from wetland, which then requires additional operator attention<br>• Additional sludge production (similar to Option 1a), which will require more frequent lagoon desludging. |
| *Option 1e- Discharge to Water*<br>*- Membrane bioreactor* | ***BOD, TSS, TN, TP, E.coli Removal***<br><br>***80% TN & TP reduction*** | Liquid:<br>• 3mm screen<br>• **Fine screen, new**<br>• **Membrane bioreactor, new**<br>Solid: as existing | Likely quality<br>BOD 5mg/L<br>TSS 5mg/L<br>E.coli 10 MPN/100mL<br>TN 5mg/L<br>TP <1mg/L | $36M | $1.7M | • Proven technology<br>• Higher level of operator knowledge and skill required than Options 1a to 1d<br>• Dedicated operator required for site<br>• Higher energy requirement than other options<br>• Power supply to site may require upgrading<br>• Additional sludge production (more than Options 1c and 1d), which will require more frequent lagoon desludging. |
| *Option 2 a -Discharge to Land*<br>*- rapid rate* | | *Existing process* ***+ high rate infiltration (rapid infiltration basins etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli 473MPN/100mL<br>TN 12mg/L<br>TP <1mg/L | $24M | $0.45M | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round.<br>• Southland has high ground water tables and so subsurface drainage likely to be required to mitigate groundwater mounding.<br>• Extensive site and soil investigation would be required to demonstrate if this option is technically feasible<br>• Pumps required to transfer treated WW to discharge site are very large with significant energy consumption.<br>• Indicative review of soils and soil moisture indicate that land disposal around Invercargill would not be feasible |

| Case Study Option | Objective of Option | Treatment Process (new units in bold) | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| *Option 2 b -Discharge to Land*<br>- *Slow rate* | | *Existing process* ***+ slow rate infiltration (spray irrigation etc)*** | Discharge to land as current WWTP<br><br>Likely quality to aquifer:<br>BOD <1mg/L<br>TSS <1mg/L<br>E.coli <1MPN/100mL<br>TN 8mg/L<br>TP <1mg/L | $66M | $0.48M | • Significant area of land required<br>• Assumes that suitable area of land available and suitable conditions for land application occur year round. Southland has extended periods of the year when soils are at or near field capacity (ie saturated) and seasonally high groundwater tables. Application of wastewater at these times would result in runoff<br>• Pumps required to transfer treated WW to discharge site are very large with significant energy consumption.<br>• No allowance for odour control at disposal site<br>• Indicative review of soils and soil moisture indicate that land disposal around Invercargill would not be feasible |

**Notes:**

1. The indicative capital costs are associated with the identified numerical quality values and are not scalable, i.e. a higher degree of contaminant removal may require some other type of treatment technology. Also, the total capital cost of the identified upgrade option cannot be averaged to create a cost per kg removal of contaminants between the current baseline performance and future 'marker' targets, as there is an initial investment in plant and infrastructure that is not scalable across the entire range. i.e. the cost of a distributor for a BTF provided to achieve a TN target of 20mg/l will be the same as required for a target of 10mg/l.
2. The identified likely treated wastewater quality targets (as medians) will require some dilution in the receiving discharge system to meet the required discharge quality under the Freshwater Management Policy.
3. The monitoring flow and load data summarised for the existing system has been processed by Market Economics using data provided by Environment Southland. The data is limited and may not include any intermittent industrial loads. Further sampling and data assessment will be required prior to commencement of actual design. Monitoring data has been reviewed for the design of Option 1e.
4. There has been no allowance for population growth.
5. For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the five contaminants of concern. The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. There are many issues that could impact on the final design and upgrade costs and these issues have not been assessed. The output is pre-feasibility level of high-level options and is intended to provide an indication of likely upgrade costs. A single treatment option has been considered for upgrading the existing WWTP to reduce each of the five contaminants to a given standard(s). Each treatment option presented above is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-tech solution for upgrading the existing WWTP to achieve the likely treated wastewater quality targets.
6. The capital costs provided above are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The Associated Issues identify the factors that can affect the capital costs but which have not been allowed for in the costs as provided.
7. Two land application mechanisms are outlined; high rate infiltration (HRI) and slow rate infiltration (SRI). It has been assumed that no treatment upgrade would be required. The appropriate mechanism for a given site is largely dependent on the treated wastewater quality, hydrogeology of the land application area, and annual profile of soil field moisture content. Two soil types have been considered to represent the range of soil types near Invercargill that could be considered for land application. These soil types are rapidly drained alluvial gravels and sandy loams, which are better suited to HRI and SRI, respectively. It is noted that there are areas of land within Southland that are not suitable for land application for some or all of the time. The unsuitability of the soil may not be able to be successfully mitigated by the use of very low loading rates, greater areas of land or provision of storage. This study assumes that there is a suitable parcel of land within 4km and that no storage is required (eg irrigation is not stopped during periods of saturated soils or wet weather).
8. For each WWTP treatment option and land application mechanism, the capital costs provide a rough-order of costs and are based on recent tendered prices, indicative prices from suppliers, or design costing MWH has undertaken for similar sized projects. No engineering design has been undertaken at this stage. An assessment of the effect on operating costs relative to the existing 'typical' WWTP and discharge location (i.e. oxidation pond with a river discharge) is also provided.
9. No allowance for handling additional sludge quantities, either treatment or disposal.
10. No allowance for upgrading power supply to site.
11. Operating costs are associated with new treatment processes only.

The following assumptions have been made during development of the cost estimates:

a. Option1a – additional sludge discharge to ponds, so desludging frequency will need to increase. No allowance for these costs.
b. Option 1b - assumes no requirement for UV feed pumping station, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river). Assumes that treated wastewater has a UV transmittance of at least 40%
c. Option1c – assumes alkalinity dosing is not required, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river). Capacity and performance of existing digesters with alum-based sludge would need to be reviewed if this option progressed.
d. Option1d – assumes filter sized for 3x average daily flow. Flows above this would be bypassed.
e. Option1e – assumes typical average winter and summer influent concentrations based on monitoring data provided by ICC.

f. Option 2a – Land cost $40k/ha, RIB rising main assumed 4km length with 40m static pumping head, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river), no allowance for subsurface drainage.

g. Option 2b – Land cost $40k/ha, SRI rising main assumed 4km length with 40m static pumping head, Assume high wet weather flows are balanced in oxidation pond or disposed/discharged elsewhere (e.g. river).

Stantec

## Bluff Wastewater Treatment Plant

| Total annual inflow: | Population: | Existing Discharge Route: | Existing Resource Consents |
|---|---|---|---|
| 474,500m$^3$<br>(1,300m$^3$/d) | 2300 people connected plus 7500 equivalent people industrial load.<br><br>From ICC Plant brochure 2001 | Foveaux Strait | Current consent to discharge 3,850m$^3$/d.<br>BOD ≤ 100mg/L and 80% of samples shall be maintained < 80mg/L.<br>TSS ≤ 100mg/L and 80% of samples shall be maintained < 80mg/L.<br>FC ≤ 6,000MPN/100mL and 80% of samples shall be maintained ≤ 1,000MPN/100mL.<br><br>Expires in 2025. |

| Case Study | Objective of Option | Treatment Process | Expected Wastewater Discharge Quality | Economic Considerations (+/-30%) | | Associated Issues |
|---|---|---|---|---|---|---|
| | | | | Indicative Capital Cost | Indicative Annual Operating Cost | |
| Bluff Existing WWTP | | Liquid:<br>• 6mm screen<br>• Aerated lagoon<br>• Clarifier<br>• UV disinfection<br>Solid:<br>• Sludge Tanks | Actual mean/median 2013 – 2015<br>BOD 17.3, 17.2, 20.9mg/L<br>TSS 48.5, 42.5, 48.9mg/L<br>FC 339, 188, 518MPN/100mL<br>TN 25.6, 35.1, 49.1<br>TP – 2.2, 4.5, 6.9 | N/A | N/A | |

**Notes:**

1. Treated wastewater currently discharges is Foveaux Strait, which is in the coastal marine area (CMA). The CMA is not covered by the Water and Land Plan and this WWTP has not been considered further as part of this study. However, it is noted that the treated wastewater discharge quality has complied with the resource consent limits for the past five years.