SOUTHLAND ECONOMIC PROJECT
APPLYING TOWN CASE STUDIES TO OTHER SOUTHLAND TOWNS

PREPARED FOR ENVIRONMENT SOUTHLAND

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Image on front cover: Tokanui Wastewater Treatment Plant

Abbreviations

E. coli	Escherichia coli
log	logarithm base 10 (log_{10})
TN	Total Nitrogen
TP	Total Phosphorus

Environment Southland

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1. Introduction

1.1 Municipal Wastewater Schemes

The three Southland territorial authorities – Invercargill City Council, Southland District Council and Gore District Council – each have several municipal wastewater schemes in one or more of the Freshwater Management Units (FMUs) within the Southland Region. Whilst there are similarities across the region, each territorial authority has its own unique wastewater challenges. The schemes managed by each territorial authority in Southland is summarised below in Table 1. In general, the larger schemes include some industrial and commercial loads whereas the smaller schemes are predominantly domestic.

Table 1: Municipal Wastewater Schemes in Southland Region

Territorial Authority	Schemes
Invercargill City Council	• One large scheme that discharges to New River Estuary, which is degraded. • Two smaller schemes that discharge to the Coastal Marine Area, which is controlled by the Coastal Plan (currently under review) • All scheme boundaries located within Oreti FMU
Gore District Council	• Two medium schemes and one smaller scheme, all within Mataura FMU • All schemes discharge to the Mataura River, which has a variety of water quality and quantity issues, and discharges to the Fortrose Estuary which has a low susceptibility to eutrophication due to its well flushed nature but is showing signs of stress[1]
Southland District Council	• Large number of predominantly small schemes spread across all FMUs • Most schemes discharge to freshwater (either directly or via groundwater connected to freshwater), however some discharge to the Coastal Marine Area • Council is currently developing a wastewater strategy to rationalise consenting, prioritisation and funding of upgrades

1.2 Town Case Studies

1.2.1 Scope

In 2016, as part of The Southland Economic Project, Stantec assisted Environment Southland and the three Southland territorial authorities to develop eight town case studies for testing wastewater treatment upgrade scenarios as outlined below. Details of each town case study are provided in the technical report titled 'The Southland Economic Project – Urban and Industry' (or the 'Urban and Industry Report')[2,].

The eight town case studies were: Invercargill and Bluff (Invercargill City), Gore and Mataura (Gore District), and Te Anau, Winton, Nightcaps, and Ohai (Southland District). These towns were selected on the basis of having a wastewater scheme that discharged to water (rather than to land), varying population sizes, and the extent of wastewater schemes within each district. The Urban and Industry Report notes *"Schemes that discharge to water 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. … In total, the eight case study towns represent over 70 percent of Southland's population."*

[1] Expert Conference – Water Quality and Ecology (Rivers, Estuaries and Lakes), Clause 78, Date of Conference 20 to 22 November 2019

[2] Moran, E., McKay, D., Bennett, S., West, S., and Wilson, K. (2018) The Southland Economic Project: Urban and Industry. Technical Report. Publication no. 2018-17. Environment Southland, Invercargill, New Zealand. 383pp

1.2.2 Wastewater Treatment Upgrade Scenarios

Wastewater treatment scenarios were developed for each town case study focused on reductions in key contaminants, including total nitrogen (TN), total phosphorus (TP) and *E. coli*. The following scenarios were considered:

- **Improved liquid treatment:** existing and new treatment plant upgrades with continued discharge to surface water (with a number of levels of improved liquid treatment considered). It is noted that improved liquid treatment results in additional sludge that also needs to be managed in some way.
- **Improved land treatment:** existing treatment plant with new discharge to land (two types of land application were considered, both including treatment within the unsaturated soil prior to discharge to the underlying aquifer). The different pathways treated wastewater can take once discharged to land are shown in Figure 1 for a sub-surface land discharge. Treated wastewater can also be applied to the land surface, which will have similar flow paths. It is noted that land treatment is different to land disposal. With land treatment, there is a reduction in contaminant load through the unsaturated soil. Whereas with land disposal, there is minimal contaminant reduction, either due to insufficient depth of unsaturated soil or soil that is too rapidly draining to allow time for treatment to occur.

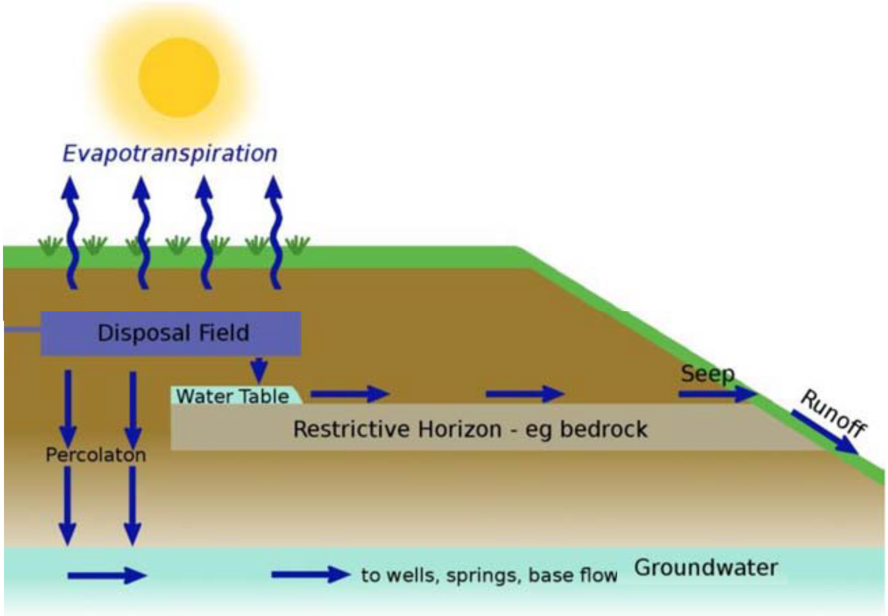

Figure 1: Wastewater Flow Pathways From a Subsurface Disposal Field[3].

Land treatment upgrade scenarios were considered for most of the case studies. However, as noted in the Urban and Industry Report, in many cases land treatment may not be technically feasible year-round. The specific constraint may be due to the nature of the soil (e.g. poorly draining soil), shallow groundwater, high risk of overland flow, or another factor. Figure 2 highlights the areas of shallow groundwater in the Southland Region. An additional consideration that several towns and rural communities use groundwater as a drinking water source (either directly or following treatment).

[3] Adapted from Ministry for the Environment (2008) *Proposed National Environmental Standard for On-site Wastewater Systems. Discussion Document.*

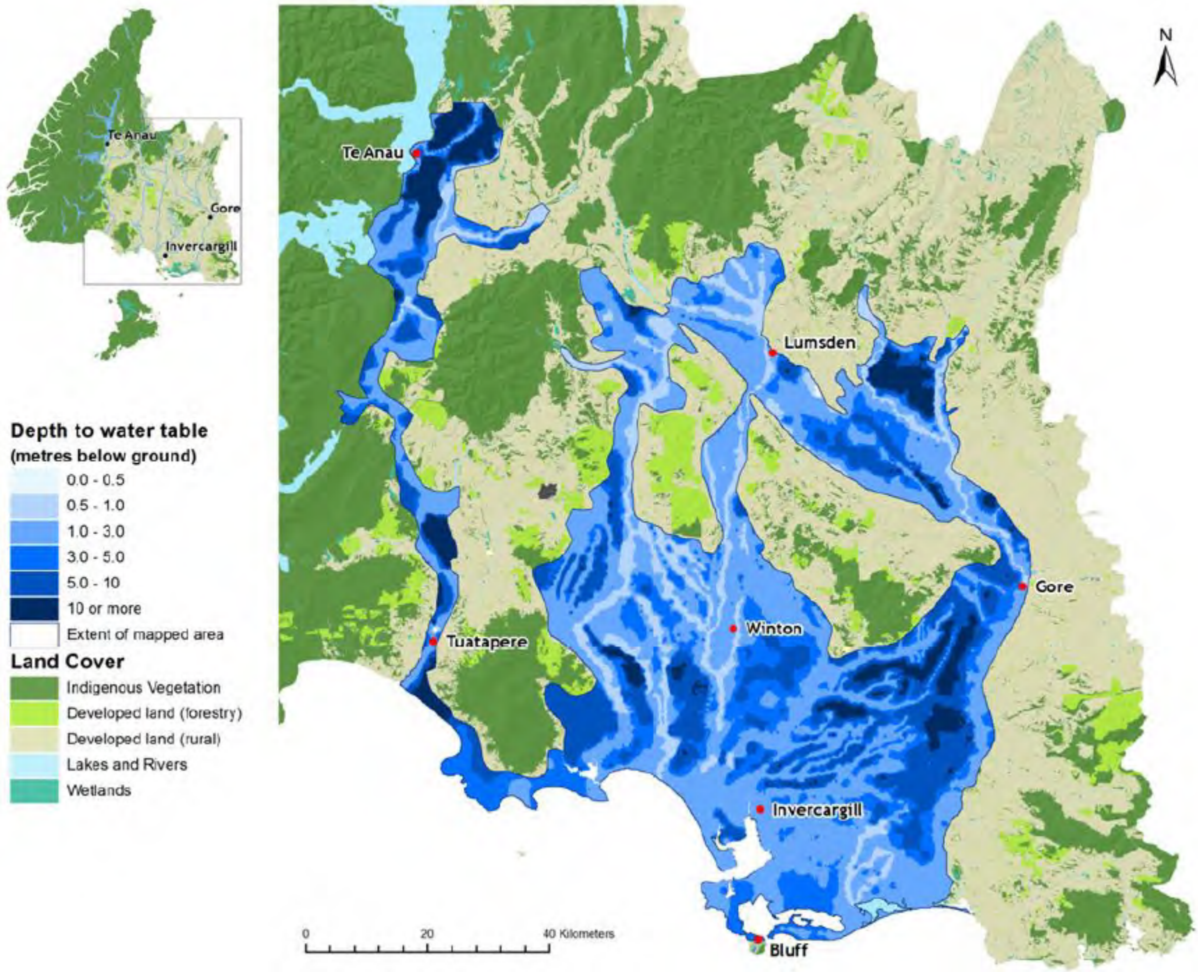

Figure 2: Depth to Groundwater Table in Areas Where Groundwater is Mapped[4].

1.2.3 Contaminant Concentrations and Loads

The wastewater contaminants considered in the town case studies were suspended sediment, biochemical dissolved oxygen, total nitrogen, total phosphorus, and *E. coli*. This indicated the high level of reduction in suspended solids and biochemical dissolved oxygen already achieved by the existing treatment plants. The focus of this report is on the potential for reductions in total nitrogen, total phosphorus, and *E. coli*.

The likely concentrations of these contaminants in the treated wastewater discharged to surface water or the underlying aquifer (via land) were defined under the existing situation (average) and each treatment upgrade scenario (median).

For aquifer discharges, an indicative level of treatment through the unsaturated soil was estimated for each contaminant using a groundwater model. This model considered local ground conditions (e.g. depth to groundwater and soil type), land application type, and published contaminant removal rates. The resulting likely concentrations were then multiplied by annual flows to calculate annual loads. This method likely over-estimates the overall annual load reduction resulting from land treatment, primarily as it assumes land application can occur within the most favourable ground conditions, and so can be achieved year-round (i.e. did not consider seasonal variability in local ground conditions).

The degree of contaminant reductions achieved by land treatment varies between contaminants due to the different biochemical and physical processes involved. Therefore, there are different reduction for the different contaminants considered, as discussed in Section 3.2.

[4] Figure A16 in the Urban and Industry Report.

1.2.4 Treatment Upgrade Costs

The wastewater treatment upgrade scenarios incur additional capital and operating costs for the new or upgraded elements of the overall treatment process (i.e. both liquid and land treatment elements). These costs were estimated for each treatment upgrade scenario to provide a perspective of relative additional cost for a given improvement in contaminant reduction.

The capital costs were for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, and GST. The study assumed that there would be a suitable parcel of land at a nominal cost of land for land treatment within 4km and that no storage is required (eg irrigation is not stopped during periods of saturated soils or wet weather). There was no allowance for handling additional sludge quantities, either treatment or disposal, and no allowance for upgrading power supply to site. Operating costs were those associated with the new treatment processes only.

1.3 Applying Town Case Studies To Other Southland Schemes

Following the development of the eight town case studies, Environment Southland subsequently engaged Stantec to apply them across the remaining towns with a municipal wastewater scheme in the Southland Region. This report summarises the key findings of this work. Figure 3 shows the locations of the wastewater schemes in the Southland Region.

A key difference between the 17 remaining schemes and the town case studies is that a large proportion of the wastewater schemes for the remaining schemes currently discharge to land or partially discharge to land, whereas all the town case studies currently discharge directly to water.

For thirteen of the remaining schemes[5], potential upgrade scenarios from the town case studies have been identified and applied to the schemes, including:

- **Invercargill City:** Omaui
- **Gore District:** Waikaka
- **Southland District:** Oban, Otautau, Balfour, Riversdale, Edendale-Wyndham, Gorge Road, Tokanui, Lumsden, Browns, Manapouri and Tuatapere.

The four remaining schemes with a municipal wastewater scheme for which upgrade scenarios have not been identified in this report are Riverton[6] and Riverton Rocks (as both schemes have coastal discharges and so do not contribute load to the relevant estuary), Monowai (as it is a very small scheme that discharges to land), and Wallacetown (as the scheme discharges to a private wastewater treatment plant at Alliance Lorneville). These four schemes are within Southland District.

For each of the thirteen remaining schemes, Stantec worked with the territorial authority to identify the most relevant treatment upgrade scenario from the town case studies for:

- Improved liquid treatment, with continued discharge via the existing route (i.e. to water, to land or a mixture) and/or
- Improved or new land treatment, with existing liquid treatment. Consideration was given to whether a land treatment scheme was likely to be feasible.

This report records the treatment upgrade scenarios considered for the thirteen schemes (improved liquid treatment and/or land treatment), median discharge load for Total Nitrogen (TN) and Total Phosphorus (TP) and concentration for *E. coli* under the existing scenario and each treatment upgrade scenario, and additional capital costs of each treatment upgrade scenario. The discharge loads/concentrations and additional capital costs for each treatment upgrade scenario for the schemes were developed from the most relevant town case study. Operating costs were not considered (see discussion in Section 4).

[5] There are fourteen towns, but two of the towns, Edendale and Wyndham, have a combined wastewater scheme.

[6] The original scope from Environment Southland for this report included Riverton. However, the treated wastewater from the existing rapid infiltration basins discharges to groundwater, then filters through Oreti beach sands to Foveaux Strait. It does not discharge to Aparima River or Jacobs River Estuary.

Figure 3: Locations of Wastewater Schemes in Southland Region

1.4 Purpose of Report

The purpose of this report is to broadly understand the potential contaminant reduction that could be achieved at the municipal wastewater schemes across Southland Region, relative to indicative capital costs of the scheme upgrades (liquid and/or land treatment upgrades).

The treatment upgrade scenarios presented in this report for each scheme have been developed with involvement from the three Southland territorial authorities to achieve the above purpose. The scenarios should be viewed as potential options, rather than any commitment from a territorial authority to upgrade the scheme.

1.5 Report Development

The initial scope for this work was developed by Environment Southland together with the three territorial authorities and Stantec. Following this, Stantec worked with each territorial authority to confirm the existing wastewater scenario for each remaining scheme, and the most relevant town case study and liquid and/or land treatment upgrade scenario for each scheme to be used for this work (this varied between schemes).

Stantec used this information to determine the resulting treated wastewater quality and loads for each scenario and developed a draft report summarising the key findings for review by Environment Southland. The draft report was issued to the three territorial authorities for comment. Stantec then contacted each territorial authority's representative to discuss the report. Based on this feedback, and further discussion with Environment Southland, Stantec modified the report as approriate.

The key changes made to the draft report were:

- Addition of overview of municipal wastewater schemes in Southland Region (Section 1.1).
- Addition of qualification to Section 1.2 and Section 3.2 stating the calculated annual loads discharged to the aquifer given in this report are likely to have over-estimated the annual load reduction through the land treatment system. Notwithstanding this, using the same approach adopted for the town case studies in the Urban and Industry Report means the relative contributions from individual wastewater schemes are able to be compared.
- Addition of Section 1.4 outlining the purpose of the report, which is to broadly understand the potential contaminant reduction relative to indicative scheme upgrade costs across the Southland Region.
- Modify land treatment upgrade scenario for Omaui. Invercargill City Council has carried out remedial works to enable the existing land application system to operate as designed. The Council does not consider additional works are required at this time, however, it would revisit requirements following performance reviews of the scheme.
- Modify land treatment upgrade scenario for Manapouri. Southland District Council requested that the report consider the scenario of conveying filtered wastewater to the proposed land application system for Te Anau, rather than providing additional land contact/ partial land discharge similar to that proposed for Tokanui.
- Modify liquid treatment upgrade scenario for Edendale-Wyndham. Southland District Council requested that the report consider the scenario of additional liquid treatment to reduce nitrogen prior to discharge.
- Modify summary table to make it clear that the liquid treatment upgrade scenario is upgraded liquid treatment with existing discharge route and that the land treatment upgrade scenario is upgraded or new land application system with existing liquid treatment. It is intended to improve, as far as practical, the summary table so it can be understood without reading the full report.
- Minor additions (e.g. use of footnotes to clarify assumptions) and corrections.

A final draft report was issued to Environment Southland for comment prior to the report being finalised.

2. Selected Treatment Upgrade Scenarios

For the thirteen schemes included in the analysis, Appendix A summarises:

- The existing wastewater scheme, including population served[7], description of liquid and solids treatment, any land contact or land application, and discharge route
- The selected liquid treatment upgrade (i.e. additional process unit(s) in the WWTP) and/or land treatment upgrade scenario considered, and
- The town case study that was used to derive the discharge loads/concentrations for the upgrade scenarios considered and additional capital costs for the selected treatment upgrade scenarios.

The selected liquid treatment upgrade and land treatment upgrade scenarios for the schemes were one of the following:

- Liquid treatment: no upgrade, new/extended wetland, or new trickling filter
- Land treatment: no upgrade, new/extended Slow Rate Infiltration (SRI), use/maximise use of existing SRI, or new Rapid Infiltration Basins (RIBs).

The selection of the type of land treatment upgrade (i.e. SRI or RIB) was based on the nature of the soils and physiographic zones in the vicinity of the scheme. The physiographic zones can be used to infer the likely percolation rate of treated wastewater through the soil, the likely contaminant removal rate (e.g. of TN, TP and *E. coli*) through the unsaturated soil, and the likelihood of overland flow (or run-off). For example, rapidly draining soils are more suitable for RIBs, whereas slower draining soils are more suitable to SRI. Some ground conditions, such as poorly draining soils, shallow groundwater, steep slopes, and shallow soils, contribute to run-off (or ponding) which is undesirable for land application of wastewater. If a scheme is only located near riverine (i.e. rapidly draining) or unsuitable soils (e.g. due to high likelihood of run-off), then the only practical land application option is via rapid rate infiltration within the riverine soils.

For one of the smaller schemes (Tokanui), the selected land treatment upgrade scenario is to provide additional land contact/partial land discharge. This is not a scenario from the town case studies but was proposed as part of the consenting process for this scheme[8], and so was adopted in this report for consistency.

For the wastewater schemes that are currently being consented or investigations are underway for recently consented upgrades, both the existing scheme (as at 2016) and the proposed scheme are presented in Appendix A. This applies to Tokanui and Riversdale

3. Annual Loads and Concentrations

3.1 Methodology

For the thirteen schemes, Stantec calculated the median discharge load for TN and TP and the median discharge concentration for *E. coli* under the existing scenario and each treatment upgrade scenario. The median was used rather than average as it better represents the "typical" flows, concentrations and hence loads.

Of the thirteen schemes, ten schemes have oxidation ponds, three are based on other treatment upgrade processes and eight schemes include a discharge to land pathway, often as well as a discharge to water. Four schemes have a discharge to water only. The details of the existing schemes is given in Appendix A.

In general, likely (median) concentrations of these three contaminants in the treated wastewater discharged to surface water or to the underlying aquifer following soil treatment were defined under the existing situation and selected treatment upgrade scenario for contaminants considered (TN, TP and *E. coli*) based on site-specific data (where available for existing situation) or the most relevant town case study.

[7] The population served by each scheme can be converted to an estimated number of households by using an occupancy rate of 2.4. This is the average household occupancy for Southland Region given in the Urban and Industry Report and was based on the New Zealand Census 2013.

[8] Consent was granted for the Takanui WWTP discharge on 5 July 2019 for a term of 15 years.

These median concentrations were then multiplied by median flows[9] to calculate median annual loads for TN and TP. This point is further discussed below.

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. Therefore, load estimates for *E. coli* were not developed in this work.

3.2 Existing Scenario

A key difference between the thirteen schemes and the original eight town case studies is that a large proportion of the wastewater schemes discharge to land or partially discharge to land, rather than discharge to water. As a result, there will be removal of key contaminants through the soil before reaching the underlying aquifer. This reduction occurs after the sampling point for the monitoring data available on the discharge quality, and hence the available monitoring data cannot be directly used to characterise the existing discharge to the aquifer.

For the schemes with a discharge to water, the median TN, TP and *E. coli* concentration was based on the observed median concentrations in the treated wastewater discharge (when available from the relevant territorial authority) or the town case study that was considered the most representative of the scheme in terms of size and nature of treatment. Typically, the available wastewater monitoring data is that required by the resource consents.

For the schemes with a discharge to land, the median TN, TP and *E. coli* concentration discharged to land (but not what reaches the aquifer) were the same as outlined above for discharge to water. A reduction factor was then applied to these concentrations to provide an allowance for reduction of TN, TP, and *E. coli* through the soil prior to discharge to the underlying aquifer based on the type of land application.

These factors, given in Table 2, were developed by Stantec based on investigations conducted for the town case studies and Stantec decided to apply them across the remaining schemes considered. The factors provide an indication of reduction rates, assuming that there are suitable conditions for land application located near the scheme and that these conditions occur year round. However, as noted in Section 1.2, .in Southland it is unlikely that there will be suitable conditions for all year round land application in all locations, and they are likely to be an over-estimate but are consistent with assumptions used in the Urban and Industry Report.

Table 2: Contaminant Reduction Through Land Application System

Contaminant	Reduction through Rapid Infiltration Basins	Reduction through Slow Rate Irrigation
TN	60%	70%
TP	40%	60%
E. coli	0.7 log	3.0 log

The actual reduction rate for a given scheme is dependent on soil type and soil texture as well as depth to groundwater and climatic variation. Greater reduction rates are expected with a greater depth of unsaturated soil, which will vary between schemes. In addition, Southland has extended periods of the year when soils are at or near field capacity (i.e. saturated) and seasonally high groundwater tables when less reduction would be expected. Hence there will be significant variability in the reduction rates through land treatment between schemes and over time, which is difficult to quantify.

This seasonal and annual variability is not included in the estimates in Appendix A. A separate report has been prepared[10] which discusses this variability in oxidation ponds. Given the assumption that suitable conditions is available year round, the estimates of contaminant reduction from land application are likely to provide an over-estimate (i.e. generous / high) of the reductions that would be achieved over a prolonged period.

For schemes that discharge partly to land, the median TN, TP and *E. coli* concentration discharged was as outlined above for each pathway (i.e. to land or to water) The annual volume of discharge was split into the

[9] From 2015/16 flow data where available, otherwise from population connected to wastewater scheme and typical unit generation rates expected based on the water supply (e.g. reticulated supply, on-site rainwater tanks).
[10] Stantec, May 2020 "Pond Based Wastewater Systems" for Environment Southland

two pathways based on an estimate of the proportion of the discharge applied to land and to water on a case by case basis (see Appendix A). For the proportion to land, the factors from Table 2 were then applied to determine the quality of the discharge to groundwater to land based on the most relevant land application system.

3.3 Selected Liquid Treatment Upgrade and Land Treatment Upgrade Scenarios

For the upgrade scenarios, the median TN, TP and *E. coli* concentration in the treated wastewater discharged to surface water or the underlying aquifer were based on that achieved for the relevant town case study with the following modifications:

- For liquid treatment upgrade scenarios: If the existing treated wastewater concentrations were markedly higher than the relevant town case study, the percentage reduction observed in the relevant town case study was adopted instead of the final concentration
- For land treatment upgrade scenarios: the relevant reduction factor from Table 2 was adopted to calculate the concentrations discharged to the underlying aquifer. This is likely to provide an over-estimate of the annual contaminant reduction (see discussion in Section 1.2 and Section 3.2), however is consistent with approach used for the town case studies in the Urban and Industry Report.

3.4 Contaminant Concentrations and Loads

Table 3 summarises the median annual loads and concentrations for the existing wastewater scenario and selected treatment upgrade scenarios for the thirteen schemes. Further information is given in Appendix A.

As noted previously, the annual contaminant reduction assumed through the land treatment upgrade scenarios is likely to be an over-estimate but is consistent with the Urban and Industry Report (see discussion in Section 1.2 and Section 3.2). In all likelihood, median annual loads and concentration in the underlying aquifer may be higher than that presented in this report for the land treatment upgrade scenarios. More detailed analysis and investigations would be needed to refine these estimates.

4. Additional Capital Costs

Stantec have estimated additional capital costs of each treatment upgrade scenario for the thirteen schemes, prorated based on the most relevant town case study. These costs are 2016 costs as developed for the town case studies.

The capital costs are rough-order costs[11] developed for the purpose of comparison, on the same basis as that used for the town case studies (see Appendix 2 of the Urban and Industry Report. The costs for the Manapouri land treatment upgrade scenario was generally developed on the same basis, however recently tendered prices for the proposed Te Anau land application system were used in preference to those in the Urban and Industry Report for Te Anau, which was based on a different type of land application system[12].

Table 3 summarises the additional capital costs for the selected treatment upgrade scenarios for the thirteen schemes. Further information is given in Appendix A.

While additional operational costs were estimated for the original town case studies, we have not estimated additional operating costs for this report. The schemes considered for this report were generally of a smaller magnitude (in terms of connected population and flow) than the most relevant town case study, which means that additional operating costs associated with any upgrade scenario would generally be less than the relevant town case study.

[11] The capital costs are for the add-on process/component of the treatment scenario and exclude planning work, feasibility investigations, gaining resource consents and other approvals, impacts on existing plant and GST. The costs provide a rough-order of costs and are based on tendered prices, indicative prices from suppliers, or design costing Stantec has undertaken for similar sized projects. No engineering design has been undertaken. For any upgrade, a range of options will be available. For this work, a single option has been selected for each scenario, which is considered to provide a conservative estimate for a realistic, robust, reasonably low-tech solution.

[12] The Urban and Industry Report provided land treatment costs for Te Anau based on slow rate irrigation via centre pivot irrigation. However, the proposed system is slow rate irrigation via Subsurface Drip Irrigation (SDI), which requires the treated wastewater to be filtered by membranes prior to land application. Manapouri land treatment costs in this report were prorated from recently tendered prices for the proposed land application system at Te Anau, including membrane filtration, conveyance and SDI field construction, plus purchasing additional off-set land as required under the resource consents (off-set area prorated from Te Anau; land costs as assumed in the Urban and Industry Report).

5. Summary

Table 3 summarises the scenarios for thirteen schemes in the Southland Region that were not included in the original set of town case studies. The Table gives the median nitrogen and phosphorus loads and *E. coli* concentrations under the existing scenario and the selected treatment upgrade scenarios (improved liquid treatment upgrade and/or land treatment) for the thirteen schemes alongside the additional capital costs. This information is the load or concentration discharged to the surface water body or underlying aquifer as relevant.

As noted earlier, it is likely the annual contaminant reduction achieved with land treatment has been overestimated, however is consistent with the approach used for the town case studies in the Urban and Industry Report. As noted in Section 1.2.4, there a number of project costs that are not included in the additional capital costs.

Table 3: Summary of Existing Wastewater Scenario and Selected Treatment Upgrade Scenarios for Thirteen Schemes

Scheme	2016 Baseline Scenario		Liquid Treatment Upgrade + Existing Discharge Route[13]		Land Treatment Upgrade + Existing Liquid Treatment[13]	
	Flow m³/day	Discharge Route & Load / Conc	Discharge Route & Load / Conc	Additional Capital Cost	Discharge Route & Load / Conc	Additional Capital Cost
Invercargill City						
Omaui	8	To land TN: 16 kg/year TP: 4 kg/year *E. coli*: <10 cfu/100mL	n/a	n/a	n/a (existing to land)[14]	n/a
Gore District						
Waikaka	14	To water TN: 90 kg/year TP: 20 kg/year *E. coli*: 5,100 cfu/100mL	To water TN: 50 kg/year TP: 20 kg/year *E. coli*: 5,100 cfu/100mL	$200k	To land TN: 30 kg/year TP: 10 kg/year *E. coli*: <10 cfu/100mL	$600k
Southland District						
Oban	165	To land TN: 360 kg/year TP: 250 kg/year *E. coli*: <10 cfu/100mL	n/a	n/a	To land (extended)[15] TN: 360 kg/year TP: 250 kg/year *E. coli*: <10 cfu/100mL	$700k
Otautau	168	To land TN: 550 kg/year TP: 110 kg/year *E. coli*: 50 cfu/100mL	To land TN: 280 kg/year TP: 110 kg/year *E. coli*: 50 cfu/100mL	$700k	n/a (existing to land)	
Balfour	142	To water TN: 670 kg/year TP: 70 kg/year *E. coli*: 33,000 cfu/100mL	To water TN: 520 kg/year TP: 70 kg/year *E. coli*: 33,000 cfu/100mL	$500k	To land TN: 200 kg/year TP: 30 kg/year *E. coli*: 30 cfu/100mL	$700k
Riversdale	182	To land & water TN: 730 kg/year TP: 210 kg/year *E. coli*: 1,100 cfu/100mL	n/a	n/a	To land TN: 500 kg/year TP: 170 kg/year *E. coli*: 480 cfu/100mL	$3.1M

[13] n/a = upgrade treatment scenario not considered.
[14] Small scheme (30 connected people) that already discharges all flow to land. The territorial authority considers that, due to the small population (and hence low solids loading), it took longer than anticipated for an adequate sludge layer to build up in the base of the pond. The sludge layer has now reduced the extent of seepage from the base such that the land application system can be used. Remedial works were carried out in 2019 and the existing land application system is now operating as originally designed. System performance will be monitored as part of ongoing reviews.
[15] Some further TN, TP and *E. coli* reduction expected with extension to land application system / addition of land contact, however not readily quantified from town case studies.

Scheme	2016 Baseline Scenario		Liquid Treatment Upgrade + Existing Discharge Route[13]		Land Treatment Upgrade + Existing Liquid Treatment[13]	
	Flow m^3/day	Discharge Route & Load / Conc	Discharge Route & Load / Conc	Additional Capital Cost	Discharge Route & Load / Conc	Additional Capital Cost
Edendale – Wyndham	310	To water TN: 3400 kg/year TP: 540 kg/year *E. coli*: 270 cfu/100mL	To water TN: 1700 kg/year TP: 540 kg/year *E. coli*: 270 cfu/100mL	$1.2M	To land TN: 1400 kg/year TP: 330 kg/year *E. coli*: 50 cfu/100mL	$2.3M
Gorge Road	7	To water TN: 50 kg/year TP: 10 kg/year *E. coli*: 630 cfu/100mL	To water TN: 30 kg/year TP: 10 kg/year *E. coli*: 630 cfu/100mL	$200k	n/a (land treatment technically difficult, small scheme)[16]	n/a
Tokanui	27	To land & water TN: 90 kg/year TP: 30 kg/year *E. coli*: 210 cfu/100mL	n/a	n/a	To land & water TN: 90 kg/year* TP: 30 kg/year* *E. coli*: 210 cfu/100mL*	$60k
Lumsden	240	To land TN: 1100 kg/year TP: 1600 kg/year *E. coli*: 700 cfu/100mL	To land TN: 530 kg/year TP: 1600 kg/year *E. coli*: 700 cfu/100mL	$700k	n/a (existing to land)	n/a
Browns	5.4	To land & water TN: 20 kg/year TP: 3 kg/year *E. coli*: 3,000 cfu/100mL	n/a	n/a	To land TN: 10 kg/year TP: 2 kg/year *E. coli*: <10 cfu/100mL	n/a[17]
Manapouri	87	To land & water TN: 190 kg/year TP: 90 kg/year *E. coli*: 540 cfu/100mL	n/a	n/a	To land TN: 115 kg/year TP: 65 kg/year *E. coli*: <10 cfu/100mL	$9M
Tuatapere	163	To land TN: 360 kg/year TP: 100 kg/year *E. coli*: <10 cfu/100mL	To land TN: 180 kg/year TP: 100 kg/year *E. coli*: <10 cfu/100mL	$300k	n/a (existing to land)	n/a

6. Acknowledgements

Stantec and Environment Southland wish to acknowledge the contributions from Invercargill City Council, Gore District Council and Southland District Council in the development of this report. Their contributions were also invaluable for the development of the original town case studies, which formed the basis for the treatment upgrade scenarios, contaminant loads/concentrations and additional capital costs for the thirteen schemes considered in this report.

[16] Land application not considered as no suitable land within 3km and small scheme (<60 connected people).
[17] Application to land year round will require a variation to the consent.

Appendices

Appendix A Overview of Wastewater Schemes

Table A1: Existing Scenario and Selected Treatment Upgrade Scenarios For Thirteen Schemes

Scheme	Population 2013[18]	Existing Wastewater Scheme			Selected Treatment Upgrade Scenarios (Town Case Study)	
		Treatment Process	Land contact / land application	Discharge Route	Liquid Treatment Upgrade + Existing Discharge Route	Land Treatment Upgrade + Existing Liquid Treatment
Invercargill City						
Omaui	102	Liquid: • 1x oxidation pond Solids: • stored in pond	Existing: • Some seepage through base/walls of ponds (assumed SRI) or, in warm weather, evaporation • Soakage area (SRI)	To land via SRI or base of pond (GWZ, to sea)	Nil	Nil (existing SRI recently reinstated; total scheme to be reviewed in 2020)
Gore District						
Waikaka	108	Liquid: • 1x oxidation pond Solids: • stored in pond	• Wetland • Discharges overland to farm drain, to Waikaka Stream	To water (Waikaka Stream, to Mataura River)	Extend wetland (Nightcaps)	New SRI (Nightcaps)
Southland District						
Oban	381	Liquid: • 1x oxidation pond • 2x maturation ponds Solids: • stored in ponds	• Soakage area within forest, above ground pipelines (SRI)	To land (GWZ, Little River, Halfmoon Bay)	Nil	Extend SRI (Nightcaps)
Otautau	798	Liquid: • bar screen • 1x oxidation pond Solids: • stored in pond	• Filter • Irrigation field, spray irrigators (SRI)	To land (GWZ, Aparima River)	New trickling filter (Winton)	Nil (existing SRI)
Balfour	126	Liquid: • 1x Imhoff tank • 1x trickling filter • 1x humus tank Solids: • Dried, disposed off-site	• Weeded drain • Drain discharges to Longridge Stream	To water (Longridge Stream, to Mataura River)	New trickling filter (Winton)	New SRI (Nightcaps)
Riversdale	456	Liquid: • 1x oxidation pond Solids: • stored in pond	Existing • Soakage channel (RIB) • Periodic overflows to Meadow Burn Proposed upgrade: • Soakage channel (existing) + RIBs (new)	Existing: • To land when possible else to water (Meadow Burn to Mataura) *(assumed 70% to land, 30% to water)* Proposed upgrade: • To land (GWZ, Mataura River)	Nil (as per long-term consent)	New RIBs (as per long-term consent)
Edendale – Wyndham	1,152	Liquid: • 2x 3mm screen • 2x balance tanks • Filter belt • Holding tank • Biofiltro beds • Alum dosing • Balance Tank • UV disinfection Solids: • Disposed off-site	• No additional land contact (biofiltro beds) • Treated wastewater pumped to Mataura	To water (Mataura River)	New trickling filter (Winton)	New RIBs (Nightcaps)
Gorge Road	54	Liquid: • individual septic tanks • 1x oxidation pond Solids: • stored in pond	• Wetland • Discharges overland to Gorge Creek	To water (Gorge Creek, to Mataura River)	Extend wetland (Nightcaps)	Nil (land treatment technically difficult, small scheme)
Tokanui	150	Liquid: • 1x oxidation pond • 1x maturation pond Solids: • stored in pond	Existing: • Seepage through base/walls of ponds (assumed SRI) or, in warm weather, evaporation • Any overflow discharges to Tokanui Stream (seldom in summer) Proposed upgrade: • land contact/partial land discharge prior to discharge to Tokanui Stream	Existing: • Generally to land via base of pond (GWZ, Tokanui Stream, to sea) else to water (Tokanui Stream, to sea) *(assumed 70% to land, 30% to water)* Proposed upgrade: • As for existing, with greater proportion to land)	Nil	Provide additional land contact / partial land discharge (as proposed in consent application)
Lumsden	453	Liquid: • 1x oxidation pond, partitioned Solids: • stored in pond	• Rapid Infiltration Basins (RIBs)	To land (to GWZ, Oreti River)	New trickling filter (Winton)	Nil (existing RIBs)
Browns	41	Liquid: • individual septic tanks • 1x activated sludge plant (bioreactor, clarifier) • 1x trickling filter • Hydrogen peroxide disinfection Solids: • stored in pond	Summer (Nov to Mar, when < field capacity): • soakage area within forest, above ground pipelines (SRI) Otherwise: • No land contact • Treated wastewater discharges to tributary of Tussock Creek	Summer: • to land (GWZ, to tributary/Tussock Creek/Oreti River) Otherwise: • To water (Tributary of Tussock Creek (to Oreti River) *(assumed 50% to land, 50% to water)*	Nil	Year-round use of existing SRI

[18] The average household occupancy adopted in the Southland Economic Project - Urban and Industry report for Southland Region was 2.4 people. This was based on the New Zealand Census 2013.

Scheme	Population 2013[18]	Existing Wastewater Scheme			Selected Treatment Upgrade Scenarios (Town Case Study)	
		Treatment Process	Land contact / land application	Discharge Route	Liquid Treatment Upgrade + Existing Discharge Route	Land Treatment Upgrade + Existing Liquid Treatment
Manapouri	228	Liquid: • 1x oxidation pond Solids: • stored in pond	• Seepage through the base/walls of the ponds (assume SRI) or, in warm weather, evaporation • Any overflow discharges to Home Creek (seldom)	• Generally to land via base of pond (to GWZ, Home Creek, Waiau River) else to water Home creek (to Waiau River) *(assumed 70% to land, 30% to water)*	Nil	New membrane filtration, transfer to extended Te Anau SRI
Tuatapere	561	Liquid: • coarse screening, mechanical • 1x oxidation pond • 1x maturation pond Solids: • stored in ponds	• Wetland /infiltration area (SRI) • Upper weeded drain / infiltration area (SRI), • Rock passage • Lower weeded drain / infiltration area (SRI) • Any overflow to Waiau River (seldom)	• Generally to land via base of wetlands and weeded drains (to GWZ, Waiau River) else to water (Waiau River) *(assumed 100% to land)*	Extend / augment wetland (Nightcaps / Winton)	Nil (existing SRI)

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