Southland Industrial and Municipal Water Values

Invercargill Case Study

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Executive Summary

This report has been commissioned by the Ministry for the Environment (MfE) as part of the Economic Impact Joint Venture Studies (EIJVS) Project, to establish the impacts and implications of water quantity and quality limits on municipal and industrial water values in the Southland economy. It is part of a series of studies for the Ministry that will be used to inform policy scenarios on quality and quantity limits in freshwater. The objectives of this report are to:

- Identify the water values associated with industrial and municipal activities, in an urban and rural context at the national level.
- Investigate the implications of changing freshwater quality limits using a case study approach.
- Establishes a list of principles highlighting the key issues and practical guidelines for Councils on how to carry out such analysis themselves

This report outlines the range of potential costs the different communities covered by the case studies discussed in here might face to meet higher water quality standards. Results are reported on as additional costs per rate payer (either a household or a business). This allows additional costs to be placed into context by referencing them to existing rate charges, and by comparing them to the national level infrastructure expenditure averages (per household) contained in the National Water Values work in Section 4.

The key findings of this report relate to the financial implications of changes or limit setting currently being assessed by central government, to meet higher water quality standards. The costs are likely to be distributed in an uneven manner. Furthermore, the wider implications of investment in additional plant to meet higher standards or the implications of plant closure if standards cannot be met due to high costs have not been explored in this report. Nor does this report definitively answer the question, "What are the costs to a small rural community of meeting higher water quality standards?" This is simply because those standards have not been set and the cost to the community is fully dependent on the difference between the status quo and the higher standards.

The timing of implementation of water quality limits impacts significantly on councils' ability to afford the infrastructure required to meet any new standards. It is understood that Regional Councils will set the timeframes but it is the territorial authorities who will have to meet these timeframes.

Table 1 combines a range of outcomes from all the individual case studies contained in this report. This means the results are not able to be combined, rather they are presented here together for convenience.

Table 1: Summary of Key Financial Impact Results ($\$_{2012}$)

Scenarios	Water Supply	Stormwater ($/hhld, bus.)	Wastewater: Winton ($/hhld, bus.)	Wastewater: Alliance Meatworks	Wastewater: On-site Wastewater Systems* ($/hhld, bus.)
Lowest Cost		$ 240	$ 463		
Low - Medium Cost			$ 477	$27,581,000	$14,405
Medium Cost		$ 526	$ 534		
Med - High Cost			$ 666	$41,368,000	$16,462
Highest Cost		$ 1,819	$ 697		
			* *For the Invercargill Study Area Only*		
	Note: Alliance Meatworks costs and Septic Tank Costs in NPV terms at 6%				

In summary;

- The effects of setting quality limits on freshwater supply in Invercargill are nil or practically nil. No additional costs are anticipated as a result of the policy changes sought. Most water quality parameters don't overlap with the parameters considered for freshwater quality limit setting. It is therefore expected that setting quality limits on fresh water nationally would be less constraining than drinking water standards already in existence.

- The effects of quality limits on stormwater are likely to be significant. In order to ensure all stormwater in Invercargill complies with higher quality limits, i.e. to reduce the key pollutants (by 50% of Phosphorous, 80% of heavy metals, 80% of hydrocarbons and all solids) it is expected to cost more than $1,800 per ratepayer household per year. This drops to $240 if only stormwater from the industrial area is treated or $526 per year if the industrial and CBD areas are treated. Note that these costs are not divided between key ratepayer groups according to any rate differential that might be used to differentiate between groups in the community based on their propensity to pollute or their ability to pay. Care must also be taken when interpreting these results as they are based on dividing total costs by the area covered by each of the land use categories. Work needs to be done to determine the quantity of pollutants in stormwater, by origin in order to distribute costs more efficiently.

- In Winton, additional wastewater treatment costs increase in relation to the percentage of pollutant removed. The figures presented here are based on combining the costs of the individual pollutant treatment processes (described in Section 8) and allowing for a 25% efficiency saving if individual processes are combined during the construction phase. In reality, the actual system built will be tailored to meet the specific water quality standards at the time. Therefore these figures can be seen as a guide to potential cost structures. The upgrade treatment costs range from between $460 and $700 per household or business annually on average over the next 25 years.

- The costs associated with the upgrade to the Alliance Meatworks wastewater processing facility are large. In total, they are roughly equivalent to 33% of a year's output based on regional averages, or the value added equivalent of 450 meat workers working for a year. Should the upgrade be developed in time to be fully operational by 2017 and meet the current published water quality standards it is expected to cost the company some $41.4 million in NPV (at 6%), terms over the economic lifetime of the upgrade (25 years). If the company is able to stage a smaller development in 2 blocks approximately 5 years apart, the costs would be almost halved ($27.6m in NPV terms). Note the efficacy of a staged approach is not known, and the costs are rough estimates at this stage. Alliance is in the early stages of investigating costs and processes and will need to stay in contact with all interested parties throughout the process.

- The wastewater upgrade for Alliance is required to meet currently published water quality standards, it does not provide Alliance with improvements to operational efficiency that may allow them to recoup these costs.

- It is likely that the future profitability of the plant is less clear given the high costs associated with the changes outlined above. This study has not established whether Alliance can afford the upgrades required to continue operating. This is an area that requires additional study

- On-site wastewater treatment systems are common in Invercargill. They have the potential to be significant contributors to pollutants of freshwater systems if they are poorly maintained, are too close to open water, are highly concentrated in number, or if they are poorly designed for the soil types. However, they are likely to be a minor contributor to overall water quality issues currently due to the small volumes of pollutants involved (on average) over a wide area. The limited data available indicates that some 1,070 systems are pre 1992 a further 414 systems are pre 2000 with the rest being post 2000. To reduce discharges, and thereby help bring freshwater quality up, is likely to cost in total between $14,000 and $16,000 per household (replacing old systems with modern ones). In doing so the volume of pollutants drops significantly.

- It is beyond the scope of this study to identify the role soil plays in further processing these wastes prior to them entering the freshwater system. Differences between sites are likely to be large so further investigation is required prior to setting binding policy.

Full results including tables detailing the environmental effects of each set of scenarios are contained in the relevant sections below.

Study Limitations

This study is a first step in understanding the effects of freshwater quality limits on municipal and industrial water values. The study is limited by the available data, the time required to prepare this report plus the limited number of other studies in New Zealand that have focused on these issues. The key limitations to this study are;

- In the absence of specified freshwater quality standards, a definitive estimate of the economic impact of improving water quality has not been able to be estimated. Once Government policy is set and the standards determined it will be necessary to repeat aspects of this study to determine the actual effect of those limits on Invercargill and Winton or similar communities nationally.

- Where practical, the case studies have been generalised to ensure they have meaning when applied more widely than the actual study area. This means that some specific characteristics of the study areas may not have been taken into account. The effect of this is that the findings must be seen as a general outcome – accurate specific studies of these areas will be needed once actual limits and standards have been set.

- Currently there is no way of identifying for the Winton case study the relative contributions of the commercial, industrial and residential discharges into the municipal wastewater treatment facility. It is a single facility attached to a single reticulation network that does not allow for differentiation of waste streams. This makes modelling meaningful change impossible as it is not possible to isolate these specific discharges.

- In respect of Invercargill's water supply, there are potential reductions in processing costs associated with higher freshwater quality standards. Estimation of the effects of these are beyond the scope of this report, as they will be specific to the standards themselves.

- It is important to note that findings in this report are based on direct water use. This means that water embodied in the goods/services used during production processes of goods consumed locally, is not included in this assessment. The analysis presented in this report captures the direct use of water supplied via the reticulated system only.

- In terms of quantity of water, Invercargill currently losses around 25% to leakage or is unaccounted for. This is more than enough to cater for growth. What is unclear is the costs involved in reducing that leakage relative to sourcing new water supplies (such as Lake Hauroko). These costs are being investigated and once known could inform this study.

- Where possible the most likely solution to treating wastewater and stormwater is to target the key pollutants that have the greatest impact on both the freshwater networks and the Coastal Marine Environments (these being nitrogens and phosphorous), rather than looking to address every pollutant equally. It is likely that other treatment system options exist, than covered in this report. This study does not pretend to be exhaustive in terms of the solutions assessed.

- Throughout this report, estimates of cost are based on dividing the total cost stream over time by the numbers of likely rate paying units (households plus businesses).

This study assumes all financial and capital costs are funded through loans and paid off through rates. This study takes no account of the wider range of funding options open to local governments including rates differentials, development contributions, grants and others. Utilising a mix of these funding mechanisms is the likely approach councils will take and will have a significant bearing on the figures in Table 1.

- This report takes no account of households ability to pay or any affordability aspects of these modelled changes nor any account of the distributional effects of new charges.
- This report has not identified the potentially positive effects of new investment in infrastructure in Southland that might flow from quality limits in terms of additional construction sector activity.

1 Introduction

The Ministry for the Environment (MfE) has initiated a project (the Economic Impact Joint Venture Studies (EIJVS) Project), consisting of a series of studies, to enable more accurate assessment of the economic impacts of freshwater quality and quantity issues. The wider purpose of these studies is to assist the MfE to develop policy scenarios on quality and quantity limits in freshwater. This work will also help inform regional councils about the potential economic impact(s) of policy options in regional plans. The Ministry is using a Total Economic Value (TEV) framework as basis for calculating the value attributed to water resources. The TEV framework includes direct use of water in economic activities, the indirect use or ancillary function that can be critical for ecosystem services and cultural systems. Direct (consumptive) and non-direct (or non-consumptive) use of water has values associated with it for individuals and the community.

Water resources are critical to human health and the natural environment, and so are vital to the New Zealand economy. Water constitutes an important input into industrial processes (e.g. agriculture, forestry, food manufacturing), is used to produce energy, provides the basis for much of our outdoor recreation, serves as a vehicle for disposal and treatment of wastes, is a critical component of ecological systems from which other important 'ecological goods and services' are derived, and provides important cultural and amenity values. However, like many other forms of environmental resources, water possess a number of features making it unique when it comes to managing its use[1]. As a result, there is an important role for management intervention to ensure the efficient allocation and quality.

The specific focus of this report is on the direct use values associated with and response to water quality and quantity limits by the urban and industrial sectors. The study has three broad aims; establish a sound theoretical basis for the assessment, application of analysis in the Southland context to understand the implications of change and; conceptually, to establish a process that can be applied more generally to other regions within New Zealand.

Industrial and municipal sectors form a portion of the set of direct users of water as outlined in the table below, provided by the Ministry for the Environment.

[1] When describing the unique economic features of water economists use terms such as 'non-rivalry', 'non-exclusive property rights' and 'production of externalities'. Essentially this means that water is a public good and that is both non-excludable and non-rivalrous in that individuals cannot be effectively excluded from use (within geographical bounds). Use by one individual does not reduce availability to others. Importantly, however it is possible for individuals acting in their self/immediate interests to diminish or degrade the original resource.

Total Economic Value	Active Use Values	Direct Use Values	Extractive & non-extractive	Irrigation –	Agriculture
					Horticulture
					Forestry
				Fisheries	
				Hydro electricity	
				Industry	
				Domestic/Municipal	
		Indirect Use Values	Functional benefits	Commercial Navigation (if relevant)	
				Recreation	
				Values covered in the MEA ecosystem services framework that are not captured elsewhere in this TEV table (*supporting, provisioning, regulating and cultural ecosystem services not included elsewhere - important to avoid double counting*)	
		Option value	Direct and Indirect values	Recreation	
				Scenic	
				Property	
	Passive Use Values	Bequest value	Environ Integrity for future generations	Species, Habitat	
				Spiritual and cultural values	
		Existence value	Value from knowledge of continued existence	Aesthetic values	
				Educational & Scientific information	

1.1 Project Objectives and Aims

The specific objectives of this study are to meet the three aims described as Tasks outlined below, as specified by the EIJVS;

- Task 1 identifies the water values associated with industrial and municipal activities, in an urban and rural context at the national level.
- Task 2 investigates the implications of changing freshwater quality limits using a case study approach.
- Task 3 establishes a list of principles highlighting the key issues and practical guidelines for Councils on how to carry out such analysis themselves

This project is a first step in trying to improve the understanding of water values associated with municipal and industrial sectors.

2 Approach and Methodology

2.1 Task 1: National Water Values

National water values have been derived by analysing Councils infrastructure investments and ongoing costs for the three categories of water (water supply, wastewater and stormwater). This is mainly based on information from the Department of Internal Affairs (DIA) covering the 2012 financial year.

Territorial Local Authorities (TLAs) have been grouped into 3 categories – metropolitan, provincial and rural in order to highlight differences in value such as average usage in volume terms and average expenditures that are conditional upon the nature of the catchment. Both operating and capital costs are incorporated and the broad impacts of imposing water quality limits are explored in each of the three waters.

Note that throughout this report all dollar values are presented in current (2012) dollar terms unless specifically stated. This is usually denoted by the subscript, $\$_{2012}$.

2.2 Task 2: Water Quality Case Studies

2.2.1 Water Supply

The approach adopted to assess the effects of quality limits consists in identifying the current values associated with water use by municipal and industrial sectors, shock the system by applying water quality limits then assess the effects these are likely to have in qualitative and quantitative terms where feasible.

A key limitation to this study is the lack of identifiable water quality limits set by central government. The focus of other Southland water studies has been on the effects of reductions in nutrient runoff brought about through land use and farm management practice changes. These reductions have then been traced through the freshwater network till they reach the Coastal Marine Environments (CMA). Some 73 sites across Southland have been modelled in this manner with the changes in farming practices aggregated into a series of outcomes in terms of how many sites achieve different levels of pollutant.

For Industrial and Municipal water, the decision was taken to model changes required to achieve percentage reductions in the key pollutants in the absence of water quality limits. This will provide the authorities the ability to set a quality limit then deduce the likely cost implications from added investment in treatment required to meet the quality limits.

Originally the project was to be limited to Invercargill City, however to provide a mix of small and larger community responses, the study was split between Invercargill and Winton, with Invercargill being the focus of water supply and stormwater and Winton being the focus of wastewater assessment.

For the Invercargill water studies this meant identifying;

- Water use by sector of the economy. This is based on data provided by Invercargill City Council (ICC) matched via land use category and location to economic sector. Water use has then been linked to economic output and employment to provide an estimate of the productive values associated with water.

- Future water use is then estimated by using the Economic Futures Model (EFM) Market Economics developed for the wider Southland Regional Water assessment study, once factored down to reflect the Invercargill specifics – that is, by concentrating activity and therefore water use for each sector based on both the presence of each sector and the scale of its output. The EFM generates estimates of future output, value added and employment by sector for the economy under a set of assumptions about the key drivers for economic growth (population growth, export performance, gross fixed capital formation rates and factor productivity change). It is important to note that while the EFM and the Input Output model that underly it can be used to assess the direct, indirect and induced effects of growth and change (or impact), this is not the case here. This report focuses on the direct water use, avoiding the need to establish water multipliers that might be used to summarise flow on effects of direct growth. Growth projections of the economy are based on sectoral growth patterns and population growth projections in Southland and Invercargill. These growth futures have been calibrated alongside those used by NZIER to guide their report titled "*The impact of water quality policies in Southland"* (a part of the overall MfE Southland Water Quality Limits study).

- We have assumed that the water relationships (effectively ratios of water consumption per unit of output remain the same in the future, with an allowance for water productivity to improve, based on international studies (Hejazi *et al.* (2013)[2] . The end result is a view of future requirements for water quantity by Invercargill residents and businesses.

- The final water quality issue is associated with the quality of the raw water Invercargill draws from the environment for purification and distribution. If quality limits are placed on fresh water, this may have implications for further purification processing by Council prior to distribution. In reality, the quality limits are far lower than the drinking water standards applicable in New Zealand (as discussed below in Section 5). This means that in all likelihood, reductions in cost will be minimal given that Councils must achieve drinking water quality standards anyway.

2.2.2 Stormwater

If the Government imposes quality limits such that the pollutants contained in stormwater need to be reduced, it is likely to have significant cost implications for Councils and therefore

[2] Hejazi, M., Edmonds, J., Chaturvedi, V., Davies, E. and Eom, J. 2013. Scenarios of global municipal water-use demand projections over the 21st century. Hydrological Sciences Journal, 53(3), 519-538

residents and businesses. Assessing these stormwater costs and the practical effects and impacts of treating stormwater required the following;

- Discussion with Council Officers who identified that the most pragmatic approach to reduction of pollutants was to promote “tidy workplaces” such that significant industrial pollutants (mostly heavy metals and hydrocarbons that are mostly contained in dust (from brakepads, abrasion and sanding of metals) and oils (either leaked or spilt) that are the by-product of industrial activity in Invercargill) are contained onsite.

- Identification of three scenarios of potential treatment that focus on first, industrial areas, then industrial and the central business district and finally all of the urban area. The rationale behind these choices is that there are limited means to reduce the standard of treatment other than by reducing either the quantity of water to be treated, or by reducing the area. Providing treatment over a limited area where it is thought the majority of pollutants are generated (such as the industrial area only, or the industrial area plus the CBD) combined with prevention at source, the programmes can be considered as a step towards a risk based approach to stormwater treatment.

- The water modelling then estimates the percentage of pollutants contained in the Invercargill stormwater, and the effects of imposing the treatment scenarios described above. There are limits to this approach that mean only estimates based on direct scaling down of the full urban area results to the area covered by the industrial area and industrial plus CBD area, have been possible to calculate.

- Costs associated with the scenarios are all assumed to be net additions to the status quo. They are divided between construction costs, design and other preliminary costs plus ongoing operation and maintenance costs.

- Costs are assumed to be funded in the first instance by the Council who borrows at 6.5% interest in real terms over 25 years to finance the capital costs. Repayment costs on an annual basis (principle plus interest) are then divided between ratepayers. Operating costs are divided directly among ratepayers.

- Depreciation has been included at an annual rate of 6% in real terms. As with the above, these costs have been distributed across ratepayers.

- It has been assumed that there are no development contributions or grants to assist in funding the capital or operational costs and that total costs are divided purely based on the numbers of each group of ratepayers (businesses and households).

- Final costs are expressed on a per household or per ratepayer basis.

2.2.3 On-Site Wastewater Treatment

In addition to assessing the effects of stormwater runoff from Invercargill City’s urban area, an assessment of the contribution to lower freshwater quality from non-reticulated on-site treatment plants was required. In the Southland environment, the majority of these are simple septic tanks that discharge to ground via field tiles to disposal fields, although it is noted that some may discharge directly into surface water bodies. There are a few more modern secondary processing systems that use aeration or special filters (textile or sand) to remove a significantly higher proportion of pollutants and produce a far higher quality of output to ground. It is also noted that the impact of on-site treatment of wastewater on water quality is directly related to the type and nature of soils, and the proximity of the discharge to the surface water body, to a greater extent that the nature of the treatment system itself.

Given the very limited data available on the types and numbers of systems in Invercargill City and the very site specific nature of the level of processing that is undertaken by the topsoil, it is beyond the scope of this report to present a definitive estimate of the freshwater outcomes of changes to on-site systems in total. Rather this report estimates the changes in water quality from discharges to land from upgrading to secondary systems as well as placing the current discharges to land into context.

The approach adopted is as follows;

- Identify the likely numbers of on-site systems within Invercargill City boundaries. This required removing the reticulated areas of Invercargill and Bluff from the data set of dwellings, leaving approximately 1,870 households in non-reticulated areas within the TA boundaries.
- Council provided a listing of 749 properties and their septic tank ages, type and description of location and state.
- Council also provided estimates of the percentages of types of systems in use. These percentages were applied to the 1,870 households estimated to be in the non-reticulated area.
- A discharge profile drawn from Auckland Regional Councils Technical Publication 58 (TP58) On-site Wastewater Systems: Design and Management Manual, was then applied to the numbers in each group to generate an amount of output from the systems of each key pollutant (pollutant load to soil, not to surface water). This publication contained the most detailed information covering likely discharge volumes and pollutant concentrations for on-site systems in New Zealand.
- These discharges represented the status quo. A second estimate has then been generated assuming all 1,870 properties change to modern secondary processing systems that incorporate either aeration or textile filtering to remove pollutants.
- Outputs are expressed in terms of the total discharges (in kgs) per hectare of non-reticulated land. For comparison purposes, the total pollutant load is also divided by the estimated area of soakage field (500sqm per property) in an attempt to model the spot loads of each system.
- In reality, the effects on freshwater from these changes is not known and more work needs to be done to identify the current state of the systems (it is beyond the scope

of this report), as well as on the manner in which the current systems interact with surface water and the effects of changes to these systems

- The difference between the status quo estimate of discharge and under the more modern approach represents the effects of quality limits – but only in so far as pollutant output to ground is concerned. There is no measure in this report of the volume of pollutant that enters the freshwater system. The effect of ecosystem processing of these outputs is not known.

The implications of this final point are that Council needs to carry out more work in this area. It is important to understand a range of data about on-site treatment systems including their number, type and discharge volumes, as well as where they are discharging. In addition to this, it is important Council begin to monitor freshwater quality in areas with high concentrations of on-site systems to determine the effect of these systems of freshwater quality. At present none of this data exists making it extremely difficult to determine the effects of policy change let alone their merits.

2.2.4 Wastewater Treatment

Winton was chosen as the location to model the effects of changes required of a wastewater system on a small community. As discussed above, the changes have not been modelled in response to a set of quality limits imposed by Government, rather a cost abatement curve approach has been taken. This means that for each of the major pollutants, targets in the form of percentage reductions in pollutant concentration have been set; and plant has been designed and costed to achieve these targets. These costs are then divided across ratepayers in much the same way as for Stormwater in Invercargill, described above. This process has involved;

- Identifying Winton's current and expected future population and based on the outcome setting a scale parameter for the plant (3,000 people). This is higher than expected (currently around 2,000) but allows for some business input to the system.
- Identifying the current pollutant load from Winton, then for the key pollutants (Ammonia, TN, TP and E.coli) design a plant or process that would remove an increasing percentage of that pollutant (generally 25%, 50%, 75 % and 90%).
- Estimating the operational and capital costs associated with each option
- Allowing for an efficiency premium to build the processes at one time and location
- Distributing the capital costs, finance costs and depreciation across the community into the future
- Expressing the results in terms of costs per ratepayer (households plus businesses) for each of 5 scenarios that have been chosen to reflect the range of costs and outcomes of the process.

2.2.5 Alliance Meatworks

The final case study centres on the Alliance meat works at Lorneville. This lies outside the Invercargill City boundary, but given the scale of the operation and the fact that it employs a significant number of Invercargill residents, plus the scale of the wastewater inputs to the Oreti River it was important to understand its current and future industrial wastewater profile.

Good information exists on the level of pollutants currently discharging from the settling ponds associated with the plant. Alliance is beginning the process of investigating options to upgrade the current arrangement in time to renew their discharge consent in 2016. In order to model these changes this report;

- Outlines the current discharge levels of key pollutants
- Estimates the upgrade costs to Alliance to meet the current water quality standards as outlined in the Southland Water Report.

The results of these case studies form the sections that follow in this report. Key findings from each case study have been combined in a single set of tables that collate the cost outcomes from all of the scenarios expressed in terms of average dollars per ratepayer (businesses plus households) in each study area.

2.3 Data Sources and Information

A range of data sources were compiled and consulted, including:

- Information from Invercargill City Council principally the resource consents database. This dataset contained all consent information regarding water takes and discharges over the past 10 years.
- Other detailed information from the 3 waters divisions within Council covering:
  - Water use – this differs from consented maximum and is not tied to the resource consent dataset. This meant totals by sector for consented maximums were calculated separately from actual water use (either monitored or measured via meters);
  - Septic tanks – a partial dataset that covered approximately 750 of the potential 1,870 dwellings with on-site treatment systems, and
  - The water reticulation system.
- A wide literature search covering water use, nutrient concentrations and wastewater management approaches
- Statistics New Zealand:
  - Business Directory for information about employment and business units,
  - Population projections
- M.E's Economic Futures Model
- The Southland Economic Region Profile and work done for MfE as part of the wider study.

A list of references is included at the end of the report. Where applicable, the information and data sources are referenced.

2.4 Report Structure

In addition to this introductory section, the report contains six other sections providing the findings of the research. The sections cover:

- Section 3 contains the findings of MfE's internal study focusing on the industrial and municipal water values in urban and rural contexts. This section focuses on the national level and includes comments on the types of values associated with municipal and industrial water uses.
- Section 4 introduces Invercargill City by providing some basic facts about the City's population and its economy. The economic situation in the City is discussed using indicators such as Value Added and Employment. A Business as Usual (BAU) future is presented showing a potential future situation under very strict growth conditions and assumptions.
- Section 5 discusses stormwater using Invercargill City as case study. The section outlines the stormwater management system i.e. the surface water management system and then highlights stormwater quality considerations from an Invercargill City perspective. Options to improve the City's stormwater quality are discussed and the financial outcomes of the (potential) measures are highlighted.
- Section 6 looks at water from an urban perspective, again using Invercargill City as case study. The investigation covers direct water use per sector. In turn the BAU Future (discussed in Section 3) is used to provide an indication of one future water use scenario.
- Wastewater is dealt with in, Section 7. Again a case study approach is followed and in this section the focus is on Winton and the Alliance Meat Works at Lorneville. The section concludes with a discussion of residential wastewater treatment plants (particularly septic tanks) in the Invercargill City context.
- Section 8 provides a short summary of key findings.
- Section 9 outlines the study principles and offers a degree of practical guidance for Councils and others seeking to replicate the assessment in other jurisdictions.

3 National Water Values

This section presents an overview the types of values associated with municipal and industrial water uses. It covers water supply, wastewater and stormwater as well as on-site water management systems (i.e. septic tanks). It presents key facts in terms of volume used/generated and the costs of reticulating, purifying and processing each type of water to provide a structure around municipal and industrial uses, and to place the subsequent Southland case studies into context. It utilises the current infrastructure investment situation at the national and subnational level for municipal and industrial water uses in New Zealand. Finally, the impacts of setting limits on water supply, stormwater and wastewater are explored.

There is on-going work attempting to assess the impact of setting quality and quantity limits on freshwater. One of the key areas of freshwater value is derived from its municipal and industrial use.

It is generally considered there are three “types of water” relating to municipal and industrial water uses: drinking water, (alternatively called water supply), wastewater and stormwater (Wakim, 2004; DIA, 2009). There are significant interconnections between the types of water, reinforcing the fact that they must be viewed as a single system. The wastewater and stormwater discharges in upstream catchments often form part of water takes in downstream catchments. This is indeed the situation in Southland with the discharges upstream of Invercargill impacting on the quality of the raw water takes of the city.

It is worth noting that urban water infrastructures are the legal responsibility of local government. They tend to be funded through local rates, grants and development contributions, and in some cases, government subsidies (Treasury, 2010). This has significance as the manner in which the costs of any new infrastructure required to meet different standards, are distributed between different groups in the community, has a large bearing on the impacts of those costs. Considerations around ability to pay, and who benefits compared with who pays are covered by the current legal framework under which all councils operate.

Most of the figures in this section, drawn from the Department of Internal Affairs reviews of local authority expenditure, have been classified according to three categories that reflect differences in the nature of the areas in order to highlight area of similarity and difference. They are metropolitan (Auckland, Wellington, Christchurch), provincial (most other urban TAs) and rural areas. Auckland is a component of the metropolitan category, it is also presented separately as Auckland’s figures tend to skew national data (in particular the metropolitan figures). Note that figures for metropolitan area include Auckland figures.

It is important to note that the figures reported here are based on a single year. They are likely to contain variations as investment by Councils is lumpy in large infrastructure areas such as pipe networks. However, given the data represents a cross section of spend across New Zealand, it highlights the relativities between areas and water sectors.

3.1 Context

The total value of water infrastructure in New Zealand in 2009 (estimated by the Department of Internal Affairs) by the optimised depreciated replacement cost[3]) was $33billion (Table 3.1).

Wastewater represents the largest component of this value (with a replacement cost of $12.7billion) slightly more than water supply (replacement cost of $11.4 billion) with stormwater having an optimised replacement cost of $8.9billion. Part of the lower value of the latter will be attributable to the lack of stormwater pollutant processing plant compared to purification plants for water supply and treatment plants for wastewater.

Table 3.1: Optimised depreciated replacement cost in the different types of water ($bn), DIA

	Water supply	Wastewater	Stormwater	Total
$billion	$11.4	$12.7	$8.9	$33.1

Investment in water infrastructure is primarily made up of capital expenditure. Operational expenditure will include a significant portion of repairs and maintenance which can be considered investment in water infrastructure, therefore has been considered as such for this assessment. The annual capital expenditure (CAPEX) on wastewater ($500 million) was significantly higher in 2009 than that of water supply ($390million) and twice that of stormwater ($256million). The annual operational expenditure (OPEX) on wastewater was $815 million. Again this was much higher than that for water supply ($605million) and close to three time more than that for stormwater ($280million). All figures are drawn from the DIA's reviews of local authority infrastructure expenditure (Table 3.2).

Given the nature of stormwater systems compared with water supply or wastewater systems, it is not surprising that stormwater OPEX is low (limited plant to operate and maintain). These figures reflect both the fact that Stormwater is not treated in New Zealand and the fact that New Zealand has high standards for potable water quality and wastewater treatment.

[3] An approach to allocating the capital costs of a project under which the regulatory asset base is periodically "re-valued" to be equal to the price of building or buying a modern equivalent asset, depreciated to reflect the shorter remaining life of the existing assets (OECD Glossary of Statistical Terms, 2013)

Table 3.2: CAPEX and OPEX in the different types of water ($m)				
	Water supply	Wastewater	Stormwater	Total
Total CAPEX per Year	$390	$500	$256	$1,146
Total OPEX per Year (incl. depreciation)	$605	$815	$280	$1,700

Source: DIA, 2009

3.2 Water supply

We use water supply as a proxy for drinking water because councils in New Zealand provide water to their communities predominantly for potable urban water use (Treasury, 2010). Some councils also supply potable and/or non-potable water to the rural sector for drinking water, stock water and irrigation (Treasury, 2010). However, such usage isn't part of this study.

Municipal water supply covers a range of uses: indoor (drinking, washing, sanitation, cooking) and outdoor (lawns, gardens) residential use, as well as commercial and industrial uses. Commercial uses of municipal water include water use for human consumption and sanitation (e.g. by restaurants, hotels and offices). Water is also used for material washing in industrial processes and for cooling systems (Smith & McDonald, 2009). Several assumptions have been made for industrial uses in municipal areas:

- It is assumed in this section that most industries in urban areas will be connected to municipal networks. This means we assume that the water used for industrial purposes and discharged by the same activities will be processed by the same plants and the outfall will meet the same standards as the residential components of municipal water.
- When this is not the case, this is because the industry in question requires water of a higher quality than drinking water and therefore the impact from setting a higher quality limit will be smaller than for drinking water, if the quality limit in fact exceeds that of drinking standard. In reality this will not be the case, and the impacts of quality limits (for water supply) will mean lower processing costs faced by councils running plants that draw raw water from the freshwater system (which presumably now exists in a higher quality state than previously).

A community drinking-water supply comprises one or more of each of the following:

- Source of raw water – many communities in Southland have only one source, so protecting its quality is vital
- Treatment plant – it is noted that not all community water supplies in Southland are fully treated. This means that freshwater water quality becomes increasingly important.
- Distribution system

In New Zealand, the drinking water quality is monitored centrally by the Ministry of Health, who establishes the criteria for compliance with drinking water (MoH, Drinking-water

Standards for New Zealand 2005 (Revised 2008), Ministry of Health). The compliance criteria are given for water leaving the treatment plant, in Section 3.3.5.

The national water consumption for water supply was 1.33 million cubic meters a day (or 485 million cubic meters a year) in 2009. 58.5% of this consumption occurred in metropolitan areas (Auckland represented half of the metropolitan consumption), 28.5 % in provincial areas and 13% in rural environment.

The national value of water supply infrastructure (Appendix 1) was, approximately $11.4billion (2009), based on its optimised replacement cost. The annual depreciation requirement of $156million represents on average, an anticipated expenditure of $105 per household per year (DIA, 2009).

3.2.1 Reticulation

The water supply reticulation network is the network of pumps, pipes and water storages designed to store and distribute water. New Zealand reticulation system has a length of about 50,000 kilometres (2009). Just under half of this length is found in provincial areas, 35% in metropolitan and 15% in rural areas. The length of reticulation per household is higher in rural and provincial areas as dwellings are more widely dispersed than in urban areas. In particular, both rural areas and provincial areas have reticulation length that is double the average per household length of metropolitan areas[4].

This has important implications for the impacts of limit setting on smaller communities.

3.2.2 Remaining lifetime of infrastructure

The remaining lifetime of water supply infrastructure is expressed as a ratio between the remaining life of the asset and its expected life. Therefore, the ratio will always be less than 100% after the infrastructure is operational; if the ratio is above 50% the infrastructure has longer life remaining than it has been in operation. It is important to note that these ratios are averages covering the entire set of infrastructure components in the water supply system. It is likely to mask significant variations between different components within the system. For example, the electrical and mechanical componentry may only have operational lifespans of 10 – 15 years, whereas the pipe networks could conceivably last for 100 years or longer.

In 2009 this ratio was 49% for infrastructure in rural areas, 58% in provincial areas and 61% in metropolitan (the ratio was 66% for Auckland). This means that overall most of the infrastructure in the country has more than half its expected life remaining. Assuming the lifetime of water supply infrastructure is around 62 years (DIA, 2009, table 6-2), this means New Zealand water supply infrastructure is still on average operational for more than 30 years[5]. Again, variations within the types of components mean this figure should be treated with some caution.

[4] Appendix A.1 for actual figures in MWH Study

[5] Appendix A.2 for actual figures in MWH Study

3.2.3 Capital expenditure (CAPEX)

The annual capital expenditure on water supply infrastructure was $390 million in 2009. The investment in metropolitan areas represented 55% of the total, 35% in provincial areas and 10% in rural areas. This is liable to reflect the dynamics of population growth in New Zealand, with the majority of new subdivisions requiring additional water infrastructure pipes etc., being located in the urban areas rather than in rural areas.

However, the annual capital expenditure per household in 2009 was highest in rural areas ($330) followed by provincial areas and metropolitan areas (respectively $280 and $250). The CAPEX in metropolitan areas was $250 per household. This means the annual CAPEX per household is between 25% and 30% in provincial and metropolitan respectively compared to rural areas. The high average CAPEX in rural areas seems to make sense given the length of reticulation[6] per household. However it highlights an important issue, given that rural households are already paying significantly more than urban households for capital investment in water supply, the imposition of additional costs associated with higher water quality standards are likely to impact more heavily on rural households. In addition, these households are most likely to have lower average incomes than their urban counterparts, meaning that their ability to pay for these upgrades is lower – adding more financial stress.

3.2.4 Operational Expenditure (OPEX)

The annual operational expenditure for water supply in 2009 was $605million. Metropolitan areas represented 55% of this total, provincial and rural areas represent respectively 33% and 12%. However, on average per household, operational expenditure was highest in rural areas followed by provincial and metropolitan.

It is worth highlighting that the average per household OPEX was 23% less in provincial areas than rural areas and 32% less in metropolitan areas than rural. Overall, the difference in average expenditure between rural areas and provincial or metropolitan areas seems to be roughly in the same proportions for capital expenditure and operational expenditure. This logically means the length of reticulation has impacts on both types of expenditure[7].

3.2.5 Impact of setting limits

As stated above, drinking water quality is monitored centrally by the Ministry of Health, which establishes the criteria for compliance with drinking water standards (Drinking Water Standards for New Zealand 2005, revised in 2008). There are several determinants for compliance

- Microbial determinants (including e-coli)
- Inorganic determinants of health significance
- Organic determinants of health significance

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[6] Appendix A.3 for actual figures in MWH Study

[7] Appendix A.4 for actual figures

- Radiological determinants
- Aesthetic determinants

The maximum acceptable value for E-coli is less than one bacterium in 100ml of samples (MOH, 2005). Most of the other parameters don't overlap with the parameters considered for fresh water quality limit setting. It is therefore expected that setting quality limits on fresh water would be less constraining than drinking water standards or they wouldn't overlap with the parameters considered for setting water limits (e-coli, nitrogen and phosphorous). This means that establishing water quality limits for water supply in a municipal supply situation is not likely to have any cost implications for communities, given that the municipal supply authorities already have to meet more stringent quality limits than those envisaged.

There might be potential savings for councils if the raw water they had to process to a potable standard was of higher quality than currently. In addition, there are likely to be communities such as some in Southland where water supply is not fully treated due to cost. By having higher water quality standards, these costs could continue to be avoided.

3.3 Wastewater

Wastewater in the New Zealand situation (and some stormwater runoff) is treated using a mix of primary, secondary and tertiary treatment processes.

- The objective of primary treatment is the removal of settleable organic and inorganic solids by sedimentation, and the removal of materials that will float (scum) by skimming. Approximately 25% to 50% of the incoming biochemical oxygen demand (BOD5), 50% to 70% of the total suspended solids (SS), and 65% of the oil and grease are removed during primary treatment. The remaining liquid is then subjected to secondary treatment.
- The objective of secondary treatment is the further treatment of the effluent from primary treatment to remove the residual organics and suspended solids. In most cases, secondary treatment follows primary treatment and involves the removal of biodegradable dissolved and colloidal organic matter using aerobic biological treatment processes.
- Tertiary and/or advanced wastewater treatment is employed when specific wastewater constituents which cannot be removed by secondary treatment must be removed. This sometimes includes the chemical or physical disinfection of the remaining treated water before discharge into the environment.

National wastewater volumes by source, in 2004, were estimated as being: domestic (58%), non-domestic including trade waste (19%) and inflow/infiltration (23%) (MED, 2004). While this might provide an indication of the volumes of through put, it may not accurately reflect the amount of processing required (by sector). For example, trade waste from the industrial sector makes up 19% of total volume but might account for 50% of the processing cost. Given that wastewater treatment systems are made up of reticulation components and treatment components, their low volumes but high processing requirements (potentially) are liable to have disproportionate impacts on total costs and therefore total funding (assuming the councils funding processes work appropriately).

Work needs to be done to identify these splits and responsibilities.

The total value of all wastewater infrastructure was, approximately $12.7 billion (2009). The annual depreciation requirement of $157 million represents on average an anticipated expenditure of $108 per household per year.

3.3.1 Reticulation

The total wastewater reticulation represents a length of 25,000 kilometres nationally. 58% of this total is found in metropolitan areas, 34% in provincial areas and 8% in rural areas. There is therefore a strong contrast with reticulation for water supply where the majority of the length can be found in rural areas[8]. This could be interpreted as rural areas having alternative (potentially on-site) wastewater treatment as the norm rather than as the exception. Again this has implications for quality limits. All the costs of upgrading on-site systems are borne by the household and they may be significant.

3.3.2 Remaining lifetime of infrastructure

The remaining lifetime of wastewater infrastructure is expressed by a ratio between the remaining life of the asset and its expected life. This ratio in 2009 was 57% for infrastructure in rural areas, 61% in provincial areas and 61% in metropolitan (the ratio was 66% for Auckland). This means that overall most of the infrastructure in the country has more than half its expected life remaining, with the same caveats as apply to water supply infrastructure, that the average masks variations in the various components of infrastructure. Assuming the lifetime of wastewater infrastructure is around 71 years (DIA, 2009, table 7-2), this means New Zealand wastewater infrastructure still has left an average operational for more than 40 years[9].

3.3.3 Capital expenditure (CAPEX)

The annual expenditure of capital investment in wastewater was $500 million in 2009. The investment in metropolitan areas represented 63% of the total, provincial areas represent 30% and rural areas represent 7%. However, the average annual capital expenditure per household are similar among the three areas, with the metropolitan area being the highest followed by provincial areas and then rural areas[10]

3.3.4 Operational Expenditure (OPEX)

The annual operational expenditure for wastewater was $815 million in 2009. Metropolitan areas represented 62% of this total, provincial and rural area representing respectively 30%

[8] Appendix B.1 for actual figures

[9] Appendix B.2 for actual figures

[10] Appendix B.3 for actual figures

and 8%. Unlike total operational costs, the average annual per household operational expenditures are remarkably similar in the three areas. Metropolitan areas still have the highest expenditure per household ($595) followed by provincial areas ($520) and rural areas ($510). Overall, the difference in total OPEX among the three areas is significant, but the per household OPEX difference is not. This might be the result of population density and reticulation length differences in the three areas[11].

3.3.5 Impact of setting limits

For wastewater, the costs of setting quality limits can come from upgrading the water disposal system and purchasing of water purifying substances. Treasury (2010) report stated that "… wastewater is treated using a mix of primary, secondary and tertiary treatment (by councils). Many systems produce 'good' quality outflow. However, around 23% of systems provide only primary treatment. While these will probably meet their current resource consents, increased requirements mean that capital upgrades may be required on expiry".

It is important to highlight the importance of the timing of implementation of water quality limits on the councils' ability to afford the infrastructure required to meet any new standards. It is understood that Regional Councils will set the timeframes but territorial authorities will have to meet these timeframes.

The timing will vary from council to council. The government can implement the new limits through different channels. The two likely channels are, amending the existing National Policy Statement (NPS) under the RMA or create a new legislation under the RMA. Either way, the government will set the bottom line limits and determine the required process in the national objectives framework for the councils to follow. Councils will then have the freedom to choose the quantity and quality limits so long as they are above the national standard. Furthermore, the councils will have the freedom to set out their own objectives, rules and consult their stakeholders so long as they comply with the process set out by the national objectives framework. As a consequence, the timing of renewing infrastructure will be depending on council's and community decisions. As highlighted above, the average remaining life of existing wastewater infrastructure is thought to be around 40 years. This means that potentially, councils might not have to invest into new infrastructure before that time – but will need to plan for it well in advance.

Furthermore, According to the Treasury (2010), "wastewater systems typically incur higher capital and operating costs than drinking water (the Ministry of Health estimates that in some cases, this can be as much as 10:1). This means that if the effect of limits on particular councils falls heavily on their wastewater system, they will need to be more aware (and plan earlier).

[11] Appendix B.4 for actual figures

3.4 Stormwater

In addition to water supply and wastewater, councils have responsibility for stormwater management, which can include stormwater treatment, drainage and flood protection systems. Primarily stormwater infrastructure is designed around moving volumes of rainwater away from people and property in order to protect lives and livelihoods. The processing of pollutants captured and suspended in the water is a secondary consideration and has only assumed importance in recent times (in most instances).

The infrastructure required in stormwater management includes;

- manholes,
- flood gates,
- inlets/outlets,
- pump stations and,
- treatment plant

The total value of national stormwater infrastructures was about $8.94 billion in 2009. The annual depreciation requirement of $78 million represented on average an anticipated expenditure of $55 per household per year.

3.4.1 Reticulation

The impact of stormwater on a region is influenced by topography, climate (and therefore soil type and structure) and intensity of development, and therefore stormwater services varies significantly across New Zealand.

Because of this marked difference among regions, extrapolating the national length of reticulation based on the numbers of households and average lengths / household per sector would not provide a fair assessment of the total asset stock (DIA, 2009). Consequently, the national length of reticulation for stormwater is not available.

3.4.2 Remaining lifetime of infrastructure

The remaining lifetime of stormwater infrastructure is expressed by a ratio between the remaining life of the asset and its expected life. This ratio was, in 2009, 53% for infrastructure in rural areas, 71% in provincial areas and 68% in metropolitan (the ratio was 72% for Auckland). This means that overall most of the infrastructure in the country has more than half its expected life remaining. Assuming the lifetime of stormwater infrastructure is around 101 years (DIA, 2009, table 8-2), this means New Zealand stormwater infrastructure still has on average an operational life of more than 65 years[12].

[12] Appendix C.1 for actual figures in MWH Study

Given a lack of processing plant in these totals means the average remaining life for stormwater infrastructure will be much higher than for water or wastewater systems.

3.4.3 Capital expenditure (CAPEX)

The annual expenditure of capital investment in stormwater was $256 million in 2009. The investment in metropolitan areas represented 75% of the total, provincial areas represent 22% and rural areas represent 3%. The per household average annual capital expenditure is consistent with the total expenditure – metropolitan areas' CAPEX ($225) doubled that of provincial areas' ($120), which doubles rural areas' ($65)[13].

3.4.4 Operational Expenditure (OPEX)

The annual expenditure of operational expenditure for wastewater was $280 million in 2009. Metropolitan areas represented 68% of this total, provincial and rural areas represented respectively 25% and 7%. The difference in average annual per household OPEX are smaller than the total expenditure; Metropolitan areas are still in the lead ($220) followed by provincial areas ($155) and rural areas ($145)[14].

3.4.5 Impact of setting limits

The impact of setting quality limits for stormwater is expected to be similar to that for wastewater. The costs will come from building new systems to process stormwater (primarily) and upgrading of existing water disposal systems.

There is potentially very important, but unknown additional expenditure for councils in order to improve stormwater quality, which will vary significantly between jurisdictions. The costs relate to the manner in which any stormwater treatment occurs (through silt traps at outflows, to settling ponds and retention, and on to plants to remove Nitrogen and Phosphorous). Additional work in this area needs to be undertaken primarily as large pollution events are associated with large stormwater events, currently unmitigated.

3.5 On-site Wastewater Management Systems

One aspect which is not captured in Department of Internal Affairs statistics, is residential on-site treatment and land disposal systems. As they are not funded by councils, they are not included in Councils financial planning. However, the environmentally sustainable disposal of domestic waste from these non-reticulated areas is critical to the environmental health of the receiving environments, therefore they have to meet the same standards than municipal wastewater and will be impacted in the same way by setting limits. There are currently a number of improved types of on-site systems on the market.

[13] Appendix C.2 for actual figures in MWH Study
[14] Appendix C.3 for actual figures in MWH Study

3.5.1 System Descriptions

On site wastewater systems are divided between conventional systems that consist basically of a septic tank and a soakage trench outfall to a soakage field and a range of new technologies developed from the 1990's that added secondary biodegrading of the organic compounds in the wastewater through the addition of aeration systems. There are many types of treatment systems within the range of aerated wastewater treatment systems, including intermittent, recirculating and intermittent bottomless filter units along with recirculating textile filter units. In addition, there are sand and textile filtration systems, organic composting systems. Finally, there are tertiary treatment systems that further remove organic and physical particles through further filtration using sand filters, or textile filters or chemical disinfection or radiation of the outflows from secondary processing prior to land disposal.

The final processing, prior to entering the water system occurs through land disposal for both conventional septic tank based systems and newer secondary processing systems. Conventional systems usually dispose through shallow field tiles to a soakage field, while newer systems generally dispose through drip irrigation that encourages vegetation growth on the property. This is usually achieved through pumping

3.5.2 Impact of setting limits

The quality of processing of waste within the soil profile is governed by the nature of the soils themselves and the degree of water logging as well as the manner in which the effluent is applied. The best processing occurs in free draining soils where the majority of pathogens die off and organic matter is degraded and stabilised, the majority of which occurs in the topmost layers of topsoil. Nutrients are best absorbed by finer clays and clay-loam soils, however nitrogen may not be reduced to the same extent and may require pre-treatment, if nitrogen are an issue.

In water logged soils aerobic processes are replaced by anaerobic processes and while they may take longer, they are still effective in removing the key contaminants in the wastewater prior to reaching groundwater.

This means that the effect of setting quality limits may require new housing in areas not covered by reticulated wastewater systems to install more costly secondary processing systems rather than rely on less expensive septic tank and field tile or soakage field systems. The true effects on the water system and the receiving environments depends on the nature of the soil profiles as well so high cost systems may not be required everywhere. This would need to be assessed on a case by case basis prior to granting consent for one type of system or another.

A key issue identified with on-site treatment systems is that they are a combination of treatment plant and natural organic soil based processes to be effective. Therefore, if the homeowner trenches the outfall directly to a surface water body or if the soakage field is too close to surface water the organic processing is ineffective and freshwater quality is reduced.

3.6 Concluding Remarks

Water is an important and scare resource although not valued accordingly. In reality water has been treated as a free resource, with investment occurring in the delivery mechanisms. Over time, the network used to distribute potable water, collect wastewater and deal with stormwater has seen heavy investment in New Zealand. Maintaining and upgrading the network is an important activity because it provides security of supply and protects property and life.

A potential future cost could relate to improving infrastructure making it possible to enhance/protect the quality of water as it moves from source to the ocean. However, infrastructure alone is not sufficient to maintain water quality and setting new water quality limits will also need shifts in how water is used. It is important to understand the potential implications of water quality limits in terms of how water is used by different users. The subsequent sections present the case studies focusing on water values and how these might be impacted by shifts in water quality standards.

4 Invercargill City

In order to understand the water supply and stormwater sectors of Invercargill and to understand the impacts and effects water quality limits might place on the city, it is important to understand the City's structure both economically and demographically. In this section a short overview of Invercargill City's population and outlook is provided, followed by a review of the City's economy using Value Added and levels of employment as indicators of performance. The final part of this section offers a description of a Business and Usual (BAU) future, that is current relationships and trends holding forth into the future. This BAU future is an important input into the subsequent section where future water use is estimated.

Invercargill is the southern-most and western-most city in New Zealand. It is the main service centre for Southland. The city has easy access to large areas of conservation reserves such as Fiordland National Park which covers the south-west corner of the South Island. In this section a short synopsis of Invercargill City is provided focusing on demographic features and the local economy.

4.1 Demographic Profile

Southland has a resident population of 94,900 people of which more than half (56 per cent) resides in Invercargill City. Table 4.1 shows the projected population for Invercargill City. Over the medium term Invercargill's population is projected to decline from the current $53{,}000_{2011}$ to 48,540 by 2031. This decline is driven by a stagnant population growth rate due to an aging population and a general drift north to larger cities with more and more diverse employment and education opportunities. This trend will see Invercargill host a smaller share of Southland's population, in the medium term.

Table 4.1: Southland's Population Projection

Year	2016	2021	2026	2031
Invercargill City	52,390	51,560	50,220	48,540
Total Southland	93,900	92,620	90,590	87,900
% of Southland	56%	56%	55%	55%
Average household size	2.3	2.2	2.2	2.1

Source: Statistics New Zealand[15]

As the population is expected to age, the average size of households will also decline. Currently, the average size of households in Invercargill is estimated at 2.3 and it is expected to drop to 2.1 by 2031. The decline in population and household size is not unique to

[15] A description of these population estimates can be found on Statistics New Zealand's website at: http://www.stats.govt.nz/tools_and_services/tools/TableBuilder/population-projections-tables.aspx#subnational

Invercargill or Southland region. New Zealand's rural regions all face similar population dynamics and are also expected to decline over the next 25 years or so.

4.2 Economic Profile

Invercargill City's economy is discussed using Value Added and Employment indicators. In 2011 the economy produced around $2.3bn_{2012}$ worth of goods and services after peaking in 2009 when $2.4bn_{2012}$ worth of goods was produced. The 5 per cent decline reflects the effect of the recession. Currently, indications are that the economic growth is picking up and Invercargill's economy is recovering. Between 2001 and 2008, the economy grew at around 1.6% (compounded annual growth) with growth increasing to 2.8% between 2010 and 2011. Table 4.2 summarises sectoral performance between 2001 and 2012.

Table 4.2: Value Added ($\$m_{2012}$)

Summary Sector	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Primary Sector	64.8	65.6	64.3	74.8	71.0	69.4	70.9	56.8	69.2	68.2	68.1
Mining and Quarrying and Oil & Gas	1.7	4.9	3.0	2.9	2.0	3.3	2.3	4.1	3.1	4.2	5.4
Meat Dairy and Food Mfg.	87.0	76.8	75.0	62.2	42.0	61.2	114.7	84.6	82.8	121.6	123.1
Textiles, Wood & Paper Mfg.	57.5	59.3	59.8	51.0	66.6	50.4	64.6	60.8	51.1	47.9	40.1
Base metal, Chems, Plastic & Rub. Mfg.	353.4	381.4	304.6	272.9	347.1	410.8	267.4	261.1	297.2	210.6	219.2
Other Mfg.	82.7	87.9	82.5	98.0	93.1	98.0	89.3	93.0	77.5	70.3	74.8
Utilities	47.0	46.3	32.7	52.7	51.8	36.7	46.8	37.7	44.7	54.9	45.7
Construction	106.8	124.9	131.5	149.0	154.6	164.5	163.7	191.3	178.2	173.3	163.6
Retail, Wholesale and Hospitality	319.4	335.6	327.1	317.8	334.4	336.7	351.2	375.1	366.1	318.8	347.9
Transport	85.2	100.4	98.7	101.1	93.4	96.5	75.1	96.1	111.9	83.6	102.5
Communications and Business	435.7	511.3	548.0	490.3	592.0	616.9	601.0	505.5	562.3	508.0	535.2
Government	90.7	107.1	108.2	114.6	107.5	110.3	106.5	137.3	173.6	145.6	140.4
Education and Health	291.6	276.7	285.9	294.0	273.7	291.2	316.7	335.6	326.5	339.8	337.6
Culture, Rec and Personal Services	64.7	68.8	70.0	85.0	84.1	80.4	82.1	97.2	76.4	84.5	90.2
Invercargill City Total	**2,088**	**2,247**	**2,191**	**2,166**	**2,313**	**2,426**	**2,352**	**2,336**	**2,421**	**2,231**	**2,294**

Source: M.E. calculations based on Annual Enterprise Survey

The main observations from the preceding table are:

1. Communications and Business is the most important sector
    a. This sector provides a key service to Invercargill and the rest of Southland's economy. Included in this sector are activities that support the day-to-day operations of the farming community as well as an administrative component i.e. accounting and book keeping services.
2. Retailing, wholesaling and hospitality

a. Invercargill's retailing sector serves local households as well as tourism activities. The city supports tourism throughout Southland capturing a proportion of tourism spend via its hospitality sector.

3. Education and health
    a. Southland Institute for Technology (SIT) provides training and education throughout NZ and in that sense it is a net exporter of education.
    b. With reference to the health sector, Invercargill hosts the region's main health care facilities and hospitals. These services are delivered to the population of the wider region and not only Invercargill's residents.
4. Metals and base metal manufacturing is a key sector
    a. The smelter at Tiwai point is included in this sector. This is a large entity but the aluminium smelter has been under pressure due to poor global market conditions and rising input costs.
    b. A variety of niche manufacturers are present in Invercargill with some focusing on supporting the agriculture sector (of Southland).
5. Agri-processing
    a. Processing agricultural goods is a key growth area with the value added (VA) generated by these activities growing from around \$87m$_{2012}$ in 2001 to over \$132m$_{2012}$ in 2012. This is a 3.5 per cent annual growth and is one of the highest growth rates of all sectors.
6. A number of smaller sectors make up the rest of the economy. Mining and quarrying have grown by 12 per cent per year between 2001 and 2012 but this growth has been off a small base. In 2012 this sector recorded a total output of \$2.1m$_{2012}$.

While the value of the economic activity provides a useful indication of the scale of economic activity, developing a rich picture of Invercargill's economy also requires an overview of sectoral employment.

4.2.1 Employment

Employment trends offer insights into the changing nature of Invercargill City's economy. Invercargill, Southland and New Zealand all experienced strong growth peaking in 2008/9, when the Global Financial Crises hit and a recession began. Since then, economies around the world have been struggling to build sustainable recoveries – this includes Invercargill and other regions throughout New Zealand. However, Southland has the highest employment rate in New Zealand at 71% (compared with 64% for NZ) and a low unemployment rate of 4.6% (compared with 6.9% for NZ).

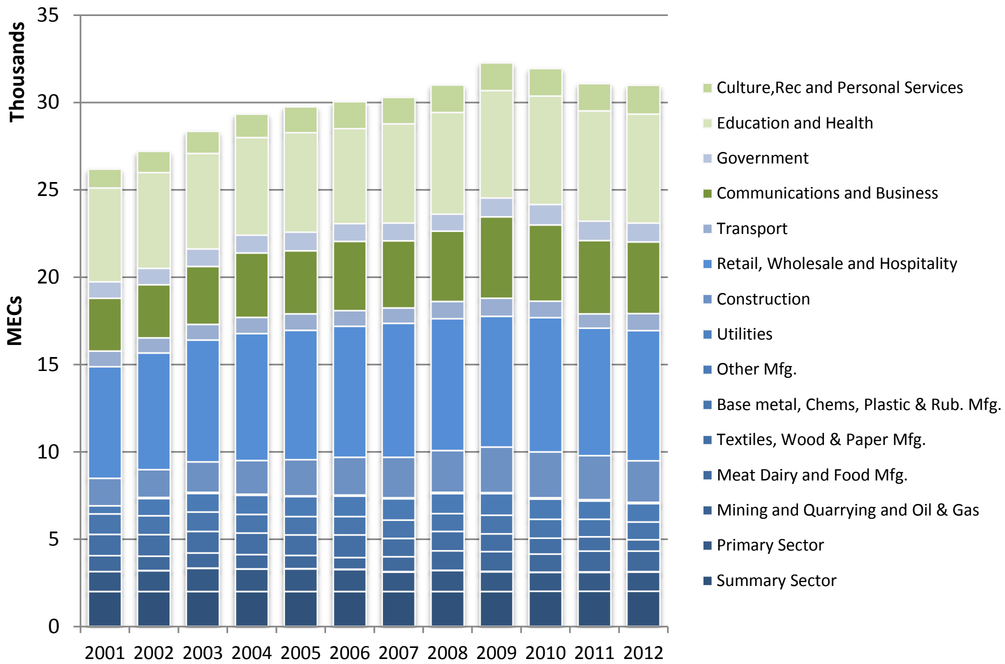
Figure 4.1 reflects the employment trends in the city using modified employee counts as indicator. The key observations are:

- Between 2000 and 2009 employment increased from around 24,235 to the peak of around 30,250 in 2009. Since 2009 total employment (MECs) have declined as the workforce shed around 4.3% or 1,290 jobs[16].

- Over the long term (2001-2012), employment in the city has grown by 4,725 MECs (up 19.5 per cent). Most of this growth was in Communications and business services which grew strongly (up 1,080; of 35.8 per cent) plus wholesaling and hospitality (up 1,080 jobs; 16.9 per cent). These two sectors accounted for 45.7 per cent of Invercargill's employment growth.

- Other manufacturing added over 600 MECs growing its employment base from around 450 to over 1,050 people – this is the highest percentage change of all sectors (133.3 per cent). Employment in this sector has more than doubled between 2001 and 2012 even after shedding 190 jobs between 2009 and 2011. This sector includes activities such as boat building and other niche manufacturing. The sector will be benefiting from the growth in dairying in the region, as well as growth in the recreational marine sector.

Figure 4.1: Employment by Sector (MECs; 2001-2012)



During the last decade or so, the relative structure of the city's employment has remained stable. Retailing, wholesaling and hospitality employ the most people with more than a quarter of the labour force working in these sectors. This is followed by the Education and health sectors (21.5 per cent) and Communication and business services (14.2 per cent).

These structures are entirely consistent with the service role Invercargill plays for the wider Southland region.

[16] This figure is based on the latest available and official Statistics New Zealand data.

4.3 Business As Usual (BAU) Future

The BAU Future reflects a baseline future assuming that economic conditions, in general, continue. Establishing such baseline offers an ability to compare alternative futures, different growth conditions and changes in the wider economy. This baseline, capturing a set of underlying drivers, can also be used to estimate Invercargill City's future water requirements. The BAU is based on a set of assumptions summarising the main drivers of final demand growth including:

- ***Household consumption*** – it is assumed that household and government future consumption grows in line with population growth with adjustments for household consumption trends.
- ***Exports*** – the export growth projections for the BAU scenario were derived econometrically using time series data, covering the period 2005-11.
- ***Gross fixed capital formation*** – Time series data of Gross Fixed Capital Formation extracted from Statistics New Zealand's National Accounts was utilised to model the future growth rates for capital growth, again using regression techniques.

For the purpose of this study, we relied on the BAU outlook defined for Southland District (and calibrated to match the New Zealand Institute for Economic Research's (NZIER) baseline). Table 4.3 presents the BAU Future for the main sectors.

Table 4.3: Sectoral outlook – BAU Future (VAm_{2012}$)

VA $m2012	2011	2016	2021	2026	2031	%Change 2011-2031
Primary Sector	68.1	77.5	87.9	99.4	112.5	65.1%
Mining and Quarrying and Oil & Gas	5	6	7	7	8	49.2%
Meat Dairy and Food Mfg.	123	131	139	148	155	25.9%
Textiles, Wood & Paper Mfg.	40	41	43	44	46	14.9%
Base metal, Chems, Plastic & Rub. Mfg.	219	242	269	298	325	48.2%
Other Mfg.	75	82	89	97	104	39.4%
Utilities	46	49	54	57	61	34.4%
Construction	164	190	217	244	271	65.7%
Retail, Wholesale and Hospitality	348	371	393	414	434	24.9%
Transport	102	109	116	123	129	26.2%
Communications and Business	535	574	612	649	685	27.9%
Government	140	149	158	165	172	22.3%
Education and Health	338	365	389	412	429	27.0%
Culture, Rec and Personal Services	90	96	102	107	111	22.6%
Total	2,294	2,483	2,676	2,864	3,043	32.7%

Under the BAU Future the Invercargill economy is projected to grow in total by 32.7 per cent between 2011 and 2031. The main observations of the BAU future are:

- Communication and business services are the main drivers of growth accounting for \$149.9m$_{2012}$. This is 20 per cent of the city's growth and is followed by construction that is projected to increase by \$105.7m$_{2012}$ to \$271m$_{2012}$ in 2031. It is important to realise that both these sectors provide services to the rest of Southland and that a portion of this growth is due to changes in the regional economy (i.e. the conversion of sheep and beef farms to dairy farming).
- Base metals, chemicals, plastic and rubber manufacturing are projected to grow by 48.2 per cent between 2011 and 2031. We note that some of this growth will be due to the increase in niche manufacturing including marine industry engineering and aluminium boat building.
- Retail, wholesaling and hospitality is projected to increase by almost 25 per cent to over \$434m$_{2012}$. This increase reflects future growth in tourism and tourism related activities with less focus on servicing the local residences. This is because under the BAU scenario, Invercargill's urban population declines (by 7.8% between 2011 and 2031).
- Sixty per cent of the city's growth is projected to come from:
    - Communication and business services,
    - Base metals, chemicals, plastic and rubber manufacturing,
    - Construction, and
    - Education and health.

The BAU Future presented above shows one possible future for the local economy. It is a projection and not a forecast given the uncertainty associated with forecasts. This BAU future provides an ability to estimate future water requirements for the city as is done in a later section.

4.4 Conclusions

Invercargill City is the main service centre of Southland and has strong links with the rest of Southland. Invercargill's economy is expected to grow into the future even if the population is expected to decline. This is most likely driven by continued expansion of the tourism sector and export education (to the rest of New Zealand) as well as from the continued presence of the Tiwai Aluminium smelter.

The project growth is expected to come from:

- Business services,
- Communication,
- Base metals and niche manufacturing,
- Retailing, wholesaling and hospitality, and
- Education and Health.

Most of these sectors are service type activities and it will be important to understand how the expected increase in economic activity will affect demand for water (and wastewater). These associated increases are investigated in Section 5.

In the long term, economic growth will be constrained by the very low population growth – in fact a slight decline in population. This means that growth must come from increasing application of technology, innovation and capital to the natural resources of the region (including the water resources).

5 Stormwater

This section explores the potential costs for treatment of stormwater from the existing urban stormwater network in Invercargill, and the potential effects on the quality of discharge to surface water. This assessment is limited to the urban area of Invercargill and does not include Bluff or other areas outside the urban Invercargill area but within the territorial local authority boundary of Invercargill City. The scope of this section is limited to high level scoping and indicative cost estimates for additional stormwater treatment, in line with current best-practice approaches for stormwater treatment in New Zealand, to achieve improvements in discharge quality. The Invercargill City situation is studied and the financial implications of infrastructure solutions aiming to improve water quality are tested.

When considering the environmental impacts that could arise from the stormwater discharges from urban environments, it is important to understand the nature of these discharges. Urbanisation involves the creation of impervious surfaces. Rain falling onto these surfaces will run off to waterways, rather than infiltrate through the soil. Any contaminants present on the impervious surface will become mobilised and will therefore be present in any water from these impervious surfaces.

Discharges of stormwater from urban sources can contain contaminants that are washed off surfaces during rainfall. The contaminants likely to be present in run-off from developed residential areas can be divided broadly into five groups: suspended solids, nutrients, hydrocarbons, metals, and microbes.

While some data has been collected on contaminant concentrations and the performance of various treatment systems more recently in New Zealand, there is still limited available information on the quality of stormwater discharges within a local context. There are however a number of sources, including a study conducted by NIWA in the 1990s and those by the former Auckland Regional Council (ARC), that provide some indication of the types and concentrations of typical stormwater contaminants that may occur in discharges from residential and commercial/industrial sites.

Ranges of contamination in run-off from residential land-uses are indicated in Table 5.1. Unfortunately, there is a lack of relevant and comparable data from NZ, and the figures are a best estimate derived from a wide range of indicative and guideline values from NZ, Australia, Europe, and the USA[17].

[17] Containment concentrations are based on information in the following references

- Christchurch City Council, 2003, Waterways, Wetlands and Drainage Guide Ko Te Anga Whakaora mō Ngā Arawai Rēpō, Christchurch City Council, Christchurch.
- Babich, J., and Lewis, G., 2001, Contaminant Loadings in Stormwater Runoff and Wastewater Overflows: A Waitakere City Case Study, URS, presented at Rain - The Forgotten Resource: the 2nd South Pacific Stormwater Conference, Auckland. New Zealand Water and Waste Association Inc.
- Chang, G., Parrish, J. and Souer, C. (1990) The First Flush of Runoff and its effect on Control Structure Design. Environmental Resource Management Division, Department of Environmental and Conservation Services, City of

Table 5.1: Range of contamination from residential land-uses.	
Contaminant	**Estimated Possible Range**
Suspended Solids (TSS)	10 – 60 mg/l or ppm
Hydrocarbons (Oil and Grease)	0 – 3.5 mg/l or ppm
Nitrogen (TN)	0 – 1500 µg/l or ppb
Phosphorous (TP)	0 – 300 µg/l or ppb
Metals	0 – 5 µg/l or ppb
BOD	5 – 10 mg/l or ppm
COD	10 – 50 mg/l or ppm
Sources: Christchurch City Council (2003); Babich, J., and Lewis, G., (2001); CHANG, G., PARRISH, J. AND SOUER, C. (1990); WILLIAMSON, R.B, (1993); MACASKILL, B. et al (2003)	

The expected peak concentration of faecal coliforms in stormwater from residential and commercial sites is approximately 8000cfu/100ml for faecal coliforms (Williamson, 1993). The source of those faecal coliforms is warm blooded animals (dogs, cats, rodents, birds and humans – primarily). Studies in North America have indicated that the share of total coliforms from animals in stormwater averaged 8.6% with the balance sourced from the soils the stormwater flowed across. The variations were large and seasonal with autumn averages as high as 21.6% in some studies[18].

However, the relative concentrations of E.coli in stormwater are less well established in the literature, particularly for New Zealand situations. Sampling undertaken at the University of Canterbury (2007), showed a very large range of E.coli concentrations in stormwater runoff from the carpark areas (250 to 5500 cfu/100ml).

There is limited data quantifying differences in stormwater quality from industrial areas and residential areas in similar localities. The NIWA and ARC studies in the 1990s indicated higher levels of contamination from industrial areas as being of the order of twice that from residential areas.

The feasibility of implementing additional stormwater treatment at specific sites within the existing Invercargill network is not considered here. This would require site-specific

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Austin, Texas. Summary in Watershed Protection Techniques Centre for Watershed Protection. Vol. 1 No.2, Summer 1994, Technical Note 28. (pp. 88-90).
- Williamson, R., Water Quality Centre Publication No. 20. Urban Runoff Data Book: A manual for the preliminary evaluation of urban stormwater impacts on water quality.
- Macaskill, B., Bowman, E., Golding, L., Horrox, J., Phillips, N., 2003, Rotorua City urban stormwater quality and prediction of environmental impacts: Technical Addendum, National Institute of Water & Atmospheric Research Ltd., Hamilton. Report HAM2002-020.

[18] Geldreich, E., Best, L., Kenner, B, 1968, The bacteriological aspect of stormwater pollution: Journal; Water Pollution Control Federation, Vol 40, No. 11 Part 1, pp 1861-1872.

assessment that is beyond the scope of this project. This section is limited to assessing likely costs and effects of treatment assuming installation of treatment devices is feasible.

Nor does this section address the need or otherwise for stormwater treatment in urban Invercargill. No assessment has been made of the effects of existing stormwater contamination on the receiving environment in this study.

5.1 Stormwater Systems in Invercargill

Invercargill City is the southernmost and westernmost city in New Zealand and is the commercial centre of the Southland region. It lies at the southern extent of the expansive Southland Plains on the Oreti River, amid rich productive farmland. Invercargill City has a population of 50,325 (based on 2006 census data) and covers an area of approximately 491km^2. The main urban area is approximately 25km^2.

There are five main surface water systems within the Invercargill urban area; the Waikiwi, Waihopai, Otepuni, Kingswell and Clifton catchments. Stormwater from the Invercargill City Council (ICC) reticulated piped stormwater network in the main urban area discharges into these five main surface waterways. The remaining areas within Invercargill City boundaries either do not have reticulated piped networks and discharge by soakage to ground, or they discharge directly into the Coastal Marine Area (CMA).

Approximately 139 separate outlets discharge from the Invercargill urban area to surface water. All 139 discharges have been included within the scope of this assessment in order to encompass the full urban network for Invercargill.

The purpose of the reticulated stormwater systems in Invercargill (and elsewhere in New Zealand) has primarily focussed on land drainage. The maintenance and upgrades of these systems have therefore revolved solely around ensuring that the systems have sufficient capacity to avoid nuisance flooding effects within the city. While more recent residential developments have incorporated measures to treat stormwater prior to discharge (such as swales and detention ponds), stormwater from the city remains largely untreated before being discharged into water. This is in-line with the majority of other New Zealand cities, where stormwater does not undergo significant treatment prior to discharge.

5.1.1 Current Stormwater Management System

The Waikiwi River is located to the north of Invercargill and is a tributary of the much larger Oreti River. The Waikiwi River flows through farmland north of Invercargill before merging with the Oreti River approximately 5km north west of Invercargill Airport. The Oreti River, with a catchment of 3,400 km^2, begins in the Thompson Mountains immediately east of North Mavora Lake and flows south through pastoral farming areas of Mossburn, Lumsden and Dipton before discharging into the sea via the New River Estuary.

The Waihopai River and its tributaries starts on the western slopes of hills northwest of Edendale and flows towards and through Invercargill, before discharging into the New River

Estuary. Flood protection measures such as stop banks have been constructed along the lower reaches of the river with several dams along its length.

The Otepuni Creek is a modified urban creek which flows through the centre of Invercargill. Like the Waihopai River it too has flood protection measures through the town reaches.

The Kingswell Creek and Clifton Channel are small surface waterways that flow primarily through rural and residential areas to the south of the Invercargill city centre before flowing into the New River Estuary.

The New River Estuary is a shallow tidal lagoon with a diverse range of cultural, recreational and ecosystem values.

In general, water quality in these rivers declines as they flow from their source to the sea and the ecosystem health of the New River Estuary ranges from moderate to very poor.

5.1.2 Stormwater Quality

ICC carried out a study on the characteristics of the Otepuni creek during several different rainfall flood events between May and August in 2005. Of all the parameters analysed (including heavy metals) only faecal coliforms and visual clarity exceeded the relevant ANZECC guidelines. The following data for median levels of contaminants in stormwater was provided by ICC from sampling carried out in March 2012 (Table 5.2).

Table 5.2: Median Contaminant Levels in Invercargill Stormwater

Suspended solids	Total Petroleum Hydro carbons	Total Nitrogen	Total Phosphorous	Total Metals	Total Coliforms	Escherichia coli (E-coli)
1.8	<0.7	3.34	0.51	0.07272	6,240	995.5
Mg/litre					MPN/100ml	

Source: Invercargill City Council

These results are at the low end of the expected range of contamination levels (see Table 5.1 presented in the introduction to Section 4). However, these results do not account for the quantity of contaminants present in peak flows, particularly in the initial runoff in a storm when higher levels of accumulated contaminants are likely to be flushed from ground surfaces.

Investigations by ICC of the stormwater network and land-uses within contributing catchments has identified that industrial sites within the city have a higher potential than residential and commercial land-uses to cause adverse effects in the receiving environment due to the nature of the activities at the site and the substances used and stored on-site.

This is reflected in the Regional Water Plan that has a stormwater rule that includes specific conditions relating to discharges from industrial or trade premises.

5.1.3 Best Practice in New Zealand

Reducing the impacts of stormwater contaminants relies on reducing the concentrations of contaminants either by source control (i.e. site management practices) or the effectiveness of stormwater treatments systems to remove contaminants from stormwater prior to the discharge entering the receiving water body.

Catch-pits and sumps at inlets to the stormwater network are normally the primary means of stormwater treatment on established urban reticulation systems. This is the case in Invercargill. Some higher-risk commercial and industrial sites may include a form of stormwater treatment but this is normally limited to trapping of spills. A recent application by ICC for resource consents from the Southland Regional Council for stormwater discharges from the urban area was based on improvement in stormwater quality by prevention of contamination at source.

Many stormwater contaminants are from non-point sources (residential areas, streets and industrial areas in general) and practice in NZ is moving to inclusion of further stormwater treatment on new systems, using methods such as detention and settlement ponds, wetlands, and vegetative and constructed filters. However, addition of stormwater treatment to existing systems is more difficult because of limited space for treatment devices and the number of separate points where stormwater is discharged. The high variability of stormwater flows (from dry periods to peak storms) is also difficult to provide for in constructed treatment systems.

For these reasons no comprehensive retro-fitting of stormwater treatment in existing systems has been undertaken in New Zealand.

Stormwater treatment in New Zealand is currently based on a best-practice approach of removing a proportion of sediments from the average flows. Peak flows are partially bypassed and not fully treated, but the approach provides for improving water quality by removal of overall contamination levels rather than irregular peak discharges. By removing sediment a number of other key contaminants are removed, particularly heavy metals. A significant proportion of phosphorus is removed with the sediment. However dissolved contaminants, including most nitrogen are not removed by this means and would require processes similar to wastewater treatment which is not considered practical or warranted for stormwater.

It is likely that as a result of limit setting, it may be necessary to upgrade stormwater systems to process discharges and reduce nutrients and other pollutants entering the freshwater system.

5.1.4 Methods to Improve Stormwater Quality

For the purposes of this report, improvement of stormwater quality can be based on three main approaches:

- Avoidance of contamination,

- Treatment at source, and
- Treatment prior to discharge.

While avoidance of contamination is normally the most cost-effective measure, it is only effective for point-source contamination, whereas non-point-source contamination (e.g. . road areas or ground surface drainage) is a significant source of stormwater contamination.

Catch-pits and sumps at inlets to the stormwater network already provide a measure of treatment at source. Determination of further appropriate treatment at source is site-specific and beyond the scope of this assessment.

In order to estimate of the costs and impacts of additional treatment of stormwater in Invercargill (or similar established localities in New Zealand) to improve the quality of discharge to surface water, an assessment was made of potential stormwater treatment at the outlet prior to discharge to surface waterways.

Typical stormwater treatment methods are:

- Detention and water quality ponds
- Wetlands
- Filtration
- Infiltration in ground
- Vegetation filters
- Gross pollutant traps (by settlement and trapping solids).

Ponds and wetlands require significant land area that can be difficult to provide as additions to existing systems. In-ground filtration also requires significant areas and has limited effect. Vegetation filters again require significant land area. These methods have a lower capital cost than more expensive filtration (assuming land required is owned), but are not likely to be able to be used comprehensively across an established urban area as is the situation in Invercargill.

For this report, options for filtration treatment by sand filter or cartridge filter (designed to remove 75% of the suspended solids load) were therefore adopted as the basis for assessment.

5.2 Additional Stormwater Treatment in Invercargill

Assessment was made of the estimated size of filtration treatment device required at the outlet of the average drainage catchment, based on the requirements of the NZTA Stormwater Treatment Standard for Road Infrastructure. This standard follows best practice approaches for stormwater treatment in New Zealand and applies this to conditions throughout New Zealand. It was therefore used in preference to alternative standards for specific localities elsewhere in New Zealand to ensure the results are more widely applicable.

The following assumptions were made:

- There is no requirement for land purchase – It is assumed that treatment devices would only be installed in available land within public spaces (e.g. road corridors, reserves) for which no land purchase was required.
- All of the surface water systems within the Invercargill area have similar runoff and contamination characteristics – This represents average conditions across the urban area.
- Treatment is to be implemented for all urban stormwater regardless of the nature of the catchment and the risk of contamination there – It is possible that a risk based approach could be taken to treating stormwater by different means according to risk, but this is beyond the scope of this report. For instance treatment in residential areas could be limited to existing traps or additional filters in sumps, while higher risk industrial catchments had outlet treatment. This type of approach would reduce overall costs of treatment and could potentially achieve significant results.
- Treatment is at a single point at the outlet of each reticulation catchment – For larger catchments it is likely that multiple treatment devices would be required at different locations within the catchment.
- Installation of a treatment device is assumed to be feasible in every catchment – No assessment was made of available land or construction practicality. The feasibility of implementing additional stormwater treatment within the existing Invercargill network would require site-specific assessment that is beyond the scope of this report.

5.2.1 Estimated Costs of Additional Stormwater Treatment

Construction costs were estimated based on the following references:

- A review of practice in the USA in 2007[19]
- Costs for filtration in recent projects in Auckland.

Annual maintenance costs were based on USA data, at 5% of construction cost for filtration devices.

There is very limited data available on the costs of stormwater treatment primarily due to the fact that it is carried out in very few locations. All cost estimates here are indicative only and have a very high level of uncertainty. Cost estimates are based on typical rates for treatment of contributing catchment areas.

[19] P. Weiss, J.Gulliver and A. Erickson, 2007, Cost and Pollutant Removal of Storm-Water Treatment Practices

Sums were included in the indicative capital cost estimate to account for costs for unidentified items, design and construction supervision, and contingency as a percentage of the base construction cost. Table 5.3 summarises the components making up the total estimated capital cost.

Table 5.3: Summary of Capital Cost Estimates

Component	Estimated Cost
Scheduled Items	$200m
Unidentified Items	*10%*
Total Construction	$220m
Preliminary and General	*7%*
Design & Supervision	*20%*
Subtotal	$280 m
Price Contingency	*5%*
Physical Contingency	*20%*
Total Capital Cost	$350m

Operating and Maintenance costs are estimated to be $11million per annum, based on 5% of the estimated Total Construction cost.

5.3 Reduced Levels of Treatment

The usual methods of stormwater treatment are such that there are limited means to reduce the standard of treatment. This can generally only be achieved by reducing the quantity of runoff to be treated by:

- Reducing the quantity of water treated in any device – A greater proportion of runoff would then be bypassed to discharge without treatment. This will reduce the capital and operating cost, and reduce the amount of solids and other contaminants removed at each treatment device.
- Reducing the area of land treated – Treatment could be restricted outfalls or discharge points from those catchments where there is the highest risk or incidence of contamination, such as industrial areas. Alternatively treatment could be restricted to outfalls where construction of treatment systems can be done most readily. This would reduce the total amount of contaminants removed from the urban stormwater runoff.

The second option can be considered as a step towards a risk-based approach to stormwater treatment. However, some sources of contamination can be from identifiable point sources where elimination of the contamination of runoff is possible. A combination of prevention, treatment at source, and treatment prior to discharge is likely to give the greatest outcome relative to cost. This requires a catchment-specific assessment that is beyond the scope of this report.

Approximately 10% of the area serviced by the Invercargill stormwater network is currently zoned for industrial use ("Enterprise" zone). An estimated 40 of the 139 outfalls have a significant contribution from areas zoned for industrial use. If the central business area is added to this, then these proportions increase to 13% of the area of the stormwater network, and 46 of the 139 outfalls.

Estimates of costs were made for two reduced levels of treatment, for treatment of only industrial areas and the central business district (CBD), and for treatment of only industrial areas.

Table 5.4 summarises the components making up the total estimated capital cost for the three extents of treatment considered.

Table 5.4: Summary of Capital Cost Estimates for Differing Treatment Scope

Component	Full urban area	Industrial and CBD areas only	Industrial areas only
Scheduled Items	$200 million	$55 million	$25 million
Unidentified Items	*10%*	*10%*	*10%*
Total Construction	$220 million	$60.5 million	$27.5 million
Preliminary and General	*7%*	*7%*	*7%*
Design & Supervision	*20%*	*20%*	*20%*
Subtotal	$280 million	$77 million	$35 million
Price Contingency	*5%*	*5%*	*5%*
Physical Contingency	*20%*	*20%*	*20%*
Total Capital Cost	$350 million	$96 million	$44 million
Annual Operating and Maintenance	$11 million	$3 million	$1.4 million

The estimated annual discharge of the main contaminants for the different levels of treatment by filtration is summarised in Table 6. This data assumes that the level of contamination of untreated stormwater from industrial and commercial areas is twice that of overall urban levels, in line with studies by NIWA and ARC in the 1990s.

5.4 Impact on Stormwater Quality and Financial Outcomes

The estimated water quality following treatment by filtration for the entire Urban area is summarised in Table 5.5.

Table 5.5: Summary of Estimated Treated Stormwater Quality

Contaminant		Existing	Estimated % removal by treatment	Estimated treated quality
Suspended Solids	mg/litre	1.8	0.8	0.36
Total Petroleum Hydrocarbons	mg/litre	<0.7	0.8	<0.7
Total Nitrogen	mg/litre	3.34	0.05	3.17
Total Phosphorus	mg/litre	0.051	0.5	0.026
Total metals	mg/litre	0.073	0.8	0.015
Total Coliform	MPN/100ml	6240	0	6240
Escherichia coli (E.coli)	MPN/100ml	995.5	0	995.5

The reduction of contaminants represents the impact on normal loadings, based on the monitoring data of ICC. Removal of peak levels of contaminants in the first-flush flows after rainfall is expected to be greater. It is noted that the while the focus of this assessment has been on reductions in Nitrogen and Phosphorus, the high concentrations of coliforms in the stormwater (more than 6 times the standard) will require treatment over and above that outlined here (either chlorination, ultraviolet radiation or ozone treatment).

When the resulting concentrations are placed against anticipated flows, the effects of full reduction and a partial reduction by covering small subsections of Invercargill are presented in Table 5.6, below

Table 5.6: Summary of Reduced Treated Stormwater Quality

Contaminant	Measure	Existing	After treatment of all discharges	After treatment of Industrial and CBD	After treatment of Industrial Only
Suspended Solids	kg/an.	48,400	9,700	42,700	44,000
Total Petroleum Hydrocarbons	kg/an.	18,800	3,800	16,600	17,100
Total Nitrogen	kg/an.	89,800	85,300	89,200	89,300
Total Phosphorus	kg/an.	1,400	700	1,200	1,300
Total metals	kg/an.	2,000	400	1,700	1,800

The costs of achieving these levels of reduction are borne by the ratepayers. As with the Wastewater assessment for Winton, above, total numbers of ratepayer units have been estimated drawn from the medium population and household projections published by Statistics New Zealand and the Business as Usual output in the form of levels of employment from M.E's Economic Futures Model for Southland (adjusted for Invercargill's share). Employment is then translated into estimates of business numbers based on the current ratios.

Using these projections plus a standard financing model that incorporates capital plus interest repayments over 25 years at 6.5% real interest rates plus a real depreciation rate of 6%, it is possible to represent the financial impacts of the investments on a per rate paying unit basis. Again, as with Winton, no allowance has been made to distinguish between groups of ratepayers through differentials that might reflect different communities' ability to pay (beyond the scope of this work). However, that work would need to be done prior to setting the upgrades in motion.

Table 5.7 highlights the high costs per ratepayer this investment generates. Once the system is fully operational (it has been assumed it would be developed over 3-4 years), Ratepayers can expect costs of between $1,770 and $2,030 per rateable unit.

Table 5.7: Ratepayer Outcomes for Hypothetical Full Urban Area Stormwater System Upgrade in Invercargill

Scenario	2013	2016	2021	2026	2031
Households	*20,613*	*20,890*	*20,840*	*20,730*	*20,520*
Businesses	*4,280*	*4,509*	*4,716*	*4,902*	*5,067*
Capex + Interest	196	1,035	1,121	1,118	1,120
Depreciation	144	703	566	414	304
Operating Costs	-	130	430	429	430
Cost/Rateable unit	**340**	**1,868**	**2,118**	**1,961**	**1,854**

Source: M.E Calculations

These costs are high, especially relative to existing rates bills and may not be achievable, given a high proportion of the community have a low ability to pay. For example a $300,000 residential house is likely to pay rates of around $2,500 for the coming year (2013/2014). Therefore these costs represent an almost doubling of the annual rates bill.

However, the final result will be driven by the setting of water quality standards. It is only at that point that the analysis can be undertaken to highlights actual costs.

The alternative, reduced area scenarios described above have lower costs and achieve lower rates of treatment. By applying the cost structures for each option as outlined in Table 5.4 to the model achieves an average annual cost for ratepayers of around $240 for the Industrial area only (Table 5.8) and $526 for the Industrial Area plus the CBD area (Table 5.9). Note that these figures are averages that draw from the entire timeline rather than the 5 snapshots presented here

Table 5.8: Ratepayer Outcomes for Hypothetical Industrial Area Stormwater System Upgrade in Invercargill

Scenario: Industrial Only	2013	2016	2021	2026	2031
Households	*20,613*	*20,890*	*20,840*	*20,730*	*20,520*
Businesses	*4,280*	*4,509*	*4,716*	*4,902*	*5,067*
Capex + Interest	$25	$141	$140	$140	$140
Depreciation ($)	$18	$93	$68	$49	$36
Operating Costs	$-	$55	$55	$55	$55
Cost/Rateable Unit	$43	$289	$263	$244	$231

Table 5.9: Ratepayer Outcomes for Hypothetical Industrial Area + CBD Stormwater System Upgrade in Invercargill

Scenario: Industrial + CBD Area	2013	2016	2021	2026	2031
Households	*20,613*	*20,890*	*20,840*	*20,730*	*20,520*
Businesses	*4,280*	*4,509*	*4,716*	*4,902*	*5,067*
Capex + Interest	$54	$310	$308	$307	$308
Depreciation ($)	$40	$204	$149	$109	$80
Operating Costs	$-	$118	$117	$117	$117
Cost/ Rateable Unit	**$94**	**$632**	**$574**	**$533**	**$505**

5.5 Summary

Stormwater treatment is a relatively new area for New Zealand Councils to consider in order to improve freshwater quality within their jurisdictions. Given the retrofitting nature of most approaches, the costs are relatively high and they offer limited removal of some of the key pollutants – notably TN, which requires Wastewater Treatment approaches. However, the removal of solids, heavy metals hydrocarbons and 50% of the phosphorous are significant outcomes as a result of investment in full treatment.

Partial treatment that focuses on the industrial areas (where Council may expect volumes to be highest), may not achieve the results anticipated. Limited drops in suspended solid removal is associated with limited reductions in TP. TN makes no significant reductions under any approach.

The financial costs of Stormwater processing are high for ratepayers (could be up to 100% increase), especially where future costs cannot be offset by development contributions – as is likely the case in Invercargill. Therefore an appropriate approach would be to understand where the key polluters are concentrated (if that is in fact the case) and target policies that achieve the best environmental outcomes in these locations.

6 Water – Invercargill Urban: Case Study

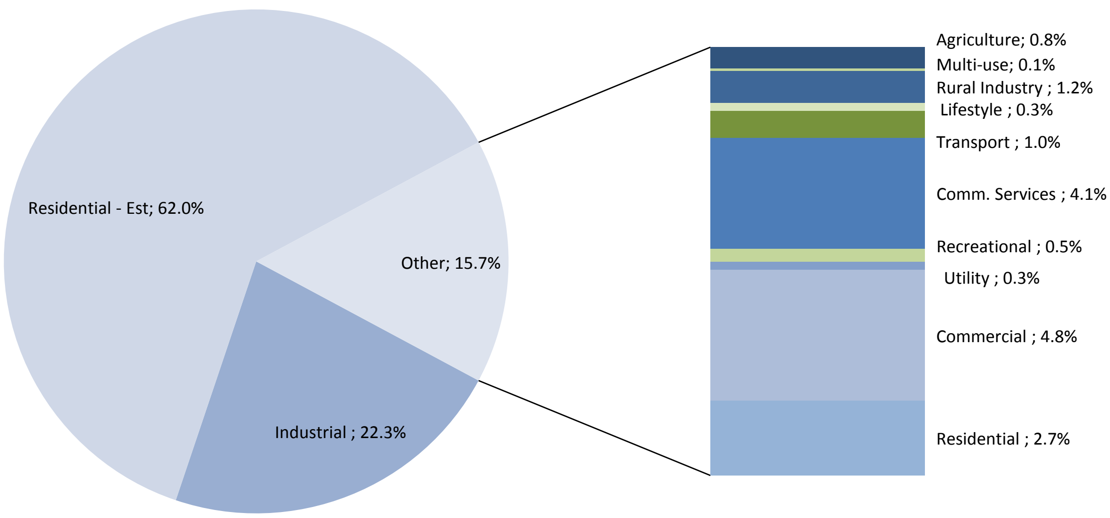
This section investigates urban water use focusing on the Invercargill City experience. The investigation covers direct water used by Invercargill's businesses as well as its households. Future water use is estimated using the BAU Future while allowing for improvements in water-use efficiency.

This section describes the water values associated with the Invercargill City reticulated water system. The focus is on the business community's water use (business covering industrial, commercial and business services) but the residential sector's future water requirements are also estimated. The focus on business use is primarily driven by the diversity of usage rates across the business sector. This means that alternative growth future can translate into very different water consumption outlooks. The same is not the case for the residential sector, where residential use is simply a function of population numbers, which are slowly declining in urban Invercargill.

6.1 Water use per Sector

Overall, the volume of water consumed (supplied to the network) has remained stable varying between 8.4m cubic meters and 8.8m cubic meters per year. Water use is distributed across industrial, commercial, business services as well as residential users (see Figure 6.1).

Figure 6.1: Share of water use by sector (based on Land-use coding)



The residential component includes both metered and unmetered users. Residential users form the largest group accounting for almost two thirds of water consumption. The unmetered residential component is around half (49.7 per cent) of water supplied.

Business users, including industrial, commercial and business service users, form the second largest user group. Over the past six years (2007 to 2012), industrial users consumed 22.3 per cent of the reticulated water supply and were followed by commercial activities (4.8 per cent) and community services (4.1 per cent). The balance, 15.7 per cent, was consumed by smaller users including metered residential users (2.7 per cent), rural industry and agriculture[20] (1.2 per cent and 0.8 per cent, respectively), transport (1.0 per cent) and recreational activities (0.5 per cent).

This distribution has remained relatively stable with the only exception being 2008 and 2009 when industrial users consumed around 1.8m cubic meters of water before falling back to around 1.3m cubic meters per year. The data suggests that this spike is due to the large (35%) increase in water consumed by users in the 'Industrial – Textiles, Leather and Fur' zone.

Assessing the data from an economic perspective and removing the residential component, makes it possible to identify sectors with high water use. Information covering water use by economic sector is not available because the Invercargill City water use database does not code water users in terms of their economic activity. This means that in order to fully describe water usage it is necessary to introduce economic sectors into the dataset. To do this, we linked Invercargill City's 59 land-use codes to the 48 economic sectors via a matrix. The land-use codes and the economic sectors do not have a clear (on-to-one) relationship and we found that one land-use code can cover multiple economic sectors. To overcome this issue, we used a binary coding process to identify the economic sectors which could be located in/on a site with a particular land-use code. Next the water used by each of the 59 land uses was proportioned to the sectors using sectoral employment as weights. Table 6.1 summarises the resulting estimates of water use per sector.

Table 6.1: Water Use per Sector ('000m^3)

Sector	2007	2008	2009	2010	2011	2012
Primary Sector	161	131	138	139	172	168
Meat, Dairy and Food Mfg.	781	903	1,118	1,113	1,114	1,030
Textiles, Wood & Paper Mfg.	586	778	438	64	67	85
Base metal, Chems, Plastic & Rub. Mfg.	79	72	95	54	53	59
Other Mfg.	74	66	64	43	41	41
Utilities	0	0	0	0	0	0
Construction	21	15	18	44	61	58
Retail, Wholesale and Hospitality	293	239	255	216	215	221
Transport	116	74	140	163	129	132
Communications and Business	70	61	58	53	44	45
Government	13	11	12	11	11	10
Education and Health	242	232	222	225	237	189
Culture, Rec and Personal Services	100	111	122	106	108	98
TOTAL	2,535	2,692	2,681	2,232	2,252	2,137

Source: M.E Calculations based on ICC data

[20] This water use relates to metered takes described in the ICC dataset as 'Farms off Bran & Bluff pipelines plus W Carrier sales'.

The preceding table suggests meat, dairy and food manufacturing activities are dominating the industrial water use. These sectors' water use has increased from 0.7m cubic meters in 2007 to 1.0m cubic meters in 2012 equating to compound growth of 5.7% per year between 2007 and 2012. This growth is in spite of a short term reduction in water usage. Water usage has decreased by 84,000 cubic meters between 2011 and 2012 after remaining flat at around 1.1m cubic meters between 2009 and 2011. The total for food manufacturing equates to approximately 48 per cent of all non-domestic[21] water – up from 30.8 per cent in 2007.

The next largest user group fall in retailing, wholesaling and hospitality. These activities use around 10 per cent of the water supply (excluding residential use) and are followed by education and health (8.9 per cent), primary sector (7.8 per cent) and transport (6.2 per cent). We note that most of the sectors' water use has declined between 2009 and 2012. However the bulk of this decline occurred between 2009 and 2010 and reflects the impacts of the recession on economic production and therefore reducing demand for water.

The current water use profiles can be used to estimate future demand for water resource by linking it to the level of economic production taking place in Invercargill. To do this it is necessary to estimate current water use intensity i.e. how much water is used to produce a unit of output. There are a variety of ways that the information obtained from these calculations can be expressed. For the purpose of this assessment we have calculated water multipliers for 48 economic industries. These multipliers show how much water each sector uses (directly) during its production process. The resulting multipliers are interpreted as follows: Assume that a sector has a water use output multiplier of 1,000 cubic meters per $1 million. This means that for every million dollars of economic output produced by that industry, 1,000 cubic meters of water is consumed when producing that $1m worth of output. As value added is generally considered a more meaningful measure of economic activity than output, the water output multipliers are converted to water: value-added multipliers.

Table 6.2 summarises sectoral water requirements i.e. the (direct) water multipliers. Note this is the direct water used to produce VA$1m and is not the total amount of water used by the sectors.

Meat, dairy and food manufacturing activities have the highest direct water requirements needing around 9,050m^3 of water to produce $\$1m_{2012}$ of VA. This is as expected considering that agri-processors (meat, dairy and food manufacturing) use a lot of water during the production process. Following these manufacturers are the agricultural activities. These include rural industries such as market gardens, orchards, specialist livestock and stock finishing activities. These primary sector activities use 2,520m^3 for every VA$1m. Other sectors using more than a 1,000 m^3 to produce VA$1m include:

- Textiles, wood and paper manufacturing (1,670m^3/VA$1m),

[21] Non-domestic water refers to the total water supplied via the reticulated system less water supplied to households. It also excludes any losses due to leakages and water treatment operations.

- Transport (1,260m^3/VA$1m), and
- Culture, recreation and personal services (1,200m^3/VA$1m).

Table 6.2: Summary of (Direct) Water Multiplier

Sector	'000m^3/VA1m_{2012}$
Primary Sector	2.52
Mining and Quarrying and Oil & Gas	-
Meat Dairy and Food Mfg.	9.05
Textiles, Wood & Paper Mfg.	1.67
Base metal, Chems, Plastic & Rub. Mfg.	0.24
Other Mfg.	0.55
Utilities	0.00
Construction	0.38
Retail, Wholesale and Hospitality	0.62
Transport	1.26
Communications and Business	0.08
Government	0.08
Education and Health	0.70
Culture, Rec and Personal Services	1.20

Source: M.E Calculations based on M.E and ICC data

6.2 Future Demand for Water

In this section we describe the future demand for water using a Business-as-Usual scenario. We have derived water use estimates by multiplying estimates of future economic activity by the estimated level of water need to produce VA$1m. The direct water multipliers presented in the preceding section is one part of the equation. The second part, the BAU economic projections (scenario), has been derived using M.E's Economic Futures Model. This BAU scenario is the same one used to estimate the future water requirements and nutrient loadings in the Southland Regional Economics Profile study. The resulting economic data has been scaled to reflect the Invercargill City component of the Southland economic future. The BAU scenario reflects (as discussed earlier), changes in final demand (including changes in h*ousehold consumption, export performance and gross fixed capital formation).*

Once these final demand projections are entered into the EFM, the model calculates the flow-on implications throughout the economy using input-output mathematics. Thus, estimates of future economic output and value added by economic sector are derived. Finally, we calibrate the model so as to ensure that its outputs for key sectors are consistent with the sector outlooks and the baseline as estimated by NZIER.

Of course water use efficiency is expected to increase over time. We have allowed for such an improvement. However projecting the rates at which economic growth might be decoupled from use of water resources is difficult. Not only do the rates of efficiency change depend on the rate at which new technologies are invented and adopted, but also more far-reaching structural changes occurring within the economy. In particular, diversification of economic production with the addition of new types of value added improvements during production chains will act to increase the direct water use coefficients. Given the project's time constraints, it has not been possible to undertake a detailed analysis of the likely future efficiency changes across all sectors under a BAU scenario. We have therefore relied on an assumed average rate of efficiency change of 0.5 per cent per annum, as adopted by Hejazi *et al.* (2013).

Table 6.3 summarises the estimated water used under the BAU scenario.

Table 6.3: Future BAU Water Use ('000m^3)

Summary Sector	2011	2016	2021	2026	2031
Primary Sector	172	188	205	225	251
Mining and Quarrying and Oil & Gas	0	0	0	0	0
Meat Dairy and Food Mfg.	1,114	1,171	1,227	1,280	1,322
Textiles, Wood & Paper Mfg.	67	62	62	62	63
Base metal, Chems, Plastic & Rub. Mfg.	53	58	63	68	73
Other Mfg.	41	45	49	53	57
Utilities	0	0	0	0	0
Construction	61	71	81	90	100
Retail, Wholesale and Hospitality	215	228	241	253	264
Transport	129	137	144	151	158
Communications and Business	44	47	50	52	55
Government	11	11	12	12	12
Education and Health	237	252	265	277	284
Culture, Rec and Personal Services	108	115	120	125	129
Total	2,252	2,384	2,518	2,649	2,768

Source: M.E Calculations

The results show that over 40 per cent of total additional water demand in Invercargill City is associated with increased demand by meat, dairy and food processing. A further 15 per cent is associated with growth in demand from the primary sector. Combined these two sectors will account for 55 per cent of non-domestic water demand in 2031.[22] A third of future demand (out to 2031) is expected from services. Education and health are projected to account for another 10 per cent of total over future water demand by growing at over 20 per cent out to 2031. Retail, wholesaling and hospitality activities will also grow more than 23 per cent; another 10 per cent of total water demand growth. Culture, recreation and personal services are projected to grow by more than 20 per cent – accounting for 4 per cent of total growth in demand for water.

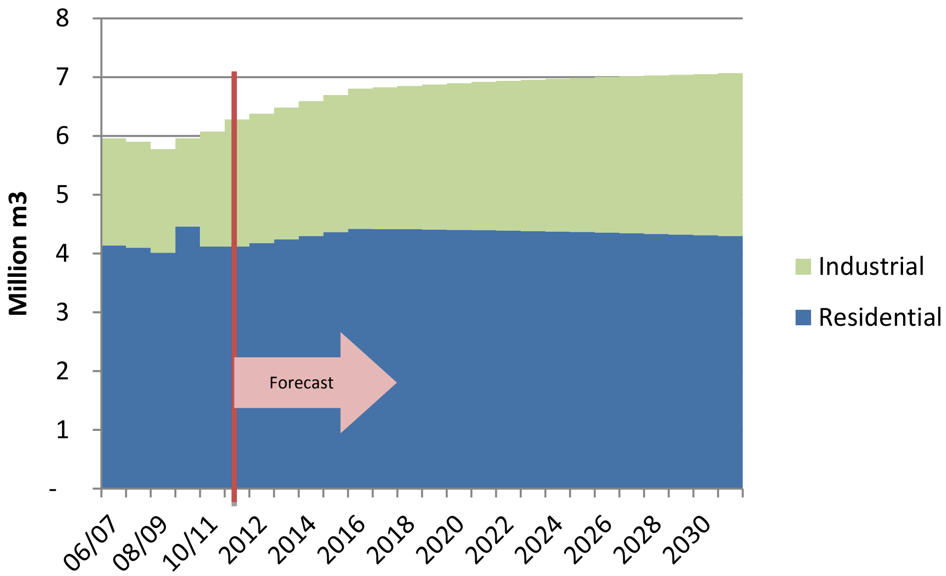
With reference to residential water, the main driver of future demand for this is the population. Using Statistics New Zealand's medium population projections (as discussed earlier) and applying Invercargill City's water use per person[23] ratios yields an estimate of future demand. Residential demand is projected to decline somewhat moving from 4.4m cubic meters in 2016 to 4.3 by 2031 with the decline caused by the declining population. This includes an allowance for households becoming more efficient water users. If

[22] This is exclusive of future residential water demand.

[23] The assumption for unmetered residential use is 220 litres/person/day and a residential occupancy rate of 2.4 persons per property.

households' water consumption kept stable at 220litres per person per day (without any eco-efficiency gains) then residential water consumption is projected to decline by less than one per cent between 2011 and 2031. Figure 6.2 shows the projected demand for water from Invercargill's town supply.

Figure 6.2: Projected Water Requirements



Over the long term, non-domestic (recorded as Industrial on the chart above) water users are expected to demand an increasingly larger share of the water supply and by 2031 it is expected that residential users will consume 60.8 per cent of the water supplied – down from around 70 per cent the past five years. This shift is due to the marginal decline in demand from residential users and the increase from industrial and non-residential users.

6.3 Future Water Quality

Drinking water standards in New Zealand are governed by The New Zealand Drinking Water Standards, in general they contain higher standards than the fresh water limits likely to be set by government as a part of this process.

For example, in Table 2.2 they stipulate Nitrate Short Term 50mg/l as NO_3 as a maximum value and in Table 2.5, Ammonia 1.5mg/l as a guideline value.

In the figures provided by Aqualinc N is less than 1mg/l in all scenarios, so doesn't appear to be an issue for drinking water at this location.

6.4 Future Water Quantity

Invercargill is facing small increases in likely water demand over the next 20 years or so. The amount of water growth is less than half the amount current estimated to be lost through leakage or that is unaccounted for. Total growth in demand to 2031 is estimated to be 685,000m^3, leakage or unaccounted for water (in 2012) equals some 2.2million m^3.

The implication of this is that Invercargill could potentially fulfil their future requirements without seeking new sources of supply – or at least address a significant portion of their future growth requirements by reducing the volume of leakage.

It is also understood that Invercargill have in the past investigated sourcing water from Lake Hauroko (a very deep freshwater lake on the edge of the Fiordland National Park) and are launching an investigation into new sources of water in the near future. These are extremely expensive undertakings[24] and can place significant burdens on ratepayers over long periods of time – especially in situations where there is limited growth meaning that the burden is carried by existing ratepayers that may be declining in numbers.

6.5 Key observations

A clear finding from the above analysis is that, at least under the BAU scenario as constructed, Invercargill City's economy is showing a degree of decoupling from water (or reduced dependency at least in terms of direct water use).

For every 10 per cent increase in economic activity, water use increases by only 8.3 per cent. Meat, dairy and food processing and the primary sector, both intensive water users, are showing high levels of decoupling. For these two sectors, a 10 per cent change in economic activity will translate to a 7.1 per cent change in water demand. Education and health shows a similar pattern. Textiles and wood and paper manufacturing is showing an overall decline in water use reflecting a high level of decoupling.

It is important to note that the above is based on direct water. This means that water embodied in the goods/services used during production process is not included in this assessment. The analysis presented in this report captures the direct use of water supplied via the reticulated system.

[24] It is understood Gore District have estimated a new water supply for Gore will cost some $20m.

7 Wastewater Case Studies

Wastewater is dealt with in this section using two case studies. The reticulated wastewater system for the township of Winton and the on-site wastewater system at the Alliance meat works at Lorneville are studied. On-site residential wastewater (i.e. septic tanks) is also covered using information on the rural residential properties within the Invercargill City territorial authority boundaries. The financial implications of implementing engineering solutions are assessed.

7.1 Winton Case Study: Introduction and Approach

Winton is a small settlement of approximately 2,100 residents residing in 990 dwellings on the Oreti River. The town currently accommodates 234 businesses employing 1,080 workers. The town is a rural service town for the mainly farming hinterland with economic activity concentrated into service sectors, primarily wholesaling, retailing, hospitality, education, transportation and other services. In addition, they have activity in the agricultural services sector (shearing and forestry services mainly) and in the manufacturing sector (fabricated metal product mfg., prepared animal feed mfg., ready mix concrete mfg.).

Winton has been chosen as the Wastewater case study location by MfE and ES. Winton represents a small rural community allowing an assessment of effects on the community of investment in infrastructure required to meet higher wastewater discharge standards to water. The Winton specific situation has been adapted where required to better reflect a more general small town in the Southland environment. This means that quirks within the current wastewater processing system that are Winton specific have been excluded from this assessment of upgrade costs.

This assessment focuses on the costs associated in removing four key contaminants from the discharge;

- Ammonia Nitrogen (NH_3-N)
- Total Nitrogen (TN)
- Total Phosphorous (TP)
- Pathogens represented by E.coli.[25]

A design population of 3,000 Population Equivalents (PE) was used in the modelling carried out by MWH. This design population is based on an existing population of 2,000 to 2,500 people with some allowance for population growth or an industry to make up the design population of 3,000 PE based on typical domestic sewage volumes and contaminant concentrations.

Note that Winton has a very high peak wet weather flow because of the aging condition of the reticulation network, implying indirect inflows from the stormwater system and other usual infiltration and inflow faults. This is typical of sewerage systems in New Zealand

[25] Refer Wastewater Treatment in the Winton Environment by MWH in Appendix 1

townships and was not considered. Instead peak flows were assumed to be buffered by the oxidation pond storage.

For any WWTP upgrade there are a number of potential approaches to eliminate or reduce contaminants that reach the freshwater stream network or groundwater. These options are dependent on the quality and quantity of the raw wastewater, the existing system and other constraints including site issues and the receiving environment.

For the purposes of this report one option to remove each of the four identified contaminants separately has been adopted (and scaled to achieve desired levels of reduction). For a detailed explanation of the approach used, assumptions made about potential treatment options, wastewater loadings and concentrations, refer to the MWH report at Appendix 1 of this report.

Once capital and operating costs have been established they are translated into an additional cost (of the upgrade) to be borne by the community. It has been assumed that Southland District Council fund both the development and operation of the upgraded WWTP through a loan repaid over 25 years at 6.5% real interest. Annual repayment costs for the capital investment, operating costs, land costs and depreciation are funded through a targeted rate to those attached to the network, in this case, households and businesses in Winton. These additional costs are then expressed in terms of additional annual costs per household and business.

7.1.1 Economic Structure

As mentioned, Winton is a rural service town in central Southland. It is currently home to some 2,120 people in 990 households. Over the next 20 years or so this population is expected to decline to around 1,930 by 2031 (approximately 9%). Over the same time, household numbers remain relatively static, declining in number by only 10 (from 990 to 980 or by 1%). At the 2006 census 28% of Winton's population was aged 65 years or older. This compared to only 14% for Southland Region as a whole. Correspondingly, Winton has a lower young population than the Southland average (16% versus 21% under 15).

In terms of occupations, Winton is dominated by blue collar trades with higher concentrations involved in Trades and Technical occupations and as machinery operators and drivers than the Southland average and lower shares of managers, professionals and administrative workers. This, along with an older population, is reflected in the Income statistics with the median income for people aged 15 years and over was $21,700 in 2006 in Winton compared with $23,200 for Southland as a whole (Statistics NZ Census 2006). However, there is a higher level of home ownership in Winton than for Southland as a whole with some 63% of home owned with or without a mortgage (compared to 60%).

Also, in line with an older population than the average for Southland, Winton has a higher share of single person households than Southland overall (31% compared with 26%, in 2006). This has implications, when combined with the lower than average incomes, for households ability to pay the additional costs associated with increasing wastewater treatment costs. As mentioned above the economy is centred around meeting the needs of local residents and the wider rural hinterland. The retail sector currently employs approximately 20% of Winton's workers. This compares to retailing making up only 9% of employment Southland wide.

The high numbers of older people in Winton, points to retired farmers moving into the township. They are likely to have a higher level of wealth than their incomes might indicate, giving them the ability to sustain a higher level of retail expenditure than might be expected.

Other standout sectors (Table 7.1) include;

- Transport (11%) compared with 5% in Southland overall (this is due to one business employing some 75 workers in Road Freight Transport)
- Education and Training (14%) compared with 6% Southland wide
- Other Personal services (6%) versus 3% for Southland

Sectors under-represented include the white collar sectors; professional, scientific and technical services, administrative and support services, public administration and Arts and Recreational services.

Table 7.1: Winton Economic Structure, 2012 (Statistics NZ Business Directory)

Sector	Businesses (GEOs)	Employment (MECs)	Business Share	Employment Share
Agriculture, Forestry & Fishing	25	98	10.7%	9.1%
Mining	1	0	0.4%	0.0%
Manufacturing	15	120	6.4%	11.1%
Electricity, Gas, Water Supply	1	1	0.4%	0.1%
Construction	30	48	12.8%	4.5%
Wholesale Trade	9	40	3.8%	3.7%
Retail Trade	26	216	11.1%	20.1%
Accommodation & Food Services	11	83	4.7%	7.7%
Transport, Postal & Warehousing	8	120	3.4%	11.1%
Information, Media & Telecommunication	1	1	0.4%	0.1%
Financial & Insurance Services	16	14	6.8%	1.3%
Rental, Hiring & Real Estate Services	36	14	15.4%	1.3%
Professional Scientific and Technical Services	5	16	2.1%	1.5%
Admin and Support Services	3	4	1.3%	0.4%
Public Administration & Safety	3	7	1.3%	0.6%
Education and Training	8	148	3.4%	13.7%
Health Care & Social Assistance	11	75	4.7%	7.0%
Arts and Recreation Services	7	6	3.0%	0.6%
Other Services	18	66	7.7%	6.1%
TOTAL	234	1077	100.0%	100.0%

7.1.2 Treatment Plant

In order to make the findings of this study more generally applicable to other centres across Southland, and potentially across New Zealand, a more stylised Winton Wastewater Treatment Plant (WWTP) is assumed to exist. This is has been described (in Appendix 1 of that MWH report) as follows;

- Services a community of 2,000 people
- Treats wastewater of a domestic quality (i.e. no significant input from industry)
- Currently consists of an oxidation pond, with 28 days detention time at average daily flow, and polishing wetland, before a direct discharge to the river

It is noted that Winton has lower than average temperatures compared to New Zealand as a whole. This has an impact on the treatment of wastewater as the biological processes operate slower in lower temperature climates.

It is also noted that Winton has a very high peak wet weather flow due to the aging condition of the reticulation system. However, that is not typical for other New Zealand locations, so for the purpose of this study has been ignored. It is assumed that the peak flows are buffered by the oxidation ponds.

7.1.3 Future Treatment Options and Outcomes

The future treatment options have been limited to those that relate to upgrading the above assumed existing treatment plant. An alternative might be the option to discharge to land rather than into the surface water directly. This should be the focus of a future assessment. The upgrades have been treated separately and focus on the four key contaminants under summer conditions. MWH have carried out a more detailed assessment of pollutants removed (see Appendix 1 in the MWH report).

In summary the study has assumed;

- A design population of 3,000 population equivalents (PEs). This allows for a degree of commercial activity to take up some capacity over and above population (or for population growth).
- Raw wastewater loads are based on average per capita contaminant loads associated with typical New Zealand domestic wastewater (details in Table 1 of the MWH report).
- Oxidation pond treated wastewater has been estimated based on monitoring results from Winton plus national surveys and making some allowance for conservative design. The concentrations of contaminants modelled are based on typical summer concentrations which coincide with the most stringent treated wastewater quality

standards as rivers are at their low flow minimums. This results in smaller plant as reaction rates are higher in summer.

- Add on processing plants have been selected to provide a realistic, robust, and reasonably low tech solution for upgrading the typical WWTP for a small community as described above.
- The four key contaminants modelled for are; NH_3-N, TN, TP and *E. coli.*

The add on treatment plants considered are;

- Upstream of the existing pond – Trickling filter (TF) – total nitrogen reduction
- Downstream of the existing pond – Nitrifying Trickling Filter (NTF) – ammonia reduction
- Downstream – Moving Bed Biofilm Reactor (MBBR) – nitrate reduction, total nitrogen
- Downstream – Clarifier and chemical dosing – dissolved reactive phosphorous and total phosphorous reduction
- Downstream – Ultra Violet (UV) Disinfection – pathogen reduction (*E. coli.)*

Details of the processes undertaken by these plant options are outlined in Table 3 of the MWH report at Appendix 1. A summary of the results is presented in Table 7.2 below. The table shows the percentage of reduction in each pollutant achieved for each plant sizing and the concentration of pollutant remaining in the discharge. Capital and operating costs are included for each plant. Five scenarios have been developed from this data to allow comparison of costs for the removal of all four pollutants. In general these range from low cost to high cost with a commensurate increasing reduction in pollutants as capital costs rise.

It is not always the case, in a few instances operating costs rise along with pollutant removal while capital costs remain steady. In general additional plant costs between $1m and $3.5m to achieve reductions of pollutants of between 25% and 98% depending on the process and pollutant. Again, detailed information is included in Appendix 1 of the full MWH report, including a full set of implications for water quality outcomes.

For the purposes of this report, it has been assumed that a productivity premium of 25% exists if the plant is built at the same time. While the actual figure is not known, discussion with water engineers indicates that this assumption is a reasonable one. This would reduce the total capital and operating costs for each of the 5 scenarios to be 75% of the sum of the individual components as listed in Table 7.2.

Table 7.2: Summary of pollutant reduction and associated investment requirements

Target	Scenario	Additional works	Typical Removal of Contaminant	Remaining Concentration	Capital Cost ($m)	Operating Cost ($/year)
Ammonia (NH_3N)	**Status Quo**		**0%**	**32.0**		
	1	Nitrifying Filter downstream of Pond (25% removal)	25%	24.0	1.0	52,000
	2	Nitrifying Filter downstream of Pond (50% removal)	50%	16.0	1.1	53,000
	3	Nitrifying Filter downstream of Pond (75% removal)	75%	8.0	1.2	55,000
	4 & 5	Nitrifying Filter downstream of Pond (90% removal)	90%	3.2	1.2	56,000
Total Nitrogen (mgN/L)	**Status Quo**		**0%**	**43.0**		
		50% of influent flow, recirculation 1:1	48%	27.0	2.1	61,000
		50% of influent flow, recirculation 3:1	54%	23.0	2.1	64,000
	1	50% of influent flow, recirculation 5:1	54%	22.0	2.1	66,000
		100% of influent flow, recirculation 1:1	63%	17.5	2.1	64,000
		100% of influent flow, recirculation 2:1	74%	<16	2.1	66,000
	2	100% of influent flow, recirculation 5:1	78%	<15	2.1	73,000
		100% of influent flow, recirculation 5:1 Clarifier and Alum Dosing downstream of pond	90%	<5	3.1	151,400
		Nitrifying Filter (75% removal) Denitrifying MBBR downstream of pond	53%	20.0	1.9	117,000
	3	Nitrifying Filter (90% removal) Denitrifying MBBR downstream of pond	65%	15.2	2.0	127,000
	4	Nitrifying Filter (75% removal) Denitrifying MBBR downstream of pond Disk Filter	72%	12.0	2.4	117,000
	5	Nitrifying Filter (90% removal) Denitrifying MBBR downstream of pond Disk Filter	84%	7.0	2.5	127,000
Total Phosphorous (mgP/L)	**Status Quo**		**0%**	**5.5**		
	1&2	Clarifier and Alum dosing	50%	3.0	1.1	78,400
	3&4	Clarifier and Alum dosing	75%	1.8	1.1	106,200
	5	Clarifier and Alum dosing	90%	1.0	1.1	131,200
E-coli (cfu/100ml)	**Status Quo**		**0%**	**10,000**		
	1, 2 & 3	UV Disinfection	95%	<500	0.5	18,000
	4 & 5	Clarifier Aluminium dosing UV Disinfection	98%	<200	1.4	87,400

Source: MWH Report

7.1.4 Funding of Expenditure & Financial Outcomes

It has also been assumed that Southland District Council will develop and operate the new WWTP. While there are a number of ways Council could fund and recoup the cost associated with this infrastructure, including; paying from retained funds, then distributing the costs more widely across the district, this study assumes the plant will be funded through a loan repaid over 25 years at 6.5% real interest rate. Alternatively, Council could distribute these costs across Winton households and businesses through a targeted rate with no differential operating between households and businesses.

In effect this treats each business as a household equivalent, this is not ideal, however it is beyond the scope of this report to develop a comprehensive funding model for Southland District.

Once funding costs have been estimated (using a standard table mortgage calculation and assuming the infrastructure is developed in 2013), operating costs are added along with depreciation (real depreciation at 6% p.a.) and land costs to produce a total cost. These costs are assumed to be funded through rates rather than loans so no funding charges (interest) accrues.

The total costs have then been divided by the number of households and businesses to derive a per household/business cost. Note that as household numbers slowly decline along with depreciation costs, the figures do change over time, albeit slowly (Table 7.3).

Table 7.3: Total Annual Wastewater Plant Upgrade Costs per Rateable Unit

Scenario		2013	2016	2021	2026	2031
Households		990	990	990	990	980
Businesses		233	231	226	220	213
Scenario	1	524	497	462	437	423
	2	539	512	476	451	437
	3	597	569	533	507	494
	4	747	711	665	632	615
	5	779	742	696	662	645

Source: M.E Calculations

This assessment indicates that costs per rateable unit are liable to lie between $524 and $779 in 2013 dropping to between $423 and $645 by 2031, to fund and operate the upgraded WWTP.

Given the assumption of no differential operating, this translates to residential ratepayers carrying approximately 81% of the funding load and business community 19%. It is likely that there are issues surrounding the communities ability to pay for these upgrades that would need to be worked through prior to establishing the final impact of these upgrades. It is noted that Southland District Council has recently changed to a District Funding model for sewerage schemes which has lowered the financial impact on individual communities.

That process is beyond the scope of this report.

In terms of impacting on actual water quality the changes while making a significant difference to the quality of the discharge, thereby improving the quality of the water in the

Oreti River, have no real implications for Invercargill's water take. Currently the water taken from the river is processed to drinking water standards, and the changes brought about by changes at Winton are not likely to have an effect on the cost of achieving those standards for the Invercargill water scheme.

7.2 Alliance Meat Works

The Alliance meat works is located just outside the boundary of Invercargill City. It has been included in this assessment as it has a significant bearing on fresh water quality in the lower reaches of the Makarewa and on the receiving coastal marine environment (New River Estuary).

The Alliance Meat works at Lorneville is the largest Ovine processing facility in the world. It has a maximum capacity to process 32,000 carcases per day. At present, due to the state of the meat processing market globally it operates at a maximum of around 28,000 carcases. IN the height of the season, the plant employs approximately 2,100 workers and has a base staff of around 200. Based on an average of 1,500 MEC's, we estimate a contribution to regional GDP of approximately $\$_{2012}$150m directly.

It is unlikely that there will be significant growth in the sector over the short to medium term with a long term trend to more Dairy conversions in Southland. Alliance are therefore not planning for growth in output from the plant.

In order for the plant to continue operating under the published water quality limits in the Regional Water Plan for Southland (2010), Alliance are researching a switch from a mainly anaerobic settling pond system to an enhanced aerated treatment process of some sort. This will focus on reducing levels of nitrogen (primarily from Ammonia) and phosphorus from the wastewater, while the current pond infrastructure will remain to remove the vast majority of organic load.

The research is in its early stages so the exact nature and composition of the final solution is not yet known. However, they are seeking a long term resource consent to allow them to continue to discharge into the river, so the solution they choose will meet the water quality standards, currently published. It is unclear what the final national position on Freshwater quality standards will be, therefore Alliances investment options are not fixed.

This change has significant cost implications for the meat works and potentially would need to be staged to ensure plant remained viable.

7.2.1 Scale of Output Currently

The Alliance meat works currently utilises some 27ha of primarily anaerobic and aerobic settling ponds to address, store and process the wastewater from the plant. The level of technology involved is reasonably low and therefore the costs associated with the process are relatively low. The proviso being that the plant has a sufficient land resource available to allow 27ha to be devoted to wastewater treatment. This is highly unlikely to be the case in other locations.

The current wastewater treatment process is very effective in removing organic matter from the waste, but does not remove nitrogen or phosphorus, except that component associated with the organic compounds.

Output from the current wastewater treatment is controlled and monitored under Consent No. 92195. Council has provided 11 years of pollutant monitoring data covering above the outfall (Bridge), the effluent itself, 200m downstream from the outfall and 'Boundary', lower again. This data is summarised in Table 7.4.

Table 7.4: Average Pollutant Concentrations (2009 – 2012)

	Year	Temp	%DO	pH	NH4	TN [g/m3]	TP [g/m3]	FC [CFU/100ml]	Clarity [cm]
Bridge	2009	13.2	96.5	6.9	0.10	1.65	0.178	34,118	42.8
	2010	13.6	98.6	7.1	0.13	1.58	0.089	11,996	45.3
	2011	13.5	98.7	7.2	0.17	1.63	0.144	6,087	43.0
	2012	12.8	78.7	7.2	0.11	1.65	0.095	4,386	42.0
200m Below	2009	13.3	90.1	7.0	3.24	4.92	0.399	2,730	40.1
	2010	13.5	90.7	7.2	3.41	4.97	0.447	5,515	43.2
	2011	13.5	89.2	7.3	3.42	5.32	0.495	8,092	41.6
	2012	12.9	92.2	7.5	3.48	4.84	0.421	2,790	35.0
Boundary	2009	13.4	87.1	7.1	3.07	4.73	0.412	1,507	40.2
	2010	13.7	89.5	7.2	2.44	3.86	0.334	22,909	43.6
	2011	13.5	90.8	7.3	2.25	3.52	0.337	2,934	41.4
	2012	13.3	88.9	7.4	6.89	3.84	0.373	3,278	37.6

Source: Southland Regional Council Makarewa River Monitoring Data.

The current consents contain relatively generous ammonia limits and contain no phosphorous limits (it is understood that this was appropriate at the time, and the consent is due to expire in 2016). Any new consent, as mentioned above is liable to tie Alliance to the water quality standards outlined in the Southland Regional Water Management Plan.

7.2.2 Future Change

The changes in water quality will be to line up with the published water quality standards in the Regional Water Plan for Southland. In Appendix G Water Quality Standards, it specifies the water standards required following reasonable mixing with the receiving waters. For Lowland Soft bed water bodies (Makarewa River fits this classification) the standards are;

- The temperature shall not exceed 23^{o}C

- Daily max temp shall not increase by more than 3C when the ambient temperature is 16C or less, if above 16C not by more than 1C
- pH of the water shall be within 6.5 and 9 and no change in pH that causes loss of biological diversity
- The concentration of dissolved oxygen in the water shall exceed 80% of saturation concentration
- There shall be no bacterial or fungal slime visible to the naked eye
- When the flow is below the median flow the visual clarity shall be not less than 1.3m
- The concentration of ammonia shall not exceed the values that are contained in Table 1 in Appendix G of the Regional Water Plan for Southland. Assuming the pH levels are achieved, this means ammonia concentrations of between 180mg/m^3 and 2460mg/m^3.
- The concentration of faecal coliforms shall not exceed 1000 coliforms per 100millilitres

7.2.3 Outcomes

In order to achieve these standards, Alliance believe they will need to build a high rate aerobic processing plant of some form. In addition to this they are likely to require a disinfecting unit to deal with the faecal coliforms, this is a further tertiary level of treatment.

In total, this type of plant would require investing up to $20m - $22m in new capital works. In addition, the operating costs associated with such a plant are anticipated to be 5 times higher than currently experienced. For example, the electricity required to run the aeration plant is expected to cost some $7,000 per week.

Given that the meat works is not anticipating any future growth, these investments are about being able to continue operating in their current form. Minimising these costs are going to be a high priority for Alliance over the next few years. Maximising the length of time their next discharge resource consent lasts for will also be a high priority as that will ensure they remain able to operate as they currently do.

In order to assess the impacts of these changes, two scenarios have been generated. The first one stages half the investment over 5 years in 2 blocks totalling $11.6m. This is a least cost capital option that Alliance may seek to undertake. It is assumed that the spending in each block is spread over 2 years with approximately $1m in the first year and $4.8m in the second. Capital has been funded over 25 years with depreciation and maintenance costs added.

The second scenario is the highest cost for Alliance but achieves the water quality standards as soon as complete. This scenario sees the full plant built in 2014 – 2015 in order to be operational by 2016 when the new consent is required. In this scenario costs are spread over 3 years with $100,000 in the first year, $5.15m in the second and $16.85m in the third. This is based on 25% of capital cost spent in year 2 with the balance in year 3. Other consenting costs are split between year 1 and 2.

The costs over time have been discounted back to 2012 dollar terms to present the net present value of costs likely to be faced by Alliance to meet the current standards from 2016 onwards. These are presented in Table 7.5

Table 7.5: NPV of Capital and Operating Costs of Potential Solution for Alliance Lorneville

Expenditure Category	Scenario 1	Scenario 2
Capital plus Interest	$10.0	$19.8
Depreciation	$7.5	$9.3
Maintenance	$3.7	$4.5
Other Operating Costs	$6.4	$7.7
TOTAL	$27.6	$41.4

Source: M.E Calculations

In NPV terms additional costs faced by Alliance equal $27.6m under the lower cost option and more than $41m under the higher cost option.

Alliance currently employ up to 2,100 workers during the peak killing season and have a permanent, year round staff of 200 or so. They pay wages and salaries to these workers who spend this money in Invercargill. It is estimated that based on these levels of activity, they generate some $150m in regional contribution to Value Added. Without carrying out a full cost benefit assessment, it is impossible to know the full effects of imposition of higher water quality standards than those currently outlined in Southlands Water Plan, however, it is likely that the future profitability of the plant is less clear given the high costs associated with the changes outlined above. It has not been established that Alliance cannot afford the upgrades required to continue operating. This is an area that requires more work.

In order to make a fully informed decision, Councils need to be aware of the economic parameters as well as the water quality parameters that are likely to include;

- Recreational values associated with the mouth of the Oreti River (the Makarewa discharges into the Oreti a few kilometres downstream from the Alliance discharge point)
- Cultural values associated with the lower reaches of the Oreti River and the New River Estuary.
- Ecosystem values associated with the New River Estuary (in particular) as well as the Oreti and Makarewa

7.3 On-Site Residential Wastewater Treatment Plants

There are significant numbers of households across Southland relying on stand alone on site WWTPs to process domestic wastewater. A recent article in the Southland Times[26] indicates as many as 12,000 households across the region have on-site systems. They can be a significant contributor to pollutants in the freshwater system especially if they are not operating efficiently or effectively. However, as the article points out, it is difficult to assess the scale of any pollution issue as there is a lack of reliable records of both the number and or the condition of the systems currently in place.

In order to assess their role in Invercargill City, a 31 page dataset from 2009 that contained information on 749 properties in the Invercargill District with on-site WWTPs, along with an address, a description of the system, and a date in which the consent to operate was granted – usually in the form of a CCC .

However, the data is suspected to be a partial set, given that the non-reticulated areas of Invercargill City were home to 1,870 residential dwellings in 2009, leaving a shortfall of 1,121. Of the 749 records provided approximately 21 (less than 3%) have recorded comments that indicate they are a more modern bio filter type system, or are a septic tank system with some form of additional filter or are a multi-stage septic tank system that will produce greater levels of treatment prior to disposal to land.

The balance of on-site systems appear to be traditional septic tank systems with drainage fields through field tiles mainly. These can also be a direct conduit to surface water.

7.3.1 Current Numbers by type

Assuming the balance of the properties that resided in the non-reticulated areas shared the same distribution as the dataset, then some 1,817 households have more traditional septic tanks in Invercargill City along with 52 households with systems that offer some form of secondary processing of waste.

In the absence of any information as to the quality of the outputs from the septic tanks which dominate the area, it is not possible to definitively state the share or numbers that might need to invest in new technology systems to achieve higher water quality standards.

In line with MfE estimates of the proportion of septic tanks that are faulty, it is estimated that some 303 septic tank systems in Invercargill City are faulty, and fail to meet current discharge standards.

7.3.2 Future Growth and Change

Auckland Regional Councils Technical Publication No.58 (TP58) outlines typical concentrations of key pollutants to land from a range of on-site treatment units. By moving

[26] The Southland Times, 30/04/2013

from traditional septic tank systems to some form of activated sludge aerobic treatment system achieves significant reductions in most of these key pollutants (Table 7.6).

Table 7.6: Typical Domestic Effluent Quality Ranges – on-site treatment options

	Treatment	BOD	TSS	NH_4	NO_3	TN	PO_4	CFU/100ml
	Raw Wastewater	250-300	100-400	varies	<1	varies	10-30	10^6-10^{10}
Traditional ST	Poor Operation	170-250	80-110	40-60	<1		10-20	10^6-10^{10}
	Good Operation	120-150	50-70	20-30	<1	40-100	7-20	10^5
	Two stage (in services)	70-120	40-60					
Modern Septic Tanks	ST with outlet filter	70-120	30			40-100	7	
	St with sand filter	<10	<10		20-25	25-40	<1-10	$4x10^2$ - $4x10^3$
	ST with recirculating sand filter	<10	2-6	2-4	30	15-40	5-15	102-10^4
	ST with recirculating textile filter	<15	15	0-5	30	30-60		10^3-10^4
Activated sludge aerobic wastewater treatment plant		20-50	20-100	<1	35	20-60	4-10	$3x10^3$

Source: Auckland Regional Council TP58 (2004), Table 7.1

The bottom three options represent appropriate ways to achieve significant reductions in domestic pollutants. In terms of cost they range between $14,000 - $16,000 plus GST. to install. These figures are based on discussion with installation companies in Auckland and represent averages. Final total costs faced by households, will vary based on soil profiles and other site specific characteristics.

Assuming a household would borrow to fund the installation, they could expect to pay between $1,150 and $1,320 annually over 25 years at 6.5% real interest rate. This equates to between $28,700 and $31,700 in total with a NPV (at 6% in real terms) of between $14,400 and $16,565.

7.4 Conclusions

The analysis suggest that the improving the Winton's wastewater quality will require an investment that is equivalent to $524-$779 per rateable unit before dropping to $423-$645 by 2031. This includes funding and operating the WWTP. This will be a large increase in the rates burden faced by households in the Winton area. The financial impact on households will need to be considered against the level of service and improvement in water quality.

With reference to the Alliance meat works at Lorneville, this operation will need to undertake substantial investment to meet higher quality standards. It is estimated that some $20m - $22m will need to be invested. Further, the operating costs would be five times greater than current levels. This is a substantial cost increase without any related increase in output that could be used to recover the investment.

With reference to the household WWTPs, the cost of improving septic tanks across the entire Invercargill City area would by around $16,565 per household with an on-site wastewater system (NPV at 6% over 25 years). This is equal to around $1,320 per year per household. Site specific characteristics could well change this amount.

8 Conclusions and Study Limitations

8.1 Key Conclusions

Should the government impose water quality and quantity limits it will have a wide range of effects on municipal and industrial water uses and the values they derive from water. This report, part of the Economic Impact Joint Venture Studies (EIJVS) Project outlines the range of potential costs the different Southland communities covered by the case studies discussed might face to meet higher water quality standards. Changes assessed include the effects of altered nutrient runoffs from dairy farms across Southland in terms of additional raw water treatment requirements, plus scenarios of pollutant reduction for both municipal wastewater and stormwater systems.

Results are reported on as additional costs per rate payer (either a household or a business). This allows additional costs to be placed into context by referencing them to existing rate charges, and by comparing them to the national level infrastructure expenditure averages (per household) contained in the National Water Values work in Section 4.

The key findings of this report relate to the financial implications of changes or limit setting currently being assessed by central government, to meet higher water quality standards. The costs are likely to be distributed in an uneven manner. Furthermore, the wider implications of investment in additional plant to meet higher standards or the implications of plant closure if standards cannot be met due to high costs have not been explored in this report. Nor does this report definitively answer the question, “What are the costs to a small rural community of meeting higher water quality standards?” This is simply because those standards have not been set and the cost to the community is fully dependent on the difference between the status quo and the higher standards.

The timing of implementation of water quality limits impacts significantly on councils’ ability to afford the infrastructure required to meet any new standards. It is understood that Regional Councils will set the timeframes but it is the territorial authorities who will have to meet these timeframes.

Table 8.1 combines a range of outcomes from all the individual case studies contained in this report. Given the nature of assessment the results are not able to be combined, rather they are presented here together for completeness.

Table 8.1: Summary of Key Financial Impact Results ($2012)

Scenarios	Water Supply	Stormwater ($/hhld, bus.)	Wastewater		
			Winton ($/hhld, bus.)	Alliance Meatworks	On-site Wastewater Systems* ($/hhld, bus.)
Lowest Cost		$ 240	$ 463		
Low - Medium Cost			$ 477	$27,581,000	$14,405
Medium Cost		$ 526	$ 534		
Med - High Cost			$ 666	$41,368,000	$16,462
Highest Cost		$ 1,819	$ 697		
			** For the Invercargill Study Area Only*		
	Note: Alliance Meatworks costs and Septic Tank Costs in NPV terms at 6%				

In summary;

- The effects of setting quality limits on freshwater supply in Invercargill are nil or practically nil. No additional costs are anticipated as a result of the policy changes sought. Most water quality parameters don't overlap with the parameters considered for freshwater quality limit setting. It is therefore expected that setting quality limits on fresh water nationally would be less constraining than drinking water standards already in existence.

- The effects of quality limits on stormwater are likely to be significant. In order to ensure all stormwater in Invercargill complies with higher quality limits, i.e. to reduce the key pollutants (by 50% of Phosphorous, 80% of heavy metals, 80% of hydrocarbons and all solids) it is expected to cost more than $1,800 per ratepayer household per year. This drops to $240 if only stormwater from the industrial area is treated or $526 per year if the industrial and CBD areas are treated. Note that these costs are not divided between key ratepayer groups according to any rate differential that might be used to differentiate between groups in the community based on their propensity to pollute or their ability to pay. Care must also be taken when interpreting these results as they are based on dividing total costs by the area covered by each of the land use categories. Work needs to be done to determine the quantity of pollutants in stormwater, by origin in order to distribute costs more efficiently.

- In Winton, additional wastewater treatment costs increase in relation to the percentage of pollutant removed. The figures presented here are based on combining the costs of the individual pollutant treatment processes (described in Section 8) and allowing for a 25% efficiency saving if individual processes are combined during the construction phase. In reality, the actual system built will be tailored to meet the specific water quality standards at the time. Therefore these figures can be seen as a guide to potential cost structures. The upgrade treatment costs range from between $460 and $700 per household or business annually on average over the next 25 years.

- The costs associated with the upgrade to the Alliance Meatworks wastewater processing facility are large. In total, they are roughly equivalent to 33% of a year's output based on regional averages, or the value added equivalent of 450 meat workers working for a year. Should the upgrade be developed in time to be fully operational by 2017 and meet the current published water quality standards it is expected to cost the company some $41.4 million in NPV (at 6%), terms over the economic lifetime of the upgrade (25 years). If the company is able to stage the development in 2 blocks approximately 5 years apart, the costs would be almost halved ($27.6m in NPV terms). Note the efficacy of a staged approach is not known, and the costs are rough estimates at this stage. Alliance is in the early stages of investigating costs and processes and will need to stay in contact with all interested parties throughout the process.

- The wastewater upgrade for Alliance is required to meet currently published water quality standards, it does not provide Alliance with improvements to operational efficiency that may allow them to recoup these costs.

- It is likely that the future profitability of the plant is less clear given the high costs associated with the changes outlined above. This study has not established whether Alliance can afford the upgrades required to continue operating. This is an area that requires additional study

- On-site wastewater treatment systems are common in Invercargill. They have the potential to be significant contributors to pollutants of freshwater systems if they are poorly maintained, are too close to open water, are highly concentrated in number, or if they are poorly designed for the soil types. However, they are likely to be a minor contributor to overall water quality issues currently due to the small volumes of pollutants involved (on average) over a wide area. The limited data available indicates that some 1,070 systems are pre 1992, a further 414 systems are pre 2000 with the rest being post 2000. To reduce discharges, and thereby help bring freshwater quality up, is likely to cost in total between $14,000 and $16,000 per household (through replacing old systems with modern ones). In doing so the volume of pollutants will drop significantly.

- It is important to note the role soils play in further processing of the wastewater discharges prior to entering the freshwater system. However, it is beyond the scope of this study to quantify this role, as it requires significant and specific scientific investigation. Differences between sites are likely to be large so further investigation is required prior to setting binding policy.

Full results including tables detailing the environmental effects of each set of scenarios are contained in the relevant sections of the report. In a study such as this there are significant limitations imposed by either the scale and scope of assessment and the range of implications that are likely to flow from the imposition of water quality limits. In addition study limitations arise from the position of the study in the development cycle of the water quality limits. As these are not quantified, it is not possible to be definitive in terms of the outcomes. Outlined below are details of the range of limitations to the outcomes of this study.

8.2 Study Limitations

This study is a first step in understanding the effects of freshwater quality limits on municipal and industrial water values. In general, the study is limited by the available data, the time required to prepare this report plus the limited number of other studies in New Zealand that have focused on these issues. The key limitations to this study are;

- In the absence of specified freshwater quality standards, a definitive estimate of the economic impact of improving water quality has not been able to be estimated. Once Government policy is set and the standards determined it will be necessary to repeat aspects of this study to determine the actual effect of those limits on Invercargill and Winton or similar communities nationally.
- Where practical, the case studies have been generalised to ensure they have meaning when applied more widely than the actual study area. This means that some specific characteristics of the study areas may not have been taken into account. The effect of this is that the findings must be seen as a general outcome – accurate specific studies of these areas will be needed once actual limits and standards have been set.
- Currently there is no way of identifying for the Winton case study the relative contributions of the commercial, industrial and residential discharges into the municipal wastewater treatment facility. It is a single facility attached to a single reticulation network that does not allow for differentiation of waste streams. This makes modelling meaningful change impossible as it is not possible to isolate these specific discharges.
- In respect of Invercargill's water supply, there are potential reductions in processing costs associated with higher freshwater quality standards. Estimation of the effects of these are beyond the scope of this report, as they will be specific to the standards themselves.
- It is important to note that findings in this report are based on direct water use. This means that water embodied in the goods/services used during production processes of goods consumed locally, is not included in this assessment. The analysis presented in this report captures the direct use of water supplied via the reticulated system only.
- In terms of quantity of water, Invercargill currently losses around 25% to leakage or is unaccounted for. This is more than enough to cater for growth. What is unclear is the costs involved in reducing that leakage relative to sourcing new water supplies (such as Lake Hauroko). These costs are being investigated and once known could inform this study.
- Where possible the most likely solution to treating wastewater and stormwater is to target the key pollutants that have the greatest impact on both the freshwater networks and the Coastal Marine Environments (these being the key nutrients, nitrogens and phosphorous), rather than looking to address every pollutant equally.

It is likely that other treatment system options exist, than covered in this report. This study does not pretend to be exhaustive in terms of the solutions assessed.

- Throughout this report, estimates of cost are based on dividing the total cost stream over time by the numbers of likely rate paying units (households plus businesses). This study assumes all financial and capital costs are funded through loans and paid off through rates. This study takes no account of the wider range of funding options open to local governments including rates differentials, development contributions, grants and others. Utilising a mix of these funding mechanisms is the likely approach councils will take and will have a significant bearing on the figures in Table 1.
- This report takes no account of households ability to pay or any affordability aspects of these modelled changes nor any account of the distributional effects of new charges.
- This report has not identified the potentially positive effects of new investment in infrastructure in Southland that might flow from quality limits in terms of additional construction sector activity.

9 Study Principles and Practical Guidance

The preceding sections outline the process and findings of the study focusing on the potential effects of setting water quality limits in the Southland environment. The results focus on the direct effects of setting quality limits and recognises that there are flow on effects as households reduce spending in other areas in order to fund the changes discussed, that are not captured by the preceding analysis but are none the less, real effects. In this section, practical guidelines and principles that other Councils throughout New Zealand could follow to undertake similar assessments are provided. New Zealand's Councils are diverse in terms of the environments they operate in as well as in their scale and complexity, meaning that not all *principles* derived from the Southland case studies will apply equally. However the *processes* needed to undertake this type of assessment will be largely similar irrespective of the environment, scale and complexity of the Council.

The process and principles are presented below. In addition to the process and principles, a general indication of each principle's 'transferability' or 'applicability' is provided. Importantly, in the following discussion the term 'water' is used in wider sense and, unless specified otherwise, includes the three types of water - wastewater, stormwater and water supplied via a reticulated system.

9.1 Summary of the assessment process

The process of assessing the effects of water quality limits on a region's economy can be summarised as follows;

- Quantify the local economy – households, population, economic output by sector plus any other relevant characteristics (large scale single sources of water pollutants or consumption of water like a large industrial works)
- Quantify the economic outlook – population, household and economic projections to identify the scale and nature of local growth.
- Quantify the water dynamics of the region area – extract from the local authority the resource consent database, identify the quantum of current and future water takes and discharges to water, by type and by sector. This will be based on matching business names or property land use codes[27] with water takes/discharges to economic sectors. It will be necessary to align any monitoring information with resource consents (if practicable) or to sectors at a minimum).
- Quantify the resulting concentrations or stream loadings of each of the key pollutants currently and into the future under the growth scenario described above.

[27] The land use codes used here originate from Quotable Value New Zealand and are in use nationally. They are possibly the only nationally used set of "land use" information, but they are not definitive as they only change when a property is sold – if at all. In this study they have been used as a cross check to business name and ANZSIC Industrial classification.

- Translate water quality standards determined at the national level to concentrations at the stream level locally and identify the degree to which change must occur in order to achieve these standards.
- Based on the target reductions required (assuming they are required), design mitigation measures accordingly – plant scope and scale, stormwater practices, community engagement, land use change. This requires specialist engineering input to identify both the current operational conditions of existing plant plus best practice/best value to address shortfalls and future growth.
- Translate these changes into economic cost streams over time. This takes 2 basic forms; first local authority costs for plant and machinery/land are distributed over time, depreciated and divided between ratepayers. This may involve the use of targeted charges, rates differentials based on ability to pay, development contributions to finance the costs of growth. Each Council will have a slightly different set of mechanisms, controlled by the Local Government Act, that guides them when financing any capital and operational expenditure. The basic approach is to assume all capital costs are debt funded over 25 years (for example) and that during that time council pays back the principal and interest. These annual costs (principal plus interest) are divided among ratepayers, once depreciation is taken into account, to estimate an annual additional charge associated with achieving the water quality limits. This charge is sheeted home to households and businesses.
- The second effect is the changes to economic output as a result of the imposition of quality limits. This effect is difficult to quantify as there are negative effects and positive effects as a result of the required changes. The negative effects include; potentially loss of productive output if limits cause a shift away from high monetary value activities to lower ones, additional costs of doing business if the limits raise rates and /or require a business to invest in on site mitigation measures in order to remain compliant. In addition, households are likely to have less money to spend as rates rise and returns from local businesses reduce. On the positive side, additional investment in infrastructure will more than likely stimulate local employment and there are, potentially flow on effects from the technology employed to attain higher water quality or efficiency of use. In addition, the preservation of the natural environment is likely to have significant positive flow on effects on the region's economy, in terms of preservation of its productive capacity, the preserved high quality environment attracting and retaining investment, population and tourism.
- Attempt to weigh up the costs associated with the imposition of quality standards with the benefits higher water quality brings in order to adjust policy settings accordingly. Water quality limits are likely to be decided upon and set at central government level and local authorities will be required to implement them. Local authorities will need to determine the extent to which the limits impact different sectors of both the local economy and society and set policies to redress inequities accordingly. To do this local councils need to understand (as much as possible) how the changes

9.2 Broad study principles

The above process as applied in Southland has highlighted a number of broad principles that are applicable more widely, by local authorities seeking to understand the effects of water quality and quantity limits. They are grouped as;

- Process principles – relating to how Councils go about assessing the effects of quality standards
- Information principles – what data and information is required and how is it obtained?
- Analysis principles – how do you use the information to determine costs and benefits of the quality limits,
- Cost Allocation and funding principles – what changes are required, how are they funded and how are the costs allocated to whom?
- Compensation principles – do inequities arise as a result of the imposition of water quality standards, what are they and who is disadvantaged?

In the sections that follow the summarised approach used is expanded and key principles that arise are identified and coded according to the above framework.

9.3 Step 1: Local economy

The first task is to establish a firm understanding of the local economy. This requires developing a basic data frame that incorporates population and households as well as businesses and levels of employment at the suburb level across the study area. It may be necessary to divide the study area into urban and rural areas, and it will be necessary to develop a dataset that divides households and businesses into catchments for water supply, wastewater and stormwater in order to analyse current consumption and discharge and to develop appropriate ways to achieve water quality limits into the future.

In practical terms this is most easily achieved through the use of a geographic information system (GIS). A GIS allows the layering of information layers such as water supply and stormwater catchments given that these will not necessarily be the same. It ensures double counting is avoided and mitigation measures are appropriately designed and located.

Use of a GIS allows the spatial relationships to be explored such as the interaction between stormwater outflows and wastewater outflows and areas of significant recreational use or cultural significance (for example).

Once the base situation is established standard projections of growth are required. Household and population projections should be sourced from Statistics NZ and cover a high medium and low future. Economic projections do not have a standard source. It is up to the individual Council to source reliable and robust views of their economic future that align with Councils other planning documents.

1. *PROCESS PRINCIPLE: Establish a robust base situation and a reliable, defendable and transparent outlook of the future.*

9.4 Step 2: Water information gathering

Assessing the implications of shifts in water quality standards and quantity limits requires detailed insights into water usage (by user group and economic sector), usage growth and change, water availability, infrastructure capacity and constraints. This means access to high quality consent and monitoring data from Council. The aim of this step is to provide a full picture of all water related issues classified according to economic sectors, spatial areas/catchments and water user types (e.g. households vs. industry).

Based on the Southland experience, assembling and cleaning this data, mostly held by councils, is time consuming and is a resource intensive process. Linking the resource consent data (consented maximums for water takes and discharges) with actual use data (monitoring data, water use accounts) and discharge data (volumes and nutrient loadings), is difficult and may require modelling based on assumptions.

However, without this linked data it is difficult to carry out the assessment and achieve meaningful outcomes. There will be tradeoffs between 100% accuracy and time/budget to achieve a workable dataset.

Early identification of key data gatekeepers within Council was important so that it was possible to access institutional knowledge of water issues. Appointing a project liaison with responsibilities for ensuring timely access to information and relevant staff was vital in progressing the Southland Case studies.

The following principles have been identified.

2. *PROCESS PRINCIPLE: This type of assessment requires executive level championing and wide cross Council buy in as the process is complex and time consuming.*
3. *INFORMATION PRINCIPLE: Analysis of the implications of changing water standards requires high quality water use (quantity) and water discharge (quality) data. Resource consent data <u>must</u> be linked to users/dischargers either directly (through the detail contained in the monitoring or consent records), or via a modelled process.*
4. *INFORMATION PRINCIPLE: Multiple datasets (spatially explicit economic data such as the business frame along with households) need to be 'integrated' with water networks and water infrastructure networks, so that a true reflection of water issues can be formulated.*

Information gathering on water use and discharges is the most important aspect of assessing the impacts of setting water quality limits. Outlined below are the key steps in this process in more detail.

9.4.1 Water Dataset Development

Councils will have most data but collating this information into a useable structure can be challenging. Following the guidelines outlined below will assist Councils through the process. The requirement is access to Councils resource consent database and its monitoring dataset (including any telemetered data).

The resource consent database is used to estimate the level of water use that is permitted (consented maximum) and the monitoring data is used to gauge actual water use. Both water abstraction and discharge needs to be assessed:

Task 1: Obtain the datasets –

- sourcing copies of the relevant datasets is crucial because without full information it is not possible to undertake the assessment. It is suggested to export the datasets into Excel or Access to enable policy analysts to design custom, area specific, queries (outlined in Task 3).

Task 2: Structure the dataset –

- Once the datasets are in Excel or Access it is possible to manipulate and restructure them into a single file containing all content data (each row should contain a single consent).
- Next, the consent database should be cleaned and coded - this step is complex and time intensive. Cleaning means identifying all water related consents by reviewing consent descriptions and conditions and isolating them from other consents.
- Then, different water consent types need to be clearly identified (ground water, surface water, stormwater, wastewater, water supply) – this will enable an analysis of each water type individually. It is suggested that the data is structured in a way that allows time series analysis so that the trends in consents and actual use can be compared. It is necessary to express all values (consented maximum and actual abstractions and discharges) in a common period (e.g. one year) – for example, some consents reflect seasonal maximums, maximum abstraction/discharge rates and these will need to be translated into consented maximums.
- Next, the consents need to be coded to a specific economic activity (e.g. ANZSIC or SNA sectors). This is done either through analysis of the description of activity associated with the consent or through the land use code for the property the activity resides on. This is a crucial step because reliance on water for economic production can be estimated by comparing economic output and water use (key aim of the analysis). Most Economic Development Agencies have economic profiles showing sector output (GDP or VA) that can be used to identify this metric. Importantly, the year being reported (in the economic profile) should be matched to the consent database. If no economic data is available then sectoral employment (sourced from SNZ's Business Directory) should be used. However this should be seen as an absolute last resort because it will limit subsequent analysis. Coding the

consents to economic sector should be done using the following guiding question: Which economic sector/activity best describes the 'water user'.

Task 3: Run queries to check for inconsistencies and outliers

- The dataset (cleaned and coded) can be reviewed using spread sheet tools such as 'sumifs', 'pivot tables' and statistical measures (percentiles and standard deviations) in order to identify patterns and totals. A focus of the initial assessment should be on identifying any inconsistencies and outliers. This is done by identifying the smallest and largest consents (in terms of quantum). Further, identifying the top (and bottom) 10 per cent of consents (abstractions, discharges, polluters, etc.) and discussing these with the resource consent team for input and verification is important to ensure accuracy.

- In addition, it will be necessary to compare sectoral total (consented maximums and actuals) for any anomalies. Importantly, data limitations may restrict the comparison/analysis of sectoral water use. In some situations it may be advisable to exclude some consents from the analysis. However we recommend allowing for problematic consents to be left in the dataset but with a bespoke 'code' to allow for easy inclusion/exclusion. The analyst will need to carefully document the coding activities so that analysis can be repeated.

Task 4: Analyse water use by sector

- Water use can now be analysed from an economic perspective. Essentially this analysis is concerned with how water is used in the local economy. The core question in this step relates to how much water is being used to produce a given level of output. This sheds light on the direct water use per sector and the water use is expressed as cubic meter water used for every $1m economic output (using GDP or VA). Mathematically this is direct water use divided by GDP (or VA; in $m).

- In more complex analyses, how much water is embodied in the production process can be assessed by linking sectoral water use and regional economic accounts and then deriving economic-ecological multipliers (i.e. water use embodied in economic activity). This step has not been carried out in the case study of Invercargill.

9.5 Step 3: Current situation and context

With the water use and discharge databases established it is possible to develop a picture of the current situation and the values associated with water in the local environment. During this step the database is interrogated to uncover trends and observations - all aspects of water values in the local context are evaluated. This includes a detailed assessment of the relationship between water and economic production based on the direct use of water. It is necessary to estimate how much water each sector uses to produce a unit of output. For example, in the Southland example, million m^3 of water used/$1m of value added was used as the measure of value. Deriving this ratio requires two information pieces:

- Water use by sector (estimated in step 2), and
- Economic production by sector (regional economic development agencies normally have this type of data) and the value added that local production generates. This is based on Step 1, above,

To fully understand the current situation, water use and trends in use need to be viewed in the wider context.

- **Regional and sub-regional interactions** – economic activity crosses administrative boundaries via production and supply chains, meaning that water considerations (e.g. water embodied in goods) can affect multiple Councils and/or regions. The key issue identified is that sectors that might be prevalent in a particular location that have a low direct water use, may in fact 'import' water through their supply chain linkages. In turn, this can mean that local economic growth has water quantity implications for other regions rather than the local region. While these affects are acknowledged in this report, they are not quantified.
- **Dynamic feedbacks** between sectors can play an important role in determining where and how water issues manifest.
- **Receiving environment** – over time the receiving environment changes, reducing its assimilative capacity, changing water use characteristics (and requirements). This changes the productive/processing capacity of the environment leading to a change in production practices. For example, an issue identified in the wider Southland study, was that freshwater quality in the key rivers is not greatly affected by land use and farming management practice changes but that the Coastal Marine Environment is greatly affected. While this is not likely to be specific to Southland, it may not be applicable everywhere else. The key point being that each Council must assess water quality limits and impacts in the context of local environmental factors.
- **Sectoral trends** – sectors grow at different rates and the relationships between sectors are non-linear. This means that over time economic structure within a district changes. Some sectors will expand faster than others leading to different water requirements. This implies that growth in direct water demand can be coupled to economic growth or show signs of decoupling (in total). It is necessary to identify and understand the sectoral drivers of growth and how recent economic shifts have changed demand for water (especially in relation to water infrastructure).
- **Special requirements** – some sectors or specific activities could have national significance and have 'special requirements'. For example, the Manapouri Hydro-electricity scheme has a large water take (in effect, this means that the Tiwai Aluminium Smelter has a large water take) affecting the ability of the community to allocate this water resource to other users.
- **Important firms and sectors** – in some instances a single large firm/entity or a small group of activities can account for a large (disproportionate) share of demand for water resources/discharges. It is important to understand both the implications of

change to the operating environments these entities operate within as well as the current technologies used in the sector and the implications of change.

- **Water capacity** – current capacity and constraints as well as operating features (e.g. leakage rates) of water infrastructure (stormwater, wastewater and water supply system) need to be investigated. Identified future growth and change to the network that alters available water capacity must be acknowledged and incorporated.

The resulting context can be described from different angles or perspectives. An economic development perspective and an environmental perspective will present the same issue differently. For example low water levels may require water saving measures and cut backs in production. From an economic perspective the issue is related to lower economic production or production being constrained by a lack of water. A potential response to this could be to allow additional water abstraction (thereby lowering stream levels even further). From an environmental perspective, the issue could be excessive stream depletion requiring and a response that reduces water takes. Assessing the current situation will require analysis from multiple perspectives (e.g. the four well-beings).

5. *INFORMATION PRINCIPLE: Water is a complex system with internal and cross border interdependencies. Understanding these complexities, feedbacks and the system as a whole is vital to understanding the true effects of quality limits. (applicable to all areas)*
6. *ANALYSIS PRINCIPLE: The perspective from which the analysis is undertaken influences the nature of the findings. It is suggested to use a balanced economic-environmental perspective. A Multi-Criteria analysis or a Cost Benefit approach are the most appropriate methods of assessment*

9.6 Step 4: Baseline future & alternative technologies

The starting point for understanding the medium term implications of current economic and population trends continuing is to define a business as usual future (BAU Future) and to estimate future water requirements. The BAU future is built-up of estimates of sectoral and domestic final demand driven by medium series population projections along with national level estimates of export performance by sector and gross fixed capital formation by sector. The BAU Future shows the level of economic production that would be needed to meet future demand. In the Southland study, we developed a BAU future at the Southland level then estimated the Invercargill proportion of the Southland total driven by Invercargill's share of growth and current sector representation, then estimated:

- Gross output, crudely equivalent to total sales/costs, per sector over time (to 2031)
- Gross Domestic Product or Value Added again by sector over time (to 2031)

- Employment (Employee counts, Modified Employee Counts[28]; by sector over time (to 2031)

Future water requirements are estimated by using the water use ratios (derived in Step 3) including adjustments for eco-efficiencies and combining it with the BAU Future for the study area.

The BAU Future and the resulting future water requirements will shed light on the implications for the wider economy of water quality and quantity limits. Where the economy is dominated by a few large sectors it will be necessary to focus on that sector and assess the investment requirements and implications on that sector in particular as a result of water limits. Similarly, where a small number of firms account for a large share of total water resource demand (e.g. discharge or take) it will be necessary to investigate further.

7. *ANALYSIS PPRINCIPLE: Pure economic and population projections tend to exclude environmental externalities and natural thresholds (and the effects of environmental degradation) are often excluded from such projections. These must be explicitly acknowledged and identified where possible and appropriate.*
8. *ANALYSIS PPRINCIPLE: The environment will constrain future growth so it is important to understand the economy-environment interface i.e. what are the limits/thresholds applicable in the local catchment, how do they relate to the current situation and anticipated future growth and changes?*
9. *ANALYSIS PPRINCIPLE: Technology changes. Traditional methods for addressing water quality limits are not necessarily the same methods to be used in future. Councils need to ensure they adopt the best practice – best value solutions for addressing water quality compliance. Analysis of the implications of setting quality limits needs to assume best practice is adopted and quantify costs and effects accordingly.*

9.7 Step 5: Financial and economic implications

Implementing technology and other solutions to meet the water quality and quantity limits has costs borne by ratepayers and benefits that are potentially unevenly distributed. This raises the question of 'who pays' the costs and who receives the benefits. Councils need to be aware of the implications of their funding decisions in relation to the Resource Management Act and the Local Government Act when determining charges.

The funding for infrastructure development can come from different sources including:

- Existing and Future Households (via council rates and development contributions)
- Existing and future Private firms (directly and/or via council rates, targeted rates, user charges and so on),

[28] Employee counts are head counts of people working in an industry. A person may, however, be employed in multiple industries and thus be counted twice. Employee counts also ignore working proprietors (which increasingly make up a significant proportion of employment). For this reason we provide a modified employee count which includes working proprietors.

- Central government and other agencies (via grants).

During this step the financial implications of meeting water quality standards are assessed. This is done by linking the solution to a particular funding source. Where the investment will be undertaken by Council, the financial implications on ratepayers are estimated by applying council's Revenue and Financing Policies. This will provide an indication of the financial outcome on a per ratepayer basis and will enable council to express the investment in terms of the 'rate increase needed' to deliver the investment.

With reference to private firms, the required investment will need to be cash, debt or equity funded. From a policy perspective, understanding the overall impacts at a firm-level (e.g. on profitability and financial sustainability) of shifting water standards is important. However, because these type of investments are likely to be 'non-revenue producing projects' normal capital budgeting rules[29] would need to be interpreted with caution. We suggest, using discounted cash flow analysis and NPV assessment to get a sense the scale of the impact and viewing the resulting in the context of expected future trends (e.g. sales of that industry/firm).

10. *ANALYSIS PRINCIPLE: The case studies suggest that the financial implications of the solutions are substantial. This means that a full set of alternatives will need to be identified and assessed against criteria such as ability to pay.*
11. *COST ALLOCATION PRINCIPLE: Distribution of costs and the impacts of infrastructure investment on households is strongly tied to the funding mechanism selected. For example, apportioning costs on a pro-rata basis (as has been undertaken in the case studies on Wastewater and Stormwater to provide a guide as to the scale of the issue) leads to very large scale impacts on residential households who may not be the prime contributors of key pollutants in the waste/stormwater discharges. This means Councils need to consider carefully; funding policies and the tools available, as well as the relationship between ability to pay, the distribution of costs and benefits and the consumption of infrastructure. Council's Revenue and Finance Policies, the LGA and the RMA must be used to guide these decisions.*
12. *COMPENSATION PRINCIPLES: With reference to individual firms, the cost of implementing and operating technology solutions to address issues of water quality limits may be prohibitively expensive and could force marginal firms to close with additional ripple effects through the local economy. Councils need to take a holistic approach to assessing water quality limits and ensure that the economic needs of the community are given due weight in any decision. Are subsidies necessary or desirable?*
13. *COMPENSATION PRINCIPLES: If one business (or sector) dominates a local economy then that economy is exposed to concentration risk. Forcing a substantial cost onto that firm/sector could potentially have a large effect on that local economy. This effect is both direct – in terms of the wages paid, persons employed and indirect, in terms of the numbers of supporting organisations that rely on the business for their sales. Any skew or specific characteristic of the local economy must be taken into account by Council with reference to assessing the impacts of water quality limits. Again, are subsidies necessary or desirable?*

[29] This includes: payback period analysis, discounted payback, NPV, IRR, MIRR and profitability Index.

14. *COST ALLOCATION PRINCIPLE: If projects are funded via council/rates then Councils funding policies will need to clarify how Council sees the investment in terms of the Local Government Act (2002), specifically Section 101 and Section 103. These sections deal with equity issues (i.e. who pays and who benefits), financial management, transparency and accountability.*
15. *PROCESS PRINCIPLE: Introducing the water standards will need to be carefully managed with detailed communication and interaction at multiple points. Council will need to communicate any changes to their funding policies via a 'Special Consultative Process'.*

By following the processes outlined in this section and adhering to the principles identified above in situations when the specifics of the local situation do not allow for exact matching of the process, other councils in New Zealand will be able to assess the implications of water quality limits being set and will be well placed to understand the implications and make decisions on timing, process, funding and compensation.

10 Glossary of Abbreviations

Abbreviation	Meaning
AES	Annual Enterprise Survey
ARC	Auckland Regional Council
BAU	Business as Usual
BOD	Biochemical Oxygen Demand
CAPEX	Capital expenditure
CBD	Central Business District
Cfu/100ml	*colony forming units* per 100 mL
CMA	Coastal Marine Area
CME	Coastal Marine Environments
DIA	Department of Internal Affairs
E.Coli	Escherichia coli
EFM	Economic Futures Model
EIJVS	Economic Impact Joint Venture Studies Project
ES	Environment Southland
GFKF	Gross Fixed Capital Formation
ICC	Invercargill City Council
M.E	Market Economics Limited
MEA	Marginal Economic Analysis
MECs	Modified Employee Counts
MED	Ministry of Economic Development
MfE	Ministry for the Environment
MoH	Ministry of Health
NIWA	National Institute Of Water & Atmospheric Research
NPS	National Policy Statement
NPV	Net Present Value
NZ	New Zealand
NZIER	New Zealand Institute for Economic Research
OPEX	Operating expenditure
RMA	Resource Management Act
SIT	Southland Institute for Technology
SS	Total suspended solids
TA	Territorial Authority
TEV	Total Economic Value
TLA	Territorial Local Authorities
TN	Total Nitrogen

TP	Total Phosphorous
USA	United States of America
VA	Value Added

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Appendices

Appendix 1: Water Supply – Basic information

WATER SUPPLY				
National length of reticulation for water supply (km)				
Auckland	Metropolitan	Provincial	Rural	Total
8,335	17,605	24,350	7,870	49,830
Ratio (remaining life/expected life) for water supply				
	Auckland	Metropolitan	Provincial	Rural
Average	66%	61%	58%	49%
Total annual CAPEX ($'m)				
Auckland	Metropolitan	Provincial	Rural	Total
125	215	135	40	390
Average annual CAPEX ($/household)				
Auckland	Metropolitan	Provincial	Rural	Total
290	250	280	330	265
WASTEWATER				
National length of reticulation for wastewater (km)				
Auckland	Metropolitan	Provincial	Rural	Total
7,220	14,160	8,290	2,300	24,750
Ratio (remaining life/expected life) for wastewater				
	Auckland	Metropolitan	Provincial	Rural
Average	66%	61%	61%	57%
Total annual CAPEX ($'m)				
Auckland	Metropolitan	Provincial	Rural	Total
220	315	150	35	500
Average annual CAPEX ($ per household)				
Auckland	Metropolitan	Provincial	Rural	Total
500	375	310	295	345
OPEX in wastewater Services ($'m)				
Auckland	Metro.	Provincial	Rural	Total
240	505	245	65	815
Average annual OPEX ($/household)				
Auckland	Metro.	Provincial	Rural	Total
545	595	520	510	565
STORMWATER				
Ratio (remaining life/expected life) for stormwater (Average)				
Auckland	Metropolitan	Provincial	Rural	
72%	68%	71%	53%	
Total annual CAPEX ($'m)				
Auckland	Metropolitan	Provincial	Rural	Total
91	193	55	8	256
Average annual CAPEX ($ per household)				
Auckland	Metropolitan	Provincial	Rural	Total
205	225	120	65	175
Total annual OPEX ($'m)				
Auckland	Metropolitan	Provincial	Rural	Total
105	190	70	20	280
Average annual OPEX ($/household)				
Auckland	Metropolitan	Provincial	Rural	Total
245	220	155	145	195

Appendix 2: Potable Water Treatment in the Invercargill Environment

This appendix examines the potential for impact on drinking water treatment of potential changes in agricultural and land use practise in Southland impacting on the Oreti River catchment. A number of scenarios have been modelled (by others), examining change in water quality in the Oreti River.

The city of Invercargill is supplied with drinking water extracted from the Oreti River at Branxholme. This report considers the water quality at Wallacetown on the Oreti River, downstream from Branxholme, predicted by the scenario modelling and the potential for impact on the water treatment plant at Branxholme.

The scope of this report is limited to high level scoping based only on information provided by others for the purposes of this assessment.

CATCHMENT SCENARIOS AND WATER QUALITY MODELLING

Water quality monitoring data from a range of sampling locations across Southland was used (by others) to develop correlations between water quality variables such as phosphorus, nitrogen, bacteria numbers and algal biomass and water physical characteristics such as water clarity, fish and invertebrate numbers.

The water quality monitoring data was used to develop models that could be used to predict water quality variables such as nitrogen and phosphorus in the Oreti River for a range of catchment practise scenarios. The predicted water quality variables for each scenario were then used to estimate the corresponding water physical characteristics such as water clarity from the correlations.

The catchment practice scenarios and the results of the water quality model predictions and subsequent estimated water characteristics are summarised in Table 1 for the sampling location at Wallacetown on the Oreti River.

SCENARIOS

The catchment practice scenarios that have been modelled (by others) are summarised here. The scenarios are based around combinations of different caps on nitrate leaching and phosphorus loss from the land. Sixteen combinations have been modelled involving changes in dairy farm practice and land use.

These have been assembled together into the following 5 basic scenario groupings:

- Scenario 1 and 2 which have no impact on nitrogen leaching or phosphorus loss. These involve no changes in dairy practice or land use.
- Scenarios 3, 5, 6 and 7 which deliver a 5% reduction in nitrogen leaching and 23% reduction in phosphorus loss for no cost impact on the value of agricultural production. These involve some changes in dairy practice and no change in land use.

- Scenarios 4 and 8 which deliver a 19% reduction in nitrogen leaching and 40% reduction in phosphorus loss at a cost of 26% to the value of agricultural production. These involve changes in dairy practice and changes in land use.
- Scenarios 9, 10 and 11 (and 12 TBC) which deliver a 25% reduction in nitrogen leaching and 40% reduction in phosphorus loss for a cost of 27% to the value of agricultural production. These involve changes in land use and further additional changes in dairy practice.
- Scenarios 13, 14, 15 and 16 deliver a 45% reduction in nitrogen leaching and 59% reduction in phosphorus loss for a cost of 81% to the value of agricultural production. These involve a complete change in land use moving away from dairy farming.

The predicted impact on water quality at Wallacetown on the Oreti River is summarised in Table 1.

ORETI RIVER WATER QUALITY AT WALLACETOWN AND DRINKING WATER

Model prediction results were received from Aqualinc Research Ltd[30]. Water clarity (visibility) estimates were received from Covec[31]. These were inspected, interpreted and the apparent water quality at the Wallacetown location (NZReach Identifier 15058642) extracted. These are presented and discussed below.

MODEL PREDICTION RESULTS AT WALLACETOWN

Relevant data from the AquaLinc modelling is shown in Table 1.

Table 1: Model prediction results from AquaLinc

NZ-Reach	Scenario	DRP (mg/l)	TP(mg/l)	NH4N(mg/l)	DIN	NO3N (mg/l)	TN (mg/l)	E. Coli
15058642	Obs	0.006	0.014	0.009	0.75	0.745	0.920	56.5
15058642	A	0.006	0.015	0.010	0.85	0.838	1.035	50.80
15058642	B	0.005	0.013	0.010	0.80	0.789	0.975	38.41
15058642	C	0.005	0.012	0.008	0.70	0.688	0.850	43.76
15058642	D	0.005	0.012	0.008	0.63	0.624	0.771	46.54
15058642	E	0.004	0.010	0.005	0.41	0.409	0.505	46.72

Scenarios A through to E in this table are interpreted here to correspond to the 5 basic scenario groupings described in Section 1, above. However, this should be confirmed as

[30] NIWA_P_N_Ecoli_Analysis_Apr13_v4.xlsx received 26th April 2013

[31] Visibility.xlsx received 26th April 2013

correct. Scenario “Obs” is understood to be the existing water quality at this location on the Oreti River.

The New Zealand Drinking Water Standards provide the following limitations for comparison:

- Table 2.2 - Nitrate short term 50 mg/l as NO3 as a maximum acceptable value
- Table 2.5 – Ammonia 1.5 mg/l as a guideline value, presumed as ammonia (NH3)

Nitrate (NO3N) is given in the table above as N. 50 mg/l as NO3 is approximately 11 mg/l as N. The figures in Aqualinc modelling are less than 1 for all scenarios so do not appear to be of concern for drinking water quality or treatment at this location.

There are limits with respect to nitrite and the sum of the ratios of nitrate and nitrite to their respective maximum acceptable values in the drinking water standards (sum less than 1.0). Dissolved organic nitrogen is given in the table above (DIN). Dissolved organic nitrogen is the sum of ammonia, nitrate and nitrite. The DIN concentrations appear to be marginally greater than the nitrate concentrations. The ammonium (NH4) concentrations given in the table are low which in conjunction with the nitrate concentrations and dissolved organic nitrogen concentrations would suggest no nitrite is present. This in conjunction with the low nitrate concentrations would suggest there is no issue here but this cannot be confirmed.

Ammonium is given in the table (NH4N). The Drinking Water Standards criterion of 1.5 mg/l ammonia (NH3) is approximately 1.6 mg/l as NH4 and 1.2 mg/l as NH4N. The figures in the Aqualinc modelling are all low compared to this.

There are no phosphorus limitations given in the Drinking Water Standards.

It would appear that generally nitrogen and phosphorus concentrations are reduced across scenarios A through to E.

The Drinking Water Standards state a limit of less than 1 *E.coli* per 100 ml. *E.Coli* concentrations at Wallacetown are given in the table as 51 down to 19 across scenarios A through to E. The existing concentration is given as 57. These are presumed to be MPN/100ml. It would appear then that the water quality is improved in this respect by the changing catchment practice. Typical water treatment practice including disinfection should maintain treated water concentrations compliant with the standards.

WATER CLARITY ESTIMATES AT WALLACETOWN

The current water clarity/visibility at this location is given as 1.8m. Scenarios A through to E are presumed to correlate to the 5 basic scenario groupings described elsewhere. It would appear that across these scenarios the clarity of the water is improved from 1.8 to 2.2m. This suggests a marginal reduction in the solids load but this cannot be confirmed or quantified.

Table 2: Water clarity estimates from Covec						
2037 Scenario results (visibility in metres)						
NZ Reach	A	B	C	D	E	Observed
15058642	1.8	1.9	2.0	2.0	2.2	1.8

REQUIREMENTS FOR CHANGES IN WATER TREATMENT

The predicted nitrogen concentrations do not appear to present any issues with respect to drinking water quality and treatment. Phosphorus is not prescribed in the drinking water standards and does not appear to present any issues. Predicted *E.Coli* concentrations do not appear problematic. The estimated water clarity or visibility figures cannot be translated into absolute solids concentrations. However the scenarios appear to improve water clarity from the existing level. Indeed, across the 5 basic scenario groupings, the changing dairy and land practices would appear to improve the water quality in terms of the parameters examined here which may translate to a reduction in load for water treatment. A reduction in load for water treatment may result in a reduction in operating costs for treatment but this cannot be confirmed or quantified.

It should be noted however that the impact of the 5 basic scenario groupings on seasonal or wet weather river water quality is unknown (the model outputs and predictions are understood to represent averages although this should be confirmed with Aqualinc and Covec). However, the estimates of water clarity all show no deterioration from existing conditions. In the absence of other data it could therefore be inferred that there would be no changes in peak or wet weather water quality conditions that may have an impact on the operation of the water treatment processes that may result in additional operating cost or the need for additional capital works and treatment plant capacity from those required at present. We note that Invercargill City Council is proposing improvements to their water treatment processes to better deal with high water turbidity events – the costs of these improvements can be considered as within the existing requirements for water treatment, and have therefore not been considered in the costs associated with the scenarios for future raw water quality in the Oreti River.

It can therefore be considered that there are no likely requirements for changes to the water treatment system and to the costs of water treatment associated with any of the predicted changes in future water quality other than those currently envisaged.

CAPITAL AND OPERATION COSTS FOR WATER TREATMENT

Information on existing water treatment costs in Invercargill was requested. Operating costs and volumetric throughput for the treatment plant at Branxholme for the years 2010/11 and 2011/12 were received are summarised in the table below for reference:

	10/11 year	11/12 year
Costs		
Lab Testing	$70,446	$72,000
Chemicals	$380,157	$288,578
Electricity	$192,813	$185,410
Maintenance	$317,578	$321,962
miscellaneous	$65,758	$54,379
Wages etc.	$177,466	$185,918
Total	$1,204,218	$1,108,246
Chemical Breakdown		
Alum	$203,380	$171,923
Lime	$38,628	$40,353
Polyelectrolyte	$12,280	$11,880
Chlorine	$41,659	$61,170
Activated Carbon & miscellaneous	$84,211	$3,251
Total	$380,157	$288,578
Water Volumes (cubic metres)		
Total abstraction (Plant Input)	9,023,757	9,000,123
Treated water output (Plant output)	8,548,998	8,626,875

Note: Activated Carbon amount for 2010/11 year represents total consignment purchased which lasted more than 1 year. As such actual cost of carbon consumed is not accurately shown.

The Invercargill City Council Annual Plan provides for operating costs for water supply of $5.4 million in the year April 2012 to March 2013. This figure encompasses both the water treatment and distribution systems. This figure is anticipated to rise (in the LTCCP) to reach some $7.5m in 2021.

Capital costs appear to be associated with periodic upgrades to the system, with $8.9m in the 2013 year listed in the LTCCP. This declines to a little over $1m in 2018 but a figure of $10.2m is recorded for 2021.

No additional capital cost for water treatment and no increase in operating costs for water treatment seem likely as a result of the changes to water quality covered by the scenario modelling results described above, based on the information provided.

RISKS AND LIMITATIONS

The following key risks and limitations have been identified in the analysis presented above.

- Water quality has been examined at Wallacetown on the Oreti River, no other locations have been examined.
- The information received from Aqualinc and Covec has been interpreted to MWH best ability but should be confirmed with these organisations as correct.
- No other water quality parameters have been considered or examined than described here.
- The validity and accuracy of the models, their predictions and estimates of water characteristics prepared by others cannot be attested.
- The impact of the catchment scenarios on potential peak or wet weather condition water quality in the Oreti River is unknown and has not been assessed, but has been assumed to result in no change to the current conditions for the purposes of this assessment.
- The capacity and performance of the existing assets at the Branxholme water treatment plant have not been assessed.

Appendix 3: Wastewater Treatment in the Winton Environment (MWH)

INTRODUCTION

This short report provides capital and operating cost estimates to upgrade a 'typical' Wastewater Treatment Plant (WWTP) from its existing treatment system to improve the quality of treated wastewater discharged across a range of contaminants. This assessment is based on concepts for the township of Winton in Southland, but modified to be more generally applicable to other townships of a similar size, character and locality (i.e. relatively small rural communities in Southland).

The receiving environment ultimately determines the quality of treated wastewater from any WWTP. Typically a greater level of treatment is required for discharges to fresh water than for discharges to land. However, regardless of the discharge location, factors such as receiving environment qualities and standards, available dilution and downstream users need to be considered.

A range of typical receiving environment 'scenarios' have not yet been identified for this project. In the absence of these 'scenarios', MWH has identified and assessed suitable treatment options reduce the concentrations of four key contaminants:

- Ammonia Nitrogen (NH3-N),
- Total Nitrogen (TN) ,
- Total Phosphorous (TP), and
- Pathogens, represented by the bacterial indicator micro-organism of Escherichia coli (E.coli).

Notwithstanding that the assessment is targeted at the above four key contaminants, the expected treated wastewater quality was also assessed for the following additional contaminants in order to provide a comprehensive view of the impact of the improved treatment processes on the quality of treated wastewater discharged:

- Nitrate Nitrogen (NO3-N),
- Organic Nitrogen,
- Dissolved Inorganic Nitrogen (DIN)
- Dissolved Reactive Phosphorus (DRP),
- Carbonaceous Biochemical Oxygen Demand, 5 day test (cBOD5),
- Total Suspended Solids (TSS),

For any WWTP requiring an upgrade, there will be a range of technically feasible treatment options to reduce one or more of the four contaminants of concern (and other contaminants if required). The feasible options are dependent on the quality and quantity of the raw wastewater, the existing WWTP, site constraints, and the receiving environment. To provide a perspective on upgrade costs, only one treatment option has been considered for upgrading a ‘typical’ WWTP to reduce each of the four contaminants.

For the purpose of this report, the ‘typical’ WWTP is assumed to:

- Service a community of approximately 2,000 people (e.g. of a similar size to Winton and Mataura)
- Treat wastewater of a ‘domestic’ quality (i.e. no significant contaminant input from industry)
- Currently consist of an oxidation pond, with 28 days detention time at average daily flow, with a direct discharge to a river.

Each option presented is considered to provide a conservative capital cost estimate for a realistic, robust, reasonably low-technology solution for upgrading the ‘typical’ WWTP for a small community. The type of treatment option and associated cost may vary for smaller or larger populations, WWTPs with different existing treatment processes, and site-specific receiving environment requirements.

The indicative capital and operating costs provided are for the add-on process/component and exclude planning work, feasibility investigations, gaining resource consents and other approvals, insurance, rates, existing operating costs, and GST.

SCOPE

The scope is limited to high level scoping and indicative cost estimates for upgrades to an existing oxidation pond based WWTP to achieve varying discharge quality for the four key contaminants noted above under summer conditions.

ASSUMPTIONS

CONCEPT DESIGN BASIS FOR SIZING PROCESS UNITS

A design population of 3,000 Population Equivalents (PE) was used. This design population is based on an existing population of 2,000 to 2,500 people with some allowance for population growth or an industry to make up the design population of 3,000 PE based on typical domestic sewage volumes and contaminant concentrations.

Note that Winton has a very high peak wet weather flow because of the aging condition of the reticulation there. This is not typical of sewerage systems in New Zealand townships and was not considered. Instead peak flows were assumed to be buffered by the oxidation pond storage.

RAW WASTEWATER

For sizing of process units upstream of the pond, design raw wastewater loads were based on per capita contaminant loads associated with typical domestic raw wastewater in New Zealand. The assumptions on the characteristics of the raw wastewater are set out in Table 1.

Table 1: Design Raw Wastewater Loads and Contaminant Concentrations

Parameter	Per Person Rate	Design Load	Design Concentration
Population	n/a	3,000 PE	n/a
Average Daily Flow	0.250 l/p/d	750 m3/d	n/a
BOD	0.065 kg/p/d	195 kg/d	260 g/m3
TSS	0.070 kg/p/d	210 kg/d	280 g/m3
TN	0.012 kg-N/p/d	36 kg/d	48 g-N/m3
TP	0.002 kg-P/p/d	6 kg/d	8 g-P/m3

TREATED WASTEWATER FROM OXIDATION POND

For sizing of process units downstream of the oxidation pond, the design oxidation pond treated wastewater quality has been estimated based on monitoring results from Winton WWTP, national surveys by Davis-Colley et al (1995) and Hickey et al (1989), and making some allowances for conservative design. The performance of the oxidation pond depicted in Table 2 is based on typical summer conditions which coincide with the most stringent treated wastewater quality requirements due to low river/stream flows into which the oxidation pond treated wastewater is discharged.

Table 2: Design Oxidation Pond Treated Wastewater Concentrations (Summer)

Contaminant	Design Concentration (Summer)
BOD	50 g/m3
TSS	110 g/m3
TN	43 g-N/m3
NH3-N	32 g-N/m3
TP	5.5 g-P/m3
DRP	5.0 g-P/m3
E.coli	10,000 cfu/100ml

ADD-ON TREATMENT PROCESS UNITS

Add-on treatment process units have been selected to provide a realistic, robust, and reasonably low-tech solution for upgrading the ‘typical’ WWTP for a small community. The add-on treatment process units were selected as most suitable to target one of the key contaminants NH3-N, TN, TP, or E.coli. However, individual units may also reduce other contaminants e.g. BOD, TSS. Multiple key contaminants can be reduced by using a combination of add-on process units. The add-on units have been sized for summer temperatures when treated wastewater quality requirements are the most stringent due to low river/stream flows. This results in smaller treatment process units as reaction rates in biological process units reduce with declining temperature. The add-on treatment process units considered and the key contaminants that they are most effective at reducing are:

- Upstream of the existing pond:
    - Trickling filter (TF) – total nitrogen reduction
- Downstream of the existing pond:
    - Nitrifying Trickling Filter (NTF) – ammonia reduction
    - Moving Bed Biofilm Reactor (MBBR) – nitrate reduction, total nitrogen reduction in combination with nitrifying trickling filter
    - Clarifier and chemical dosing –dissolved reactive phosphorous and total phosphorous reduction
    - Ultra Violet (UV) Disinfection – pathogen reduction (represented by E.coli)

These processes are summarised in Table 3.

Table 3: Add-on Treatment Process Units

Add-on Treatment Process Unit	Target Contaminant	Process Description
Trickling Filter (TF)	TN (by biological reactions)	A plastic media TF treating the raw wastewater. NH_3-N and NO_3-N are reduced in the TF by microorganisms that grow on the media. A recycle returns TF treated wastewater rich in nitrate back onto the TF for denitrification (BOD in the raw wastewater provides a carbon source for denitrification). Nitrogen uptake into algal biomass further reduces ammonia and nitrate prior to discharge. The level of TN reduction is controlled by the recycle rate around the TF.
Nitrifying Trickling Filter (NTF)	NH_3-N (by biological reactions)	A plastic media TF treating oxidation pond treated wastewater. Soluble BOD is reduced in the pond, so NTF is sized for ammonia reduction only. Microorganisms that grow on the media provide the treatment.
Moving Bed Bioreactor (MBBR)	TN in combination with nitrifying trickling filter (by biological reactions)	MBBR treats the NTF treated wastewater and reduces nitrate, thereby providing TN reduction. MBBR comprises a fully mixed reactor with suspended plastic media carriers. Microorganisms that grow on the media provide the treatment. An external carbon source (e.g. ethanol) must be provided to support denitrification
Clarifier & Chemical Dosing	DRP, TP (by chemical reaction)	A circular clarifier with chemical (Alum) dosing. The Alum forms a precipitate with DRP in the wastewater, thereby removing it. Chemical sludge is collected in the bottom of the clarifier and pumped to sludge storage.
Ultra Violet (UV) Disinfection	Pathogens (E.coli) (by UV light)	The UV system comprises UV lamps in an open channel. The UV light kills pathogens. Solids removal can be used to improve the oxidation pond treated wastewater quality and reduce the UV system size.

It should be noted that there are limits to the effectiveness of the technology available in removing the individual contaminants, and the concentrations of contaminants cannot be reduced beyond these limits.

Table 6 on the final page summarises the indicative capital and operating costs for a range of treated wastewater qualities using the add-on treatment process units above.

INDICATIVE COST ESTIMATES

BASIS OF INDICATIVE CAPITAL COST ESTIMATES

The indicative capital and operating costs provided are for the add-on treatment process units and exclude planning work, feasibility investigations, gaining resource consents and other approvals, insurance, rates, existing operating costs, and GST.

Indicative capital cost estimates have been compiled to estimate the cost to upgrade an oxidation pond based WWTP to improve the treated wastewater quality. The estimates are based, as far as possible, on tender or construction prices for similar process units at various sites within New Zealand. Where tender and construction data was not available, budget cost estimates from suppliers have been used as a basis.

An allowance for costs of land acquisition were included. All the treatment processes have only a small site area so purchase costs for 1 hectare as a minimum assumed land parcel were included.

Sums were included in the indicative capital cost estimate to account for costs for unidentified items, design and construction supervision, and contingency as a percentage of the base construction cost. Table 4 summarises the percentages used for this and the components making up the total estimated capital cost.

Table 4: Percentages Used for Capital Cost Estimates

Component	Percentage
Scheduled Items	$
Unidentified Items	*10%*
Total Construction	$
Preliminary and General	*7%*
Design & Supervision	20%
Subtotal	*$*
Price Contingency	5%
Physical Contingency	*20%*
Total Cost	$

BASIS OF INDICATIVE OPERATING AND MAINTENANCE COST ESTIMATES

The indicative operating and maintenance costs are estimated as costs in addition to the typical operating and maintenance costs of a small oxidation pond based WWTP. That is no allowance has been made for operation, maintenance or depreciation costs associated with the existing oxidation pond based WWTP.

The WWTP is assumed to operate 365 days per year. If enhanced nitrogen or phosphorous reduction is required, operating costs associated with these add-on treatment processes could be reduced by operating these processes on a seasonal basis.

Removal of additional sludge from chemical dosing is included as an annualised cost.

Table 5 below summaries the rates for the main inputs used in estimated operating costs for the add-on treatment process units. No allowance has been made for depreciation, insurance, or rates.

Table 5: Rates for Operating and Maintenance Cost Estimates

Component	Rate
Labour	$50/h
Overall pump efficiency	60%
Electrical	$0.20/kWh
Maintenance	Mechanical and Electrical: 4% of capital cost
Civil: 0.5% of capital cost	
Chemical sludge removal	$600/tonne dry solids

INDICATIVE COST ESTIMATES

Table 6 provides the indicative capital and operating costs and the expected treated wastewater qualities for each of the add-on treatment processes considered.

Table 6: Indicative Cost Estimates for WWTP Upgrades to Achieve Varying Treated Wastewater Quality for Four Key Contaminants

Additional Works	Typical Removal of Target Contaminant	Water Quality										Capital Cost	Capital Cost	Operating Cost
		BOD (mg/L)	TSS (mg/L)	NH_3-N (mgN/L)	NO_3-N (mgN/L)	DIN (mgN/L)	OrgN (mgN/L)	TN (mgN/L)	DRP (mgP/L)	TP (mgP/L)	*E.Coli* (*cfu/100mL*)	$ Million OLD	$ Million	$/year
None - Status Quo	n/a	50	110	32	0	32	11	43	5.0	5.5	10,000	n/a	n/a	n/a
Nitrifying Filter downstream of Pond (sized for 25% NH3N removal)	25%	50	110	24	8	32	11	43	5.0	5.5	10,000	$ 0.8	$ 1.0	$ 52,000
Nitrifying Filter downstream of Pond (sized for 50% NH3N removal)	50%	50	110	16	16	32	11	43	5.0	5.5	10,000	$ 0.9	$ 1.1	$ 53,000
Nitrifying Filter downstream of Pond (sized for 75% NH3N removal)	75%	50	110	8	24	32	11	43	5.0	5.5	10,000	$ 1.0	$ 1.2	$ 55,000
Nitrifying Filter downstream of Pond (sized for 90% NH3N removal)	90%	50	110	3	29	32	11	43	5.0	5.5	10,000	$ 1.0	$ 1.3	$ 56,000
TF upstream of Pond: treating 50% of influent flow, recirculation 1:1	48%	50	110	8	8	16	11	27	5.0	5.5	10,000	$ 1.7	$ 2.1	$ 61,000
TF upstream of Pond: treating 50% of influent flow, recirculation 3:1	54%	50	110	8	4	12	11	23	5.0	5.5	10,000	$ 1.7	$ 2.1	$ 64,000
TF upstream of Pond: treating 50% of influent flow, recirculation 5:1	54%	50	110	8	3	11	11	22	5.0	5.5	10,000	$ 1.7	$ 2.1	$ 66,000
TF upstream of Pond: treating 100% of influent flow, recirculation 1:1	63%	50	110	<3	5	<7	11	18	5.0	5.5	5,000	$ 1.7	$ 2.1	$ 64,000
TF upstream of Pond: treating 100% of influent flow, recirculation 2:1	74%	50	110	<3	3	<5	11	<16	5.0	5.5	5,000	$ 1.7	$ 2.1	$ 66,000
TF upstream of Pond: treating 100% of influent flow, recirculation 5:1	78%	50	110	<3	<2	<5	11	<15	5.0	5.5	5,000	$ 1.7	$ 2.1	$ 73,000
TF upstream of Pond: treating 100% of influent flow, recirculation 5:1 + Clarifier and Alum Dosing downstream of pond	90%	20	20	<3	<2	<5	2	<5	2.5	3.0	4,000	$ 2.6	$ 3.1	$ 151,400
Nitrifying Filter (75% NH3N removal) + Denitrifying MBBR downstream of pond	53%	50	110	8	1.0	9	11	20	5.0	5.5	5,000	$ 1.6	$ 1.9	$ 117,000
Nitrifying Filter (90% NH3N removal) + Denitrifying MBBR downstream of pond	65%	50	110	3	1.0	4	11	15	5.0	5.5	5,000	$ 1.7	$ 2.1	$ 127,000
Nitrifying Filter (75% NH3N removal) + Denitrifying MBBR downstream of pond + Disk Filter	72%	20	40	8	1.0	9	3	12	5.0	5.5	5,000	$ 2.0	$ 2.5	$ 117,000
Nitrifying Filter (90% NH3N removal) + Denitrifying MBBR downstream of pond + Disk Filter	84%	20	40	3	1.0	4	3	7	5.0	5.5	5,000	$ 2.2	$ 2.6	$ 127,000
Clarifier and Alum dosing	50%	20	20	32	0	32	2	34	2.5	3.0	5,000	$ 0.9	$ 1.1	$ 78,400
Clarifier and Alum dosing	75%	20	20	32	0	32	2	34	1.3	1.8	5,000	$ 0.9	$ 1.1	$ 106,200
Clarifier and Alum dosing	90%	20	20	32	0	32	2	34	0.5	1.0	5,000	$ 0.9	$ 1.1	$ 131,200
UV Disinfection	95%	50	110	32	0	32	11	43	5.0	5.5	<500	$ 0.4	$ 0.6	$ 18,000
Clarifier+Alum dosing + UV Disinfection	98%	20	20	32	0	32	2	34	2.5	3.0	<200	$ 1.2	$ 1.4	$ 87,400

Note: The treated wastewater quality for the targeted contaminant is highlighted in orange

Table 7: Indicative Breakdown of Capital Cost Estimates for WWTP Upgrades to Achieve Varying Treated Wastewater Quality for Four Key Contaminants

Target Contaminant	Additional Works	Typical Removal of Target Contaminant	Scheduled Items	Unidentified Items	Total Construction Cost	Preliminary & General	Design & Supervision	Sub-total	Price Contingency	Physical Contingency	Total Cost	Land Cost	Total
Ammonia	Nitrifying Filter downstream of Pond (sized for 25% NH3N removal)	25%	$ 520,000	$ 60,000	$ 580,000	$ 50,000	$ 110,000	$ 740,000	$ 40,000	$ 150,000	$ 930,000	$ 40,000	$ 970,000
Ammonia	Nitrifying Filter downstream of Pond (sized for 50% NH3N removal)	50%	$ 590,000	$ 60,000	$ 650,000	$ 50,000	$ 130,000	$ 830,000	$ 50,000	$ 160,000	$ 1,040,000	$ 40,000	$ 1,080,000
Ammonia	Nitrifying Filter downstream of Pond (sized for 75% NH3N removal)	75%	$ 650,000	$ 70,000	$ 720,000	$ 60,000	$ 140,000	$ 920,000	$ 50,000	$ 180,000	$ 1,150,000	$ 40,000	$ 1,190,000
Ammonia	Nitrifying Filter downstream of Pond (sized for 90% NH3N removal)	90%	$ 680,000	$ 70,000	$ 750,000	$ 60,000	$ 150,000	$ 960,000	$ 50,000	$ 190,000	$ 1,200,000	$ 40,000	$ 1,240,000
TN	TF upstream of Pond: treating 50% of influent flow, recirculation 1:1	48%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 50% of influent flow, recirculation 3:1	54%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 50% of influent flow, recirculation 5:1	54%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 100% of influent flow, recirculation 1:1	63%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 100% of influent flow, recirculation 2:1	74%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 100% of influent flow, recirculation 5:1	78%	$ 1,140,000	$ 120,000	$ 1,260,000	$ 90,000	$ 260,000	$ 1,610,000	$ 90,000	$ 320,000	$ 2,020,000	$ 40,000	$ 2,060,000
TN	TF upstream of Pond: treating 100% of influent flow, recirculation 5:1 + Clarifier and Alum Dosing downstream of pond	90%	$ 1,730,000	$ 180,000	$ 1,910,000	$ 140,000	$ 380,000	$ 2,430,000	$ 130,000	$ 480,000	$ 3,040,000	$ 40,000	$ 3,080,000
TN	Nitrifying Filter (75% NH3N removal) + Denitrifying MBBR downstream of pond	53%	$ 1,050,000	$ 110,000	$ 1,160,000	$ 90,000	$ 230,000	$ 1,480,000	$ 80,000	$ 290,000	$ 1,850,000	$ 40,000	$ 1,890,000
TN	Nitrifying Filter (90% NH3N removal) + Denitrifying MBBR downstream of pond	65%	$ 1,120,000	$ 120,000	$ 1,240,000	$ 90,000	$ 250,000	$ 1,580,000	$ 80,000	$ 320,000	$ 1,980,000	$ 40,000	$ 2,020,000
TN	Nitrifying Filter (75% NH3N removal) + Denitrifying MBBR downstream of pond + Disk Filter	72%	$ 1,350,000	$ 140,000	$ 1,490,000	$ 110,000	$ 300,000	$ 1,900,000	$ 100,000	$ 380,000	$ 2,380,000	$ 40,000	$ 2,420,000
TN	Nitrifying Filter (90% NH3N removal) + Denitrifying MBBR downstream of pond + Disk Filter	84%	$ 1,420,000	$ 150,000	$ 1,570,000	$ 110,000	$ 320,000	$ 2,000,000	$ 100,000	$ 400,000	$ 2,500,000	$ 40,000	$ 2,540,000
TP	Clarifier and Alum dosing	50%	$ 590,000	$ 60,000	$ 650,000	$ 50,000	$ 130,000	$ 830,000	$ 50,000	$ 160,000	$ 1,040,000	$ 40,000	$ 1,080,000
TP	Clarifier and Alum dosing	75%	$ 590,000	$ 60,000	$ 650,000	$ 50,000	$ 130,000	$ 830,000	$ 50,000	$ 160,000	$ 1,040,000	$ 40,000	$ 1,080,000
TP	Clarifier and Alum dosing	90%	$ 590,000	$ 60,000	$ 650,000	$ 50,000	$ 130,000	$ 830,000	$ 50,000	$ 160,000	$ 1,040,000	$ 40,000	$ 1,080,000
E.coli	UV Disinfection	95%	$ 273,000	$ 37,000	$ 310,000	$ 30,000	$ 60,000	$ 400,000	$ 20,000	$ 80,000	$ 500,000	$ 40,000	$ 540,000
E.coli	Clarifier+Alum dosing + UV Disinfection	98%	$ 768,000	$ 82,000	$ 850,000	$ 60,000	$ 170,000	$ 1,080,000	$ 60,000	$ 210,000	$ 1,350,000	$ 40,000	$ 1,390,000