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Christchurch City Council

Akaroa Water Management Strategy
Part 6: Wastewater Treatment Options

Council Version

February 2008

Quality Assurance Statement	
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Christchurch City Council

Akaroa Water Management Strategy Part 6: Wastewater Treatment Options

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1 Introduction

This report assesses the wastewater treatment and disposal options available for Akaroa. The objectives of this assessment are to identify future demand for wastewater treatment, and to identify options for disposal of treated wastewater and for the treatment plant upgrades required for those disposal routes.

The report presents the methodology used, the existing treatment plant and the expected future requirements for wastewater treatment. Then issues with the current treatment and disposal system are identified before presenting options for alternative disposal routes and treatment plant upgrades to address these issues. Finally the upgrade options are discussed and a course of action recommended.

1.1 Purpose of Report: Study Methodology

The intention of this report is to present practical options for treatment and disposal of wastewater for consultation with stakeholders. After consultation, detailed investigation of the short listed options can be completed.

This report presents the findings of an initial desktop study of the issues and options for wastewater treatment and disposal for Akaroa (there has been no consideration of wastewater from Takamatua at this stage – Takamatua currently has no sewer but could potentially be connected the Akaroa sewer system in the future). The study has been limited to viable options and does not include options that are not considered realistic such as an ocean outfall. No assessment of environmental effects has been done with regard to the treatment upgrade options or the disposal options presented.

The disposal route for the treated wastewater determined the treatment plant upgrades needed to meet the requirements of the receiving environment. Three disposal routes were identified: harbour outfall, land disposal and treated wastewater reuse (for the purposes of this report, treated wastewater reuse refers to public non-potable use within private properties and does not include a council operated land disposal scheme, which is dealt with separately as 'land disposal'). Upgrade options for the treatment plant were developed based on these disposal routes. The upgrade options were developed based on the structure illustrated in Figure 1-1 on the next page. The capacity upgrade is the minimum required and would maintain the current treated wastewater quality. The other upgrade options would incorporate the capacity upgrade and also improve the quality. As discussed in later sections of this report these upgrades can be additive rather than stand alone upgrades (e.g. the capacity upgrade can be combined with the nutrient removal and the microbiological upgrades).

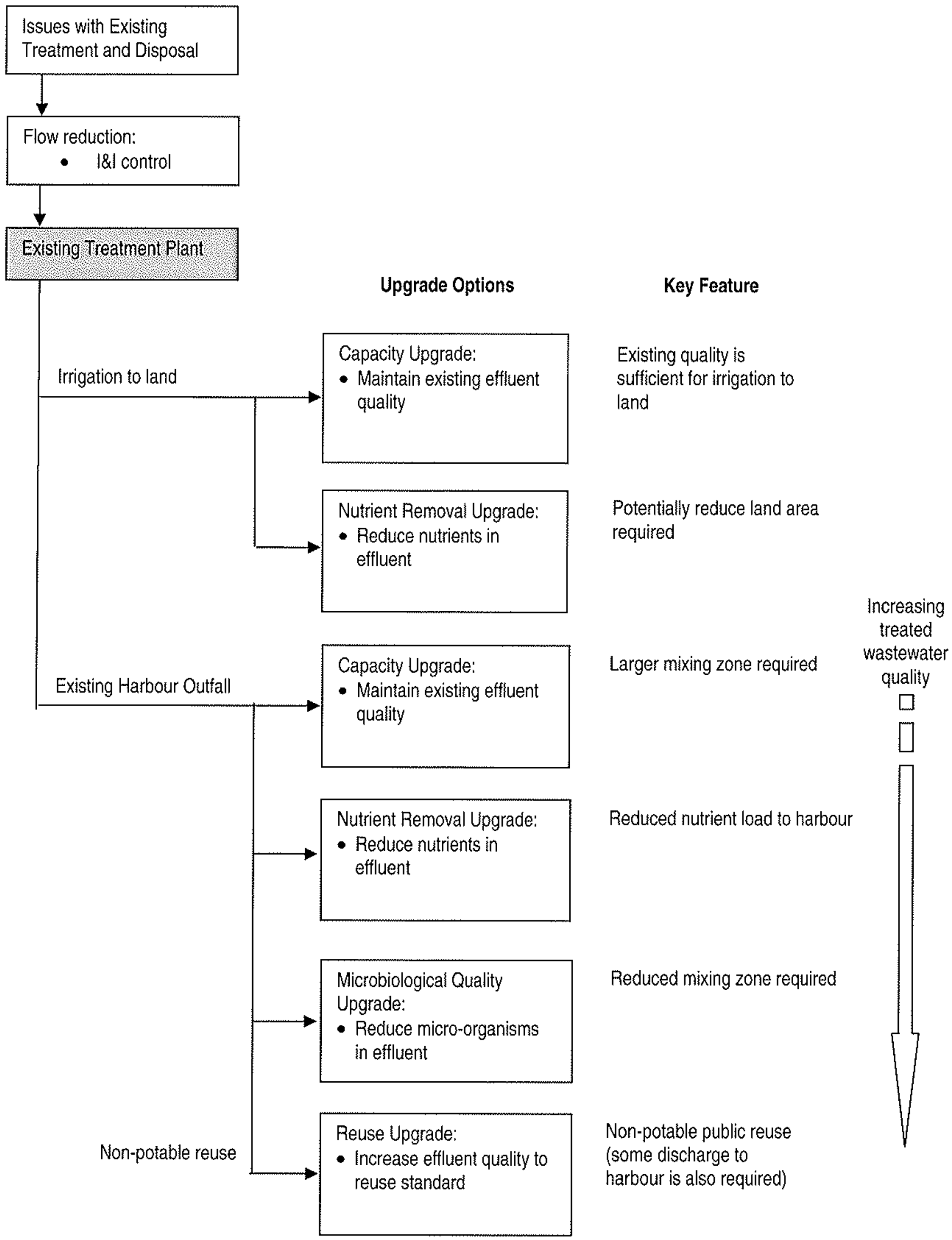


Figure 1-1 : Development of Upgrade Options

2 Existing Wastewater Treatment Plant

The Akaroa wastewater treatment plant (WWTP) was built in the 1960s and then upgraded in 1984 and again in 1998. The treatment plant comprises the following components:

- Inlet screen
- Flow balancing/splitting tank
- Dual Imhoff tanks operated in parallel
- Rock media trickling filter with a hydraulically driven distributor arm
- Secondary clarifier
- UV disinfection system

A site layout plan of the treatment plant is contained in appendix A.

2.1 Process Description

Wastewater from the Akaroa township flows via gravity to three pump stations near the waterfront. They are located at the Recreation Ground at North Akaroa, the Fire Station at Mid Akaroa and the Glen at South Akaroa. The wastewater is then pumped from the pump station at the Glen via a rising main system to the inlet screen located on top end of the flow balancing/splitting tank at the top of the treatment plant site.

The flow of screened wastewater is split between to the two Imhoff tanks in the flow balancing/splitting tank. Suspended solids settle out of the wastewater in the two Imhoff tanks and are stored and anaerobically digested in the bottom compartment.

Settled wastewater from the Imhoff tanks flows to the trickling filter inlet chamber, where it combines with recycled trickling filter effluent. The combined wastewater flows by gravity to the centre of the distributor arm where it is applied to the biological trickling filter (BTF). The wastewater is treated by the biomass attached to the rock media.

Effluent from the BTF drains to the recycle chamber. A submersible pump in the chamber recycles some of the effluent back to the BTF inlet chamber to maintain the minimum required wetting rate of the media. Effluent that is not recycled flows to the secondary clarifier where the solids from the BTF (called humus) is allowed to settle out. The humus is removed from the bottom of the clarifier and pumped to the flow splitting tank where it combines with the screened wastewater and co-settles in the Imhoff tanks with the suspended solids.

Clarified effluent flows from the clarifier to the UV disinfection system, where it flows through a channel with UV lamps. Disinfected effluent then flows by gravity through the outfall pipe into the Akaroa Harbour. During periods of high flow and/or high harbour water level, a booster pump located in a wet well downstream of the UV system is automatically activated.

Treated wastewater is discharged into the Akaroa Harbour via an open-ended 160mm diameter outfall pipe that extends 100m into Redhouse Bay, more or less perpendicular to the shoreline. Treated wastewater normally flows by gravity to the outfall, which is located at a depth of approximately 3.5 metres at low tide and 6 metres at high tide.

3 Future Flows & Loads

This section discusses options for reducing flow and load to the WWTP. The expected future flows and loads including flow reduction options are presented.

3.1 Flow Reduction Options

3.1.1 Inflow & Infiltration

Inflow and infiltration (I/I) refers to storm water and ground water that enters the sewer system during wet weather. Inflow refers to storm water which enters the sewer via illegal connections or through manhole covers. Infiltration refers to infiltration of ground water (the ground water level raises during wet weather due to rainfall) into the sewer system through leaks in the sewer pipes. Christchurch City Council is currently undertaking an I/I control programme to reduce the amount of I/I entering the Akaroa sewer system.

It is apparent that there is a significant I/I problem in Akaroa. Wet weather flow is typically a factor of around 5 times the average dry weather flow (ADWF) while in Akaroa the factor is has been 7 to 20 times (based on recorded discharge volumes since 2000). It is therefore reasonable to assume that an aggressive I/I programme will reduce flows. Results of other I/I programmes within New Zealand have generally resulted in a low reduction, however, if significant I/I is occurring then a target of around 20% reduction may not be too unrealistic. This decrease may need to be offset by any flow that is not currently being recorded.

The design flow rates used for this report have been adjusted for expected I/I reduction.

3.1.2 On-site Greywater Reuse

The term "greywater" applies to all non-toilet domestic wastewater, including wastewater from showers, baths, spas, hand basins, washing machines, laundry tubs, dishwashers and kitchen sinks. A typical on-site greywater reuse system will collect and treat the greywater from an individual house and then store it for reuse. Typical uses include subsurface irrigation of lawns or gardens.

Although on-site greywater reuse may reduce the wastewater volume from individual houses, thus reducing the volume to the WWTP, greywater reuse will only have a small impact on plant design because the maximum flow rate to the plant is dominated by I/I into the sewer system.

On-site greywater reuse would reduce the load to the WWTP because it has a significant load in terms of Biochemical Oxygen Demand (BOD) – up to 45% of the total BOD load (USEPA, 1992), which would affect the design of the secondary treatment system. This reduction could only be reliably achieved if virtually all of the properties connected had a greywater reuse system installed, which would most likely require a bylaw.

In general terms, greywater use can present significant health risks. Either a high level of treatment or careful end use practices are required to limit the public health risks. There are also some other negative implications of on-site greywater reuse:

- Typical residential section sizes in Akaroa do not have sufficient land areas or soil absorption characteristics to support the re-use of greywater under all weather conditions. Therefore either greywater will need to be stored on-site during wet weather/winter periods or be discharged into the sewer system.

- If the soil becomes overloaded from application of greywater then there is potential for odour problems.
- Individual on-site wastewater treatment systems are expensive to install and operate.
- The existence of privately-owned on-site wastewater treatment systems in an area with reticulated services raises significant management issues that could increase the risks to public health in the absence of effective management and monitoring arrangements.

Although on-site greywater reuse systems may have some advantage in reducing the BOD load to the WWTP, it is not recommended because of the public health risks and management issues associated with it. It is safer and more easily and reliably managed if capacity for the full BOD load is installed at the WWTP. For the purposes of this report it is assumed that there is no significant on-site reuse of greywater.

3.2 Design Flows and Loads

The design flows and loads are based on a combination of the 2026 population projection from the 2005 Response Planning Report *Serviced Areas: Population and Visitor Projections* and 2026 to 2041 population projections from the *Greater Christchurch Urban Development Strategy.* Table 3-1 shows the population projection for Akaroa in the design year 2041.

Table 3-1 : Population Projections for Akaroa

		2004		2026		2041	
Population	**ratio to 1 p.e.**	**High Season**	**Maximum**	**High Season**	**Maximum**	**High Season**	**Maximum**
Resident	1.00	650	650	850	850	930	930
Holiday Homes	1.00	1,700	2,200	2,100	2,700	2,290	2,940
Commercial accommodation	1.00	500	800	1,300	1,700	1,420	1,850
Overnight friends	0.60	50	80	130	170	140	190
Day visitors	0.25	1,700	2,500	6,600	9,000	7,190	9,810
Total people		4,600	6,200	11,000	14,400	12,000	15,700
Total p.e.		**3,300**	**4,300**	**6,000**	**7,600**	**6,500**	**8,300**

Notes:

1. p.e. stands for population equivalent equal to 1 resident
2. 2004 to 2026 populations are based on the 2005 Response Planning Report
3. 2026 to 2041 are based on a 9% growth rate as per the Greater Christchurch Urban Development Strategy

The 2041 design flow rates are summarised in Table 3-2 on the next page. The ADWF is based on the projected 2041 maximum population (occurs 1 day/year) and per capita rates for Akaroa, which were derived from recorded daily discharge volumes from the WWTP and population estimates. The per capita rate of 87 L/p/d is very low, probably due to the population estimate being higher than the actual population and the effect of water restrictions in summer. The maximum day flow is based on expected inflow and infiltration during wet weather (including allowance for I/I reduction). The peak hourly flow is expected to remain at the current pumped flow rate to the plant of 60 L/s. A discussion of how these flow rates were derived is contained in appendix B.

The ADWF, maximum day flow and peak hourly flow are important design parameters. They are used to size the various treatment process units and the connections between them. The peak hourly flow is especially important for the hydraulic design of the WWTP to ensure there are no spills of wastewater.

Table 3-2 : 2041 Design Flows

Per capita flow rate	87 L/p/d
ADWF	710 m^3/d
Maximum day flow	3,400 m^3/d
Peak hourly flow (pump capacity)	60 L/s

Expected loads to the WWTP based on 2041 high season population (occurs 45 days/year) of 6,500 population equivalents (p.e.) and typical per capita rates for domestic sewage in New Zealand as shown in Table 3-3 below. These loads are used to design the treatment process.

Table 3-3 : 2041 Design Loads

High Season Loads (45 days/year)	Per Capita Rate (g/p/d)	Daily Load (kg/d)
BOD	60	390
TSS	60	390
TKN	15	100
TP	3	20

There is very little influent data available for wastewater in Akaroa. The concentrations that can be derived from the flows and loads above are very high compared with typical wastewater concentrations because the flows are based on actual measured discharge volumes, while the loads are based on population projections. Characterisation of the influent wastewater is needed for the design of future upgrades to the WWTP.

4 Existing Wastewater Treatment System Issues

This section discusses the technical and cultural issues with the current WWTP, including the disposal of treated wastewater to the harbour, the existing treatment capacity and condition of assets, and the existing site. These issues have directed the development of options for disposal and future upgrades of the WWTP.

4.1 Disposal to Harbour

There are two issues with the existing disposal of treated wastewater to the harbour. One is the cultural concerns of Maori with respect to disposal of human waste into fresh or marine waters without passage through the land. The other is environmental concern of the effects of the discharge on the harbour water quality.

The quality of treated wastewater discharged from the Akaroa WWTP has not complied with the resource consent conditions on occasion, particularly during the summer holiday season when the load to the plant is at its highest. Work to improve the reliability of the treatment processes has resulted in improved quality and reduced the occurrence of non-compliances with the conditions of resource consent.

4.1.1 Existing Resource Consent

The existing discharge consent contains effluent quality standards for suspended solids, Biochemical Oxygen Demand (BOD), and faecal coliforms. These standards are:

- Suspended solids – 30 g/m^3 (median of last five samples),
- BOD – 30 g/m^3 (median of last five samples),
- Faecal coliforms – 1,000 CFU/100ml (median of last five samples).

The consent also requires monitoring of the quality of the effluent prior to discharge, including monitoring of BOD_5, suspended solids, faecal coliforms, nutrients (ammoniacal nitrogen, total nitrogen, dissolved reactive phosphorus) and metals (lead, copper, chromium, arsenic, nickel, mercury, zinc and cadmium) within the treated wastewater prior to discharge. The frequency of the monitoring required varies, with BOD, suspended solids, and faecal coliforms monitored weekly over summer (December to February) and monthly over the rest of the year; nutrients monitored monthly, and metals monitored annually. Faecal coliforms are also monitored in the receiving environment around the outfall, along the shoreline and at the rocky outcrops to the north and south of the outfall.

The application for a new resource consent is currently being processed. The new consent application proposes the same conditions as above but with a change to increase the discharge volume to 3,400 m^3/d to reflect the actual flows of wastewater delivered to the plant. The new consent application also proposes increased monitoring of nutrient concentrations in the receiving environment around the outfall and at a control site. The consent duration desired is five years.

4.1.2 Summary of WWTP Performance

The plant performance has been reviewed previously in the application for resource consent (MWH, 2006). In general the plant performance has been improving as a result of changes to management and minor upgrade works.

Improved management of the Imhoff tank sludge levels by using a sludge interface detector has resulted in a lower suspended solids concentration in the effluent during periods of peak loads since 2005 (Figure 4-1). The reduction in suspended solids also improves the BOD and faecal coliform results because the solids have a significant BOD load and can shield pathogens from the UV lights, which reduces kill during UV disinfection. Improved sludge management has reduced the amount of suspended solids in the clarifier effluent (there has been no exceedance of the consent conditions for suspended solids since the sludge management changes were implemented) and consequently improved the UV system performance. Nevertheless, the median effluent faecal coliform count exceeded the consent limit on 5 occasions during the 2005/2006 summer season, with a peak median of 1650 CFU/100ml[1].

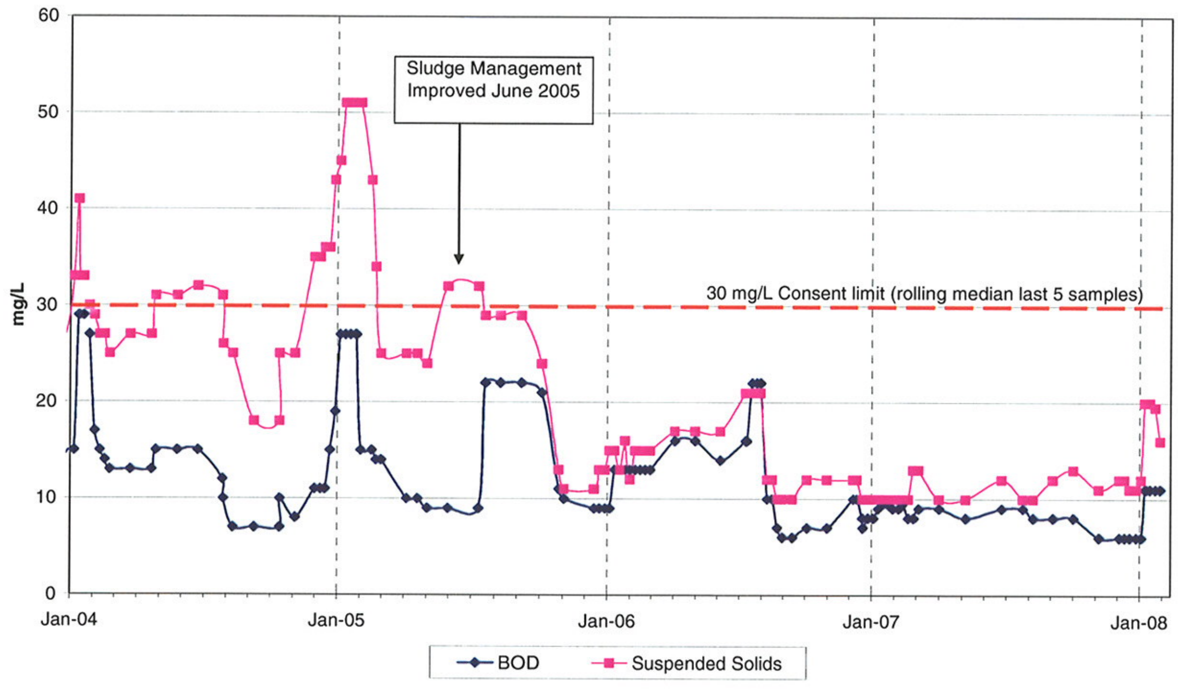


Figure 4-1 : WWTP Effluent Rolling Median BOD and suspended solids results 2004 to January 2008

The installation of a UV recycle in mid January 2007 has improved the UV performance further (Figure 4-2). The recycle enables operation of both UV channels during dry weather flows, which doubles the number of UV lamps operating, thereby increasing the UV dose. This increase in UV dose results in an improved kill of pathogens and a reduction in faecal coliforms (the indicator organism used to indicate the presence of pathogens) in the discharge, particularly during the peak summer season. The median faecal coliform results

[1] The extent of improvement that has occurred since the sludge management changes were implemented can be seen by comparing the 2005/2006 summer peak median faecal coliform concentration with that of the 2003/2004 and 2004/2005 summer seasons, which were 27,000 CFU/100ml and 100,000 CFU/100ml respectively.

(rolling median last 5 samples) have been less than 500 cfu/100ml since January 2007 and often less than 100 cfu/100ml.

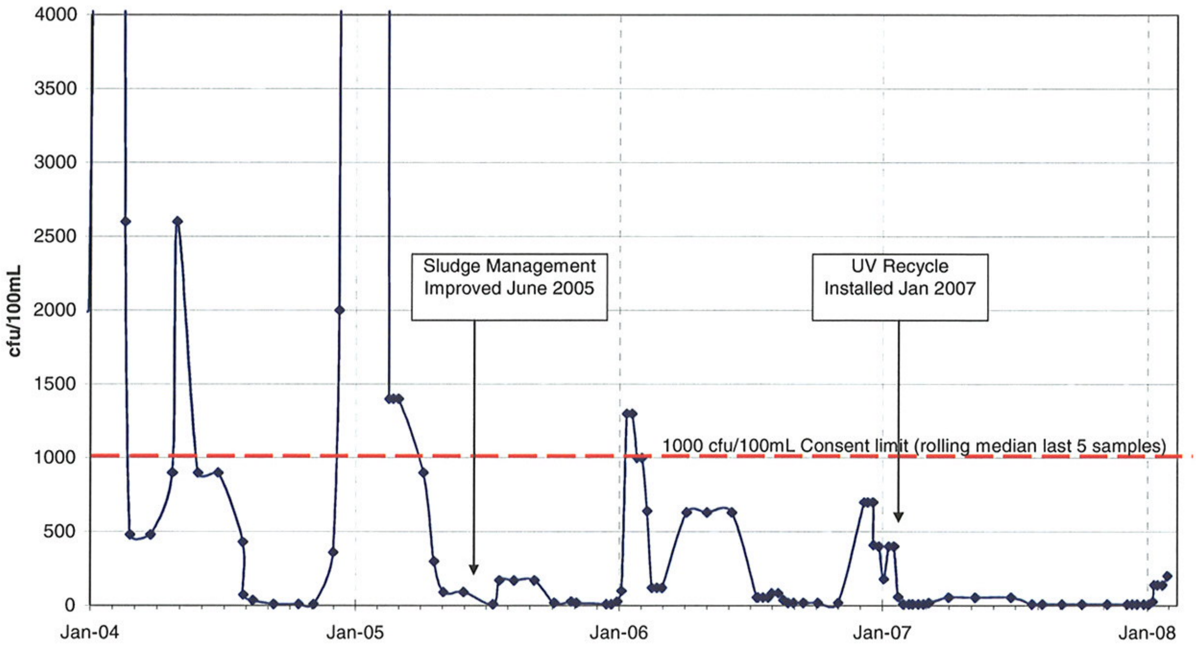


Figure 4-2 : WWTP Effluent Rolling Median Faecal Coliform Results 2004 to January 2008

Nutrient and heavy metals concentrations in the WWTP discharge are within expectations for domestic wastewater in New Zealand from a catchment and treatment process such as that at Akaroa.

A recent review of the nutrient status of Akaroa Harbour was undertaken by ECan (Environment Canterbury, 2005). This review indicates that over the period of 1989 to 2004, there was no overall trend of a decrease or increase in nutrient concentrations in the harbour (with the exception of NH_3-N, which has decreased). This suggests that over the reviewed period, any increase in nutrient inputs to the harbour via streams, sewage and stormwater has not resulted in an overall increase in nutrient concentrations in the harbour. However, the monitoring for nutrients around the outfall has been increased in order to better understand the effect of nutrients in the discharge.

In conclusion, the performance of the WWTP has improved in recent years and the results from effluent monitoring have been within the limits set by the resource consent since January 2006. More data is currently being gathered to assess the effect of the nutrient load from the WWTP on the harbour water quality.

4.2 Existing WWTP Assets

4.2.1 Capacity

The capacity of the existing Akaroa wastewater treatment plant (WWTP) has been assessed using typical per capita rates and standard design criteria for each process unit. The assessment of the existing capacity is shown below (Table 4-1).

Table 4-1 : Capacities of Existing Process Units

	Hydraulic Capacity		BOD Capacity*		Basis for capacity estimate
Process Unit	**Instantaneous Flow (L/s)**	**Daily Flow (m^3/d)**	**kg BOD/d**	**Population (p.e.)#**	
Inlet Screen	60	5,184			Based on manufacturer's information
Imhoff Tanks (Total)	15	1,317	126	2,100	Surface Overflow Rate 1 m^3/m^2 /h Digester loading rate 7 p.e./m^3 (WEF, 1998) 0.06 kg BOD/p.e.
Trickling Filter	69	5,937	268	3,820	Hydraulic load 22.8 $m^3/d/m^2$ (WEF, 1998) BOD loading 0.40 kg/d/m^3 Assuming 30% reduction of BOD in Imhoff Tanks (Metcalf & Eddy, 1991) 0.06 kg BOD/p.e.
Clarifier	63	5,429			SOR 0.5 $m^3/m^2/h$ average SOR 2.0 $m^3/m^2/h$ peak
UV System	60	5,184			Based on manufacturer's information

* BOD capacity is in terms of raw sewage entering the plant and includes BOD removal by upstream units to allow comparison
\# Population equivalent (p.e.) equal to 1 resident

The plant capacities above are compared to the expected future flows and loads in Figure 4-3 and Figure 4-4 below.

The Imhoff tanks has two functions: settling of screened wastewater and digestion and storage of sludge. The Imhoff tanks have limited hydraulic and sludge digestion capacity. The settling compartment has sufficient capacity for the diurnal peak during dry weather flows until around 2016 (Figure 4-3), but during wet weather flows the settling compartment is currently overloaded.

The capacity of the digester compartment of the Imhoff tank is limited to around 2,100 p.e. The current high season population exceeds this capacity, although during the low season the capacity is not exceeded even in 2041(Figure 4-4). The digester compartment will be overloaded during the high season which is a critical time for operation of the WWTP. During the high season the digester compartment will need to have sludge removed more often and the storage tank will need to be emptied more often.

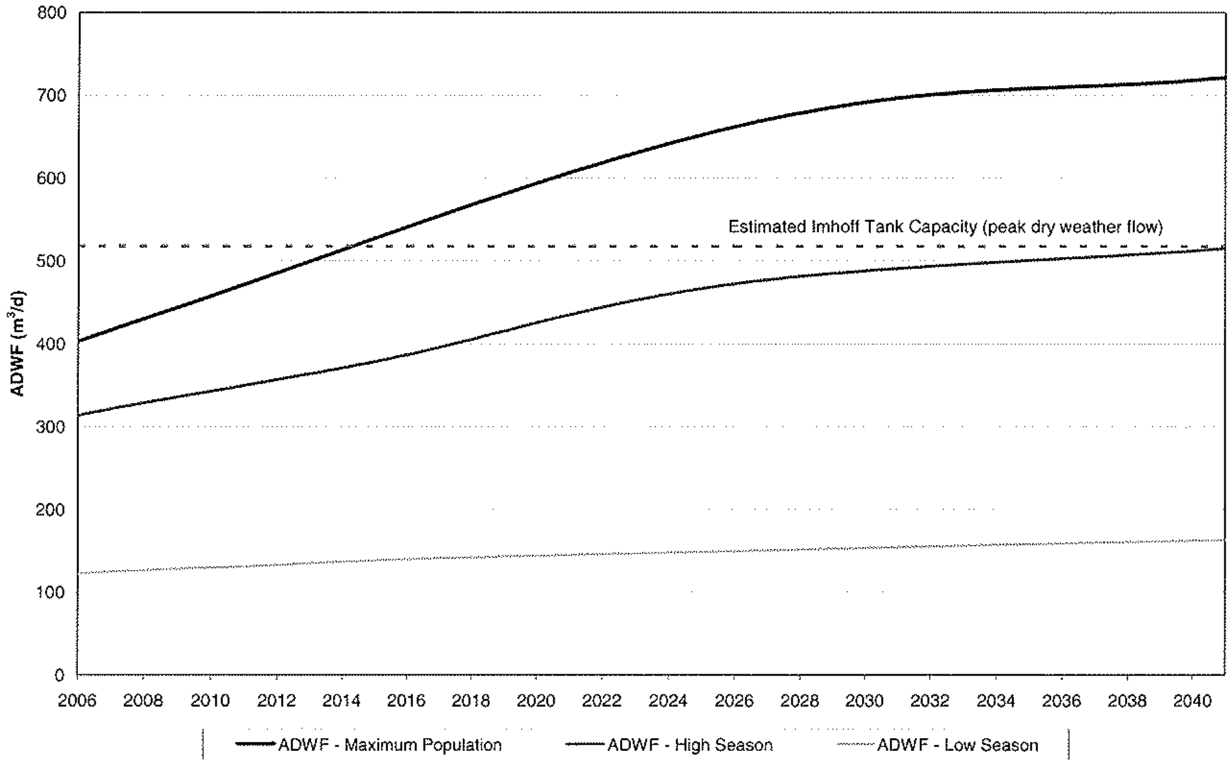


Figure 4-3 : Projected Average Dry Weather Flow to Akaroa WWTP

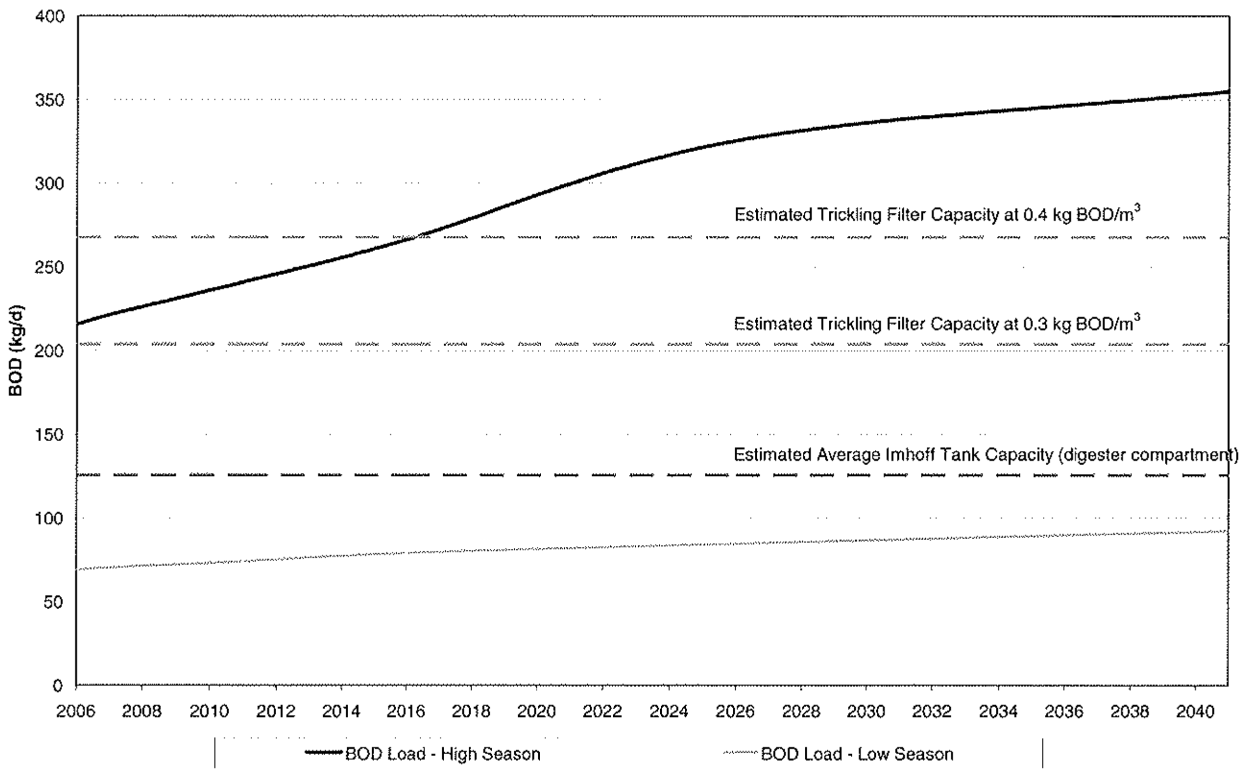


Figure 4-4 : Projected BOD Load to Akaroa WWTP

The remaining capacity of the existing trickling filter is difficult to determine exactly because the upgrade of the trickling filter distributor in 2008 should improve the treatment performance to some extent. The upgrade of the distributor and the implementation of a daily flushing regime should offer some improvement in treatment performance because the application rate onto the media will be more efficient due to motorised control of the rotational speed. The recommended maximum limit for BOD loading this type of trickling filter is around 0.4 kg BOD/day/m^3 of media, which corresponds to approximately to an incoming sewage load of 270 kg BOD/day to the WWTP (projected to occur around 2016). A more conservative loading rate would be around 0.3 kg BOD/day/m^3, which corresponds to 200 kg BOD/day – the current estimated BOD load to the plant during the high season. Ongoing monitoring of the WWTP effluent will show the extent of performance improvement with the new distributor and will also indicate the safe capacity of the trickling filter.

The current WWTP effluent monitoring results for BOD and ammonia from the last two years (with the existing distributor operating and no daily flushing) indicate that the trickling filter is nearly at capacity (Figure 4-5), although the new distributor and daily flushing should result in improved performance. The BOD has been around 10 mg/L (rolling median) during the summer and has had a slightly higher median (20 mg/L) during the winter when temperatures are lower (which reduces the biological activity of the biomass in the trickling filter). The BOD results indicate that the trickling filter is able to treat the current load to the plant. The ammonia is low during the year but has a peak of around 33 to 37 mg/L during the December/January holiday period, which indicates that most of the media is being utilised to treat the BOD load during this period (the oxidation of ammonia to nitrates (nitrification) only occurs after oxidisation of BOD is completed). The typical influent ammonia concentration is around 40 mg/L so some nitrification could be occurring during the December/January period. In conclusion, the ammonia results indicate that although the existing trickling filter (with the existing distributor) has sufficient capacity to treat the current BOD load, there is limited capacity for future loads.

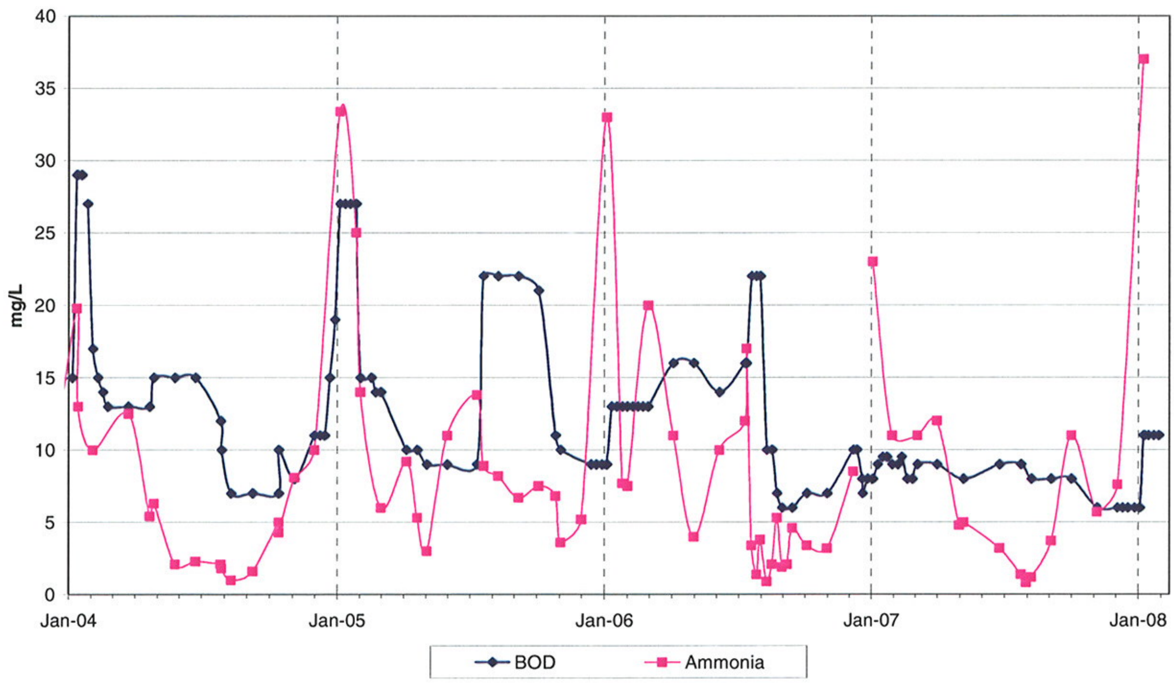


Figure 4-5 : WWTP Effluent BOD and Ammonia Monitoring 2004 to January 2008

The other process units have sufficient capacity for the estimated future flows in 2041.

4.2.2 Age of Existing Assets

The WWTP was originally constructed in the 1960s. The original plant comprised one Imhoff tank, the trickling filter and the humus tank (now decommissioned). The first upgrade occurred around 1984 and included a new Imhoff tank and sludge drying beds. The last upgrade was in 1998 and included an inlet screen, clarifier and UV disinfection system. The age of the various process units is shown in Table 4-2 below.

Table 4-2 : Existing WWTP Asset Age

Process Unit	Date Constructed
Inlet screen structure	1998
Imhoff Tank 1 (harbour side)	1960s
Imhoff Tank 2 (hill side)	1984
Trickling Filter	1960s
Clarifier	1998
UV System	1998

Although the original Imhoff tank and trickling filter are 40 to 50 years old the structures are in reasonable condition and with refurbishment works and renewal of the mechanical components these structures can still be utilised in the treatment process. Concrete structures have an accepted lifetime of 100 years so with proper maintenance these structures will have a lifetime beyond the design year of 2041.

The existing UV disinfection system was installed in 1998. By the end of the proposed short term Resource Consent in around 2013, this unit will be 15 years old and the electrical components will require replacement (normal operating life for electrical components is considered to be 15 years). The inlet screen will also be 15 years old and as it is a high wear piece of equipment it will also require refurbishment or replacement. For the purposes of the report, replacement of the inlet screen and UV system are assumed for future upgrades.

4.2.3 Hydraulic Bottlenecks

The WWTP site has suffered some wastewater spills during heavy rain. While the individual process units have sufficient capacity for the full pumped flow to the WWTP, there are issues with the interconnections between the process units and other bottlenecks. These spill events have occurred infrequently. Spills have been observed to occur when there has been a period of 2 or 3 days of rain followed by a heavy rain event. Hydraulic bottlenecks at the plant have been identified and the work to alleviate them is on going.

The installation of a new motorised distributor arm on the trickling filter (early 2008) will alleviate the current hydraulic bottleneck caused by the existing distributor arm and reduce the risk of spills upstream of the trickling filter.

Christchurch City Council (CCC) is also currently undertaking an I/I control programme which will reduce the flow rate to the WWTP during wet weather and thereby reduce the risk of spills at the WWTP.

4.3 Existing Site

The area between Ōnuku and Akaroa known as Takapuneke (Red House Bay) that the WWTP is sited on has special historical, cultural and spiritual significance and is listed in the Register of Archaeological or Wahi Tapu Sites. The 2007 CCC Akaroa Harbour Basin Settlements Study sums up the significance of the area:

> *"A key historical event is that of the 1830 attack of the settlement of the Ngai Tahu chief, Te Maiharanui, by the Ngati Toa chief, Te Rauparaha, resulting in the deaths of many men, women and children at Takapuneke and later at Onawe. Some consider the involvement of the British Captain Stewart and the merchant ship Elizabeth in this event to be one of the reasons that led to the British authorities visiting the Bay of Islands in 1833 and, to the consequent signing of the Treaty of Waitangi. In 1840, the Treaty was signed by Ngai Tahu chiefs at Onuku, one of the few South Island signing locations, and the HMS Britomart was dispatched to raise the British flag at Green's Point, demonstrating British sovereignty to the arriving French and German settlers. The Britomart Memorial on Green's Point exists today to commemorate the raising of that flag on 11 August 1840. Therefore, these sites in close proximity to each other, Takapuneke, Green's Point and the Britomart Memorial, are nationally significant to the history of New Zealand."*

In 2002, the Historic Places Trust registered the entire area as wahi tapu. Discussion between the Ōnuku Rūnanga, the district council and the government about the future of this area is ongoing.

4.4 Cultural Issues

Cultural issues concerning the disposal of wastewater to the harbour and with the existing WWTP site have been mentioned in the sections above. Consultation with the local runanga may be able to identify solutions for wastewater treatment and disposal that resolve these concerns.

At other WWTPs such as Invercargill, Dunedin, Palmerston North, and Westport, a rock passage/wetland has been agreed by the local runanga as appropriate to provide passage of wastewater through the earth prior to discharge to fresh or marine waters. At Hastings WWTP the treatment of wastewater by biological trickling filters has been agreed by the local runanga as appropriate to transform the human waste into another form (biological solids that form on the media), which can then be disposed of into the sea. Screenings (inert materials removed from the wastewater by the inlet screen) will also be washed at Hastings WWTP to remove any human waste before the screenings are transported to land fill.

As stated in the previous section there is ongoing discussion between the Ōnuku Rūnanga, the district council and the government about the future of the area that the WWTP is located on.

An appropriate solution for Akaroa wastewater needs to be identified through consultation with the local runanga.

4.5 Summary of Wastewater Treatment and Disposal Issues

The issues discussed above are summarised in Table 4-3 below with potential mitigation methods indicated.

Table 4-3 : Summary of Wastewater Treatment and Disposal Issues

Issue	Explanation	Potential Solutions
Discharge to harbour	Cultural and environmental concerns of community	- Disposal to land - Other appropriate solution reached through consultation
Existing Assets:		
Capacity	Trickling filter nearly at capacity	-Upgrade the secondary treatment process
Age	UV and inlet screen will need replacement	-Replace UV system -Refurbish inlet screen
Spills at WWTP site	Spills occur infrequently during heavy rain	-Ongoing work to fix bottlenecks & I/I
Existing Site	Cultural concerns and possible urban growth	-Investigate potential new sites
Cultural	Cultural issues with disposal to water and the existing site	-Disposal to land -New site -Other appropriate solution reached though consultation

Potential solutions to the issues with the existing wastewater treatment and disposal system are discussed in the sections 5 and 6 below.

5 Disposal Options for Treated Wastewater

The options available for disposal of treated wastewater are discussed in this section. The options are land disposal, discharge to harbour via the existing outfall, and reuse of treated wastewater for non-potable uses.

5.1 Land Disposal

Recent experience with resource consent applications by the former BPDC for treated wastewater discharges from small communities into Akaroa Harbour have required strong consideration of land based disposal. There is strong opposition to harbour discharges from iwi, harbour users, the local community and the wider community when there are practical alternatives. A corresponding strong support exists for land based disposal.

Irrigation of treated wastewater to land makes use of the treated wastewater as a resource but does not require high levels of treatment if irrigation is on a controlled site (i.e. fenced and signed to restrict access). The land further treats the wastewater as it percolates through the soil.

The Tikao Bay land disposal system provides a useful reference point for a land disposal system for Akaroa. The Tikao Bay system has reportedly operated well since its commissioning around two years ago. Tikao Bay has much lower volumes of wastewater and hence requires much less land area than Akaroa. The key design parameters of the Tikao Bay land disposal system are:

- Peak daily flow: 30 m^3/d
- Maximum daily application depth: 4 mm/d
- Land Disposal Area: 0.75 ha

5.1.1 Area Required

The general land around Akaroa makes development of land disposal difficult because it is generally steeply sloping, which is unsuitable because of the risk of surface runoff to waterways. The area required for irrigation of treated wastewater to land is based on the volume to be disposed and the application rate. The average application rate for land around Akaroa is likely to be in the order of 2 to 3 mm/day because of the limited ability of the soil to absorb and drain the wastewater without becoming saturated (the appropriate application rate must be confirmed by site investigations) and the need to deal with adverse rainfall events. A rate of 3 mm/day has been assumed for the purposes of this report.

For irrigation of dry weather flows only (up to 710 m^3/d), an irrigation area of 24 ha is required based on an application rate of 3 mm/day. The total area required may be around 50 ha including areas for a storage pond, buffer zones and areas that are not suitable for irrigation (e.g. around streams and gullies).

For irrigation of wet weather flows the area of land required is around 113 ha for irrigation, plus the area required for storage, buffer zones and areas not suitable for irrigation. The total area required could be up to 225 ha, which would have a high cost (estimated at \$3.4 million at a rate of \$15,000/ha) when compared to irrigating dry weather flows only and require a large percentage of available usable land around Akaroa. Wet weather flows could either be stored until it is able to be irrigated or discharged to the harbour.

From historical data collected over the last 6 years, the highest volume discharged during wet weather was 7,278 m^3 over 4 days during August 2000. The next highest was 6,856 m^3 over 4 days during September 2000. Therefore for storage of future wet weather flows a 4 day event could be expected with 1,700 to 1,800 m^3/d on average with a peak of 3,400 m^3/d (the expected maximum day flow). Based on the rainfall patterns during the two events above, a total storage volume of around 5,000 m^3 would be required. While detailed site schematics have not been completed, there may be a suitable area for a storage pond of this volume near the land disposal site, however, this location would incur a higher energy cost due to the need to pump peak flow rates. It would be preferable to locate storage at the WWTP site but site limitation may prevent this. An emergency discharge route to the harbour would still be required in the event of the storage pond becoming full or pump failure. In conclusion it is expected to be possible to store wet weather flows for disposal on the land irrigation site, and hence a target land area of approximately 50 ha is required.

5.1.2 Potential Land Disposal Areas

Potential land disposal areas have been identified by a desktop study considering only the topography of the land (average slope of less than 15°) supplemented by a field inspection to provide a reality check and enable an initial subjective ranking. No soil investigation has been done to date. There has been no contact or consultation with the local runanga or land owners at this stage.

The land surrounding Akaroa has been assessed for potential land disposal areas in a desktop study. This assessment was limited to areas on the Akaroa side of the harbour and no further up the harbour than Takamatua Hill in order to identify the most pragmatic options. The areas identified have the following features:

- South of Takamatua Hill
- Outside urban areas
- Outside water catchments
- An average slope of less than 15°
- Area of at least 50 ha

The three most promising areas for land irrigation have been identified. A map indicating the potential land disposal areas is shown in figure 1 in appendix C. The potential areas are:

1. The south slope of Kaik Hill
2. The south slope of Takamatua Hill
3. Along Lighthouse Rd and/or Flea Bay Rd near the head of the harbour

A preliminary site check has been completed by MWH and soil scientist Dr Anthony Davoren of Hydro Services Ltd. to assess the potential of each area for irrigation. The potential land areas are compared in Table 5-1.

Option 1, Kaik Hill has the most potential for irrigation. It is the closest area to the WWTP which is an advantage in terms of capital and operating costs for pumping to the site. This site has been divided on to three sub-options; the upper slope, lower slope and bush land. All three sub-options appear to have adequate soil conditions for the proposed irrigation.

The upper slope (the top of the ridge line from Lighthouse Rd and the top slopes on the south side of the ridge) has the best potential for irrigation. It contains reasonably sized parcels of land suitable for pasture or coppicing[2] using different types of irrigation systems. The lower slope contains less open area and has potential for drainage into the harbour via streams. The bush land could be irrigated but may be a culturally sensitive site and may have poorer drainage.

Option 2, Takamatua Hill has more potential issues. It is potentially a culturally sensitive site because it is acknowledged as a silent file in Te Whakatau Kaupapa. It also has potential issues with run off to the harbour, possible future urban development and high visibility to residents and tourists of Akaroa. This area is a reasonable distance from the WWTP site and will require either a pipeline back through the town or a pipeline across the harbour to deliver treated wastewater to the site.

Option 3, Lighthouse Rd/Flea Rd is a greater distance from the WWTP and would require pumping to very high heads. The area contains 2 or 3 potential irrigation areas, which are separated by up to 1 km. This area would also have variable evapotranspiration (ET) because of its height (low cloud) and exposure to wind and sun, which would affect the possible application rate for irrigation. This option is also quite isolated and a long distance from the WWTP site.

The south slopes of Kaik Hill offer the best potential for land disposal and should be pursued further. They contain three possible areas for irrigation and are the closest to the WWTP site. There has been no consultation with land owners at this stage and this should be a priority before any information is presented to the general public.

[2] Practise of short term (5 year) crop rotation by cutting trees back to stumps and allowing regrowth, thereby avoiding stopping irrigation to clear trees and replant.

Table 5-1 : Summary of Potential Land Disposal Areas

Option	Location	Distance from WWTP	Soil Conditions	Potential Area Available	Comments	Subjective Ranking
1A	Kaik Hill (upper slope)	Good (<1km)	Good	Good	Good potential for irrigation Suitable for pasture or short rotation coppicing* Potential for different irrigation systems Good sized land parcels	8/10
1B	Kaik Hill (lower slope)	Good (<1km)	Good	Good	Potential runoff issues Potential for drainage to Akaroa Harbour More suitable for short rotation coppicing and trickle irrigation	7/10
1C	Kaik Hill (bush land)	Good (<1km)	Good	Good	Potentially a culturally sensitive site – contains Maori reserve land Basin could be wet and have poorer drainage (some rushes visible) but is a larger area than sub-options A & B above	5/10
2	Takamatua Hill (south slope)	Average (2.5km)	Good	Average	Potentially a culturally sensitive site (acknowledged as a silent file in Te Whakatau Kaupapa) Potential runoff to harbour Potential aesthetic issues, high visibility to residents and tourists to Akaroa Potential area of future development	4/10
3	Lighthouse Rd/ Flea Bay Rd	Poor (8km)	Poor to Good	Average (suitable land parcels separated)	Contains 2 or 3 potential irrigation areas near to the road Variable ET# due to low cloud, exposure, sun. Long distance from existing site – high capital and energy costs for pumping	2/10

* Practise of short term (5 year) crop rotation by cutting trees back to stumps and allowing regrowth, thereby avoiding stopping irrigation to clear trees and replant.
# Evapotranspiration (ET) – loss of water from the soil by both evaporation and by transpiration from the crops growing in the soil.

All of the potential disposal areas would require high pumping heads, especially option 3. Typical pumping heads for raw wastewater are limited to 60 to 70 m, while for treated wastewater higher heads are possible. Options 1 and 2 have static heads of 320 m and 160 m respectively and option 3 has a static head in excess of 600 m. Therefore, for all of the land disposal options relocating the WWTP to the irrigation site is not possible due to limitation of pumping raw wastewater

Figure 5-1 below shows the pipe routes to the potential land areas including vertical rise and length. One high head pump station is preferred over multiple pump stations because of the cost for the associated works (e.g. civil works, power supplies). Although it is possible to pump the treated wastewater to the heads required for option 3, it is not considered a sustainable option because of the high energy costs incurred.

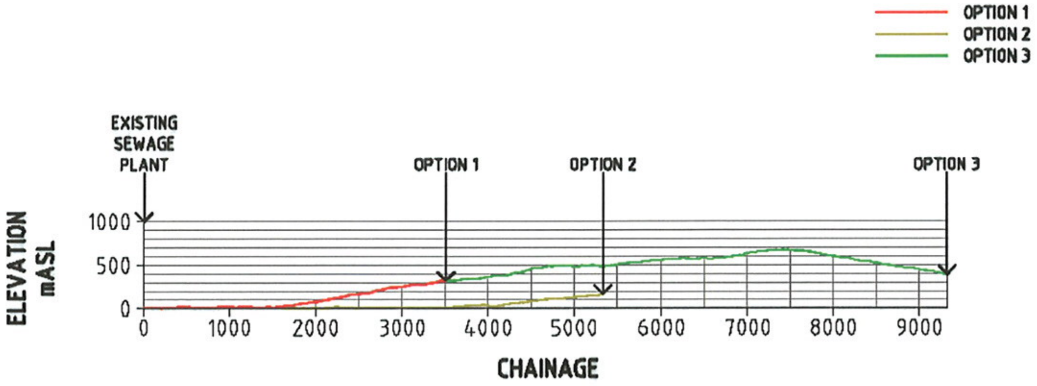


Figure 5-1 : Long sections of pipe routes to potential land disposal areas

5.1.3 Options for Transfer of Wastewater to the Land Disposal Area

Because of the large volumes of wastewater to be disposed of (up to volume of 3,400 m³/d maximum day flow at maximum flow rate 60 L/s during wet weather) and the limited suitable land area available, it is not feasible to irrigate the maximum daily treated wastewater volume on to the land each day. Therefore some storage of wastewater or discharge to harbour will be required. There are two options for storage and transfer of raw or treated wastewater to the land disposal area listed below and illustrated in Figure 5-2:

1. Store treated wastewater, including all WW flows, then dispose at the average dry weather flow rate to the land disposal site.
2. Pump treated wastewater dry weather flows (DWF) to the land irrigation site and divert treated wastewater flows above 710 m³/d (i.e. wet weather flows) to the harbour.

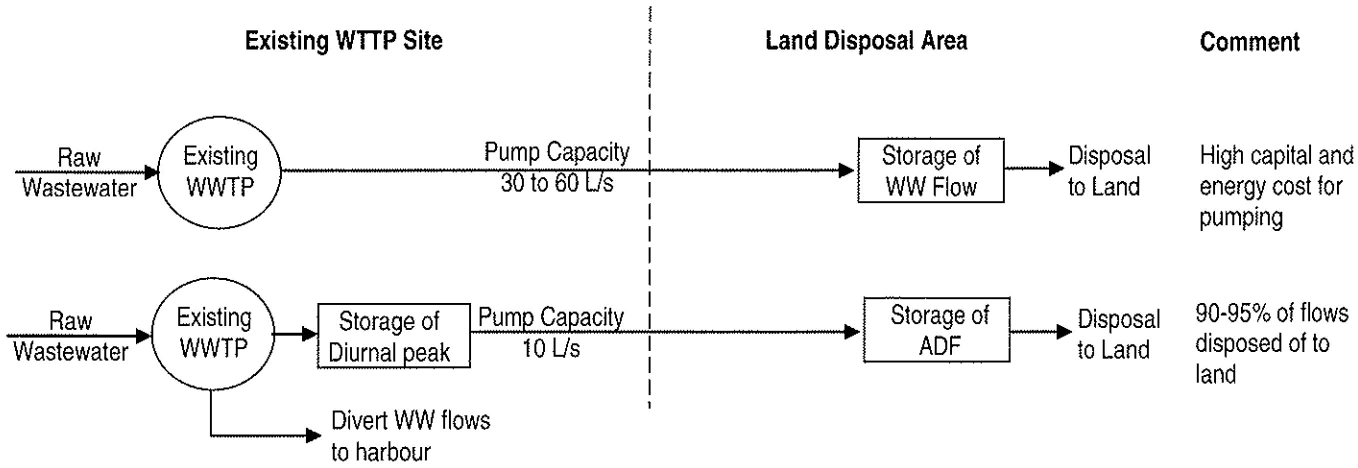


Figure 5-2 : Options for Transfer of Wastewater to Potential Land Disposal Sites

The first option is to pump all treated wastewater flows from the WWTP (up to the pumped capacity of 60 L/s) to storage near the irrigation area. This option incurs high capital and energy costs because of the volume and high heads to pump against. Some capital cost saving could be made if there is a suitable area for storage near the WWTP site allowing a reduction in flow rate to around 30 l/s, but energy costs would remain high. This option is preferable to option 3 to divert wet weather flows to the harbour, although it will incur higher energy costs.

The second option to divert wet weather flows to the harbour via the existing outfall is will have a lower energy cost for pumping because the reduction in volume to be pumped reduces the pumping energy required compared with the full wet weather volumes. Storage of the diurnal peak is also practical to implement on or near the existing WWTP site and will allow the pump capacity to be reduced, which reduces the capital cost for the pump station and pipeline to the disposal site.

Option 2 would result in treated wastewater being disposed of to land most of the time because the majority of daily flows will be below the design ADWF of 710 m^3/d. The 95^{th} percentile from the last year of recorded daily discharge volumes was 360 m^3/d. The design ADWF of 710 m^3/d (based on maximum population which occurs 1 day/year) is expected to be around the 90^{th} to 95^{th} percentile in 2041 (based on 2006 flow and population data). Therefore, diversion of wet weather flows to the harbour would occur on 18 to 37 days per year in 2041 and less often in the years preceding this. The actual volume of wastewater diverted to the harbour would depend on the intensity of the rain event, and the wastewater will also be diluted by stormwater and groundwater entering the sewers.

In conclusion, although the option to dispose of dry weather flows to land (up to 710m^3/d) and divert wet weather flows to the harbour is a lower cost solution, the first option to store wet weather flows for later disposal to land is likely to be preferred because it removes normal discharge from the harbour.

5.1.4 Estimated Capital and Operating Costs

The capital and operating cost associated with pumping at a flow of 30 L/s (assuming some storage is available at or near the WWTP site) to each potential land disposal area has been estimated (Table 5-2). These estimates are approximate and should be used for comparing the different options relative to each other only. The capital costs estimates include the approximate costs to deliver treated wastewater from the existing

WWTP site to the irrigation area (the pump station and pipeline only) and do not include the cost for installing the irrigation system itself or purchasing the required area of land, which are common to all the potential land disposal sites. The operating costs include costs for electricity, maintenance and replacement of pumps.

Table 5-2 : Pumping to Irrigation Areas – Estimated Capital and Operating Costs

Option	Location	Pumping Distance	Approximate Capital Costs ($million)	Approximate Annual Operating Costs
1A	Kaik Hill (upper slope)	1.5km and 320m in height	$ 1.4	$ 351,000
1B	Kaik Hill (lower slope)	1km and 200m in height	$ 1.1	$ 162,000
2	Takamatua Hill	5.4km and 160m in height	$ 3.0	$ 735,000
3	Lighthouse Rd	9.5km and 660m in height	$ 5.0	$ 1,200,000

Option 3 has high capital and energy costs due to the length of pipe and the head to pump against. From the basis of pumping costs the preferred sites are options 1A and 1B at Kaik Hill. As discussed in section 5.1.2 Kaik Hill is also the preferred land disposal site based on suitability for irrigation.

Consultation with the land owners of the preferred site (Kaik Hill) must be completed and the local runanga must also be consulted concerning the cultural significance of the bush land and the potential to allow treated wastewater to be disposed of at these sites. If irrigation at this site is not possible then the other two sites could be considered.

Site investigations including soil investigation and surveying must be completed at the preferred site to determine the suitability of the soil for irrigation and the available area suitable for irrigation.

5.2 Disposal to Harbour

The existing disposal route from the WWTP is into the Akaroa Harbour via an open-ended 160mm diameter outfall pipe that extends 100m into Redhouse Bay, more or less perpendicular to the shoreline. The main issues with disposal to harbour are cultural and environmental.

The cultural concerns of Maori with regard to human waste being disposed of into fresh or marine waters needs to be addressed. At the Hastings, Dunedin, Palmerston North and Westport WWTPs an appropriate solution has been found through consultation with local runanga. An appropriate solution for the treatment and disposal of wastewater in Akaroa needs to be identified through consultation with the local runanga.

An assessment of environmental effects of the discharge to the harbour has been completed as part of the current consent application for the WWTP. The performance of the WWTP has improved in recent years and has had no non-compliances with the conditions of the resource consent since January 2006. Nutrient and heavy metals concentrations in the WWTP discharge are within expectations for domestic wastewater in New Zealand from a catchment and treatment process such as that at Akaroa. However, although a recent review of the nutrient status of Akaroa Harbour (Environment Canterbury, 2005) showed there has no overall increase or decrease of nutrients, the monitoring for nutrients around the outfall has been increased in order to better understand the effect of nutrients in the WWTP discharge.

If future WWTP upgrades include disposal of wastewater to the harbour then a rock passage (papatuanuku) and nutrient removal may be required. Consultation is required to determine an appropriate solution to address the cultural concerns of Maori. The results of the increased nutrient monitoring will indicate whether nutrient removal is necessary. Normally nitrogen removal only is required for discharges to marine waters unless phosphorus loading is of particular concern.

5.3 Reuse of Treated Wastewater

Treated wastewater reuse (also referred to as reclaimed or recycled water) is common in areas with limited water resources such as Australia and California. Wastewater is treated to a high standard and provided for non-potable use, or less commonly for indirect potable reuse (blending with raw water prior to treatment to drinking water standard).

For Akaroa, wastewater would be treated at the WWTP to a high standard and then provided for non-potable uses within Akaroa. The following potential end uses are presented in Table 5-3 on page 25:

Option 1 - Supplementing stream base flows
Option 2 - Irrigation of public reserves
Option 3 - Irrigation of agricultural land
Option 4 - Irrigation within private properties
Option 5 - Non-potable use within private properties
Option 6 - Indirect potable reuse (mixing with raw water sources)

Option 1, supplementing stream base flows, would require treated wastewater to be pumped to the Alymers Valley stream (downstream of the water intake) to supplementing stream base flows. This would not reduce the consumption of potable water but would increase the residual flow in the stream during dry weather.

Options 2, 3 and 4 to provide treated wastewater for irrigation will result in a minimal reduction in water consumption because water restrictions are enforced during water shortages (option 3 includes the land disposal option discussed in section 5.1). In practice these options would reduce the level of restrictions but would only have a minimal effect on potable water consumption.

Option 6, indirect potable use, would involve pumping treated wastewater to the Alymers Valley stream above the water intake, which would reduce water consumption by up to 20% but it is likely to have significant opposition from the public. Indirect potable use involves high quality treated wastewater being blended with raw water sources before receiving full water treatment to drinking water standard for potable use by the public. Understandably, there are negative connotations associated with recycling wastewater into drinking water even if it is by an indirect means. However, indirect potable use has been accepted overseas in areas where there is a shortage of water and has occurred since the 1970s in the USA. A more recent example is Singapore's "NEWater" plants which produce high quality recycled water (by reverse osmosis and disinfection), which is then used for non-potable industrial use and indirect potable use. Although this practise has been accepted overseas it is unlikely to be acceptable to the community in Akaroa.

Option 5, non-potable use within private homes (e.g. toilet flushing and garden irrigation), has a significant effect on water consumption without the strong negative perceptions of indirect potable use, and therefore should be pursued further. This option also has an advantage of reducing water consumption every day, rather than during dry weather only as most of the other options do. A 'third pipe' non-potable water network is required to deliver the treated wastewater to households. Although almost all houses will need to be connected to achieve the estimated reduction in waster consumption, it is recommended the 'third pipe' network be installed in a staged manner to reduce the initial capital costs and disruption involved. New dwellings should incorporate plumbing for connection to the 'third pipe' when it is available. In the interim treated wastewater could be made available via tanker truck for filling of onsite tanks for private garden irrigation as per option 4.

Table 5-3 : Options for Reuse of Treated Wastewater

Option	End Use	Benefits	Reduction in Water Use*	Volume Reused	Comments
1	Supplement stream base flows: To Alymers Valley stream	• Supplements stream water base flow	0%	Up to 710 m^3/d (Full ADWF)	• Requires high head pump station and pressure main to Alymers Valley stream
2	Irrigation of parks and reserves: Jubilee Park, Stanley Park, other reserves (estimated area 6 to 10 Ha)	• Replaces potable water	Minimal	100 to 300 m^3/d	• Minimal water savings because water restrictions are likely to be in place • Dry weather only • Requires pump station and pipeline to irrigation areas • Potential application/public usage issues
3	Irrigation to agricultural land (i.e. land disposal)	• Disposal of wastewater to land (reduces discharge to harbour)	0%	Up to 710 m^3/d (Full ADWF)	• Same as land disposal option. Requires sufficient land area to dispose of ADWF volume. • Commercial usage would be variable with weather. • Council use on restricted area would be consistent regardless of weather.
4	Private garden irrigation: • tanker truck to fill onsite tanks, or • reticulation	• Replaces potable water	Minimal	0 to 500 m^3/d	• Minimal water savings because water restrictions are likely to be in place • Dry weather only • Tanker truck delivery less costly than reticulation • Reticulation is most cost effective for full non-potable use as in option 5 below
5	Non-potable use in private homes: Full 'Third Pipe' reticulation into each house for non-potable use (e.g. toilet flushing, garden irrigation)	• Replaces potable water • Only option to reduce potable water demand during peak water shortages (level 4 restrictions) • Provides daily reduction in water consumption regardless of weather	20%	Up to 710 m^3/d (Full ADWF)	• Requires a new non-potable reticulation system
6	Indirect potable use: Blend with raw water in Alymer Valley steam prior to full water treatment at L'Aube WTP)	• Supplements potable water supply • Reduces demand on raw water reserves	20%	Up to 710 m^3/d (Full ADWF)	• Requires high head pump station and pressure main to Alymers Valley stream. • Significant negative public perception issues

* percentage of maximum day water consumption

Overseas water experience suggests that the reuse of treated wastewater for non-potable purposes can make a significant contribution to reducing demand on existing water resources. Due to the extreme water shortages experienced in Australia, effluent reuse is presently being implemented in a variety of different methods ranging from full domestic 'third pipe' supply systems to the irrigation of community parks. At Akaroa there is good potential to reuse the treated wastewater effluent. Potable water could be substituted by non-potable grade (disinfected, low turbidity) treated wastewater into toilets and for outside watering / irrigation purposes. Reuse would have three main benefits:

- Lower utilisation of the drinking water supply for irrigation and toilet resulting in estimated water consumption savings of up to 20%.
- Reduced abstractions from water supply streams resulting in greater flows available for maintenance of in-stream values.
- Little or no discharge from the WWTP at critical dry weather periods to the harbour receiving environment

5.3.1 Required Treated Wastewater Quality for Reuse

The main risk with reusing domestic wastewater is the microbial health risk, either through direct contact with the recycled water, or contact with the ground or irrigated crops. The risk is controlled by several levels of treatment to reduce the concentration of micro-organisms in the recycled water. The required quality standard for reuse of treated wastewater is discussed below and depends on the end use of the water. End uses with greater risk of contact with the public require a more stringent quality standard.

Use of recycled water in New Zealand is governed by different regulations according to the purpose of the reuse. Reuse in domestic dwellings and industry is covered by the Health Act (1956) and the Building Act (2004). For discharges to the natural environment such as reuse in irrigation, aquifer recharge and aquaculture, the appropriate legislation is the Resource Management Act (1991).

Guidelines for the reuse of treated wastewater for irrigation purposes are provided in the 'Public Health Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land', New Zealand Department of Health (DoH) (1992). The DoH Guidelines are for disposal to land only and are not applicable to domestic reuse in houses. In the case of domestic non-potable use more recent Australian or American guidelines are relevant.

The Californian Title 22 Regulations for reclaimed water remain the most stringent and have formed the model for a number of regulations in the USA and around the world. These standards can be achieved by a robust disinfection system that inactivates virus and bacteria. In reuse options where public health is of utmost concern, these regulations have been adopted in a number of situations.

The 2006 Australian Guidelines for Water Recycling are the current guideline for water reuse in Australia. These guidelines give an E.coli limit of 1 cfu (colony forming unit) / 100 ml as a measure of microbial water quality. Title 22 uses total coliforms which, for the same numerical value, are a more stringent requirement.

Table 5-4 on page 28 summarises some key criteria from each of these standards and guidelines as mentioned above. For the purposes of this report it is assumed that the end use for the treated wastewater will be non-potable use by the public or disposal to land.

Based on the 2006 Australian Guidelines for Water Recycling, the following microbiological standards for domestic non-potable use have been adopted for this report:

- Bacteria: <1 E.Coli / 100 ml
- Viruses: 5.0-log reduction (measured against raw sewage concentration)
- Turbidity: < 2 NTU (average)

For disposal to land the 1992 DoH guidelines would probably prevail, which have the following restrictions for irrigation of fodder crops and pasture:

- <10,000 faecal coliforms/100 ml
- No harvesting or grazing for 48 hours or while wet with irrigated water
- Warning signs around irrigated area

Table 5-4 : Comparison of Treated Wastewater Reuse Standards

Criteria	Australia & New Zealand Joint National Water Quality Management Strategy for Reclaimed Water	DoH Public Health Guidelines for the Safe use of Sewage Effluent and Sewage Sludge on Land (1992)	California Title 22 Regulations	USEPA Urban Reuse	Victorian Environmental Guidelines for use of reclaimed water	NSW Guidelines for Urban and Residential use of Reclaimed Water	NSW Environmental Guidelines Use of Effluent by Irrigation	Australian Guidelines for Water Recycling: Managing Health and Environmental Risks
Microbiological guideline / standard for urban non-potable reuse and irrigation of raw eaten crops	FC < 10 / 100 mL (median)	Irrigation of crops only: FC < 10 / 100mL	TC < 2.2 / 100mL (median)	FC = 0 /100 mL	E. coli < 10 / 100 mL (median)	FC < 1 / 100 mL (100%ile) TC < 10 / 100mL (95%ile)	Faecal coliforms < 10 / 100mL	E. coli < 1 / 100 mL
Disinfection (when using chlorine as primary disinfectant)	T = 30 minutes 1 mg / L – residual chlorine	-	CT of 450 T = 90 minutes at peak dry weather flow	T = 30 mins minimum 1 mg/L residual chlorine	T = 30 minutes 1 mg / L – residual chlorine	T = 60 minutes min. 5 mg / L chlorine dose	T = 30 mins 1 mg/L residual chlorine	CT >=60 mg.min/L (dual reticulation)
Virus requirements	Quality criteria and Process requirements are 'deemed to satisfy'	-	5 log removal of polio virus from influent wastewater	Quality criteria and process requirements are 'deemed to satisfy'	Viruses < 1 / 50L Protozoa <1 / 50L Helminth < 1 / L	Viruses < 2 / 50 L Parasites < 1 / 50L	Quality criteria and Process requirements are 'deemed to satisfy'	No specific limit. Indicative – 5.5 log reduction of Rotavirus
Effluent Turbidity - Granular media - Membranes	< 2NTU (median)	-	< 2NTU (95%ile) < 0.2 NTU (95%ile)	< 2NTU (median) -	< 2NTU -	< 2NTU (median)	=<2NTU. 5NTU not to be exceeded	<=2NTU
pH	6.5 – 8.5 (90%ile)	-	-	6.0 – 9.0	6.0 – 9.0 (90%ile)	6.5 – 8.0 allowable range 7.0 – 7.5 desirable range	6.5 – 8.5 (90%ile)	-
Treatment Process	• Secondary Treatment • Tertiary treatment consisting of lagoons, filtration or microstraining • Disinfection	• Biological oxidation (or equivalent) • Tertiary disinfection	• Secondary treatment (fully oxidised effluent) • Coagulation if turbidity to filters > 5 NTU • Clarification if turbidity to filters > 10 NTU • Filtration using granular media or membranes • Disinfection to meet above requirements	• Secondary Treatment • Filtration • Disinfection	• Tertiary and Pathogen reducttion with sufficient log reduction to meet virus requirements	• Primary treatment • Secondary treatment • Coagulation • Tertiary Filters • Disinfection	-	• Secondary treatment • Coagulation • Filtration • Disinfection

6 WWTP Upgrade Options

The options to upgrade the WWTP have been developed to attempt to address the issues raised in section 4 Existing Wastewater Treatment System Issues. These issues are technical (existing assets), environmental (discharge quality) and cultural (disposal to harbour). The options presented in this section address the technical and environmental issues only. The cultural issues require consultation with the local runanga to identify an appropriate solution for Akaroa.

As a minimum, the existing WWTP will need to be upgraded to increase the treatment capacity and maintain the current treated wastewater quality. In order to meet the higher quality requirements discussed in the previous section further upgrades will also be required. There are four WWTP upgrade options listed below, each option also has choice of two sub-options for the type of secondary treatment process as presented in Table 6-1 on page 31:

- Option 1: Capacity upgrade (increase treatment capacity for future needs)
- Option 2: Nutrient removal upgrade (reduce nitrogen in discharge)
- Option 3: Microbiological upgrade (reduce pathogens in discharge)
- Option 4: Reuse upgrade (produce water for non-potable reuse)

The capacity upgrade is the minimum upgrade required and will maintain the current effluent quality. Nutrient removal and/or microbiological upgrades can be added to improve effluent quality. The reuse upgrade is required if wastewater is to be treated to reuse standard for non-potable uses within Akaroa.

Each of the upgrade options are discussed in sections 6.3 to 7.6 below and are presented in Table 6-1 on page 31. The new process units required for each upgrade are listed and the approximate percentage of existing assets that are utilised in each upgrade option has been assessed. The percentage is based on the estimated cost to replace the existing assets with new compared with the overall cost estimate for the upgrade. The advantage of using the existing assets are capital cost savings by utilising existing structures or equipment.

The upgrade options above are discussed in more detail below. The options for secondary treatment and sludge treatment are discussed separately below.

6.1 Secondary Treatment

For all of the WWTP upgrade options, there are two options for secondary treatment upgrade; either continued use of biological trickling filters (BTF) or an activated sludge process. Process flow schematics for these two options are shown in Figure 6-1 on page 32 and discussed below.

6.1.1 Option A: Biological Trickling Filters

The existing BTF cannot be upgraded unless the rock media is replaced with plastic media. This is not possible because the existing BTF cannot be taken out of service unless alternative treatment is provided.

If BTFs are considered, then a new BTF with plastic media would be preferred to take the full design load. The existing BTF could then be decommissioned. The new BTF would be a modern design using random plastic media similar to the BTFs at the Invercargill and Hastings WWTPs. The new distributor being installed in 2008 could possibly be modified to suit the new BTF. Plastic media is superior to the existing rock media because it has a higher surface area per unit volume, which allows the BTF to treat a higher load. Depending on the depth of the media, forced ventilation will be used to ensure aerobic conditions are maintained in the media. The existing BTF could also be upgraded to plastic media at a later stage.

If BTFs are used then the existing Imhoff tanks would be retained and converted to sludge digester/storage tanks (anaerobic digestion is preferred for BTF sludge).The new plastic media BTF is able to operate without primary settling prior to the wastewater entering the BTF. Research has shown that plants with no primary treatment preceding lowly loaded BTFs have not had any reduction in performance.

In general, BTFs have lower operating costs than activated sludge plants because they have lower power requirements and produce less sludge. BTFs have less equipment and require much less aeration than activated sludge, which results in less power demand. Any sludge produced will have to be processed and disposed of so any reductions in sludge production will also reduce operating costs. Other advantages of BTFs are that they are easier to operate and more reliable due to them being less complex than activated sludge plants.

Some nitrogen removal can be achieved by keeping the load to the BTF low and having a large recycle flow of the BTF effluent. However, in order to achieve a high reduction in nitrogen an activated sludge reactor can be used in conjunction with the BTF as a hybrid system. The BTFs and activated sludge would work in series. The BTF would remove BOD load and the activated sludge would nitrify (convert ammonia to nitrates). The nitrified effluent would be recycled back to the BTF for denitrification (reduction of nitrates to nitrogen gas). Phosphorus removal, if required, is achieved by chemical precipitation in the clarifier.

The advantages of using BTFs as the secondary treatment are:

- Easier and more reliable operation
- Lower operating and maintenance costs compared to activated sludge from:
  - Lower power demand
  - Lower sludge production
  - Less operator input
  - Less mechanical and electrical components

Table 6-1 : Akaroa WWTP Upgrade Options

	Upgrade Option	Treated Wastewater Quality	Options for Disposal of Treated Wastewater	Sub-option	New Construction Required	% Assets Retained in Operation	Comments
1	**Capacity Upgrade**	Typical for New Zealand	Irrigation to land/harbour. Disposal options: 1. 100% to harbour 2. 100% to land (storage of wet weather flows) 3. Dry weather flows to land and wet weather flows to harbour	A	1. BTF	58%	
				B	1. Activated sludge	57%	
2	**Nutrient Removal**	Reduced nitrogen concentration	Disposal to harbour or to land. Disposal options as above.	A	1. As for 1a, and 2. ASP for nitrification	49%	
				B	1. As for 1b, and 2. Activated sludge BNR (N removal)	53%	
3	**Microbiological Upgrade**	Contact recreation standard	Harbour	A	1. As for option 1 or 2, and 2. Cloth media filter	54%	
				B	1. As for option 1 or 2, and 2. Cloth media filter	53%	
4	**Reuse Upgrade**	Reuse standard	Non-potable reuse (~30%) and harbour (~70%)	A	1. As for 2a, and 2. chemical phosphorus removal 3. Membrane filtration	36%	
				B	1. As for 2b (with biological phosphorus removal), and 2. Backup chemical phosphorus removal 3. Membrane filtration	39%	Treatment options: 1. Treat 100% of flow to reuse standard, Or 2. Treat enough to reuse standard to meet demand, rest to standard of option 1, 2 or 3.

Notes:

1. Replacement or refurbishment of the existing inlet screen and UV disinfection system is assumed for all options.
2. Percentage of assets retained in operation is based on the estimated capital cost for replacement and includes costs for replacement of existing plant infrastructure (site civil works, building, road, power, electrical components, process pipes and valves).
3. BTF stands for biological trickling filter, BNR stands for biological nutrient removal.

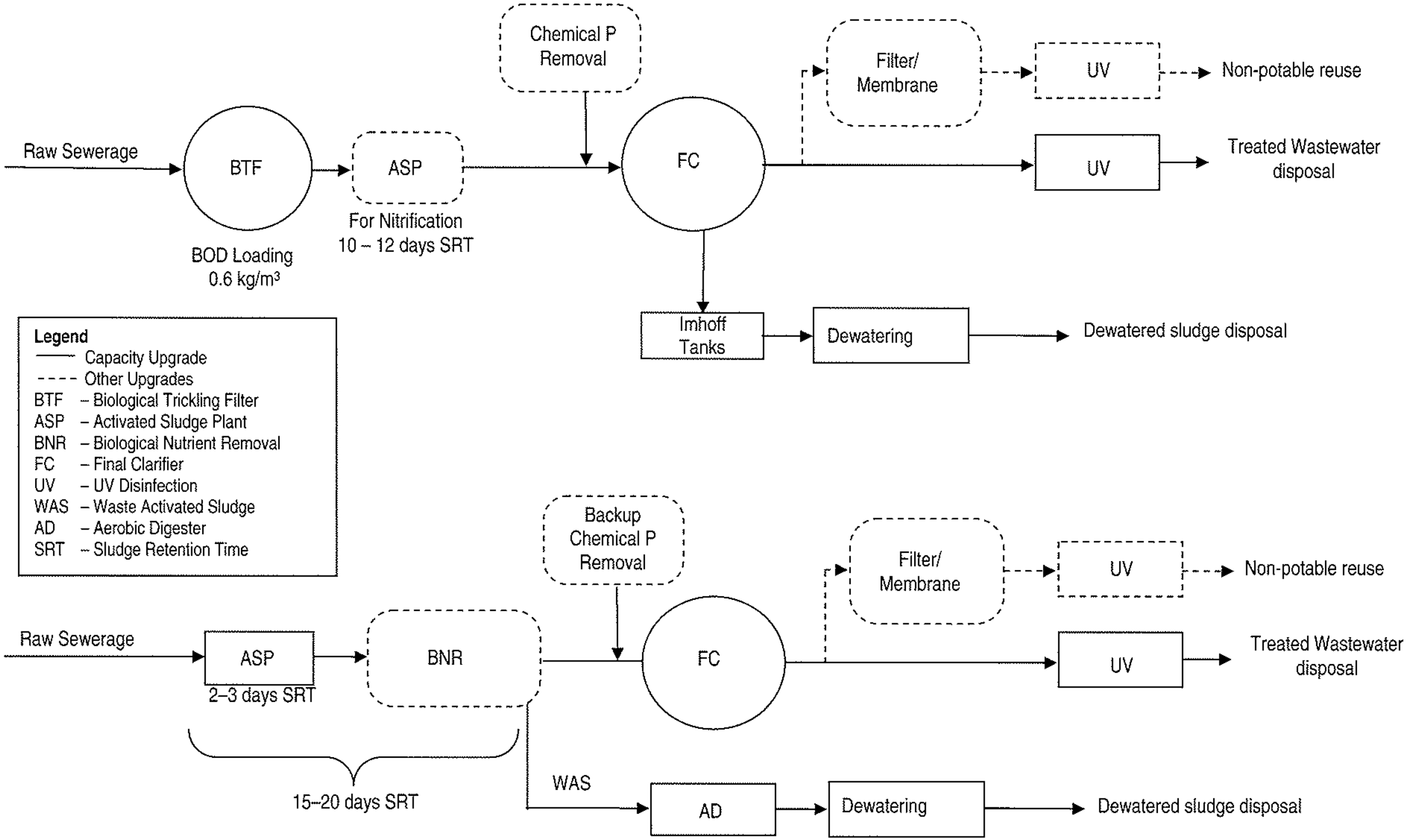


Figure 6-1 : WWTP Upgrade Options Process Flow Schematic – BTF or Activated Sludge Based Upgrades

6.1.2 Option B: Activated Sludge Plant

If an activated sludge plant is preferred then an activated sludge bioreactor would replace the existing BTF and Imhoff tanks (although they could be kept operational for if desired). The activated sludge plant would comprise a rectangular concrete tank (bioreactor) with aeration provided by blowers and fine bubble air diffusers. The existing clarifier could be retrofitted with larger pumps to include return activated sludge (RAS) to the bioreactor. The existing trickling filter would be decommissioned and the Imhoff tanks can be used for sludge storage and/or aerobic digestion.

Biological nutrient removal is achieved through the addition of anoxic zones (for nitrogen reduction) and anaerobic zones (for biological phosphorus reduction). Depending on the level of phosphorus removal required this can be either achieved by biological means or a combination of biological and chemical means. The addition of the extra zones for biological nutrient removal (BNR) results in an increase in bioreactor size and also requires mixers and recycle pumps and a greater degree of process control.

Activated sludge is a more energy intensive process but has the benefits of a smaller footprint and it would replace the older Imhoff tanks and trickling filter structures with a single new structure. Primary settling would not be required to replace the Imhoff tanks for an activated sludge plant in a community the size of Akaroa.

The advantages of using activated sludge as the secondary treatment are:

- Replaces older existing assets
- Smaller footprint (plant area)
- Better treated wastewater quality than a BTF (especially for nutrient reduction)
- Lower chemical addition (if phosphorus removal is required)
- Sludge easier to settle in the clarifier

6.2 Sludge Treatment

For any of the upgrade options sludge treatment and dewatering is recommended. If either a BTF or activated sludge is chosen for secondary treatment then the existing Imhoff tanks will be converted to sludge storage tanks or aerobic digesters and not be used for primary settling (the Imhoff tanks capacity for primary settling is not sufficient for future flows and loads). Without primary settling there is less gas production from anaerobic digestion so aerobic digestion is preferred and will provide stabilisation of the waste sludge to grade B biosolids. However, whether the sludge is stored or aerobically digested depends on the final disposal route. Options for disposal of dewatered sludge include the Bromley treatment plant in Christchurch, landfill or further treatment to achieve biosolids grade A or B.

The stored or digested sludge would then be dewatered from 0.5 to 1% dry solids (DS) up to 15 to 20% DS to reduce transportation costs. The liquid removed during sludge dewatering would be returned to the inlet of the plant to be treated.

6.3 Upgrade Option 1: Capacity Upgrade

6.3.1 Purpose

The capacity upgrade would maintain the current effluent quality and be designed for future flow and load based on the projected population of Akaroa in 2041. The existing WWTP produces a treated wastewater effluent typical of a New Zealand WWTP discharging to a harbour.

6.3.2 Construction Required

This upgrade would require an upgrade of the secondary treatment system: either a new BTF or new activated sludge plant. The existing inlet screen and UV disinfection system would also require replacement because they will be approaching the end of their useful life.

6.3.3 Effluent quality

The existing effluent quality would be adequate for irrigation to land, so this upgrade is a good option to be used in conjunction with land disposal. The existing effluent quality can be maintained by utilising either biological trickling filters (BTFs) or an activated sludge plant for the secondary treatment. If land disposal is the preferred disposal route then some discharge to harbour may still be required. This upgrade could be used to both provide treated wastewater for irrigation and for discharge to harbour.

The expected median treated wastewater quality from this upgrade is the same as the existing WWTP:

- Suspended Solids (SS) 30 mg/L
- Biochemical Oxygen Demand (BOD) 30 mg/L
- Faecal Coliforms (FC) 1,000 cfu/100mL
- Total Nitrogen (TN) 40 mg/L
- Total Phosphorus (TP) 10 mg/L

This upgrade option could potentially require a larger mixing zone than the proposed 250m around the outfall to allow achieve dilution and dispersion of the treated wastewater because, although the concentration of contaminates would remain the same, the mass load would increase due to increased treated wastewater volumes in the future.

6.4 Upgrade Option 2: Nutrient Removal Upgrade

6.4.1 Purpose

The nutrient removal upgrade would enhance nutrient removal in the treatment process with the aim of reducing the nutrient load to the harbour (if discharge is to the harbour) or reducing the land area required for irrigation.

6.4.2 Construction Required

This upgrade would be similar to the capacity upgrade (to ensure treatment of future flows and loads) but with design for nutrient removal. Nutrient removal can be achieved using either a two stage BTF and activated sludge hybrid plant or a single stage activated sludge plant designed for biological nutrient removal (BNR). Normally only nitrogen removal would be required (i.e. without phosphorus removal) for discharge to harbour or to land disposal. The plant could also be upgraded for phosphorus removal if required.

6.4.3 Effluent Quality

The expected median treated wastewater quality from this upgrade is similar to the capacity upgrade but would also have a lower nitrogen concentration:

- SS 20 mg/L
- BOD 20 mg/L
- FC 1,000 cfu/100mL
- TN 10 mg/L
- TP 10 mg/L

This upgrade would be suitable for discharge to harbour or to land. The nitrogen load in the treated wastewater will be reduced by approximately 75%.

6.5 Upgrade Option 3: Microbiological Upgrade

6.5.1 Purpose

The microbiological upgrade would reduce the level of micro-organisms in the effluent to the ANZECC (2000) contact recreation guidelines of a median faecal coliform concentration of 150 cfu/100mL.

6.5.2 Construction Required

This upgrade could be combined with either the capacity or nutrient removal upgrades. To increase clarity and reduce solids in the clarifier effluent, tertiary filtration is required. The filters will protect the UV disinfection system to ensure a high kill of micro-organisms. The UV disinfection system may also require special design to meet the quality standard required.

6.5.3 Effluent Quality

The ANZECC (2000) *Guidelines for water quality in Australia and New Zealand* contains guidelines for microbial indicators for contact recreation. The guidelines for 'primary contact' waters state that the bathing season median should not exceed 150 faecal coliform organisms per 100mL or 35 entrococci organisms per 100mL. Primary contact is described as water used for primary contact activities, such as swimming, bathing and other direct contact water sports.

This upgrade would ensure a 150 cfu/100mL faecal coliform median is maintained at all times. This will require extra capacity in the UV system and may also require tertiary filtration or a second clarifier to reduce the suspended solids to the UV system. The existing plant has been producing low faecal coliform results since the UV recycle was installed. The faecal coliform median since 17 January 2007 has been less than 100 cfu/100mL, however, this does not include the summer holiday season when the load to the plant is at its highest or wet weather events.

The expected median treated wastewater quality from this upgrade is (assuming no nutrient removal):

- SS 10 mg/L
- BOD 10 mg/L
- FC 150 cfu/100mL
- TN 40 mg/L
- TP 10 mg/L

This level of treatment would be best suited to harbour discharge because it is at a level in excess of that required for land irrigation and below that required for reuse. The mixing zone required around the outfall would be reduced because of the reduced concentration of faecal coliforms.

6.6 Upgrade Option 4: Reuse Upgrade

6.6.1 Purpose

The reuse upgrade would produce treated wastewater to reuse standard for non-potable uses within Akaroa. This upgrade would help to reduce the demand for water resources within Akaroa.

6.6.2 Construction Required

This upgrade would be similar to the option 2 (nutrient removal upgrade) but with a membrane filtration plant added prior to UV disinfection. The recycled water treatment plant would comprise a membrane filtration plant and pressure UV disinfection to achieve the required microbiological standards.

The demand for treated wastewater for reuse will not be equal to the amount of wastewater produced each day, so not all of the wastewater could be reused. Typically reuse would account for up to 20% of the potable water consumption. There are opportunities for capital and operating cost savings by treating a portion of the wastewater flow to reuse standard to meet demand, but treating the remaining flow to another standard for discharge to harbour. The reuse upgrade incorporates nutrient removal so the discharge to harbour would be equivalent to the standard of option 2 (nutrient removal upgrade) and phosphorus removal.

The capital cost estimates for this option have assumed the capacity of the recycled water plant (treating to reuse standard) to be equal to the design ADWF of 710 m^3/d. A means of utilising the treated wastewater for reuse is also required. A 'third pipe' system delivering non-potable water from the WWTP to the town is one option. Installation of a 45 km of 100mm PVC non-potable main from the treatment plant through Akaroa throughout the town with laterals to the boundary of each property have been estimated to have a total cost of around $9.6 million. The capital cost estimate is based on recent tender prices for pipe installation contracts (including contracts in the Akaroa area).

6.6.3 Effluent Quality

Based on the 2006 Australian Guidelines for Water Recycling, the following microbiological standards for treated wastewater reuse have been adopted for the purposes of this report:

- Bacteria: <1 E.Coli / 100 ml
- Viruses: 5.0-log reduction (measured against raw sewage concentration)
- Turbidity: < 2 NTU (average)

The discharge to the harbour of portion of the treated wastewater that is not required for reuse would be at the quality of option 2 but with phosphorus removal. The expected median treated wastewater quality to harbour is:

- SS 20 mg/L
- BOD 20 mg/L
- FC 1,000 cfu/100mL
- TN 10 mg/L
- TP 2 mg/L

The discharge to harbour would have a reduced nutrient load due to lower discharge volume (because of treated wastewater reuse) and nutrient removal.

6.7 WWTP Site Options

There are no obvious alternative locations for the WWTP site around Akaroa apart from the irrigation areas identified in section 5.1 above. However, as stated in section 5.1.3, pumping raw wastewater against the high heads required to reach the irrigation sites is not practical. Therefore the WWTP must be near Akaroa and within normal pumping heads. Sites near to Akaroa and within normal pumping heads are limited, and there is no obvious alternative to the existing site.

From a technical perspective, the existing site is in an appropriate location because it is out of sight of the main community, approximately 1km from the urban area of Akaroa and within normal pumping heads. The options for disposal all include some discharge of treated wastewater to the harbour (even if only for emergency use), and the existing outfall is located in a reasonable area for dispersion of treated wastewater.

The existing sewer network has been constructed to deliver wastewater to the existing site. If a new site was to be used it would be preferable to retain some of the current site for construction of the main pumping station feeding the new site because there is very limited area around the existing pump stations.

There are significant assets at the site that can be utilised for any of the upgrade options (all upgrade options utilise 50% or more of the existing plant on a replacement cost basis, with the exception of the reuse options which are around 35% to 40%). The capital cost to locate the WWTP on a new site is estimated to be $4.5 million on top of the costs of the preferred WWTP upgrade option and disposal options. This cost estimate includes costs for land purchase, a new pump station and 2 km of rising main to a new site.

As discussed in section 4.3, the WWTP is located in an area known as Takapuneke (Red House Bay), which is of special historical, cultural and spiritual significance and is listed in the Register of Archaeological or Wahi Tapu Sites. The location of the WWTP is therefore a sensitive issue and consultation with the local runanga is required to find an appropriate solution for the treatment and disposal of wastewater in Akaroa. It is understood that there is already ongoing discussion between the Ōnuku Rūnanga, the district council and the government about the future of this area.

From a technical perspective, the existing site is the most pragmatic option for the location of the WWTP because it is near Akaroa and within practical pumping heads, the existing sewer network was designed to deliver wastewater from Akaroa to this site, and the outfall is in a reasonable location for dispersion of the treated wastewater.

7 Comparison of Upgrade Options

The preferred disposal route for the treated wastewater usually determines the level of treatment and hence type of upgrade required; normally the level of treatment is lowest for land disposal (because the land performs further treatment), higher for discharge to harbour, and very high quality for reuse standard. There is also the possibility of having a mixture of disposal routes for the treated wastewater e.g. irrigation to land with wet weather flows to harbour, or reuse to meet demand for non-potable water and disposal to harbour.

When the preferred disposal route(s) have been determined the choice of WWTP upgrade will become more straightforward, although capital and operating costs for each option also need to be considered.

7.1 Capital & Operating Costs and NPV Analysis

The capital and operating costs for a selected combination of disposal route(s), WWTP upgrade option and WWTP location have been estimated along with a net present value (NPV) analysis until 2041 (Table 7-1). The selected options represent the most practical combinations of disposal, upgrade and WWTP location.

It is assumed that for all options the upgrade works are completed in the first year for the purposes of the NPV analysis. This provides a good base for comparison of the total capital and operating cost for each option, however, in practice some capital costs could be deferred by staging the upgrades over a number of years. This is especially true of the capital costs for the non-potable network which would most likely be spread over a number of years.

The capital costs estimated are based on recent tender prices or supplier estimates. Sums for preliminary and general, contingency and professional services (design and construction monitoring) have been included in the capital cost estimates as 15%, 20% and 20% of the nett capital cost respectively.

Operating costs are based on the current annual operating cost, estimates for increases in labour, power and chemical use, and rates of 0.5% and 4% of the capital cost for the maintenance of civil structures and mechanical plant respectively.

The load of nutrients (nitrogen and phosphorus) to the harbour is estimated based on the expected discharge volume and nutrient concentrations.

The 'issues addressed' for each combination indicate that an improvement has been made over the existing system with respect to the issues identified in section 4, but do not suggest that the upgrade will resolve the issue completely (with the exception of the WWTP capacity – all upgrades will include increases in capacity to satisfy wastewater treatment requirements until 2041).

The cost estimates presented are preliminary only and have an accuracy of -10% to +30%.

Table 7-1 : Capital and Operating Cost Estimates and NPV Analysis of Disposal Route and WWTP Upgrade Combinations

Disposal and Upgrade Combination			Load to Harbour		Issues Addressed				Cost Estimates# (excl. GST)		
Disposal Route(s)	WWTP Upgrade Option	WWTP Site	TN (kg/d)	TP (kg/d)	Capacity	Site	Harbour Quality	Cultural[Φ]	Capital Cost ($million)	Annual Operating Cost	30 Year NPV Analysis ($million)
Harbour (Status Quo)	1a (BTF capacity upgrade)	Existing	81	20	✓				$ 3.6	$ 140,300	$ 6.2
	1b (ASP capacity upgrade)	Existing	81	20	✓				$ 3.8	$ 233,700	$ 6.8
Harbour (improved microbiological quality)	3a (BTF Microbiological upgrade)	Existing	81	20	✓		✓		$ 4.3	$ 165,000	$ 7.2
	3b (ASP Microbiological upgrade)	Existing	81	20	✓		✓		$ 4.4	$ 262,000	$ 7.8
Disposal to Land & storage of WW flow	1a (BTF upgrade)	Existing	0	0	✓		✓	✓	$ 9.4	$ 747,500	$ 14.4
	1b (ASP upgrade)	Existing	0	0	✓		✓	✓	$ 9.6	$ 844,600	$ 15.0
^Reuse/Harbour	Option 4a (BTF&ASP hybrid N&P removal, membranes)	Existing	11	3	✓		✓		$ 20.5	$ 717,900	$ 23.4
	Option 4b (BNR N&P removal, membranes)	Existing	11	3	✓		✓		$ 19.7	$ 804,500	$ 23.2

Notes:
* The capital cost for pumping treated wastewater is included assuming that option 1 (Kaik Hill) is chosen. Other land disposal sites will incur higher capital and operating costs.
^ Reuse options include the $9.6m capital cost for a non-potable network from the WWTP throughout the town.
[Φ]Cultural issues with disposal of treated human wastewater to the harbour may be resolved with an appropriate solution identified by consultation.
[#] These cost estimates are preliminary only and have an accuracy of -10% to +30%.

The option to upgrade the WWTP capacity and continue to dispose of treated wastewater to the harbour is presented as a reference because this is the minimum upgrade required. The estimated capital cost of this upgrade is $3.6-3.8 million depending on the choice of secondary treatment; BTF or activated sludge plant.

The options to continue disposal of all of the treated wastewater to the harbour have the lowest capital costs because they have less new construction and also lower operating costs than the other options. The microbiological upgrade makes improvements on the issues of harbour quality and WWTP capacity. From a least-cost point of view these options are the most attractive.

For combinations that include nutrient removal, secondary treatment of an activated sludge BNR plant has lower capital costs than a BTF and activated sludge plant hybrid system. For options that do not require nutrient removal, the BTF has similar capital costs to the activated sludge plant (BTF is slightly lower), but operating costs are higher for activated sludge plants.

The reuse options have higher capital costs and high operating costs due to the nutrient removal plant and membrane plant to treat to reuse standard, and the $9.6m capital cost of the non-potable network from the WWTP throughout the town to deliver water to reuse standard. Costs for delivery of non-potable water to the end users have not been included (e.g. connection and plumbing to each property) this is estimated at $1,000 per property. Reuse can reduce the demand on water resources while still improving the quality of treated wastewater to the harbour by nutrient removal. It is not intended that the wastewater discharged to harbour is treated to reuse standard, however, the treatment process prior to the membrane plant includes the nutrient removal upgrade.

The option for land disposal incurs a large capital and operating cost associated with pumping the treated wastewater to the disposal site (pump station and pipeline), purchase of land and the large irrigation system. The existing effluent quality is sufficient for land disposal. Wet weather flows could be stored for disposal to land or could be diverted to the harbour. The analysis is based on storage of wet weather flows. If diversion of wet weather to the harbour is required, it is expected to occur only 5 to 10% of the time (or 18 to 37 days per year) in 2041 and less often in the years preceding this. The actual volume of wastewater diverted to the harbour would depend on the intensity of the rain event, and the wastewater will also be diluted by stormwater and groundwater entering the sewers. Nutrient removal is not required because the annual load to the harbour will be greatly reduced due to the wastewater being disposed of to land 90 to 95% of the time.

Land disposal has an advantage in removing most or all of the wastewater discharge from the harbour. There is strong local support for this option. The irrigation system incurs capital costs above the WWTP upgrade costs of $3.8 million including land purchase, the irrigation system, high head pump station and pipeline from the existing WWTP to the irrigation area (assuming option 1 Kaik Hill is preferred). Operating costs are also high due to pumping to the land disposal area and maintenance of the irrigation system. No benefit costs have been included (e.g. from sale of hay or crops from the land disposal area).

The options to dispose of the treated wastewater to the harbour have the lowest NPV ($6.2-7.8 million), indicating that the combined capital and operating costs are similar for these options. Land disposal has a NPV of $14.4-15.0 million due to higher capital and operating costs, while reuse has the highest NPV of ($23.2-23.4 million) because it has the highest initial capital costs associated with the water recycling plant and the non-potable water network as well as high operating costs.

7.2 Discussion of Disposal and Treatment Upgrade Options

Since the last major upgrade of the wastewater treatment plant (WWTP) in 1998 the plant has performed reasonably but struggled under periods of peak load. The quality of the treated wastewater from the WWTP has been improved in recent years through changes to sludge management and installation of the UV recycle. The results from effluent monitoring have been within the limits set by the resource consent since January 2006.. There have been no obvious impacts on the environment from the WWTP, although further monitoring is being done to provide more information on the environmental effects. However, experience from earlier consent applications for this and other wastewater treatment schemes suggest that there will be interest in better quality, lower nutrient impact and a desire to remove the discharge from the harbour for future resource consent applications. Some further improvements to performance and treatment capacity are also expected when the new distributor arm is installed in early 2008.

The existing WWTP requires upgrades to meet future demand for wastewater treatment. The Imhoff tanks have limited capacity especially for wet weather flows, although they can be retained for sludge digestion and storage. The trickling filter is nearly at capacity and, although the new distributor arm should increase capacity to some extent, the secondary treatment must be upgraded for future loads prior to 2016 at the latest. The choice of secondary treatment depends on the type of upgrade required. Currently, the biological trickling filter (BTF) is preferred over a single stage activated sludge plant if nutrient removal is not required (nutrient removal is easier to implement with an activated sludge biological nutrient removal (BNR) plant than a BTF based option). However, future needs must also be considered. If there is potential for nutrient removal to be required in 10 or 20 years, then the integration of an activated sludge bioreactor with a BTF could be implemented to provide a system capable of meeting the discharge requirements.

The existing site has sufficient land available for all the WWTP upgrade options presented above. The site is within an area of special historical, cultural and spiritual significance. The Ōnuku Rūnanga, the district council and the government are in ongoing discussion about the future of the area. From a purely technical point of view there is no need to shift from the site because it is located in a practical position and there are significant assets at the site that can be utilised for any of the upgrade options (all upgrade options utilise 50% or more of the existing plant on a replacement cost basis, with the exception of the reuse options which are around 35% to 40%). In conclusion, the existing site is the most practical for Akaroa; it is close to the town and within normal pumping heads, has existing useful assets and is suitable for all of the upgrade options presented.

The preferred disposal routes will determine the upgrade required for the WWTP. The current WWTP has performed well over the last 2 years and from the present environmental monitoring there appears to be no environmental drivers to upgrade the quality of the treated wastewater. Although there is some concern from the community about the nutrient load entering the harbour, a study of the nutrient status of Akaroa harbour (Environment Canterbury, 2005) concluded there is no overall increase or decrease in nutrient concentrations in the harbour. All of the WWTP upgrades presented (capacity, nutrient removal, microbiological or reuse) are practical to implement on the current site. Further consultation with the community and further investigation into environmental impacts and feasibility of land disposal is required to determine the desired disposal route and hence the WWTP upgrades necessary to meet the requirements of the receiving environment.

Of the disposal options presented, disposal of treated wastewater to the harbour is the most cost effective and sustainable option to implement. However, given the pressure on water resources in Akaroa and the potential for wastewater reuse to reduce demand on potable water sources, the reuse option has value in being pursued as part of the integrated water management strategy for Akaroa. Reuse of treated wastewater is common in areas where water is limited such as Australia or California. It requires a higher level of treatment than the other options and therefore incurs higher capital and operating costs, but it has the potential to reduce demand on potable water resources by up to 20%. The report 'Akaroa Water Management Strategy Part 4: Water Supply and Treatment Options' (MWH, 2008) discusses in detail the integrated water management strategy for Akaroa, including wastewater reuse.

Land disposal has strong local support and has the potential to address the issues important to the local community, such as the quality of the discharge to harbour and disposal of human wastes to the harbour. There are also regional policies, such as the Regional Plan for Natural Resources (Environment Canterbury, 2004) and the Regional Coastal Environment Plan (Environment Canterbury, 2003), which require a preference for disposal to land unless it is not practical to do so through lack of suitable land or prohibitive costs. This study has identified some potential areas that may be suitable for irrigation. Discussion with landowners over land tenure must be the priority to pursue this option further before any information is presented to the general public. Site investigations will also be required to determine the suitability of the soil the actual area of land suitable for irrigation.

With any of the options presented there may be some discharge of treated wastewater to the harbour (even if only for emergency use). Nutrient removal and/or microbiological upgrades can be included if required by an assessment of environmental effects or the local community. Cultural issues also need to be discussed with the local Runanga to determine an appropriate solution for treatment and disposal of wastewater for Akaroa.

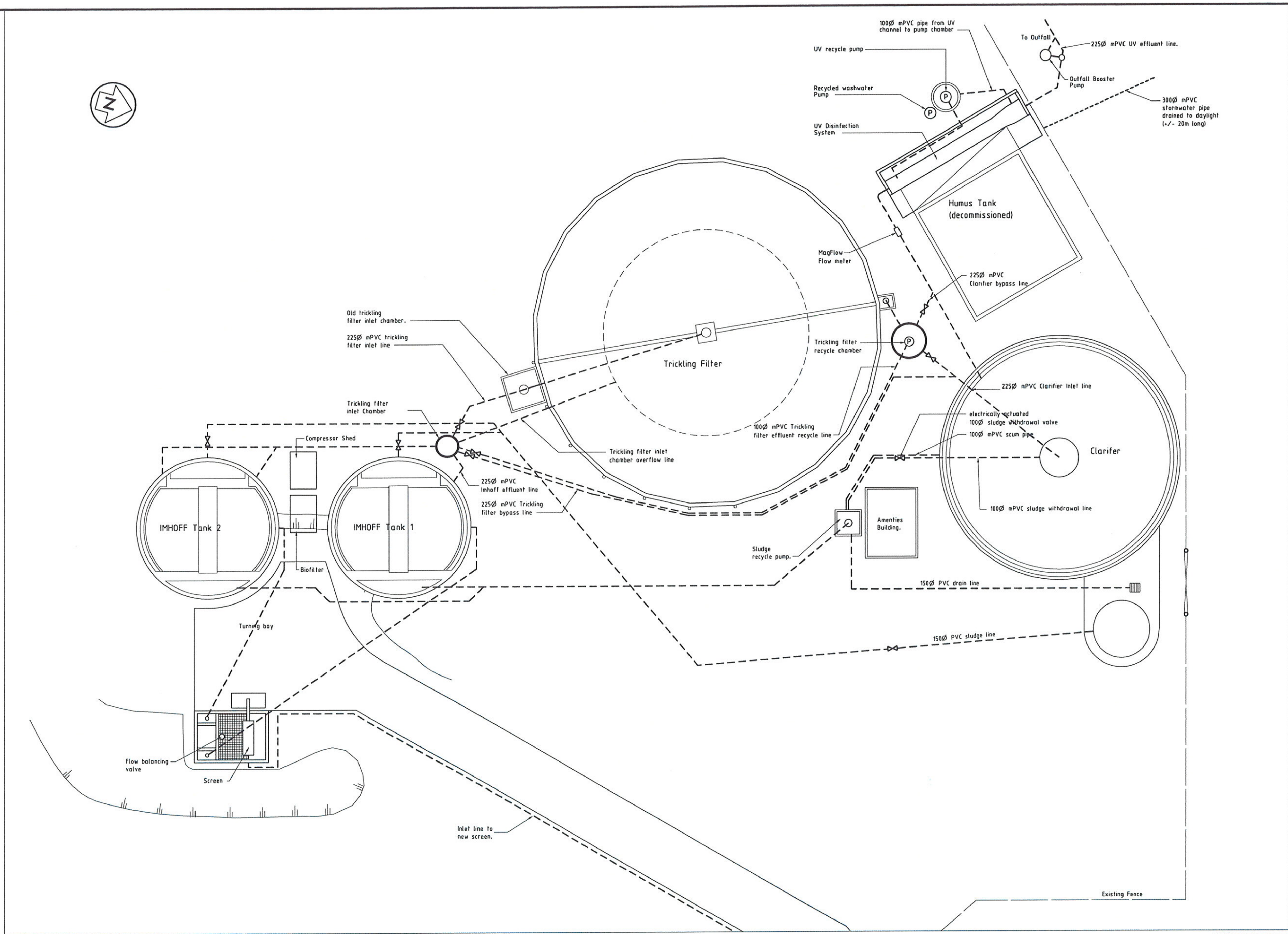
At this stage only capital and operating costs have been presented, there has been no consideration of the affordability of the disposal and WWTP upgrade options to rate payers. Although these costs also need to be considered against the environmental outcome of the upgrade options, the feasibility of some of the options may be affected by consideration of the affordability to the rate payers.

8 Conclusions

The purpose of this document is to identify the issues and options available for treatment and disposal of wastewater for Akaroa. From the options discussed in the previous section, the following course of action is recommended:

1. The priority is to discuss with land owners tenure of land for irrigation of treated wastewater at the preferred site on the south slopes of Kaik Hill prior to presenting any information to the general public.
2. Further site investigation of the preferred site to determine actual suitable area for irrigation and concept for the disposal system.
3. Community consultation to determine preferred disposal route(s) and hence the required WWTP upgrade options
4. Further investigation of the reuse of treated wastewater as part of the integrated water management strategy for Akaroa
5. Further investigation of short listed WWTP upgrade options

Appendix A Existing WWTP Layout



ORIGINAL SIZE A1

DO NOT SCALE - IF IN DOUBT, ASK

NOT FOR CONSTRUCTION

	AJ	11.98	
	GCL	05.07	
	CJM	05.07	
REV	REVISIONS		

MWH

CHRISTCHURCH
CITY COUNCIL · YOUR PEOPLE · YOUR CITY

AKAROA WWTP
TRICKLING FILTER UPGRADE

SITE LAYOUT PLAN

Status Stamp: FOR APPROVAL

Date Stamp: 02/05/2007

SCALES (A1) AS SHOWN

Project No.	Sheet No.	Rev.
Z1366004	FIG.1	A

Appendix B Discussion of Design Flows and Loads

MWH

Design Basis – Akaroa Wastewater Treatment Options

1 Purpose

The purpose of this document is to set a basis for the expected wastewater flow and loads to the Akaroa wastewater treatment plant (WWTP). These flows and loads will be used to estimate the required capacity and process requirements for future upgrades of the Akaroa WWTP.

2 Design Population

The design population is based on a combination of 2026 population projection from the 2005 Response Planning Report *Serviced Areas: Population and Visitor Projections* and the *Greater Christchurch Urban Development Strategy* projections from 2026 to 2041. The projected populations used for design are shown in Table 2-1 below.

Table 2-1 : 2041 Population Projections for Akaroa

		2004		2041	
Population	**Ratio to 1 p.e.**	**High Season**	**Maximum**	**High Season**	**Maximum**
Resident	1.0	650	650	930	930
Holiday Homes	1.0	1,700	2,200	2,290	2,940
Commercial accommodation	1.0	500	800	1,420	1,850
Overnight friends	0.6	50	80	140	190
Day visitors	0.25	1,700	2,500	7,190	9,810
Total people		4,600	6,200	12,000	15,700
Total p.e.		**3,300**	**4,300**	**6,500**	**8,300**

Notes:

1. p.e. stands for population equivalent equal to 1 resident
2. 2004 to 2026 populations are based on the 2005 Response Planning Report
3. 2026 to 2041 are based on a 9% growth rate as per the Greater Christchurch Urban Development Strategy

3 Design Criteria for Wastewater Treatment Plants

The most important criteria for design of the WWTP are the maximum flow rate for design the hydraulic design of the physical structures, and the maximum monthly organic load for design of the treatment process.

The design flow rates are based on the maximum population which is calculated to occur 1 day per year, while the design load is based on the high season population which occurs 45 days per year (during the 'peak season': summer holiday period and long weekends during summer). Taking these populations as the design basis ensures that the treatment plant will have hydraulic capacity for the maximum expected flow rate and treatment capacity for the maximum monthly organic loads.

The peak instantaneous flow the WWTP is dependant on the pump capacities in the sewer network. The current pumps feeding the WWTP are one duty "dry weather" pump with a capacity of 30 L/s and one "wet weather" pump with a capacity of 60 L/s. The pumps do not operate together.

4 Wastewater Flows

4.1 Average Dry Weather Flow

The expected dry weather wastewater flows to the WWTP are based on the 2041 Maximum population (occurs 1 day/year) and estimated per capita rates for Akaroa.

The existing per capita flow rates were estimated based on recorded dry weather discharge volumes from the WWTP and the estimated current population. The per capita rates are much lower than normal, probably due to the population estimates being higher than the actual population. However, for the purpose of estimating future flows they are adequate because the current and future populations are from the same source with the same assumptions made.

The 2041 average dry weather flow (ADWF) was then calculated as 710 m^3/day from the per capita rates and the 2041 maximum population (Table 4-1).

Table 4-1 : 2041 Maximum Population and Average Dry Weather Flow

Population Estimate	People	Ratio to 1 p.e.	Per Capita Rate (l/p/d)*	Flow (m^3/d)
Resident	930	1	86	80
Holiday Homes	2940	1	86	253
Commercial accommodation	1850	1	86	159
Overnight friends	190	0.6	52	10
Day visitors	9810	0.25	21	211
TOTAL (ADWF)				**710**

*These per capita rates are very low. It is expected this is caused by the population estimates being higher than the actual population. However, these rates are adequate as a reference for estimating future flows.

4.2 Wet Weather Flow

The 2041 maximum day flow was estimated from the ADWF above plus the expected I/I based on recorded daily volumes since 2000 (the maximum recorded wet weather flow was 3,431 m3/d on 20 August 2000). The peak hourly wet weather flow was taken as the current pumped capacity assuming that the I/I control programme will reduce peak wet weather flows. The Design flows are shown in Table 4-2 below.

Table 4-2 : 2041 Design Flows

ADWF	710 m^3/d
Maximum day flow	3,400 m^3/d
Peak hourly flow	60 L/s

The figures above were derived from recorded discharge volumes and standard design criteria. The method of calculation of these values is discussed below.

Using the NZS4404 approach, the future peak wet weather flow (PWWF) is calculated by applying a factor of 5 to the future 2041 average dry weather flow:

$$PWWF = 5 \times ADWF = 5 \times 710 = 3,550 \text{ m}^3/\text{d}$$

Currently the WWTP receives pumped flow of 60 L/s and occasionally the maximum recorded day of 3,431 m^3/day, which is nearly equal to the future PWWF calculated above. It is also possible that the WWTP does not receive all of the wastewater flow in the catchment, hence if the population capacity was increased the peak flows could also increase.

It is apparent that there is a significant infiltration and inflow (I/I) problem. Usually wet weather flow is a factor of around 5 times the ADWF while in Akaroa the factor is has been 7 to 20 times (based on recorded discharge volumes since 2000). It is therefore reasonable to assume that an aggressive I/I programme will reduce flows. Results of other I/I programmes within New Zealand have generally resulted in a low reduction, however, if significant I/I is occurring then a target of around 20% reduction may not be too unrealistic (i.e. a maximum day flow of 2,840 m^3/d). This decrease may need to be offset by any flow that is not currently being recorded. A figure of around 3,000 m^3/d may be appropriate given this consideration.

While overflows of raw sewage are not desirable a pragmatic approach based on return periods is sometimes required. Because the flow monitoring periods have been relatively short, statistical analysis is likely to be inappropriate, however, from figure 2 (attached) it can be seen that:

- The maximum discharge of 3431 m^3/d has occurred once in 6 years
- Discharges >2700 m^3/d have occurred 3 times in 6 years
- Discharges >2000 m^3/d have occurred 10 times in 6 years

A return period of 1 in 2 years is a reference basis in Christchurch City and on this basis a present day maximum design flow of 2,700 m^3/d could be concluded. However, given the sensitivity of the receiving environment overflows should be avoided, so any adopted basis should be conservative. Given the present infrequency of the maximum recorded flow of 3,431 m^3/d and the expectation of an aggressive I/I control programme, a present day design flow of 2,700 to 3,000 m^3/d would be reasonable. Allowing for the effect of population increase, the corresponding 2041 design flow would be 3,400 m^3/d.

The estimated 2041 peak hour flow is based on the peak diurnal flow plus the expected wet weather I/I flow:

$$\begin{aligned}\text{Peak hour flow} &= \text{ADWF} \times \text{diurnal peaking factor} + (\text{I/I} - \text{domestic base flow}) \\ &= (710 \times 2.5 + (3,400 - 710)) / 86.4 \\ &= 52 \text{ L/s}\end{aligned}$$

Because the figure above is less than the current pumped flow of 60 L/s to the WWTP, the 2041 peak hour flow will be assumed to be 60 L/s.

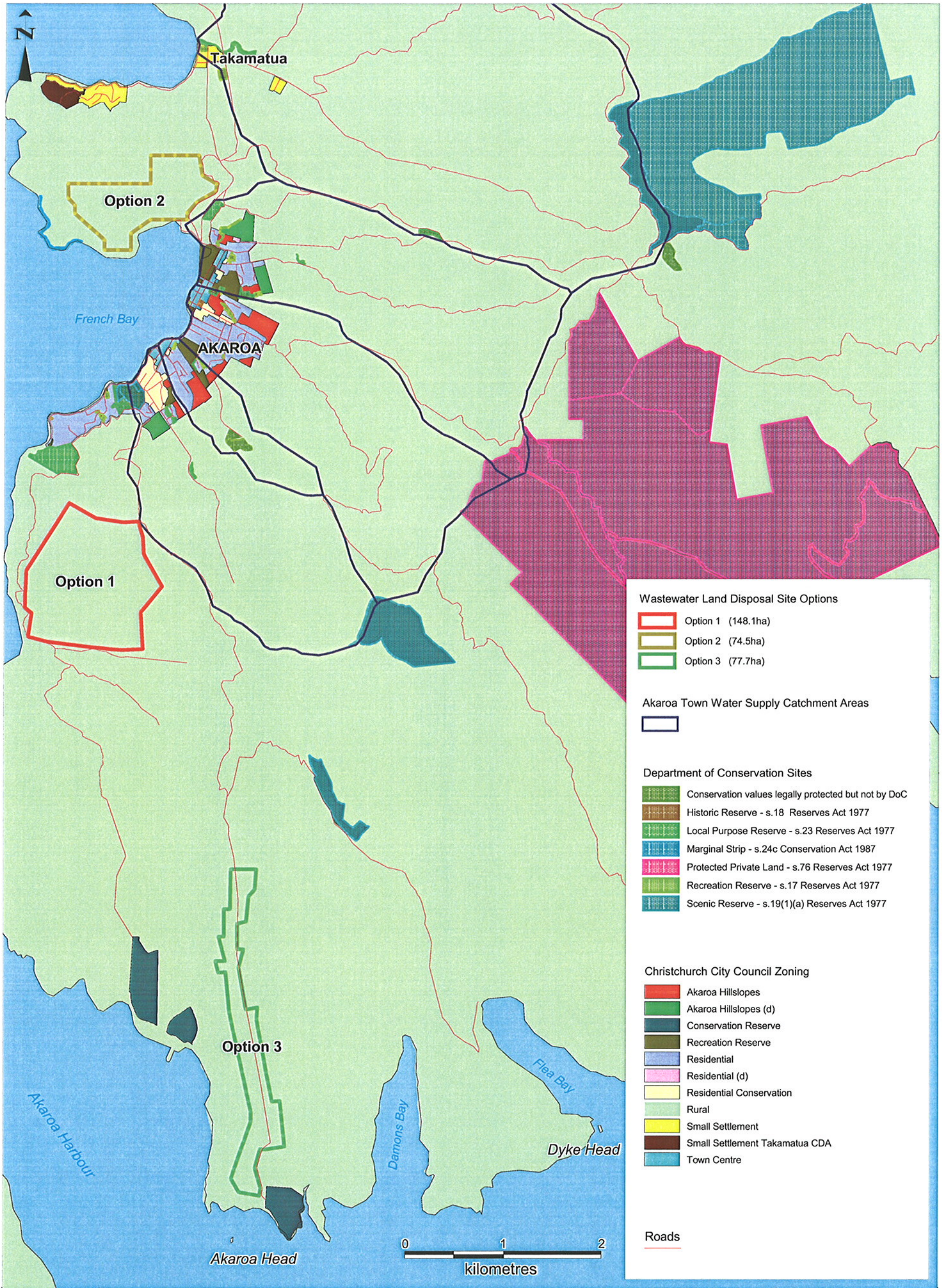
5 Wastewater Loads

Expected loads to the WWTP based on 2041 High season population (occurs 45 days/year) of 6,500 population equivalents (p.e.) and typical per capita rates for domestic sewage as shown in Table 5-1 below.

Table 5-1 : 2041 Design Organic Loads

High Season Loads (45 days/year)	Per Capita Rate (g/p/d)	Daily Load (kg/d)
BOD	60	390
TSS	60	390
TKN	15	100
TP	3	20

Appendix C Potential Land Disposal Areas



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AKAROA WASTEWATER DISPOSAL INVESTIGATION

WASTEWATER LAND DISPOSAL SITE OPTIONS

FIGURE 01	Rev 0
DATE: February 2008	
SCALE: 1:350,000 @ A3	
PROJECTION: NZMG	

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Appendix D Capital Cost Estimates

WWTP Upgrade Options: Capital Cost Estimates

Plant Items	1. Capacity Upgrade		2. Nutrient Removal		3. Micro Upgrade		4. Reuse Upgrade	
	a. BTF	b. ASP	a. BTF	b. BNR	a. BTF	b. ASP	a. BTF	b. BNR
			Incorporates option 1 costs		Incorporates option 1 costs		Incorporates option 2 costs	
Refurbishment of Imhoffs	$ 132,000		$ 132,000		$ 132,000		$ 132,000	
Inlet Screen	$ 103,000	$ 103,000	$ 103,000	$ 103,000	$ 103,000	$ 103,000	$ 103,000	$ 103,000
BTF	$ 1,216,000		$ 1,216,000		$ 1,216,000		$ 1,216,000	
ASP		$ 887,000		$ 887,000		$ 887,000		$ 887,000
ASP Hybrid			$ 1,166,000				$ 1,166,000	
BNR upgrade				$ 437,000				$ 437,000
Chemical P removal							$ 128,000	$ 128,000
Cloth media filter					$ 462,000	$ 462,000		
Membrane Plant (incl. pressure UV system)							$ 896,000	$ 896,000
UV Disinfection	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 204,000	$ 204,000
'Third pipe' non-potable network							$ 9,641,000	$ 9,641,000
Sludge Treatment	$ 515,000	$ 999,000	$ 515,000	$ 999,000	$ 515,000	$ 999,000	$ 515,000	$ 999,000
Electrical	$ 358,000	$ 454,000	$ 358,000	$ 454,000	$ 358,000	$ 454,000	$ 358,000	$ 454,000
Total Nett Cost	$ 2,528,000	$ 2,647,000	$ 3,694,000	$ 3,084,000	$ 2,990,000	$ 3,109,000	$ 14,359,000	$ 13,749,000
Preliminary & general (15%)	$ 252,800	$ 264,700	$ 369,400	$ 308,400	$ 299,000	$ 310,900	$ 1,435,900	$ 1,374,900
Contingency (20%)	$ 328,640	$ 344,110	$ 480,220	$ 400,920	$ 388,700	$ 404,170	$ 1,866,670	$ 1,787,370
Professional Services:								
- Design (15%)	$ 379,200	$ 397,050	$ 554,100	$ 462,600	$ 448,500	$ 466,350	$ 2,153,850	$ 2,062,350
- Construction monitoring (5%)	$ 126,400	$ 132,350	$ 184,700	$ 154,200	$ 149,500	$ 155,450	$ 717,950	$ 687,450
Total (excluding GST)	**$ 3,615,000**	**$ 3,785,000**	**$ 5,282,000**	**$ 4,410,000**	**$ 4,276,000**	**$ 4,446,000**	**$ 20,533,000**	**$ 19,661,000**

These cost estimates are preliminary only and have an accuracy of -10% to +30%

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