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Report

Akaroa Wastewater - Concept Design Report for Alternatives to Harbour Outfall

Prepared for Christchurch City Council
Prepared by CH2M Beca Ltd

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Revision History

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Document Acceptance

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Executive Summary

CH2M Beca is assisting Christchurch City Council (Council) in developing alternative options and locations for wastewater management at Akaroa.

The Council has obtained resource consents for building and operating a new Akaroa Wastewater Treatment Plant on Old Coach Road and a new pump station in the boat park at Childrens Bay, and for upgrading wastewater mains and the three existing pump stations. Council also applied for a consent to construct a new harbour outfall for discharge of treated wastewater. At the consent hearing the Commissioners concluded that the strong policy them of statutory requirements was that disposal of even highly treated human effluent into the Coastal Marine Area was not a good option, and should only be considered necessary in some circumstances after all other options had been fully investigated. In addition the Ngāi Tahu parties were strongly opposed to a direct discharge to harbour. The Commissioners considered that the Council had not undertaken sufficient investigation of alternative locations and options for disposal of treated wastewater as required under the Resource Management Act. This conclusion, and the objection from the Ngāi Tahu parties, lead to the consent for the outfall being declined.

Through a collaborative process involving the Ngāi Tahu parties and Council, the Council is again considering alternatives. The Council and the Ngāi Tahu parties have agreed that several land-based alternatives will be investigated further.

This report summarises the work involved in developing options, including those options that are not being progressed, and provides conceptual designs and layouts, consenting evaluation, comparative costs and risks for the shortlisted schemes in comparison with the harbour discharge option for which Council originally sought consent. The report does not fully assess the environmental and other effects of the options investigated nor does it provide detailed design information. Further work will be required to develop any preferred option and conduct a range of investigations to reach a stage where it could proceed through a resource consent process and into detailed design.

The overall findings of the work are that a land-based wastewater scheme is technically viable and a similar capital cost to the original scheme involving a 2.5 km harbour outfall – except non-potable reuse which is significantly more expensive.

A description of shortlisted options is as follows – all capital costs described are for the land treatment component of the scheme only. The costs for the new wastewater treatment plant and town network and pump station changes, estimated at $21M, are additional to this cost. The cost of the harbour outfall is estimated at $6.7M.

All the land-based options require additional treatment for wet weather bypass flows. Council is undertaking a programme to reduce groundwater infiltration and stormwater inflow into the network, which currently contribute significantly to the wet weather flows in Akaroa. The future design flows used assume that this work will continue and further reductions will be achieved – these reductions are important to reducing costs associated with treatment and storage of bypass flows.

The Ngāi Tahu parties have provided commentary on cultural acceptability of the different options. Year round irrigation to land (either under trees or to pasture) is the only option that they consider is consistent with Ngāi Tahu cultural values.

Option 1 – Year Round Irrigation to Trees

This year-round irrigation option is based on 25 ha of land planted in trees with surface drip lines. A further 0.7 ha is needed for storage and 2.5 ha for 5m buffer zones giving a total land requirement of 28.2 ha. Suitable land areas have been identified in the Takamātua area, split into at least 3 blocks over 8 to 10 land titles. The scheme incorporates the consented Biological Nutrient Removal (BNR) treatment plant, a 12,000 m^3 storage pond to capture peak flows, a pump station and reticulation to the irrigation blocks. There is no discharge of wastewater to the harbour associated with this scheme at any time of the year. Indicative capital costs for this land treatment option are $4.5 - $6.1M depending on storage pond location.

Option 2 – Year Round Irrigation to Pasture

This year-round irrigation option is based on 27 ha of land in pasture with K-line spray irrigators and a further 2.5 ha for storage and 8.1 ha of land for 25m buffer zones around the spray area giving a total land requirement of 37.6 ha. The same land that would be suitable for irrigation to trees would be suitable for irrigation to pasture. The scheme incorporates the consented Biological Nutrient Removal treatment plant, a 30,000 m^3 storage pond to store wastewater when the soil is too wet to irrigate, a pump station and reticulation to the irrigation blocks. There is no discharge of wastewater to the harbour for this option. The indicative capital cost for irrigation to pasture is $7.3M based on a storage pond located at or around Location A. There is an option to change the technology used for wastewater treatment for this option since a high level of nitrogen removal is not required. This could result in up to a $2M saving on the capital cost of the treatment plant and potentially some operational cost savings.

Option 3 – Summer Only Irrigation plus Wetland or Infiltration Basin

Summer only irrigation plus wetland or infiltration basin involves land irrigation in summer and in winter land passage through a subsurface wetland or infiltration basin after which the wastewater flows through a coastal infiltration gallery. Irrigation fields, totalling 12 ha, could potentially be obtained from a single land owner. The scheme also incorporates the consented treatment plant, either a 7,000 m^3 storage pond for the infiltration basin or a 12,000m^3 storage pond for the wetland to capture peak flows, plus a subsurface wetland or infiltration basin and engineered pathway to the harbour. Approximately 1.4 ha is required for construction of the storage pond and wetland and 1.5 ha for storage pond and infiltration basin. An allowance of 3.6 ha has been made for 25m buffer zones around the spay area so a total of 17 – 17.1 ha would be required. The engineered pathway consists of an infiltration gallery built into the shoreline in the intertidal zone at the head of Takamātua Peninsula. In the winter, and after passage through either the subsurface wetland or infiltration basins, wastewater flows via the coastal infiltration gallery. Indicative capital costs are $4.9 - $5.1M for the wetland option and $5.6 - $5.8M for the infiltration basin option, depending on storage pond and wetland/infiltration basin location.

Option 4 – Subsurface Flow Wetland

Under this option wastewater passes through a subsurface wetland, some of the wastewater is taken up by the wetland and the remaining wastewater flows to the harbour via a coastal infiltration gallery. The wetland and 12,000 m^3 storage pond require 1.4 ha of land in total. Retention time in the wetland is at least 2 days in summer and 3 days in winter. Land could be obtained from a single land owner. The scheme also incorporates the consented treatment plant. Wastewater flows through the coastal infiltration gallery after passing through land within the wetland. In summer the flow will be reduced by water uptake by wetland plants. Indicative capital costs are $3.6 - $4.0M depending on storage pond and wetland location.

Option 5– Infiltration Basins

The infiltration basin option is similar to the subsurface wetland scheme, except the passage through land occurs vertically downwards through the infiltration basin rather than horizontally within a wetland. The storage pond size is reduced to 7,000 m^3 and the land area required is slightly greater at 1.5 ha. The conceptual design is based on 7 basins and the flow is rotated around the basins every few days, with a minimum residence time of 2 days. Wastewater flows through the coastal infiltration gallery year round after passing through land within the infiltration basin. Indicative capital costs are $4.3 - $4.8M depending on storage pond and infiltration basin location.

Option 6 – Non-potable reuse

Non-potable reuse describes a system where the treated wastewater is reticulated to households and the township for use in toilet flushing, garden watering, boat washing etc. Non-potable reuse cannot dispose of all the treated wastewater with certainty as, although connection to the scheme could be made compulsory, the volume of treated wastewater used it is reliant on the amount utilised by the community. Hence non-potable reuse would function as an add-on to Options 1 – 5, enabling reuse of a proportion of the treated flow within Akaroa and rural surrounds. To implement this option a new storage system and reticulation network would need to be installed, and each property fitted with an appropriate connection point and signage. It is estimated that 20% of the wastewater flow could initially be reused in summer (in toilet flushing) and approximately 10% in winter. Reuse rates may increase over time with community acceptance of the benefits of reuse water. The cost for option 6 is estimated at $10.9M.

Treated Wastewater Quality

All of the land-based schemes investigated will have a final discharge wastewater quality similar to, or better than, the treated wastewater quality proposed as part of the 2014 consent for discharge via a 2.5 km long harbour outfall, except Option 2 where a higher nitrogen content in the treated wastewater may be acceptable. There are some minor differences in quality attributes among the schemes. These can be developed and refined further in the next stage of the work for any preferred option. Key points regarding wastewater quality are as follows:

- Year round land irrigation will have no measurable effect on the harbour as wastewater will be taken up by plants and filtered by soils within the irrigation area
- The subsurface wetland scheme (Options 3 and 4), including a coastal infiltration gallery to the coastal zone, will further polish the wastewater from the treatment plant prior to discharge, although it is likely to cause small increases in BOD and suspended solids levels in the final discharge. This is due to organic material breakdown within the wetland. The wetland scheme will also remove some of the residual bacteria and viruses present in the wastewater to assist in managing public health risks
- The infiltration basin scheme (Options 3 and 5) is similar in performance to the wetland scheme, except it is unlikely to remove bacteria and viruses as effectively as a wetland.
- Discharge of treated wastewater via the coastal infiltration gallery located at the shoreline will not be as effective the dilution achieved by a 2.5 km harbour outfall pipe. Nevertheless, taking into account the overall performance of the wetland and infiltration basin schemes, and the dilution efficiency, public health risks are expected to be well managed.

Projects risks and opportunities relating to each option are as follows:

Option 1 – Year-Round Irrigation to Trees

Year round irrigation to trees represents an opportunity to completely eliminate the discharge of wastewater to the receiving waters. This will minimise public health risks and environmental impacts. Balancing these positives are significant risks around land access and land procurement given that extensive irrigation fields are required. The dispersed nature of the irrigation fields, spread across at least three land areas, could increase community opposition as numerous landowners will be affected directly or indirectly. Strong community opposition could extend timelines for implementation and result in increased costs if onerous consent conditions are imposed. It may be difficult to acquire sufficient land, which could significantly extend the timeframe.

Option 2 – Year Round Irrigation to Pasture

Year round irrigation to pasture has similar opportunities and risks as year round irrigation to trees. However if irrigating to pasture the risk of erosion increases and will need to be carefully managed. The year round irrigation to pasture option is the highest capital cost option. However it may be possible to change the wastewater treatment plant design to reduce the plant cost and offset the higher cost of irrigation to pasture. Irrigated pasture may be grazed for part of the time. Access for grazing is related to the withholding period post-irrigation and this will be determined based on microbiological risks associated with the wastewater, nutrient uptake and localised soil types and profiles.

Option 3 – Summer Only Irrigation plus Wetland or Infiltration Basin

Summer only irrigation plus wetland or infiltration basin involves a simpler and smaller irrigation scheme combined with a wetland or infiltration basin and coastal infiltration gallery. Opportunities within this scheme include easier implementation and lower costs as well as elimination of wastewater discharge to the harbour during summer; the time when most fishing, food gathering and recreational use takes place. Community opposition may be less than for a year round scheme as the irrigation area is smaller and can be positioned relatively remote from most rural residential properties. Nevertheless the Kingfisher Point subdivision is nearby and opposition from this residential group could extend timelines and impose higher costs. Capital costs are moderately high to high as both irrigation field and wetland or infiltration basin components need to be constructed. The combination of summer only irrigation and infiltration basin are relatively high capital cost options. Environmental and public health risks are slightly higher compared to a year round irrigation to land as treated wastewater flows into the coastal environment in winter after passing through land.

Option 4 – Subsurface Flow Wetland

The subsurface wetland provides passage through land within a confined area in a wetland rather than over an extensive area of land. The opportunity is for a simpler scheme that may be supported by the wider community due to reduced land usage and less impacted parties, will be easier to operate, with low public health and environmental risks. Land requirements are also minor (2 ha) and the scheme may be implemented within a relatively short time frame, after land access and resource consents have been secured.

Option 5 – Infiltration Basin

The infiltration basin scheme is similar in terms of opportunities and risks to the subsurface wetland. The infiltration basin is also a relatively simple scheme, although more costly than a subsurface wetland, that is likely to be supported by the wider community, will be easier to operate, with low public health and environmental risks. Land requirements are minor (2 ha) and the scheme may be implemented within a relatively short time frame, after land access and resource consents have been secured.

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1 Introduction

1.1 Background

Christchurch City Council (Council) submitted resource consent applications in June 2014 for a new wastewater scheme in Akaroa. The new scheme would enable the existing Akaroa wastewater treatment plant (WWTP) to be moved away from its current location, which is culturally significant to Ngāi Tahu. The proposed upgrade involved reconfiguration of the existing wastewater trunk mains, a new terminal pump station, a new biological nutrient removal (BNR) WWTP with treated wastewater discharged via a new outfall out into the mid-harbour. A diagram of the scheme proposed in the resource consent application is attached in Appendix A.

An Akaroa wastewater working party had been established during the scheme development to gain community input to the scheme, including into the method of disposal of treated wastewater. The working party had completed extensive work on investigating alternatives; however this work was not comprehensively documented or compiled in a single output that could be submitted to the hearing. The Commissioners' granted consents for the proposed new treatment plant and reticulation changes, but not for the harbour outfall or the discharge to the harbour.

The Commissioners concluded that the strong policy theme of statutory requirements was that disposal of even highly treated human effluent in to the Coastal Marine Area was not a good option, and should only be considered necessary in some circumstances after all other options had been fully investigated. In addition the Ngāi Tahu parties were strongly opposed to a direct discharge to harbour. The Commissioners considered that Council had not undertaken sufficient investigation of alternative locations and options for disposal of the treated wastewater as required under the Resource Management Act. This conclusion and the objection from the Ngāi Tahu parties lead to the consent for the outfall being declined.

In response to the outfall consent being declined Council initiated further investigations into alternatives to the harbour outfall in August 2015. CH2M Beca (Beca) was commissioned to assist Council with this investigation. This work generated a long list of all possible alternatives to the proposed harbour outfall. The long list was refined to a short list by qualitative evaluation and consultation with the Ngāi Tahu parties. The results of the investigation and evaluation are documented in the draft Beca report *Akaroa Wastewater Project – Review of Disposal Alternative for Ngāi Tahu – First Stage* dated 8 September 2015.

Council then engaged Beca to complete the concept design investigation and analysis of the short listed land-based options for disposal of treated wastewater from Akaroa.

1.2 Purpose

This report describes all options considered by Council, presents concept designs for the scheme options shortlisted in consultation with the Ngāi Tahu parties in September 2015 and compares those options with the harbour outfall for which the Council sought consent. The work includes evaluation of treatment requirements, land irrigation, infiltration and wetland processes, scheme layouts and review of locational options, initial geotechnical and hydrogeological assessment, equipment and pipeline sizings, and project risks and costs.

The preferred option identified by the Ngāi Tahu parties, referenced to the Beca report of 8th September 2015 was irrigation to land – with wetlands as storage before or after irrigation. The Ngāi Tahu parties also indicated that they were interested in subsurface flow wetlands and infiltration basins being investigated further to provide sufficient detail for them to form a view on this option. Non-potable reuse and a reduction in the volume of stormwater entering the network were highlighted as other areas that should also be investigated further.

The purpose of the work is firstly to inform the Council's consideration of alternatives to discharging directly into the harbour. Secondly this work will assist with the Environment Court mediation process that is underway with the intention of reaching a satisfactory conclusion to resolve the appeals.

1.3 Scope

The scope of the study is to describe all options considered, develop more detail on the short listed options, provide information that assists with evaluation of their merits, benefits and costs, and to determine if any of the options have fatal flaws which would mean they could not be carried forward. For each shortlisted option the following information was developed to a concept level:

- Analysis of flows and application and discharge rates
- Description of the proposed treatment – key components of scheme
- Area of land/volume required for storage
- Area of land required for construction
- Layout - what the scheme will look like, where it will be positioned
- Likely discharge points and nature of discharge after land treatment (if any)
- Opportunities for use of local materials (whether soil, gravel or rock is required to be imported for each land treatment system).
- Capital and operational costs
- Consents required
- Qualitative advice on risks around consenting including consideration of potential marine ecological effects, landscaping effects, affected parties, recreational effects, public health and amenity (note: this does not constitute an Assessment of Effects but evaluates the consentability of the proposed activity and appropriate mitigation)
- An assessment of considerations such as silent files, archaeological requirements, operational requirements, land acquisition requirements, timing and cost.

For non-potable reuse the report summarises high level information on what the reticulation system would look like, the typical on-property installation and associated cost estimates.

The shortlisted options are assessed using a list of criteria that includes public health risk, cultural acceptability, cost and other social impacts.

1.4 Statutory Overview

Consideration of alternatives is critical given the provisions of the Resource Management Act including Section 105 (which relates to discharges) and Section 168A (which relates to designations) as well as various policies in the New Zealand Coastal Policy Statement, the Canterbury Regional Policy Statement, the Land and Water Regional Plan and the Regional Coastal Environment Plan (RCEP) relating to alternatives for the discharge of wastewater into the coastal area. There is also case law on the necessity to give adequate consideration to alternatives including the discharge of wastewater, particularly having regard to Maori matters set out in Section 6(e), Section 7(a) and (e) and Section 8 of the Act.

2 Design Flows and Loads

2.1 Design Wastewater Flows

2.1.1 Dry Weather Flows

To estimate the amount of land needed for each land treatment option, an estimation of the future wastewater flows from Akaroa was required. The future design flows for Akaroa had previously been estimated in the CH2M Beca report *Akaroa Wastewater Preliminary Design Report* dated April 2014. These flows are presented in Table 2.1. The future flows are estimated to 2041 – it is proposed that in the next stage of design the future flows be assessed to 2051 to be consistent with the consent application duration.

Table 2.1 – Future Design Influent Flows

Flow		Current	Design (2041)
Winter Average Dry Weather Flow (ADWF)	m^3/d	200	290
Annual Average	m^3/d	246	357
Summer Average	m^3/d	386	561
Peak Summer Day	m^3/d	696	1,011
Peak Instantaneous	L/s		65

Council indicated at the hui with the Ngāi Tahu parties on 21 October 2015 that through a programme of pipe renewals it had been able to reduce infiltration and inflow to the network. As a result peak wet weather flows have reduced from around 3,000 m^3/day to 1,800 m^3/day and further reductions will be achieved as the Council continues its programme of work. The future design flows have assumed the peak wet weather flows will remain at 1,800 m^3/day even though the peak summer day will increase from 386 m^3/day to 561 m^3/day – representing a reduction in the ratio of peak wet weather daily volume to summer average from 4.7 to 3.2.

Council has also provided daily flows from the Akaroa wastewater treatment plant and rainfall data from NIWA weather station in Akaroa for the period between June 2006 and October 2015. The rainfall data is from a single station in Akaroa – Akaroa EWS (STN 36593) – recording commenced at this station on 12 November 2008. Flow data was recorded from 2006 onwards.

This data was used to correlate rainfall to flow information, to determine the rate of increase in flow leading up to the peak and the rate of decrease of flow after a peak event i.e. how many days of high flow are expected either side of a peak day. This information was then used to help size the storage pond to make sure it could cope with the total flow around peak events. The data also provided a flow trend on a year by year basis and confirmed the information from Council that the peak day flow was approximately 1,800 m^3/day. The annual volume of wastewater is expected to range between 131,000 and 142,000 m^3, with an average of approximately 137,000 m^3.

To estimate the size of land required for the land treatment options the current flow record data from 2008 to 2015 was modified as follows to achieve the future design flows shown in Table 2.1:

- In summer when there is no rainfall, increase the summer flows (1 December to 28 February) to 95% of the summer average, and when there is rainfall increase the influent to account for inflow and infiltration so that the average flow for the summer period is approximately 561 m^3/day

- In winter when there is no rainfall, use the future winter average dry weather flow of 290 m^3/day and where the recorded flows were greater than 290 m^3/day use those flows
- For the rest of the year increase the daily flow to 95% of the annual average flow and where the flows are greater than the annual average flows use those flows
- Cap all flows to a maximum of 1,800 m^3/day

No allowance has been made for climate change. On the east coast of the South Island the impact of climate change is generally expected to be drier summer conditions with heavier storm events (more intense rainfall over the same duration). This may result in greater localised flooding during the event, but is unlikely to cause any greater infiltration into the wastewater network than already allowed for. In addition, as the Council continues work on reducing infiltration and inflow into the network, any small increases that may be attributed to climate change would likely be offset by decreases in flow from improvements to the network. The net result is that climate change is not expected to affect design flows significantly.

2.1.2 Wet Weather Flows

The peak wet weather flow in winter is assumed to be the same as in summer at 1,800 m^3/day. Average wet weather flow has not been calculated. Current data indicates that wastewater flow is influenced by rainfall for some days after the rainfall event for some events but not others. Future wet weather flows are assumed to be same as current wet weather flows except capped to maximum of 1,800 m^3/day.

2.1.3 Bypass Flows

The consented wastewater treatment plant is sized to provide full treatment for a flow of 14 L/s. The terminal pump station in Akaroa Township will have a mechanical screen (3 mm gap) and will pump flows of up to 65 L/s to the wastewater treatment plant site. Normal flows (up to 14 L/s) will receive full treatment using the Biological Nutrient Removal (BNR) process with membrane filtration. Flows higher than 14 L/s will be stored in the balance tank at the WWTP. Once the capacity of the balance tank at the site is reached, additional flows above 14 L/s will bypass the main treatment process, receiving full primary treatment and UV disinfection, before recombining with the treated wastewater from the main process. An additional disc filtration step on the bypass is also proposed for all scheme options (except the harbour outfall), and this is outlined in Section 4.2.

The wastewater flow for all significant wet weather events from 2010 to 2012 was modelled as part of the preliminary design for the project. The results show that for the 250 m^3 balance tank proposed there would be an average of two events per year when some wastewater bypasses the treatment plant and receives primary treatment plus disc filtration and disinfection only. The typical duration of these events is 1 – 2 days.

Section 4.2.5 describes the quality of the discharged treated wastewater during bypass flow events.

2.2 Wastewater Storage Requirements

In addition to the 250 m^3 of buffer storage within the treatment plant, additional storage of treated wastewater will be required for all land based disposal scheme options in order to optimise the overall area of the land required and to accommodate peak wet weather flows.

All the shortlisted options are based on a flow of up to 65 L/s and 1,800 m^3/day being supplied to the storage ponds upstream of the land treatment. Evaluation of storage requirements for each land treatment option is outlined in Section 4.

2.3 Design Wastewater Loads

The predicted quality of treated wastewater from the consented wastewater treatment plant was adopted as the design basis for the land treatment scheme options. This information, extracted from the preliminary design report for the scheme upgrade, CH2M Beca report *Akaroa Wastewater Preliminary Design Report* dated April 2014, is summarised in Table 2.2. The predicted wastewater quality has been determined from knowing the quality of the influent wastewater, and using industry experience of what can reasonably be expected of a biological nitrogen removal plant with membrane solids removal and disinfection.

Table 2.2 - Design Treated Wastewater Values

Parameter		Winter Dry Weather	Peak Summer
Total suspended solids (TSS)	mg/L	2	4
Carbonaceous biological oxygen demand ($CBOD_5$)	mg/L	5	10
Ammoniacal nitrogen	mg/L	1	5
Total Nitrogen	mg/L	10	15
Faecal coliforms	cfu/100mL	10	100
Enterococci	cfu/100mL	10	100

2.4 Design Land Irrigation Rates

The land irrigation application rates used for irrigation under trees are based on the parameters which were used to size and consent the Wainui Irrigation Scheme. These are:

- Application rate of 5 mm/day in summer (December to February)
- Application rate of 1.5 mm/day in winter (June to August)
- Application rate of 3 mm/day for remainder of the year
- When rainfall exceeds 50 mm/day or averages more than 50 mm/day over a number of days (the maximum is 5 days for the rainfall data available) then no irrigation occurs
- If the allowable irrigation is less than wastewater flows or cannot occur due to high rainfall, wastewater is stored (in the upstream storage basin) and irrigated when the capacity in the irrigation system becomes available.

The Wainui application rates are considered appropriate for this stage of concept design as the Wainui land type is similar to the area proposed for irrigation for Akaroa. However, if irrigation is selected as the preferred option, more detailed investigations will be required at the next stage to confirm application rates. The application rates used have considered potential effects on groundwater and land stability. An assessment of hydrogeological conditions in the area was undertaken and the summary report is included in Appendix C. Monitoring reports from the Wainui treated wastewater irrigation scheme are included in Appendix J.

Application rates for irrigation to pasture have been determined based on a soil moisture deficit balance calculation that is described in detail in Section 4.5.2.

2.5 Design Flows to Wetland

The subsurface flow wetland needs to be sized to handle maximum flows, but not made so big that it dries out when flows are at their lowest level as it is important for the wetland to remain wet at all times. The upstream pond storage can be used to buffer out peak flows, helping to reduce the overall size of the wetland. The sizing of the subsurface flow wetland was considered over a range of design flows from 1.5 times the future winter average dry weather flow (DWF) = 435 m^3/day to the peak summer flow of 561 m^3/day, to find a cost effective combination of wetland and storage sizes. At the lower end of the flow range 1.5 times the future winter average dry weather flow was considered a reasonable flow rate to balance the difference between the low winter flows and the much higher summer rates.

Due to the costs of gravel (in particular) the smaller wetland with a design flow of 435 m^3/day, and more buffering conducted in the storage pond, is considered the most cost effective solution. However, a smaller wetland does take up less of the wastewater during summer.

The wetland is sized to provide at least 2 days contact time with the media at the design flow. This contact time assumes plug flow without short circuiting, and represents an average time in the wetland at the design flowrate of the wetland. Short circuiting of a small proportion of the flow is possible, however the geometry of the wetland can be configured to minimise the risk of this occurring. The Ngāi Tahu parties previously indicated the importance of allowing the wastewater to have good contact with the land. The minimum contact time of 2 days is consistent with other subsurface flow wetlands that have been installed elsewhere in New Zealand to meet cultural requirements for contact with land (e.g. Outward Bound at Anikiwa). The size of the wetland, and the cost of constructing it, increase with increasing contact time.

At the winter DWF, when flows are lower than the design flow, the contact time increases to 3 days. When the design flow is exceeded, flow to the wetland is kept to the design flow and the extra wastewater will be stored in the pond until capacity becomes available again in the wetland.

2.6 Design Flows to Infiltration Basin

The infiltration basin sizing and storage requirements are based on seven basins, each with the capacity to infiltrate the future annual average daily flow (357 m^3/day). The use of seven basins has been selected for ease of management as one basin can be used per day. When the flow exceeds the average daily flow then up to two basins can operate at one time. If the flow exceeds the capacity of two basins then the wastewater is stored in the upstream pond until capacity becomes available in the infiltration basins.

The infiltration basins will be a little over 1 m deep. As with the subsurface wetland, for cultural reasons a minimum contact time of 2 days has been targeted and the current design for the infiltration basins will provide a minimum of 2 days contact time of the wastewater through the soil in the basins.

3 Development of Options

3.1 Environment Court Mediation

While committed to working with the Ngāi Tahu parties to seek a resolution, considering the possibility that at the end of the investigations the original proposal may be found to be a preferred option, Council submitted an appeal to the Environment Court against the decision to refuse the consent for the harbour outfall. On 30th September 2015 representatives from Council, the Ngāi Tahu parties and Environment Canterbury met in mediation. Below are the actions and timetable agreed to by the parties at the mediation, and as subsequently amended by agreement:

1. The Appeal is to be put on hold pending the outcome of investigations and decisions by Christchurch City Council (as applicant) on alternative options for the discharge of treated sewage at Akaroa.

2. The applicant is to fully involve the Ngāi Tahu parties (and keep Canterbury Regional Council informed) in the development and selection of options for disposal.

3. The applicant is to provide a status report to the parties on the outcome of the investigations, and the options and recommendations prepared for Council consideration and decision, by 1 July 2016.

4. The applicant is to provide a status report to the Court and to the parties on the Council decision, and what that may mean for the progress of the appeal, by 5 August 2016.

3.2 First Stage of Investigations

In July 2015 in response to Environment Canterbury declining the Council application for consent to discharge to Akaroa Harbour via an outfall, Council initiated a new and comprehensive investigation into alternatives to discharging via a new harbour outfall.

The first step in this work was to develop a long list of all possible disposal options and to run through a screening evaluation, in consultation with the parties to the Council's Environment Court appeal, to determine suitability for further consideration. The options were assessed against the outfall option as the baseline to compare cost, technical feasibility, timeliness, environmental impact, cultural acceptance and social acceptance. The options that were identified and assessed are listed in Table 3.1.

For all options, except tankering or pumping to the Christchurch Wastewater Treatment Plant (CWTP), it was assumed that the new wastewater treatment plant on Old Coach Road, the terminal pump station, and the reconfigured wastewater trunk network within Akaroa Township would continue as proposed in the resource consent application. The options listed relate to methods of disposal of the treated wastewater from the proposed wastewater treatment plant.

The Council Infrastructure Transport and Environment (ITE) Committee undertook a preliminary consideration of options on 1 September 2015. The Council Committee did not favour the options of non-potable reuse, or potable reuse, or tankering and/or pumping to CWTP and saw no benefit in investigating those options further.

Table 3.1: Disposal Options Assessed

Category	Option	
NO OUTFALL OPTIONS	A1	Irrigation to land
	A2	Passage through land
	A3	Non-potable water reuse
	A4	Potable water reuse
SURFACE WATER OR OUTFALL OPTIONS	B1	Wetland flow to coastal waters or outfall
	B2	Overland flow to coastal waters or outfall
OTHER OPTIONS	C1	Tankering wastewater to Christchurch Wastewater Treatment Plant
	C2	Pumping wastewater to Christchurch Wastewater Treatment Plant
OUTFALL OPTIONS	D1	Discharge via Rakahore chamber to harbour outfall
	D2	Discharge to harbour outfall (as per consent application)

Council presented these options and the initial evaluation of the options as a draft to the Ngāi Tahu parties on 21 September 2015 and the Ngāi Tahu parties responded with their preferred options on 8th October 2015. A summary of the Ngāi Tahu response is shown in Figure 3.1

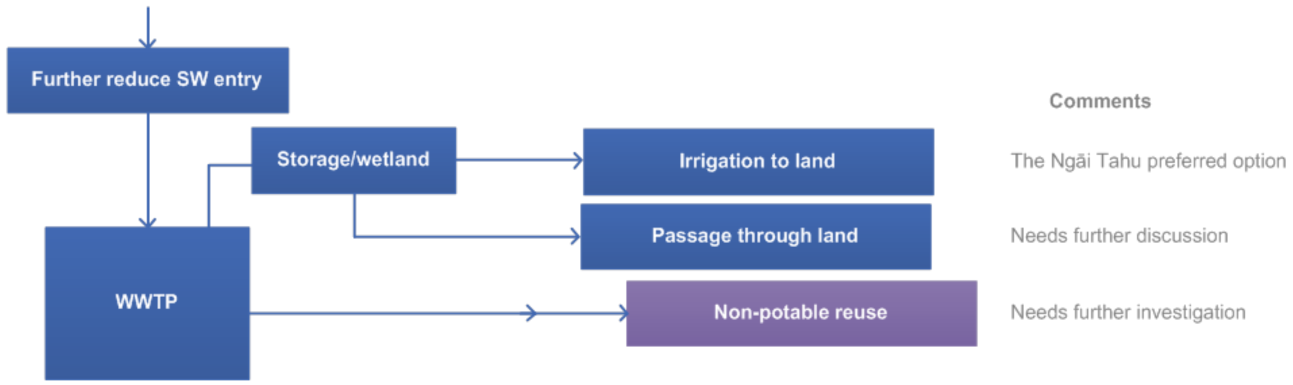

Figure 3.1 - Ngāi Tahu Preferred Pathways for Wastewater Disposal at Akaroa

3.3 Options Not Being Progressed

The following options from Table 3.1 were not preferred and so were not progressed through to the next stage of design. The reasons for this selection are given in the following sections.

3.3.1 Option A4 – Potable Water Reuse

For a potable reuse scheme the treated wastewater would be further treated to provide three levels of protection (membrane treatment + reverse osmosis + storage and chlorine contact) and then connected into the Akaroa potable water supply storage and reticulation system. The potable reuse water could be plumbed directly into the current potable water reticulation system or used for groundwater recharging, or pumped up to the existing Akaroa water treatment plant. Additional storage would likely be required to match the seasonal demand and supply of reuse water, taking into account wet weather inflows to the system.

This option was not progressed as it was considered that it would not be publically or culturally acceptable as potable reuse is not currently used elsewhere in New Zealand. The operating costs would be high and the scheme would not be able to be implemented before the existing consent expires.

3.3.2 Option B1 - Surface flow wetland to coastal waters or outfall

In this option wastewater would be reticulated to a constructed wetland where it would pass over the surface of a planted wetland and then discharge to coastal water via a natural or constructed watercourse or via an outfall. If discharge to coastal waters occurs after the wetland, further treatment would be required for wet weather bypass flows to appropriately mitigate public health risks at the point of discharge. If the wastewater is discharged to outfall after treatment through the wetland, no further treatment to the wet weather bypass flows would be required.

Due to their nature, birds are likely to use the wetland which may result in elevated level of nutrients, faecal bacteria and other viruses being entrained in the outlet stream from the wetland. This may pose some risk to public health and shellfish gathering although at a relatively low level as non-human source viruses pose a lesser risk to humans. Algae growth may cause an increase in BOD and suspended solids.

This option was not progressed as it scored poorly across all the evaluation criteria and was not considered to meet cultural land contact requirements.

3.3.3 Option B2 – Overland flow to coastal waters or outfall

This scheme would be based on passing treated wastewater through an overland flow area and then discharging it into the coastal marine area. The overland flow area may consist of a manmade or natural watercourse or swale. The wastewater would flow over this feature without intentionally being absorbed into the soil. The treated wastewater could either be captured after the overland flow area and piped to a local waterway, or the area may be positioned such that treated wastewater exiting flows directly into a local waterway or coastal marine environment. Alternatively the discharge from the overland flow area may be captured and released via an outfall.

Positioning of the overland flow feature would need to take account of aesthetic (visual) effects, location relative to the coastal marine area, and residual nutrient and virus risks to the environment and people related to the discharge. The quality of the treated wastewater may decline due to entrainment of soil and other contaminants on the land, however overland flow may also reduce the nutrient concentration of the wastewater.

This option was not progressed as it scored poorly across all the evaluation criteria and was not considered to meet cultural land contact requirements.

3.3.4 Option C1 - Tankering wastewater to Christchurch Wastewater Treatment Plant

In this option untreated wastewater would be tankered from Akaroa to the Christchurch WWTP (CWTP) at Bromley. Engineering requirements include untreated wastewater storage and a purpose built pumping station for loading tankers in Akaroa. There is potential for odour nuisance from the storage of raw wastewater at Akaroa, and the possibility of raw wastewater spills in the tanker loading area. The additional load would be unlikely to have a significant impact on CWTP in terms of treatment performance.

At the current average flow of 230 cubic metres per day, and a tanker volume of 12 cubic metres, approximately 20 tanker loads per day would be needed. This would require four tankers doing five loads a day each (say 4.5 – 4.8 hours return trip) and a team of 20 tanker drivers working rotating shifts. Additional vehicle movements would be required during peak holiday times or wet weather events when the flow increases. This option would have a negative environmental effect due to use of fuel and emissions from the vehicles and would also have a negative impact on the traffic flows in and around Akaroa, particularly during the peak tourist season.

For these reasons this option was not progressed.

3.3.5 Option C2 – Pumping wastewater to Christchurch Wastewater Treatment Plant

In this option untreated wastewater would be pumped from Akaroa to the CWTP at Bromley. This option would involve installation of a pipeline and multiple pump stations between the two sites. The Banks Peninsula area is hilly and with difficult ground conditions. The pipeline would be at least 80 km long if the roadway were to be followed. No treatment or disposal would be undertaken at Akaroa. The additional load would be unlikely to have a significant impact on CWTP in terms of treatment performance.

Due to the length of time the raw wastewater would spend in the pipeline there is potential for odour nuisance at the pump stations and at the necessary air release valves on the pipeline. Land purchase (possibly through compulsory acquisition) would be required along the pipeline for pump stations. Maintenance and operation costs for this option are likely to be significant, in addition to the high capital costs which would be many times more than the cost of the outfall. For these reasons this option was not progressed.

3.3.6 Option D1 - Discharge via Rakahore chamber to harbour outfall

A Rakahore chamber is the term used to describe a chamber through which treated wastewater is passed effecting contact with land. The Rakahore chamber would generally consist of a concrete chamber with rocks embedded such that the rocks contact the land underneath as well as the wastewater. Option D1 is based on adding a Rakahore chamber to the proposed harbour outfall scheme. After treatment via the Rakahore chamber, the water would be released via the outfall at the harbour mid-point.

Wet weather bypass flows do not require further treatment and will flow through the Rakahore chamber on the way to the harbour outfall. The risks to the environment, public health and shellfish gathering remain unchanged from the baseline outfall option.

Although this option scored well across the majority of the evaluation criteria, the Ngāi Tahu parties do not consider a harbour outfall a culturally acceptable option and so it was not progressed any further.

3.3.7 Option D2 – Discharge to harbour outfall (as per consent application)

Option D2 involves a 2.5km long harbour outfall as per the current consent application. A map showing an overview of the harbour outfall scheme is attached in Appendix A. Treated wastewater passes through the outfall which is buried under the seabed and has risers at the end of the outfall pipe to disperse the wastewater into the harbour.

Under Option D2 the highly treated wastewater is rapidly and efficiently dispersed through two outfall diffusers located at 10 m depth, 2.5 km off Childrens Bay in Akaroa Harbour. The outfall scheme minimises the potential for environmental effects as well as public health risks, and is also supported by some sectors of the community based on the small number of submissions received during the recent hearing process and the working party process. No additional treatment is required for wet weather bypass flows, and no additional land is needed (other than that already procured for the treatment plant). It can be completed to agreed timelines.

As previously discussed an outfall into the harbour is not considered culturally acceptable. However as this option scored very well across the remaining criteria and is the basis of the Council's consent application this option was retained as the baseline with which to compare the other shortlisted options as the investigations progressed.

3.4 Second Stage of Investigations Initiated

A further outcome of the mediation was that the Ngāi Tahu parties requested the opportunity to be involved in defining the scope of further investigations into the preferred options. To facilitate this process Beca and Council prepared a draft proposal for the next stage of works that was issued to the Ngāi Tahu parties on 15 October 2015.

3.5 First Hui – To Agree Process for Second Stage

In response to the draft proposal for the second stage of works a hui was scheduled in Akaroa on 21 October 2015. The primary purpose of the hui was to allow Council and the Ngāi Tahu parties to jointly brief Beca on further investigating the preferred options for non-harbour discharge that may be technically feasible and consentable and meet cultural needs for the disposal / reuse of the treated wastewater. The draft proposal was discussed and a methodology was agreed for consulting with the Ngāi Tahu parties throughout the second stage of works. This methodology agreed involved the following steps;

- Beca receives briefing from the Council and the Ngāi Tahu parties – 21st October 2015
- Initial review with the Ngāi Tahu parties of concepts – 2nd December 2015
- Site walkover – December 2015, date to be agreed (was held on 8 December 2015)
- Present draft report to Ngāi Tahu parties – 27th January 2016
- Receive formal feedback on draft report – 17th February 2016
- Finalise report and issue – 23rd February 2016

As agreed with the Ngāi Tahu parties, the formal feedback on the draft report was delayed to allow for peer review, and this delayed issuing of the final report past the dates listed above.

The Ngāi Tahu parties also asked for further explanation of the passage through land options (infiltration basin and subsurface wetland) and the collection of the water after the basins/wetlands. Diagrams and photographs of this type of treatment were produced and described. At the end of the briefing discussions the project team undertook a visit to the proposed treatment plant site with the Iwi representatives and to view and discuss the "possible" land areas that could be involved in the non-harbour discharge options.

3.6 Second Hui - Initial Workshop of Desktop Study and Concepts

On 4 December 2015 representatives from the Ngāi Tahu parties, Council, Environment Canterbury, Beca and Pattle Delamore Partners (PDP – subconsultants providing specialist advice on land disposal options) met to review the findings of the initial desktop study of flows and load and the concepts that Beca planned to progress further.

At this hui estimated land areas and possible locations for each option were presented, and the concepts of the subsurface flow wetland (described in Section 4.6) and engineered pathway were introduced. A coastal infiltration gallery was the term agreed for a constructed device for discharging any remaining treated wastewater into the receiving environment. The details of a coastal infiltration gallery are described in Section 4.8. Initial discussions were that the infiltration gallery would be built into the shoreline in the intertidal zone at the head of Takamātua Peninsula

Some of the initial findings presented at this hui are outlined in the following bullet points. Note that several of these points have been refined by the work that was completed after the hui.

- Irrigation to land for the year round option would likely be drip irrigation under trees as per Wainui
- An area of approximately 21 – 26 ha would be required for year round irrigation
- Initially would not be able to use irrigation while trees are growing until the canopy had formed

- An area of approximately 16 – 20 ha would be required for summer only irrigation plus another 1 – 2 ha for storage and wetland/infiltration basin
- Two options for passage through land – infiltration basin or subsurface wetland
- Both passage through land options would need to be lined due to soil conditions – remaining wastewater to be collected and discharged via a coastal infiltration gallery
- Both passage through land options need upstream buffer storage occupying 1 – 2 ha of land The only local option for gravel media for passage through land options is from Birdlings Flat
- Passage through land options sized for a retention time of 1 – 2 days
- Takamātua headland has areas of potentially irrigable land and areas where storage wetlands and infiltration basins could be constructed – but historic slips, undulating land and silent file areas to be considered
- Three locations for engineered pathway discharge – to dry gully, stream or coastal environment (coastal infiltration gallery)

Drawing GIS-6517986-20-03 in Appendix D shows an overall view of the area of land being considered and some of the constraints of the area.

3.7 First Site Walkover

The first site walkover was conducted on 8 December 2015 and was attended by representatives from the Ngāi Tahu parties (Rik Tainui, Ngaire Tainui), Council (Mike Bourke and Ben Scott), Beca (Greg Offer, Richard Young and Rae Stewart) and PDP (Andrew Brough and Peter Callander). The site visit started with a boat trip around the Takamātua headland to get a closer view of the soil types and nature of the headland with the intention of identifying possible locations for a coastal infiltration gallery discharge. This area was chosen, as it is not commonly used for recreation or shellfish gathering purposes.

The visit then moved on to the proposed treatment plant site on Old Coach Road and the land just across the State highway that had been identified as an area of relatively flat land suitable for irrigation or construction of a basin. From there the attendees walked up Takamātua hill to view the land between the state highway and the coast and gain an appreciation of the steepness and changing slope of the area.

Council had organised the opportunity to meet with and talk to a number of land owners down Old French Road so the visit moved to this area. Council has commissioned Lincoln University to undertake a trial on the amount of wastewater than can be irrigated onto and taken up by different species of plants (including native species). The trial site also uses lysimeters to measure the amount of actual evapotranspiration which is released by plants. The visit was concluded with a stop at the Lincoln University irrigation trial site in Duvauchelle.

3.8 Second Site Walkover

As some key members of the Ngāi Tahu parties were not able to attend the first site walkover, and the chance to visit the site was considered a very valuable and enlightening part of the process, a second site walkover was undertaken on 26th January 2016. This also had the benefit of being able to look at more specific locations for the options being considered, as the concept designs had been developed since the first site walkover.

Attendees at the walkover were George Tikao, Rik Tainui, Kirsty Huxford, Karen Morgan, Lizzie Thomson and Philippa Lynch from the Ngāi Tahu parties, Bridget O'Brien and Ben Scott from Council, and Andrew Brough from PDP.

The site walkover covered the areas of the Takamātua headland and valley that had been identified as possibly suitable for land irrigation and construction of a storage pond, wetland and infiltration basins.

3.9 Third Hui – Presentation of Draft Concept Report

On the 27th January 2016 representatives from Council, the Ngāi Tahu parties and Environment Canterbury gathered at the Ngai Tahu office in Riccarton to receive a presentation from Beca and PDP on the draft findings of the concept report. This presentation revisited some of the key concepts discussed in the presentation of the results of the desk top study, with refined estimates for the land area required for each option. More detail was presented on the use of an engineered pathway, showing how and where a coastal infiltration gallery could be constructed.

During the presentation a series of location maps were tabled showing parcels of land suitable for locating storage ponds, wetlands or infiltration basins and for irrigation of treated wastewater. A review of consenting concluded that all options were consentable, and the draft cost estimates indicated that all options would likely be less than the cost of a harbour outfall. However it was noted that a number of assumptions had been made around land purchase costs and these would need to be validated.

At this hui it was agreed to amend the dates for finalising the concept report as the Ngāi Tahu parties had engaged a peer reviewer to look at the draft report. It was agreed that the draft peer review report would be issued approximately two weeks after Beca submitted the draft of the concept report. The hui to receive formal feedback on the draft concept report was scheduled for 4th March 2016.

3.10 Fourth Hui – Formal Feedback from Ngāi Tahu Parties on Draft Concept Report

On 25th February 2016 Council received a copy of the draft peer review report and a summary feedback letter from the Ngāi Tahu parties. The final version of the peer review report is included in Appendix B. At a hui at the Onuku marae in Akaroa on the 4th March the Ngāi Tahu parties gave context to the feedback presented in the letter and the peer review report by outlining the cultural importance of the area and in particular the harbour as mahinga kai. The key messages delivered are summarised as follows;

- The Ngāi Tahu parties did not think the introductory sections of the report accurately captured that one of the main reasons the consent for the outfall had been declined was for cultural reasons
- The summary of Ngāi Tahu preferred options given in Section 1.2 and shown in Figure 3.1 did not accurately represent the feedback Ngāi Tahu had previously given on their preferences
- The Ngāi Tahu parties are opposed to the use of a traffic light evaluation of options and requested that this be removed from the report.

The letter advised that the six key findings from the peer review report were:

- Further improvement in excluding stormwater from the Wastewater Treatment Plant (WWTP) inflow should be actively sought;
- The WWTP designed and consented for a harbour outfall would not necessarily be the most appropriate and cost-effective treatment plant if a different final effluent disposal is chosen;
- Option 1 Irrigation to Land should include the alternative of irrigation to pasture;
- The report should further clarify and emphasise the wastewater treatment and disposal process provided by Options 3 and 4 (Sub-Surface Wetland and Infiltration Basin respectively);
- It should be made clear that the Ngāi Tahu parties are yet to advise whether the "passage through land" options satisfy cultural requirements; and
- The section on "Positive Effects" contains inaccuracies and needs re-writing.

Further discussion was undertaken around the ability of passage through land options to satisfy cultural requirements. Iaean Cranwell advised that, when assessed against the Ngāi Tahu cultural framework, these options failed to meet the cultural requirements. The only option which did satisfy the values set out by the framework was irrigation to land.

The next phases of the project were discussed. Council committed to answering all the queries raised in the peer review report and in feedback from the Ngāi Tahu parties in the final version of the concept report. A table summarising how the peer review points have been addressed within the report is attached in Appendix B. It was agreed that the concept report would be finalised and separate work on transitional options from the existing treatment plant and outfall to the new plant and irrigation disposal would be undertaken. The focus turned to consultation with the wider community and how this would be undertaken collaboratively.

4 Description of Options

4.1 Overview of Shortlisted Options

The preferred options for concept design identified by the Ngāi Tahu parties on 8th October 2015 that were agreed to be progressed for further investigation include (refer to Section 3.1):

- Irrigation to land – with wetlands as storage before or after irrigation
- Subsurface flow wetland or infiltration basin
- Non-potable reuse

In discussions following the site walkover held with the Ngāi Tahu parties and Council on 21st October 2015, it was agreed that this list should be further refined as follows:

- Irrigation to land all year round
- Irrigation to land for summer only with a passage through land option for treatment at other times of the year
- Subsurface flow wetland (passage through land) with engineered pathway discharge
- Infiltration basin (passage through land) with engineered pathway discharge
- Non-potable reuse – supplementary to the above options.

After review of historical geotechnical information and a site walkover of land around Akaroa and Takamātua it became apparent that due to the undulating nature of the area and the presence of many historic slip areas, procuring sufficient suitable land to achieve year round irrigation may be problematic. For this reason summer only irrigation plus a passage through land treatment was included in the options list.

In addition, while the Ngāi Tahu parties had previously indicated that a wetland was not preferred as the wastewater only flowed over the land rather than through it, a new concept of a subsurface flow wetland was added to the list. In this option the wastewater flows through land, beneath the surface of a wetland. A subsurface wetland would support plant growth, further treat the wastewater, and would also take up some water so the residual discharge flow is reduced.

Non-potable reuse cannot dispose of all the treated wastewater with certainty as it can only be used for flushing toilets, washing machines and watering gardens. Hence it will need to be in conjunction with one of other listed options.

4.2 Wastewater Treatment Plant Design Changes

4.2.1 Consented Treatment Plant

The proposed wastewater treatment plant that was successfully consented in July 2015 will produce very high quality treated wastewater with very low residual solids consistently throughout the year. The treatment plant incorporates a bypass for wet weather flows when they exceed the capacity of the full treatment process. This is required at Akaroa because of the high stormwater inflow and groundwater infiltration into the wastewater network during heavy rainfall.

This level of inflow and infiltration, and therefore the flow into the treatment plant during heavy rainfall, is not expected to be affected by climate change as discussed in Section 2.1.1. The flowrate of discharge to the receiving environment during these peak events will be less than the flow through the treatment plant due to the buffering effect of the balance tank and storage pond.

The design of the treatment plant has been reviewed with respect to the different options to determine if the consented plant is the most appropriate and cost effective for each option. The type of treatment considered suitable for each option is described in the following sections.

4.2.2 Treatment for Irrigation to Trees

To determine what level of treatment would be necessary for irrigation to trees the amount of nutrients that can be absorbed by the trees needs to be estimated.

A literature search gave no clear indication of the annual uptake of nutrients from kānuka and mānuka. Franklin, H. M. (2014) "The Interaction of New Zealand Native Plants with Nitrogen in Canterbury's Agricultural Landscapes", reports on nitrogen uptake in the foliage of native seedlings when nitrogen is applied at 200 to 1600 kg N/ha. The best response to nitrogen was for the 200 kg N/ha trial with the percentage of nitrogen applied being taken up by the plants reducing as the application rate increased. There is no information on long term nitrogen uptake.

With regard to nitrogen uptake by forests there are several conflicting sources. There are values as high as 140 kg N/ha/yr (Land Treatment Collective guidelines, 2000) while other references suggest 70 kg N/ha/yr or as low as 35 kg N/ha/yr. At Wainui the Council plans to apply up to 200 kg N ha/yr and in Andrew Brough's evidence at the consent hearing he evaluated the impact based on an application rate of 140 kg N/ha/yr, noting that the excess (i.e. nutrients that pass through the soil profile without being taken up by the trees) is unlikely to impact on the environment as there is no groundwater resource.

A trial using different phosphorus sources "Apparent Phosphorus Uptake And Change In Nitrogen Content Of Pinus Radiata Growing On Soils Of Different Phosphorus Retention, Treated With Superphosphate And A-Grade Rock Phosphate" (I. R. Hunter and J.A.C. Hunter) New Zealand Journal of Forestry Science 21(1): 50-61 (1991) had the results shown in Table 4.1. While the phosphorus uptake was relatively consistent there is a wide range for nitrogen uptake. None of the soils are particularly similar to Banks Peninsula loess.

Table 4.1: Examples of Phosphorus Uptake by Trees

TABLE 6 –Apparent uptake of phosphorus by the trees and differential content of nitrogen (kg/ha)

Site	A-grade rock		Superphosphate	
	Nitrogen	Phosphorus	Nitrogen	Phosphorus
Tairua	39	13	–19	11
Riverhead	100	19	81	18
Waipoua	39	15	24	15

At this stage, for approximately 25 hectares of irrigable land, and adopting a nitrogen uptake of 70 kg N/ha/yr and phosphorus uptake of 15 kg N /ha /yr then the average concentrations in the treated wastewater would need to be 12.8 g/m³ of nitrogen and 2.7 g/m³ of phosphorus. However, higher concentrations can be used accepting that some leaching of nitrogen could occur to an environment not adversely impacted (i.e. groundwater not being used) and that phosphorus will slowly build up in the soil. For drip irrigation the wastewater will need to be screened down to 130 microns to prevent blockages.

Bacterial concentrations are not as important to consider for irrigation to trees as bacteria will be filtered out by the soil. However, it will be necessary to consider the risk of someone walking through the area coming into contact with treated wastewater. The "Guidelines for the Microbiological Quality of Treated Wastewater Used in Agriculture: Recommendations for Revising WHO guidelines" (Ursula J. Blumenthal et. al., 2000) recommend revised microbiological guidelines for treated wastewater use in agriculture. For irrigation to trees by any method they recommend a geometric mean concentration for faecal coliforms of less than or equal to 1,000/100 mL where the exposed group is "Workers, including children <15 years, nearby communities". The limit drops to ≤ 100,000 /100 mL where there are no children exposed.

The 2006 WHO Guidelines "Guidelines For The Safe Use Of Wastewater, Excreta And Greywater: Volume 2 Wastewater use in Agriculture" (2006) use a concentration of 1,000 faecal coliform per 100mL where the farming practices are labour intensive and 100,000 faecal coliform per 100mL where the farming practices are highly mechanized. An average E. coli count of 1,000 MPN/100mL has been used as a target. This level is consistent with standards that apply to similar spray application of wastewater to land in Canterbury including the Selwyn District Council Pines Plant in Rolleston.

To achieve this quality treated wastewater the wastewater treatment process would remain as per the consented BNR plant with membranes. The main drivers are the requirement for a high level of nitrogen removal and a high microbiological standard and the consented plant provides both of these. It may be possible to use conventional clarifiers instead of membranes at some cost saving, however this may put the denitrification performance at risk as fine solids will pass through a clarifier and these contain nitrogen.

4.2.3 Treatment for Irrigation to Pasture

Irrigation on pasture will generally mean the treated wastewater can have higher nutrient levels as the pasture that absorbs these can be removed on a regular basis, preventing nutrient build-up in the soil. For cut to carry pasture the typical uptake (NZAEI, 1984) is:

Nitrogen - 350 kg N/ha/yr

Phosphorus – 40 kg P/ha/yr

However given the uncertainty as to the land that will actually be available, for purposes of assessing the treatment required the nitrogen uptake is assumed to be 300 kg N/ha/yr.

The land area required for irrigation to pasture is estimated at 27 hectares. Based on an annual average volume of 137,000 m^3 then the average concentrations in the wastewater would be 59 g/m^3 for nitrogen and 7.8 g/m^3 for phosphorus.

For bacterial concentrations the literature (e.g. USEPA, 2000) indicates low risk at quite high concentrations, however public perception means that lower concentrations are normally adopted. It is considered that the concentrations used for the irrigation of treated wastewater at Rolleston would be appropriate at this location due to public the perception – this limit is 500 MPN/100mL faecal coliforms.

To achieve this quality treated wastewater we have looked at a range of options for detuning the treatment plant, including:

- Activated sludge without denitrification
- Packed bed reactor
- Biofiltro reactor (proprietary packaged plant based on composting using worms)
- Biological trickling filter

Activated sludge treatment can readily meet the required standard and is similar to the consented treatment plant, although the biological process is simplified and either membranes or a conventional clarifier could be used for solids separation. If the membranes are retained, the reactors will be somewhat smaller than currently proposed and hence a saving of approximately $1.0M in capital costs may be achieved.

A packed bed reactor, similar in concept to the Tikao Bay treatment plant process, would be a feasible option for Akaroa in terms of treated wastewater quality, with the benefit that sludge production is very low. However as the size of the packed bed required for the Akaroa is 1,000 m^2 it will not readily fit within the proposed site. The treatment plant currently occupies an area of 450 m^2. To provide a flat land area within the proposed treatment plant site of 1,000 m^2 with suitable maintenance access would require extensive retaining walls given that relatively steep terrain above the current treatment site would need to be utilised. If the treatment plant is relocated to an alternative, larger and relatively flat site then further investigations could be undertaken to re-evaluate feasibility, cost and performance of a packed bed reactor option.

Biofiltro is a proprietary technology developed in Chile that has recently been introduced to New Zealand, with five small Biofiltro plants built here to date. The NZ plants built so far have been installed as final polishing filters after oxidation ponds. In this application the Biofiltro treatment loads are relatively minor as most of the BOD is processed by the upstream oxidation ponds. Limited information on Biofiltro performance in NZ is available although some non-compliances in terms of BOD, suspended solids and total nitrogen level in the final discharge have been observed. The Biofiltro system is essentially a media bed filled with sawdust and worms. Wastewater passes through the bed over a period of 4 hours and the worms consume the media which is saturated with the wastewater. Based on recent NZ experience it is assumed that the Biofiltro would need to be operated in conjunction with an oxidation pond system or other upstream treatment device. Oxidation ponds are not considered suitable for the Akaroa wastewater application for a number of reasons including odour risks and lack of sufficient land area. Further work would be needed to develop a suitable concept for implementing a Biofiltro treatment scheme for Akaroa with available space being a significant constraint.

The final alternative consists of a lightly loaded biological trickling filter (BTF) fitted with an Imhoff tank and secondary clarifiers provided instead of membrane separation. Initial sizing of the plant suggests a single BTF 10 m in diameter with two secondary clarifiers, each 6 m in diameter, operating duty/duty at peak loads. Treated wastewater would be filtered to 130 microns if subsurface drippers are to be employed. This plant will fit within the proposed site. New consents or consent variations may be needed to authorise a BTF plant due to the different physical layout and the relatively large BTF tank which could affect visual impacts. An advantage of BTFs is low sludge production and the small amounts of sludge that are produced would be stored in the Imhoff tank and trucked to the Christchurch wastewater treatment plant once every 1- 2 months. Reduced sludge production simplifies plant operation and significantly reduces the plant operational costs. A BTF plant also has lower energy usage. The capital cost for a BTF plant with secondary clarifiers is estimated at approximately $9M, offering a potential saving of approximately $2.0M on the current estimate for the proposed MBR plant.

4.2.4 Treatment for Subsurface Wetland or Infiltration Basin

The consented treatment plant is assumed to be retained for the subsurface wetland and infiltration basin options as the treated wastewater is discharged into the coastal shoreline environment and needs to be of very high microbiological quality.

4.2.5 Additional Treatment on Bypass Flow

The treatment scheme consented in 2015 included UV disinfection of the bypass flow prior to discharge to the harbour outfall. For alternatives based on land treatment it is proposed that a disc filter be added into the wet weather bypass line. The disc filter is needed to screen solids in the bypass flow during wet weather events. The disc filter is a mechanical device that will operate automatically when the bypass is operating, screening solids down to 50 microns for the wetland or infiltration basin options or 130 microns for land irrigation. The recovered solids will be returned to the inlet of the treatment plant. Additional filtration of bypass flows will provide two main benefits:

- Additional Solids Removal by Disc Filter

The disc filter will remove solids that could collect downstream in the storage pond or cause blockages in the irrigation scheme.

- Improved Performance of UV as Contribution to Overall Virus Removal

Additional filtration will improve the performance of the UV disinfection unit. This will contribute to the overall pathogen removal performance of the treatment scheme, which is summarised for both dry and wet weather flows in Table 4.2 and Table 4.3.

The performance is described in terms of log removal. Log removal is a measure of the ability of a treatment process to remove pathogenic micro-organisms. One log removal equates to a 10-fold reduction in virus concentration, two log removal equates to 100 fold reduction and three log removal equates to 1,000 fold reduction.

Table 4.2 Comparison of Virus Removal Performance for Dry Weather Flows (based on norovirus)

Option 4 – Subsurface Wetland		Option 5 – Infiltration Basin	
Treatment Step	**Log Removal[1] (typical)[1]**	**Treatment Step**	**Log Removal[1] (typical)[1]**
Membrane filtration treatment plant	3 logs	Membrane filtration treatment plant	3 logs
Bypass filter + UV	0 logs (not operating)	Bypass filter + UV	0 logs (not operating)
Subsurface wetland	0.5 logs	Infiltration basin	0 logs
Pond storage	0 logs (inflow = outflow)	Pond storage	0 logs (inflow = outflow)
Approximate Total	3.5 log removals	Approximate Total	3 log removals

Notes 1. Further work is required to confirm more accurately the virus removal performance of each treatment step.

Table 4.3 Comparison of Virus Removal Performance for Wet Weather Flows (based on norovirus)

Option 4 – Subsurface Wetland		Option 5 – Infiltration Basin	
Treatment Step	**Log Removal[1] (typical)[1]**	**Treatment Step**	**Log Removal[1] (typical)[1]**
Membrane f filtration treatment plant	0 (bypassed)	Membrane filtration treatment plant	0 (bypassed)
Bypass filter + UV	1.5 logs	Bypass filter + UV	1.5 logs
Subsurface wetland	0.5 logs	Infiltration basin	0 logs
Pond storage	1 logs[2]	Pond storage	0.7 logs[2]
Approximate Total	3 log removals	Approximate Total	2.2 log removals

Notes 1. Further work is required to confirm more accurately the virus removal performance of each treatment step

2. This reduction is achieved by reducing the rate of discharge from 65 L/s to 12 L/s through buffering flow peaks in the storage pond. The Quantitative Microbial Risk Assessment is based on the rate of virus discharge to the receiving environment

The 0.5 log reduction for the subsurface flow wetland is an estimate based on published literature (a summary of which is provided in Appendix I). Virus reduction in the wetland may be as high as 1 – 2 logs, but this not proven for norovirus in New Zealand and will also be influenced by the design of the wetland. Therefore a conservative estimate of 0.5 log removal has been assumed at this stage. This is lower than the reduction assumed across the storage pond, which is achieved by virtue of the reduction in flow between inlet and outlet.

The NIWA Quantitative Microbial Risk Assessment (QMRA) model for the harbour outfall assumed a rate of discharge for norovirus (viruses per second) of 65 L/s. Therefore if the discharged flow for the wetland scheme is reduced to 6 L/s by buffering in the storage pond then the rate of viruses released to the environment will be reduced by approximately 1 log compared to the harbour outfall option. (It should be noted that the flowrate through the infiltration basin is higher at 12 L/s and hence the effective reduction in the rate of virus release is calculated at 0.7 logs instead of 1.0 logs as shown in Table 4.3).

Tables 4.2 and 4.3 show that the subsurface wetland scheme will provide a higher quality of discharge to the engineered pathway during both dry and wet weather conditions, compared to the infiltration basin. This is achieved through biological processes that occur in the wetland that filter and absorb the viruses. These processes are less likely to occur within an infiltration basin. A further factor is the higher flowrate through the infiltration basin which results in a higher rate of virus discharge via the engineered pathway.

4.3 Storage Pond Design

For all the disposal options, a storage pond will need to be constructed downstream of the treatment plant and upstream of the disposal option to buffer out high flows and enable a constant flow to be transferred through the land treatment device. The size and requirement for the storage pond varies depending on which scheme is adopted. A summary of the pond requirements is provided in Table 4.4 (refer to Section 5.1 for discussion on pond sizing).

Table 4.4 Scheme Wastewater Storage Requirements

Option	Proposed Storage (m^3)	Operation	Pond Cover Required
1. Year Round Irrigation - trees	12,000	Short term wet weather storage only. Pond empties completely after use.	Yes. Some odour risk hence cover required.
2. Year Round Irrigation – pasture	30,000	Long term storage over winter. Pond contains water at all times.	No. Pond will contain water and algae year round and any bypass flows will be rapidly diluted in the pond water. Pond algae produce oxygen and this will control odour risks.
3. Summer Irrigation + SSF Wetland (Option 3) or year round wetland (Option 4)	12,000	Short term wet weather storage only. Pond empties completely after use.	Yes. Some odour risk hence cover required.
3. Summer Irrigation + Infiltration Basin or year round infiltration basin (Option 5)	7,000	Short term wet weather storage only. Pond empties completely after use.	Yes. Some odour risk hence cover required.

The possibility of a floating cover on the storage pond will need to be considered at the next stage of design. A floating cover is likely to be applicable for Options 1, 3 and 4 but is not proposed for Option 2 – Year round irrigation to pasture. A pond cover is not proposed for Option 2 because the pond is relatively large and will hold water all year round. Algae will grow in the pond and these algae will oxygenate the pond through photosynthesis. Bypass flows coming into the pond for Option 2 will be rapidly diluted in the fully oxygenated pond water and hence the odour risk is low. The increased pond area relative to the other options also allows for wind action to maintain oxygen levels and to further enhance natural control of any potential odour-causing contaminants in the incoming flow.

For the covered pond option a cover vent would be fitted with an odour treatment device to control any minor odours that may be emitted while the pond is in use. Location options for the storage pond are covered in Section 5.

4.4 Option 1 - Year Round Irrigation to Trees

4.4.1 Description of Operation

Treated wastewater is irrigated onto the soil beneath a tree plantation – the wastewater passes into the soil and drains slowly through the soil. Trees take up water and nutrients and filtration through the soil allows microbes in the soil to remove nutrients, bacteria and viruses. The tree canopy prevents a proportion of rainfall from reaching the ground, allowing increased irrigation during wet periods, which typically occur in the winter.

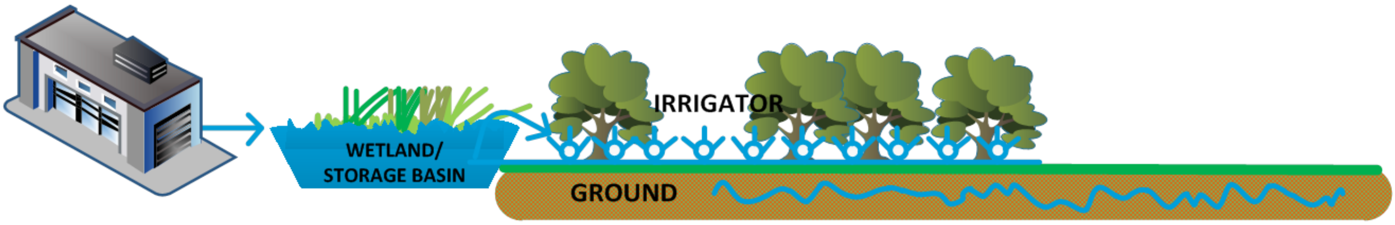

Figure 4.1 – Schematic of All Year Round Irrigation to Trees

4.4.2 Land Area Required

Approximately 25 ha of land is required for year round irrigation to trees. This includes 5 ha of land to allow for the removal and replacement of trees as irrigation would not be possible during this time and full irrigation of recently planted areas would be limited to periods of dry weather until the newly planted trees have formed a canopy.

Buffer storage is required for significant wet weather events when the soil is wet and irrigation is not possible. Using the wastewater flow record generated for the future design flows (section 2.1.1) and the irrigation application rates and constraints (Section 2.4) a time series of storage volumes was calculated. The maximum storage volume from the calculation is estimated to be 12,000 m^3. This requires approximately 0.7 ha. A further 2.5 ha of land would be needed for buffer zones around the forestry areas. This gives a total land requirement of 28.2 ha.

The areas assessed as suitable for irrigation are:

- Contiguous blocks of greater than 1 ha as areas smaller than this would be inefficient to irrigate
- With land slope of 15º or less as steeper slopes that this cause the wastewater to run off the land rather than pass through the land

- Not active unstable areas as application of wastewater to these areas runs the risk of causing further slips and erosion
- Not small residential lots as residential areas were considered ineligible zones for wastewater irrigation in terms of community acceptability and ability to acquire the land

The location maps in Appendix E show that 25 ha of suitable irrigable land can be found in the Takamātua area. This land would be split into at least 3 blocks over 8 to 10 land titles. The map also gives suggested locations for the buffer storage.

The maximum flow to the year round irrigation system is 14 L/s over summer, reducing to 4.2 L/s in winter. These flows are based on irrigating approximately 5 ha per day over 20 hours i.e. not all the land area will be irrigated at one time. The amount of land required and the estimated irrigation flowrates are based on irrigating sections of the total area and rotating between these sections. The design operating pressure will depend on the final locations of the irrigable areas but a nominal pressure of 50 m of head is estimated to supply treated wastewater out to the head of the Takamātua Peninsula.

4.4.3 Contact Time with Land

All wastewater has full contact with the land. During summer, most wastewater will be taken up by the trees and very little wastewater will travel past the root zone of the trees. There is no discharge to the harbour.

Irrigation year round will not be possible until a full tree canopy is established. Industry experience suggests that it may be up to 7 years before a pine plantation canopy is fully established, or 4-5 years for a kānuka canopy – this duration is to be confirmed and will depend on the tree type planted.

A number of options have been considered for disposal of the treated wastewater until the canopy is fully established, these include:

- Increase storage to hold flows that are unable to be irrigated
- Use a coastal infiltration gallery discharge for flows that are unable to be irrigated
- Start planting now but apply to extend consent of existing WWTP and outfall until trees fully established

4.4.4 Tree Selection

There are a number of options for the type of trees that could be planted in the irrigation area:

- Mānuka/kānuka as representative of local native species
- Pines (as at Wainui and Tikao Bay)
- Eucalypts for coppicing as fire wood

Pines and eucalypts need additional areas to allow harvesting of blocks and re-establishment of trees. There is little information available about the use of mānuka/kānuka in a wastewater irrigation scheme. Lincoln University is currently undertaking field trials on applying wastewater to a variety of plants including mānuka and kānuka. The Ngāi Tahu parties have expressed their preference for the use of mānuka or kānuka as they are endemic.

In a memo dated 29 February 2016, Trevor Partridge (CCC Botanist) advised that mānuka is now rare on Banks Peninsula due to mānuka blight disease and the associated sooty mould, so kānuka would be preferable. His best estimate is that it would take 4 - 5 years of good conditions for a kānuka canopy to establish.

4.4.5 Irrigation Method

Surface drip irrigation (as at Wainui) is preferred as the irrigation method as spray irrigation through trees is problematic due to tree trunks intercepting the spray and causing uneven distribution of wastewater over the land surface.

Figure 4.2 – Dripline Irrigation at Wainui

Figure 4.3 – Dripline Irrigation Under Trees at Wainui

4.4.6 Irrigation Field Maintenance

If pines or eucalypts were selected, once planted the trees will need to be pruned regularly, and will probably be harvested and replanted at some stage. Spraying beneath the trees may be required to control weed growth. Pruning, harvesting and spraying would probably not be required if mānuka or kānuka were selected. Replacement of parts of the irrigation system would be required if it becomes damaged during harvesting or maintenance (surface drip irrigation would be rolled up out of the way).

4.4.7 Advantages of Year Round Irrigation to Trees

- All wastewater reaches the soil and most of it will be absorbed by trees.
- No discharge of wastewater to the harbour.
- Trees can be grown which may have ecological value and some economic value (e.g. honey production).
- No spray drift, as irrigation would be drip irrigation on the ground surface.
- If native species were chosen, around 25 hectares of regenerating native bush could enhance the Akaroa environment.
- This option is strongly supported by Ngāi Tahu, as it is consistent with their cultural values.

4.4.8 Disadvantages of Year Round Irrigation to Trees

- A large land area is required, which is likely to provide only minimal income.
- People may not want to sell, lease or licence suitable land. Compulsory purchase under the Public Works Act may be required if agreement with landowners cannot be reached.
- There are some ongoing costs to maintain trees and irrigation systems.
- A long establishment time is required to grow the trees (around five years for kānuka), so an alternative discharge for most of the wastewater will be needed once the current discharge consent expires in 2020. This could be a new short term consent for the current wastewater treatment plant at Takapūneke, or a new coastal infiltration gallery.

4.5 Option 2 - All Year Round Irrigation to Pasture

4.5.1 Description of Operation

Treated wastewater is irrigated onto pasture when there is a soil moisture deficit – the wastewater passes into the soil and drains slowly through the soil. The pasture takes up water and nutrients and filtration through the ground allows microbes in soil to remove nutrients and help kill any bacteria. Without the canopy cover provided by trees more, moisture finds its way into the soil. When there is no soil moisture deficit, such as in winter and in high rainfall events, the treated wastewater is stored until irrigation can commence again.

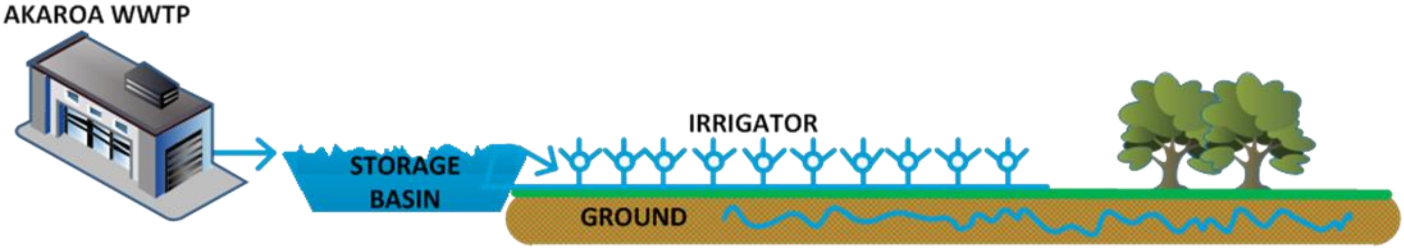

Figure 4.4 – Schematic of All Year Round Irrigation to Pasture

4.5.2 Land Area Required

To assess the irrigation area and storage requirements it is assumed the scheme will only apply irrigation when there is a soil moisture deficit. The amount that can be irrigated and when it can be irrigated is assessed using a soil moisture balance. The balance assesses the difference between the evapotranspiration losses from the soil moisture and the gains from effective rainfall - when there is a deficit irrigation can occur to fill up that deficit.

Effective rainfall is the rainfall which contributes to the soil moisture. Much of the area that is potentially available to irrigate is on slopes up to 15 degrees. During rainfall some runoff from the land is likely, the amount of runoff will depend on the conditions at the time. Generally measurements elsewhere indicate that runoff is higher in winter than in summer and it is not unreasonable to expect that will occur here as well.

The current estimate of the land area and storage required is based on the rainfall and evapotranspiration measured from 2008 to 2015 at the Akaroa EWS (Electronic weather station).

Other assumptions to calculate the area and storage are:

- Soil plant available water (PAW) is 72 mm. This is how much water is retained in the root zone of the pasture.
- Runoff varies from season to season depending on the monthly depth of rainfall. In the absence of specific data for pasture at Akaroa typical runoff figures for other small catchments on the east coast have been used.
- The daily wastewater volumes for 2041 have been used.
- Irrigation commences as soon as there is a deficit in the soil moisture balance and the deficit is filled by that day's irrigation.
- The area required has been assessed using spray irrigation or subsurface drip irrigation.
- For spray irrigation 85% of the irrigated water is assumed to be available to fill the soil moisture deficit. The rest is lost by volatilisation and spray drift.
- For drip irrigation 95% of irrigated water is available to fill the soil moisture. The rest is lost to drainage.

A range of possible combination of land area and storage requirements have been considered, however, it appears that the storage requirements do not decrease significantly with increase in irrigable area as there is a regular and extended period over winter when no irrigation can occur. For the purposes of this report the minimum irrigable area as determined by the soil moisture balance calculation has been used. If additional land were available to irrigate, such as if an entire parcel of land was purchased giving area in excess of that required, then the storage volume could decrease slightly.

Approximately 27 ha of land is required for year round irrigation to pasture, plus another 2.5 ha for the storage pond. Further land will also be required for buffer zones around the irrigation areas – this will depend on the size of the land parcels and the location of the land. It is assumed that an extra 30% or 8.1 ha will be required for buffer zones giving a total land requirement of 37.6 ha. The land being irrigated needs to be planted with something that can be cut regularly and taken off site such as grass or lucerne.

The application rate varies from day to day depending on the moisture in the soil but the maximum rate will be 7.1 mm/day averaged over the 27 ha. Buffer storage is required for when the soil is wet and irrigation is not possible. Storage of approximately 30,000 m³ will be required assuming the use of K-line irrigators.

The areas assessed as suitable for irrigation are the same as for irrigation to land under trees, however slopes and access will need to be suitable to allow harvesting of grasses (cut and carry). The location maps in Appendix E show that 37.6 ha of suitable land can be found in the Takamātua area split over multiple blocks.

Not all the land area will be irrigated at one time. The amount of land required is based on irrigating parts of the total area and rotating between these parts – the size of the parts will depend on the land that is acquired for irrigation but will be no less than 20% of the total area for each part.

4.5.3 Contact Time with Land

All wastewater has full contact with the land. During summer most wastewater will be taken up by the pasture and very little wastewater will travel past the root zone of the plants. There is no discharge to the harbour as wastewater will be stored when irrigation to pasture is not possible.

4.5.4 Irrigation Method

There are two irrigation methods that have been considered for irrigation to pasture - surface drip irrigation (as at Wainui and discussed in the previous section) or K-line spray irrigation as shown in Figure 4.5. Movable sprinklers have lower capital cost but higher operating cost in that labour is required to move the sprinklers periodically. However it is easier to harvest the pasture with removable sprinklers.

Figure 4.5 – K-Line Spray Irrigation at Blenheim

4.5.5 Irrigation Field Maintenance

If K-line type spray irrigators are used these will need to be moved periodically. Regular harvesting of the pasture will be required and there may need to be regular application of fertiliser and/or lime depending of the final nutrient content in the treated wastewater.

Replacement of parts of the irrigation system may be necessary if damaged during harvesting (hitting fixed sprinklers with machinery).

4.5.6 Advantages of Year Round Irrigation to Pasture

- No discharge of wastewater to the harbour.
- A crop of economic value can be grown (e.g. hay).
- There is potential to change the design of the wastewater treatment plant as a high level of nitrogen removal is not required. This could save up to $2 million.
- This option is supported by Ngāi Tahu, as it is consistent with their cultural values.

4.5.7 Disadvantages of Year Round Irrigation to Pasture

- This option requires the largest area of land and largest storage volume required
- People may not want to sell, lease or licence suitable land. Compulsory purchase under the Public Works Act may be required if agreement with landowners cannot be reached.
- This is potentially the most expensive option, although this may be partially offset by changing the design of the wastewater treatment plant and income earned from growing an economic crop.
- There may be spray drift, although this is limited and of very low risk to public health as there will be separation distances between the irrigation system and neighbours and the wastewater is very well treated.

- There are ongoing costs to maintain pasture and irrigation systems.
- Large buffer storage required – falls into category of “dam”, extensive earthworks and retaining required.

4.6 Irrigation to Land Hybrid Option

Another possible way of constructing an irrigation to land scheme is to utilise a combination of trees and pasture. The BNR treatment plant would be retained for this option. Compared with a pasture only option there is no practical change in the land area required. The main advantage to this option is a reduction in the amount of storage required, as the trees will allow irrigation in winter. To irrigate the winter flows to trees will require at least 20 ha of trees to keep the storage the same as for the tree only option. If the area of trees that is irrigated is reduced the volume of storage will increase. For instance for 10 ha of trees the estimated storage increases from 12,000 m^3 to 17,000 m^3. However even with the BNR plant retained, nutrient uptake may be an issue for the irrigation of wastewater on only 10 ha over winter depending on the amount of nutrient leaching that would be acceptable.

The irrigation of trees with drip irrigation does have the advantage over spray irrigation in that it can be placed closer to residential properties as there is no spray drift. Once access to suitable irrigation land has been identified then consideration can be given to the appropriate irrigation method for that land.

4.7 Option 3 - Summer Only Irrigation Plus Wetland or Infiltration Basin

4.7.1 Description of Operation

Treated wastewater is irrigated onto pasture or trees when ground conditions permit. If the wastewater is irrigated onto pasture the scheme will likely using spray irrigation because this is significantly cheaper to install than dripline irrigation and there is no risk of the sprays being interrupted by vegetation. Pasture is the preferred option as it offers a better potential return from utilising a cut and carry operation. Less land would need to be purchased for pasture irrigation as there is no allowance for maintenance and rotation of trees and as the majority of the land in the area is already in pasture, this would be more in keeping with the current environment and visual aspects.

When the ground is too wet and/or the amount of wastewater is greater than the land area available to be irrigated, then the remaining wastewater is passed through either a subsurface flow wetland or infiltration basin, followed by a coastal infiltration gallery.

The pasture takes up water and nutrients and filtration through the soil reduces nutrients, bacteria and viruses.

4.7.2 Land Area Required

It is estimated that around 12 ha of land would be required for summer irrigation plus another 1.4 ha for the storage pond and wetland, or 1.5 ha for the storage pond and infiltration basin. The size of the subsurface flow wetland or infiltration basin will not be much smaller than if it were a stand-alone option. Approximately 3.6 ha would be need for 25 m buffer zones around the irrigation areas assuming spray irrigation is used. This gives a total land requirement of 17 – 17.1 ha.

The type of land suitable for irrigation is the same as for year round irrigation (see Section 4.4.2). Slopes will need to be flat enough to allow harvesting of grasses (cut and carry) and generally less than the 15° specified for irrigation areas so machinery can be used on this land. Buffer storage of approximately 12,000 m^3 for the wetland option and 7,000 m^3 for the infiltration basin option, is required for significant wet weather events when the amount of rainfall prevents irrigation or exceeds the capacity of the passage through land treatment used.

4.7.3 Contact Time with Land

All irrigated wastewater has full contact with land. During summer, most wastewater will be taken up by the pasture and very little wastewater will pass through the root zone of the pasture. Contact time through the subsurface flow wetland or infiltration basin will be as described in the Sections 4.8.3 and 4.9.3.

4.7.4 Pasture Type

To maximise the potential income from the land the pasture type needs to be suitable for a cut and carry operation - grass or lucerne are the most likely options. Alternatively it would be possible to plant the area with trees as discussed in 4.4.1.

4.7.5 Irrigation Method

Some form of spray irrigation is suggested if irrigation is onto pasture as it is more cost effective than drip irrigation and will not be intercepted by trees. Options include fixed in ground sprinklers (high capital cost) or movable sprinklers (e.g. K-line). Movable sprinklers have lower capital cost but higher operating cost in that labour is required to move the sprinklers periodically. However it is easier to harvest the grass or lucerne with removable sprinklers.

4.7.6 Irrigation Field Maintenance

In addition to regular harvesting of the pasture there may need to be regular application of fertiliser and/or lime since the amount of nutrients in the treated wastewater is less than optimal for maximising plant growth. Replacement of parts of the irrigation system will be required if damaged during harvesting such as hitting fixed sprinklers with machinery.

Maintenance of the subsurface wetland or infiltration basin will be as described in Sections 4.8.7 and 4.9.7.

4.7.7 Advantages of Summer Only Irrigation

- During summer, most of the wastewater will be absorbed by the plants, with very little going further than the roots.
- A crop of economic value can be grown (e.g. hay).
- Less land is required compared to year -round irrigation.

4.7.8 Disadvantages of Summer Only Irrigation

- A large area of land is required, although less than half that required for year -round irrigation.
- People may not want to sell, lease or licence suitable land. Compulsory purchase under the Public Works Act may be required if agreement with landowners cannot be reached.
- There is a possible risk associated with spray drift, although this is limited and of very low risk to public health as there will be separation distances between the irrigation system and neighbours and the wastewater is very well treated.
- There are ongoing costs to maintain plants and irrigation systems, as well as the infiltration basin or wetland.
- A coastal infiltration gallery is needed to discharge treated wastewater not taken up by pasture/trees. Mixing and dilution will be less than for the mid-harbour outfall option, so there may be a slightly higher public health risk from contact recreation or eating raw shellfish.

- The Ngāi Tahu parties have significant reservations about this option, as it does not use natural processes to restore the mauri of the wastewater, and continues discharge of it into the harbour.

4.8 Option 4 - Sub Surface Flow Wetland

4.8.1 Description of Operation

A basin is constructed and lined, then filled with media and planted with wetland plants on the surface. Treated wastewater flows horizontally through media, below the surface of the wetland, rather than over the top as in a traditional wetland. Plants on the surface take up nutrients and water with excess wastewater collected at the end to be discharged through a coastal infiltration gallery.

Buffer storage is required to smooth out high flows and to ensure wastewater always remains below the surface of the subsurface wetland. Location options are described in Section 5.

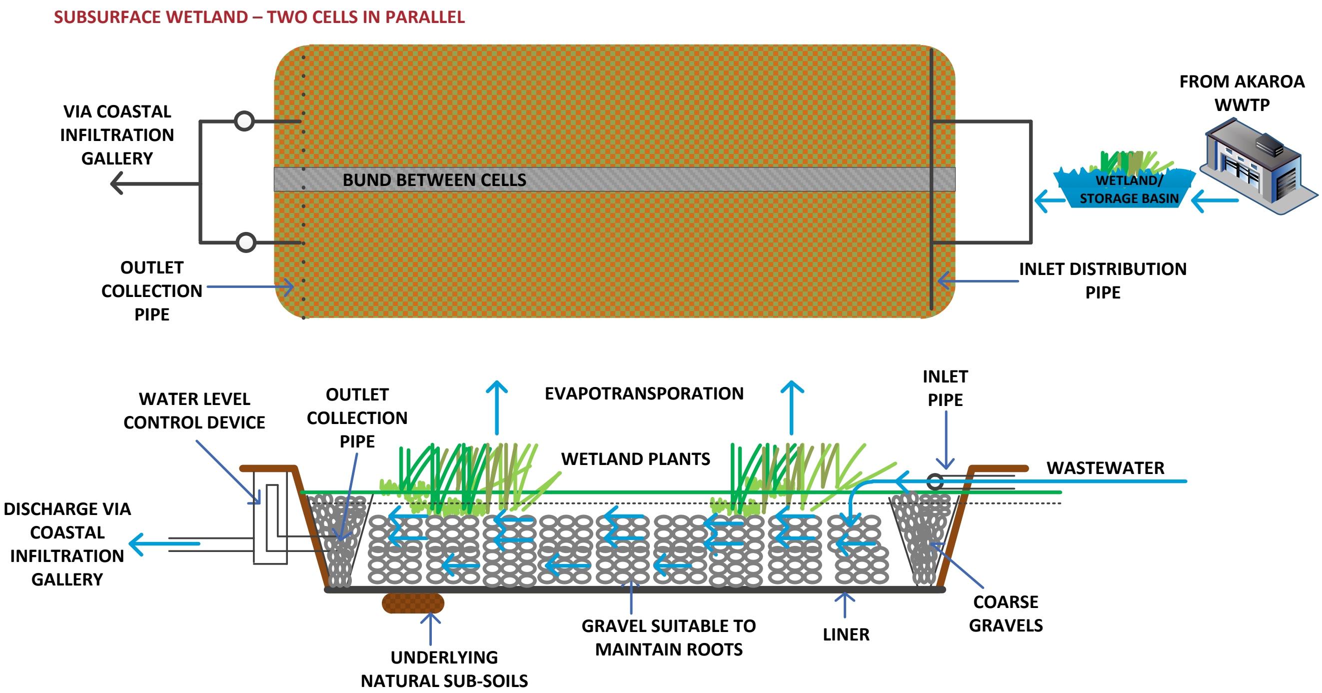

Figure 4.6 – Arrangement of Subsurface Flow Wetland

4.8.2 Subsurface Wetland Size

It is estimated that about 0.7 ha will be required for the construction of the sub surface wetland. This area allows for the bund between wetland cells, and the embankments around the wetlands. The wetland will be about 0.5 m deep to maximise the re-use of wastewater. The wetland cannot be too deep otherwise the roots of the wetland plants will not grow through the full depth of media.

Because of the relatively small area required, the wetland can be shaped to fit into the land contours. Ideally it would be constructed on a relatively flat section of land to minimise the retaining and therefore cost and technical complexity. The scheme design incorporates two wetlands in parallel – this allows maintenance of one wetland while wastewater continues to be treated in the other wetland.

Using the time series of future wastewater flows described in 2.1.1, and the allowable flows through the wetland, a calculation of the range of daily storage volumes required was undertaken. From this analysis a maximum storage volume of approximately 12,000 m^3 is required to balance the flows. The storage is mainly required to balance the difference between the average summer flow and the capacity of the wetland. A storage pond of about 0.7 ha is needed assuming a depth of 2.5 m. A depth of 2.5 m is assumed as land area required is minimised if the depth is maximised. Loess is expected to be approximately 3m deep and dam regulations are triggered at depths over 3 m, so a depth of 2.5 m was chosen.

The areas required are:

- Wetland: 7,000 m^2
- Storage pond: 7,000 m^2
- Total: 14,000 m^2

The areas above are at the surface (allowing for the bunds, with 1V:2H internal side slopes, and 1V:4H side slopes on the outside of the 3m wide bunds around the perimeter). The proposed scheme is based on using two wetland cells in parallel to allow one to be taken offline for maintenance while maintaining flows through the other.

The design flow to the wetland is 6 L/s based on 435 m^3/day delivered over a 20 hour period.

4.8.3 Contact Time with Land

To a certain extent the wetland can be sized to achieve a specific contact time. A longer contact time can be achieved with a bigger wetland, this will increase the construction cost of the wetland. Current sizing has been based on a minimum time of 2 days (for peak summer flows).

Often in summer there will be a reduction in discharge, and sometimes no discharge, as plants take up wastewater and evapotranspiration also occurs. Winter time wastewater flows will take around 3 days to pass through the wetland. This is because the average daily winter flow is less than the average daily summer flow, so since the volume of the wetland remains unchanged, the lower flow takes longer to pass through the volume of the wetland.

4.8.4 Media Type

The media will be primarily gravel in a size range 5 - 20 mm. Locally sourced gravels e.g. from Birdlings Flat are likely to be suitable for the subsurface flow wetland. Some suitable material may be available from sites closer to Akaroa; this will be investigated further in the future design stages.

4.8.5 Subsurface Wetland Plants

The wetland can be planted with locally sourced wetland plants such as:-

- Carex secta (purei),
- Schoenoplectus tabernaemontani (kapungawha, soft-stem bulrush or lake clubrush),
- Bolboschoenus fluviatilis and B. medianus (purua grass, kukuraho, riri-waka, river bulrush, marsh clubrush)

Harakeke/flax or other marginal wetland species can also be planted on the banks of the basin.

Figure 4.7 – Construction of a Subsurface Flow Wetland (at Abel Tasman courtesy of Cameron Gibson and Wells Ltd)

Figure 4.8 – Planted Subsurface Flow Wetland at Abel Tasman (Cameron Gibson Wells Ltd)

4.8.6 Other Design Considerations

The wetland will need to be lined with an artificial liner to prevent migration of water into underlying soils which would otherwise result in a risk of tunnel gully erosion of the loess soils. The lining also helps stop the bed from drying out in long hot periods.

4.8.7 Subsurface Wetland Maintenance

It will be necessary to keep birdlife out during establishment to prevent plants from being eaten or pulled out. Routine weeding of the wetland will also be needed to remove unwanted plants which arrive over time through windborne seed. Some dieback will also occur in winter and this material will also need to be removed each year. Every 10 years or so the wetland media and/or plants may need to be removed and replanted, depending on clogging.

4.8.8 Subsurface Wetland Advantages

- Reduced discharge in summer, as wastewater is absorbed by wetland plants.
- Wetland plants can be used for other purposes (e.g. Harakeke/flax for weaving).
- Small area of land required, so obtaining enough land should be easier than for irrigation options.
- This is the lowest cost option.
- Wastewater is not present on the surface of the ground.

4.8.9 Subsurface Wetland Disadvantages

- Discharge of treated wastewater to the harbour is required. If discharge is at the coast, mixing and dilution will be less than for the mid-harbour outfall option, so there may be a slightly higher public health risk from contact recreation or eating raw shellfish.
- This option is not supported by the Ngāi Tahu parties, as it does not use natural processes to restore the mauri of the wastewater, and continues discharge of it into the harbour.

4.9 Option 5 - Infiltration Basin

4.9.1 Description of Operation

A basin is constructed and lined, then filled with media which will allow the wastewater to pass through at a controlled rate. Treated wastewater is discharged onto the surface of the infiltration basin and flows vertically through media. Generally these are unplanted, but grasses can be established on the surface of the infiltration area, which helps to take up nutrients. Filtration through the media allows microbes in soil to remove nutrients and reduce bacteria. The scheme would require around 7 basins - each basin will be dosed with treated wastewater and then left for the wastewater to drain away and the basin to recover before applying wastewater again.

Wastewater that has infiltrated through the basin and has been collected at the base of the infiltration basin will need to be discharged through a coastal infiltration gallery.

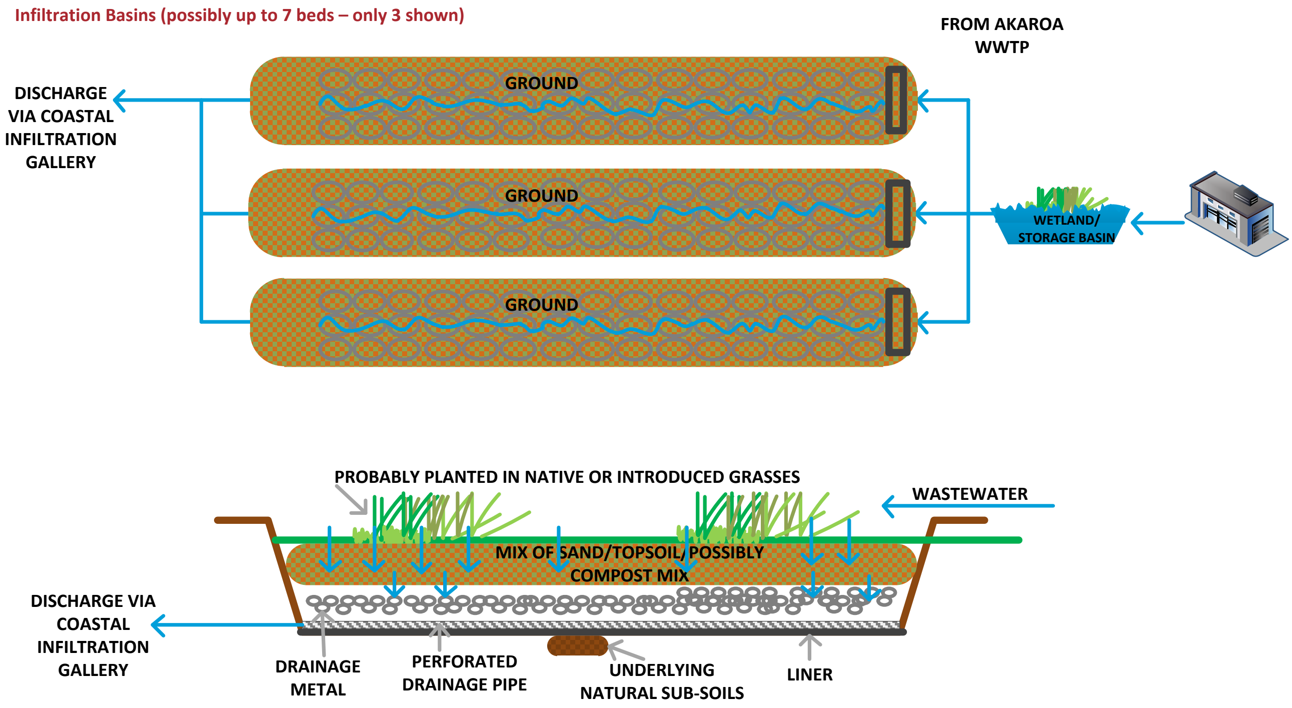

Figure 4.9 - Arrangement of Infiltration Basin

4.9.2 Infiltration Basin Size

Current estimate for the land area required is about 1.1 ha for a system of 7 infiltration basins. The number of basins is somewhat arbitrary and the final design may differ. A system of 7 basins has been chosen for ease of management. One basin can be filled per day and each basin is filled once per week. The basins would be about 1 m deep to achieve 2 days contact time with media at an infiltration rate of approximately 20 mm/hr. The basins can be shaped to fit into the land contours. The total surface area of the basins will be approximately 12,300 m² and the total volume would be approximately 6,300 m³. The infiltration media will be a mix of sand and soil to provide a suitable infiltration rate.

Buffer storage is less than for a wetland because more than one basin can be filled with wastewater during high flow conditions. Using a similar storage calculation using future flow data to that used for the wetland, the maximum storage required is approximately 7,000 m³. Assuming a pond depth of 2.5m, a storage pond area of approximately 0.4 ha is needed. A depth of 2.5 m is assumed as land area required is minimised if the depth is maximised. Loess is expected to be approximately 3 m deep and dam regulations are triggered at depths over 3 m, so a depth of 2.5 m was chosen. Therefore the total area required would be about 1.5 ha.

These areas and volumes are based on side slopes of 1V:4H and a 3 m wide crest on the bunds around and between the infiltration basins. The flow to the infiltration basins will depend on whether one or two are required to be operated. For a single basin, at the design flow of 290 m³/day, the flow through the basin is 5 L/s and for two basins the flow is 10 L/s.

Location considerations are discussed in Section 5.

Figure 4.10 – Aerial View of Multiple Infiltration Basins (Cambridge)

4.9.3 Contact Time with Land

The contact time through the infiltration basin is dependent on the depth of the basin and the rate at which the wastewater passes through the media. The nature and size of the media particles determines the rate of wastewater passage. The concept design for the basins achieves a contact time of 2 days.

There is a continuous discharge from the infiltration basins as the loading rate is higher and there is limited uptake of water if the basins are planted. Evaporation is minimal as the basins are designed so that wastewater does not pond on the surface.

4.9.4 Media Type

The media placed in the infiltration basins would be a mixture of topsoil, sand, and possibly compost. The intention would be to use topsoil from the site, plus sands from the area (although it is important to get the right grade of sand). Compost may need to be brought in from Christchurch if used.

4.9.5 Infiltration Basin Plants

Generally infiltration basins are unplanted, or planted in native or introduced grasses.

4.9.6 Other Design Considerations

The infiltration basins will need to be lined with an artificial liner to prevent migration of water into underlying soils, which could cause tunnel gully erosion of the loess soils.

4.9.7 Infiltration Basin Maintenance

Some mowing of any grasses that are planted on the basins may be required. In some cases the media may become blocked. In this case there may be a need to use a mechanical aerator to break up the media. In worst cases the media may need to be removed and replaced. This risk is significantly reduced by membrane filtration of most flows.

4.9.8 Infiltration Basin Advantages

- Requires the smallest storage pond because of the number of basins used.
- Small area of land required, so obtaining enough land may be easier than for irrigation options.
- This is the one of the lowest cost options.
- Wastewater is not present on ground surface long enough to provide a habitat for midges or mosquitos.

4.9.9 Infiltration Basin Disadvantages

- Construction can be complex as the basins need to be deeper than other options.
- Wastewater will pond on the surface briefly before draining away.
- A coastal infiltration gallery is needed to discharge treated wastewater to the harbour. Mixing and dilution will be less than for the harbour outfall option, so there may be a slightly higher public health risk from contact recreation or eating raw shellfish.
- This option is not supported by the Ngāi Tahu parties, as it does not use natural processes to restore the mauri of the wastewater, and continues discharge of it into the harbour.

Figure 4.11 – Infiltration Basin (Cambridge)

Figure 4.12 – Infiltration Basins at Leeston

4.10 Options for Discharge to the Harbour

Options 3, 4 and 5 involve passing treated wastewater through land, either in a wetland or infiltration basin, before ultimately discharging it to the harbour. It would also be possible to discharge via a piped outfall to the harbour, as originally proposed. However, the cost of this is estimated to be $6.7M in addition to the cost of the wetland or infiltration basin. The Ngāi Tahu parties have advised that they do not favour a piped discharge. For these reasons, a piped outfall for Options 3, 4 and 5 has not been considered further. Three other discharge route options are available in the proposed locality of the scheme, namely:

- Discharge to ground or to a dry gully
- Discharge to a stream or waterway
- Discharge to a coastal environment

An initial assessment of the harbour discharge route options is described in the next sections.

4.10.1 Discharge to ground or to a dry gully

For a scheme involving a wetland or infiltration basin, the final wastewater could be discharged direct to ground or to a dry gully. The geology in the scheme locality consists of loess soils overlying volcanic bedrock. A direct discharge to land could be achieved by drilling into the bedrock. However given uncertainties about rock layering and fracturing below the land surface, the injected water could re-emerge at another unspecified location. This would simply transfer the problem to another location without solving it and hence this option is not recommended.

The alternative, discharging to a dry gully, is also not without risk. Banks Peninsula soils, which are composed of loess, are highly erodible. Direct discharge of wastewater to a dry gully would likely cause erosion of soils on an ongoing basis. Sloping land in the discharge area could be destabilised by ongoing water ingress and eroding solids may transfer sediments to the harbour. The wastewater itself would also end up in the harbour. Taking into account concerns regarding slope destabilisation, soil erosion and harbour sedimentation, a dry gully discharge is considered high risk and is not preferred due to erosion potential.

A dry gully discharge could be engineered by lining it with impermeable materials. Under this scenario the treated wastewater would follow directly to the harbour via the lined gully. There are no apparent advantages to this option over a discharge to the coastal environment and additional costs would be incurred in constructing the lined gully.

4.10.2 Discharge to a Stream or Waterway

A topographic map showing surface water courses in the vicinity of the Akaroa Wastewater Scheme is shown in Figure 4.13.

Figure 4.13. Surface Watercourses in Locality of Akaroa Wastewater Scheme

There are a number of small catchments along the eastern slopes of the upper harbour basin that could conceivably receive treated wastewater from the Akaroa scheme. These include Robinsons Bay Stream, Takamātua Stream, Grehan Stream and Balguerie Stream. Takamātua Stream is nearby and has the highest flow and the largest catchment area. While the treated wastewater discharge from the Akaroa treatment scheme will be very high quality, it will contain nutrients, microbiological contaminants and small amounts of BOD and solids. During wet weather bypassing, contaminant loads will be increased.

A discharge of wastewater containing nutrients, BOD and other contaminants may pose environmental risks to these small streams taking into account their ecological sensitivity and the limited dilution available due to low natural flows, especially during low flow periods in summer when wastewater loads will be highest. The local community may also be opposed to discharge of wastewater to freshwater streams and there may be cultural concerns.

Overall, discharging treated wastewater to streams in the upper harbour basin is not favoured due to environmental, social and cultural concerns.

4.10.3 Discharge to Coastal Environment

The requirement for an environmental receptor for treated wastewater for Options 3, 4 and 5 could be met by discharging to the coastal environment. The eastern harbour shoreline contains a number of potential locations for a coastal discharge after wastewater has passed through land in a wetland or infiltration basin. To assess locational options the eastern shoreline has been divided into three zones:

- Upper harbour, north of Takamātua
- Takamātua headland, between Takamātua and Akaroa
- South of Akaroa

An initial evaluation of these zones has been undertaken in the following sections.

4.10.3.1 Discharge to Upper Harbour

The upper harbour zone north of Takamātua is predominantly shallow and of low gradient, with extensive mudflats exposed at low water[1]. Potential locations for a coastal discharge could include small headlands that protrude into the upper harbour. A discharge at such a location would provide for mixing of the discharge with harbour waters at some distance from the coastal settlements and the majority of contract recreational use that is primarily focussed on beaches and within bays in the harbour.

Nevertheless there are two clear disadvantages with an upper harbour discharge location; firstly the shallow waters and confined nature of the head of harbour mean that dilution and dispersion of wastewater would be restricted. Restricted mixing poses higher risks to the environment and to public health. Secondly, the significant distance from the proposed treatment plant location would require lengthy reticulation pipeline to reach the discharge point, increasing the scheme costs. For these two reasons an upper harbour discharge location is not favoured.

4.10.3.2 Discharge at Takamātua Headland

The Takamātua headland between Takamātua Bay and Childrens Bay (refer to Figure 4.12) protrudes into the mid-upper harbour. LINZ bathymetry (study of ocean floor depth) mapping shows a fairly uniform seabed and bathymetry in this area, except near the headland at Lushingtons Bay where a trench has been scoured close to shore by localised tidal flows[1]. A preferred location for a discharge on this headland would be at a point along the tip of the headland. This area provides some separation distance from the majority of harbour and beach recreational use to allow for a coastal mixing zone. The presence of a near shore trench along

[1] Upper Akaroa harbour Sediment Bathymetry and Soft Sediments : A Baseline Mapping Study, ECAN, 2009

the headland tip is also beneficial as it indicates tidal flows through this area and increased water depth, both of which will assist with rapid dilution and dispersion of discharging wastewater.

Further benefits of this locality are the relatively close proximity to the proposed treatment plant and reasonable access to the coastal zone, minimising the length and cost of pipelines for transferring the wastewater from the treatment plant and any wetland or infiltration basins to this location. An example of a potentially suitable location for a coastal discharge is indicated in Figure 4.14. This location is also specified on the scheme location maps in Appendix E.

There may be other suitable locations along the tip of the Takamātua headland to the north or south. Further work is recommended, if this concept is taken to the next stage, to review location options and confirm a preferred site taking into account a range of factors including access requirements, engineering risks and consenting risks and costs.

Figure 4.14– Possible location of Takamātua headland for construction of coastal infiltration gallery

The potential advantages of the location shown in Figure 4.14 include:

- Relatively remote from recreational users or residential properties
- Adjacent to nearshore seabed trench featuring significant tidal flows
- Accessible by either land or sea
- Ground conditions and material type are suitable for construction
- Reasonable depth of coastal waters at this location within the harbour (compared to further up the harbour where the receiving waters become very shallow).

4.10.3.3 Discharge to Southern Harbour

South of Takamātua headland the coastline extends from Childrens Bay through Akaroa Township and south past Green Point to The Kaik, where Ōnuku Marae is located. Discharge locations within Akaroa Township are considered unsuitable due to the concentration of beach and harbour users in this area and the potential for environmental, public health effects as well as community opposition. Discharge in the vicinity of, or south of, Green Point would bring the discharge back to its current location. Consultation by Council with Ngāi Tahu in the process of developing the Akaroa wastewater scheme has highlighted strong cultural opposition to discharge at this location.[2]

4.10.4 Design of Coastal Infiltration Gallery

The coastal infiltration gallery discharge structure on the coast would consist of a buried infiltration structure (or gallery) composed of locally sourced rock with a central slotted or drilled pipe running along its length. The infiltration structure would be buried in the beach in the intertidal zone. The beach would be reinstated to its original form after the infiltration structure is constructed. The flow of wastewater through the infiltration structure will vary between 6 L/s and 10 L/s depending on the upstream treatment option.

A longer discharge pipe will provide improved wastewater dilution - a 20 m long pipe is initially proposed. A gabion wall to retain the structure would be provided – this would be approximately 20 m long and 2 m wide utilising 600 mm square gabions filled with 50 -100 diameter locally sourced rocks. The structure would be completely buried with no visible manmade structures.

It is assumed that the infiltration structure will not provide any improvements to treated wastewater quality. A summary of the treated wastewater quality likely to be achieved for each option is provided in Section 4.11. Figure 4.15 provides schematic of the proposed coastal infiltration gallery.

[2] Akaroa Wastewater Treatment Plant Options for Locating New Wastewater Treatment Plant p.10

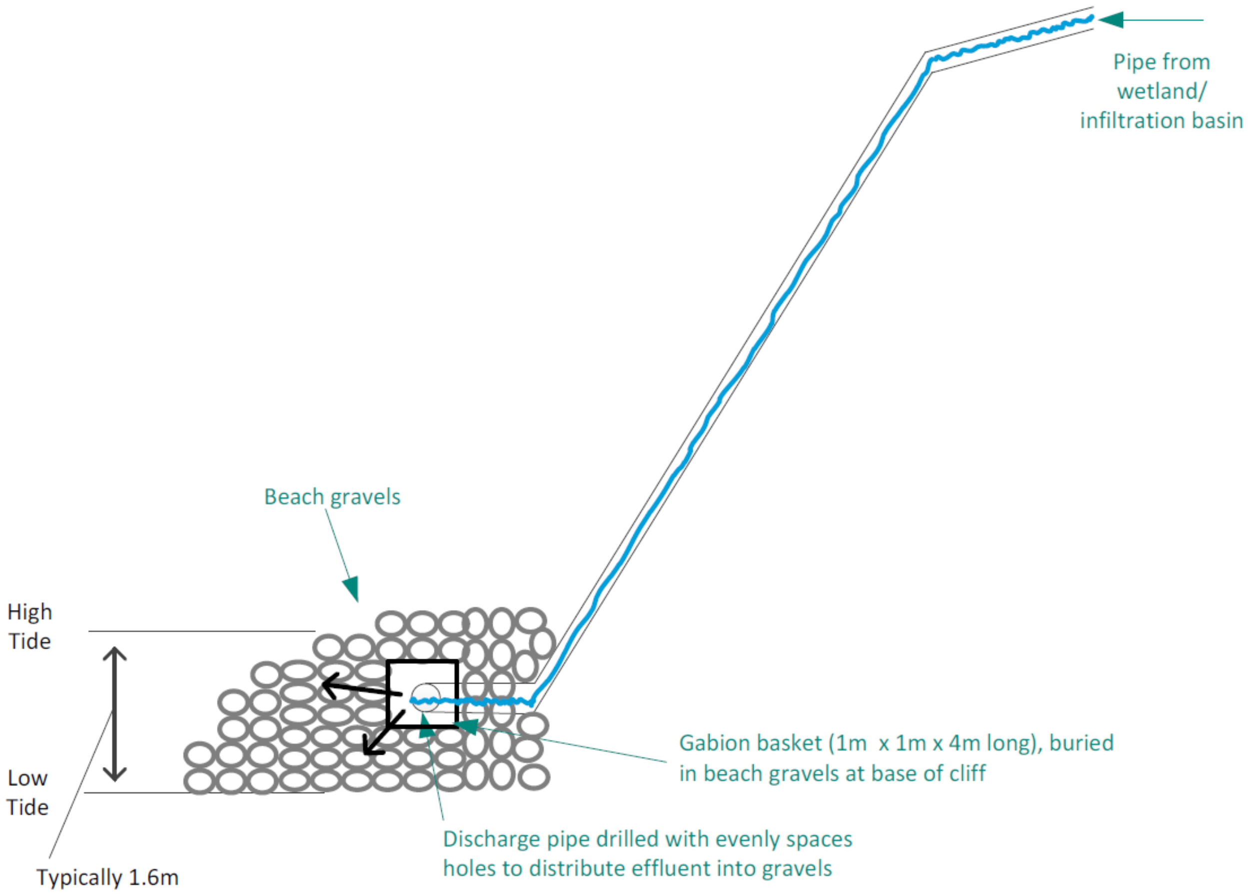

Figure 4.15 – Schematic of Coastal Infiltration Gallery

4.11 Treated Wastewater Quality

The options investigated in this report will achieve similar treated wastewater standards to those proposed for the Akaroa BNR treatment plant in 2014. This is underpinned by retaining the BNR treatment plant as an integral part of all scheme options except for year round irrigation to pasture where higher nutrient levels can be absorbed and a biological trickling filter process could be used. The proposed quality of discharge from the consented treatment plant is set out in Table 2.2.

Some options will provide wastewater quality at the point of discharge either slightly above or below that expected from the treatment plant. Land irrigation year round, for example, avoids a direct discharge to receiving waters and this represent an improvement over a harbour outfall scheme in terms of harbour water quality. There are also some quality differences between subsurface wetland and infiltration basin performance. Key differences are set out below, however it is important to note that the use of the subsurface wetland or infiltration basin prior to discharge results in very little change to the treated wastewater quality that would have been discharged through the harbour outfall, with the disadvantage that the mixing from the proposed coastal infiltration gallery will not be as good as from the outfall.

4.11.1 Option 1 – Irrigation to Land Year Round Under Trees

Very high quality treated wastewater from the BNR plant will be irrigated to land. Bypass flows will be screened to 130 microns and UV disinfected prior to land irrigation. There is no point source discharge to the harbour so there will be no measurable effects on the harbour.

4.11.2 Option 2 – Irrigation to Land Year Round to Pasture

If the BNR plant is replaced with a biological trickling filter process for this option, the treated wastewater will be higher in nutrients. Bypass flows will still be screened to 50 microns and UV disinfected. There is no point source discharge to the harbour so there will be no measurable effects on the harbour.

4.11.3 Option 3 – Summer Only Irrigation plus Subsurface Wetland or Infiltration Basin plus Coastal Infiltration Gallery

Summer time irrigation to land will have no measurable effects on harbour water quality during summer when there is no discharge to the harbour other than an occasional minor discharge associated with keeping wetland plants wet during summer. During winter the discharge from either a wetland or infiltration basin will be to the harbour via the coastal infiltration gallery.

Wastewater discharging from a wetland will be influenced by the growth and die-off of biomass in the wetland itself – biological oxygen demand (BOD) and suspended solids levels will be slightly elevated due to release of wetland organic matter. At the same time dissolved inorganic nitrogen (DIN) and dissolved reactive phosphorus (DRP) levels will be slightly reduced due to absorption and nutrient take up by wetland plants. Ammonia levels are unlikely to change significantly through the wetland.

Wetland wastewater virus levels are likely to be improved over the 2014 consent proposal, especially during wet weather flow periods, due to the changes to the treatment process, virus removal in the wetland, and the effects of flow attenuation (by storage pond buffering). This feature is important in protecting public health as the mixing and dilution provided by the coastal infiltration gallery will be less efficient than that achieved by a mid-harbour outfall. Wetland virus removal performance is described in Tables 4.2 and 4.3 in Section 4.2.5 of the report. The subsurface wetland scheme will improve the removal of norovirus over the BNR plant performance alone during both dry and wet weather operation. Taking into account the lesser efficiency of a shoreline discharge via the coastal infiltration gallery, and the improved efficiency of bacteria and virus removal within the treatment scheme, public health risks are expected to be well managed overall.

Wastewater discharging from an infiltration basin is expected to be little changed from the influent flowing onto the basin. Some oxidation of ammonia to nitrate may occur but otherwise the very low levels of suspended solids, BOD and nutrients (N and P) present in the influent are expected to also be present in the discharge. There is uncertainty about destruction of bacteria and viruses in an infiltration basin; this will be influenced by the design of the basin. A conservative evaluation of likely virus removal through an infiltration basin scheme is provided in Tables 4.2 and 4.3 in Section 4.2.5 of the report. The infiltration basin scheme virus removal will be similar to the BNR plant. Slight improvements may be achieved during wet weather operation, as shown in Table 4.3. Taking into account the less effective mixing provided via the coastal infiltration gallery to the coastline, the public health risks for this option are assessed as low. Nevertheless they will be slightly higher than for other options including a mid-harbour outfall discharge.

4.11.4 Option 4- Subsurface Flow Wetland

As described under Option 3, the discharge from wetland to the coastal infiltration gallery will be influenced by the growth and die-off of biomass in the wetland itself – BOD and suspended solids in the discharge will be slightly elevated due to release of wetland organic matter. Dissolved Inorganic Nitrogen (DIN) and Dissolved Reactive Phosphorus (DRP) levels will tend to be slightly reduced due to absorption and nutrient take up by wetland plants. Ammonia levels may not be reduced but are unlikely to be increased.

The reduction in bacteria and virus levels will also be improved – in the case of viruses during both dry and wet weather operation as shown in Tables 4.2 and 4.3. As outlined under Option 3 above, this feature is important in protecting public health. If the subsurface wetland is chosen as the preferred option then the detailed design of the wetland would carefully consider requirements for human health including maximising virus removal.

4.11.5 Option 5 – Infiltration Basins

The discharge from the infiltration basins to the coastal infiltration gallery will be similar to that proposed in the 2014 consent application. The infiltration basin is unlikely to reduce BOD, suspended solids and organic components below the levels contained in the BNR plant discharge but nor will it increase them. Some conversion of ammonia to nitrate may occur.

The infiltration basin scheme virus removal will be similar to the BNR plant. Taking into account the less effective mixing provided via the coastal infiltration gallery to the coastline, the public health risks for this option, while remaining low, are slightly higher than for other options including a mid-harbour outfall discharge.

4.11.6 Treated Wastewater Quality Summary

All of the land-based schemes investigated will have final discharge wastewater quality similar to, or better than, the treated wastewater quality proposed as part of the 2014 consent application for discharge via a 2.5 km long harbour outfall. There are some minor differences in treated wastewater quality between the schemes, but these are not of sufficient magnitude to be of relevance to the assessment of options. Key points regarding wastewater quality are as follows:

- Year round land irrigation will have no measurable effect on the harbour as the wastewater will be taken up by soils within the irrigation area
- The subsurface wetland scheme (Options 3 and 4), including a coastal infiltration gallery to the coastal zone, will further polish the discharge from the treatment plant prior to discharge, although it is likely to cause small increases in BOD and suspended solids levels in the final discharge. This is due to organic material breakdown within the wetland. The wetland scheme will also remove some of the residual bacteria and viruses present in the wastewater to assist in managing public health risks
- The infiltration basin scheme (Options 3 and 5) is similar in performance to the wetland scheme, except it is unlikely to remove bacteria and viruses as effectively as a wetland.
- Dilution of treated wastewater discharged via the coastal infiltration gallery located at the shoreline will not be as effective as the dilution achieved by a 2.5 km harbour outfall pipe. Nevertheless, taking into account the overall performance of the wetland and infiltration basin schemes, and the dilution efficiency, public health risks are expected to be well managed.

4.12 Non-Potable Reuse

The first stage of investigations identified that non-potable reuse of wastewater could not be a standalone option as it would utilise only part of the total wastewater generated (estimated to be around 20%). However both the Council and the Ngāi Tahu parties were interested in investigating this option further as something that could be implemented in future.

Non-potable reuse refers to the use of treated wastewater for toilet flushing water, gardening, boat washing etc. (but not for drinking). To facilitate reuse a new reticulation network (known as purple pipe network) would be required within Akaroa, including new pipework, and new property connections to convey the treated wastewater from the treatment plant to households. Additional booster pump stations may be needed within the township to reticulate the treated wastewater to properties above the level of the wastewater treatment plant.

Reticulation of the treated wastewater would be directly from the treatment plant, via a storage facility. Additional treatment at the treatment plant would be required for wet weather bypass flows to reduce viruses to an acceptable level for non-potable use; or alternatively only take water for reuse when the bypass is not operating (this would be a simpler alternative). Fully treated wastewater would be acceptable for non-potable use.

Evaluation of this option assumes that non-potable reuse would be compulsory for properties in Akaroa for uses such as toilet flushing and garden use. A purple pipe system would reduce the consumption of potable water. Storage would be required as the quantity of non-potable water use in winter is likely to be less than the volume of treated wastewater due to the reduced population and increased wet weather at this time of year. The size and location of such storage has not been investigated at this stage.

Compulsory installation of a purple pipe network would need careful consultation with the general public to gain public buy-in to the scheme. Feedback to date is that both the community and the Ngāi Tahu parties strongly support a non-potable reuse scheme. As a large amount of earthworks on public roads and plumbing works on private property would be required, engagement with the community and individual landowners would be required. Consequently there is potential that the project could run past the current resource consent period. There is some risk to public health through incorrect use of the scheme; this risk could be mitigated through clear labelling of the reuse pipework and through public education. There are no purple pipe schemes in New Zealand but they are extensively used in Australia and the U.S.A.

To implement this option a new storage system and reticulation network would need to be installed, and each property fitted with an appropriate connection point and signage. It is estimated that 20% of the wastewater flow could initially be reused in summer (in toilet flushing) and approximately 10% in winter. Reuse rates may increase over time with community acceptance of the benefits of reuse water. The cost for Option 5 is estimated at $10.9M and this includes for 2,000 L of storage at each property.

5 Land Requirements, Location and Layout

5.1 Land Area Requirements

Land areas required for land irrigation, wetlands and irrigation basins are summarised, along with relevant assumptions in Table 5.1. Proposals for wastewater storage volumes are also stated. Storage of wastewater after it has been treated is necessary to smooth out peak wet weather flows so that the size of the land irrigation fields or wetlands/infiltration can be optimised.

Buffer zones will be required between irrigation areas and neighbouring land. Subject to an assessment of environmental effects, a 5m buffer between the forestry area and neighbouring properties (assuming dripline irrigation) and a 25m buffer between pasture irrigated areas and neighbouring properties (assuming spray irrigation) has been assumed. The actual amount of land required will depend on the size and shape of the blocks deemed suitable for irrigation. For the purposes of estimating the total land area that needs to be purchased for each option an allowance of 10% additional buffer zone land has been made for dripline irrigation and 30% additional buffer zone land for spray irrigation. Note that land for the buffer zones does not need suitable for irrigation, and is additional to the blocks identified in the location plans in Appendix E.

Table 5.1 Irrigation, Wetland and Infiltration Basin Area and Storage Requirements

Option	Storage Required (m^3)	Area Required for Treatment (ha)	Area Required for Buffer Zones (ha)	Area Required for Storage (ha)	Total Area Required (ha)
Year Round Irrigation - trees	12,000(2)(3)	25	2.5(1)	0.7	28.2
Year Round Irrigation – pasture	30,000	27	8.1(6)	2.5	37.6
Subsurface Flow Wetland	12,000(3)	0.7(1)	0	0.7	1.4
Infiltration Basin	7,000(4)	1.1(1)	0	0.4	1.5
Summer Irrigation + Wetland	12,000(5)	Irrigation 12 Wetland 0.7(5)	3.6(6)	0.7	17
Summer Irrigation + Infiltration Basin	7,000(5)	Irrigation 12 Infiltration basin 1.1(5)	3.6(6)	0.4	17.1

Notes

(1) A 5 m buffer between the forestry areas and neighbouring properties is likely to be required. For the purposes of assessing the total area to be purchased the land area required has been increased by 10% to allow for buffer zones.
(2) Based on not irrigating for a week during very wet conditions
(3) Based on peak daily wet weather flow of 1,800 m^3/d
(4) Assumes two basins can be operated together for wet weather flows
(5) Sizes of systems and storage are similar to those required to treat all flow as winter wet weather conditions dominate the size
(6) A 25m buffer between the pasture irrigated areas and neighbouring land is likely to be required to mitigate spray drift. For the purposes of assessing the total area to be purchased the land area required has been increased by 30% to allow for buffer zones.

5.2 Overall Location Options

It has been assumed for this concept study that the new treatment plant will be retained at its current location at the top of Old Coach Road. A topographical map of land areas along the eastern side of Akaroa harbour is shown in Figure 5.1.

Figure 5.1 – Topographical map of Akaroa harbour

Transferring wastewater to the western side of the harbour has been ruled out due to high costs involved in cross harbour pipelines or around-shoreline pipelines that would be required to reach this area, and it is uncertain whether there are any good size parcels of suitable land in this area.

Focussing on the eastern harbour slopes (the Akaroa side of the harbour), there are a number of potentially irrigable areas to the north and south of Akaroa township. Land areas to the south of Akaroa were investigated in an earlier study by Harrison Grierson in 2010[3] and ruled out in conjunction with the Ngāi Tahu parties and the Akaroa Working Party due to the proximity of this land to Ōnuku Marae[4]. Areas of land above

[3] Akaroa Wastewater Options and Risk Analysis Report, Harrison Grierson, 2010

[4] Mike Bourke, CCC Senior Technician, pers. comm.

Akaroa township are also considered unsuitable as they are too steep for wastewater application (slope greater than 15 degrees), at higher elevations (higher pumping costs) and contributing lands to the catchment areas for the main stream water supplies to Akaroa.

The remaining areas for investigation include land on Takamātua Headland, Takamātua Valley and land further north. The land within this zone up to 7-8 km away from the treatment plant is relatively similar in landform, slope and soil type. Because of the ridge and gully system that is prevalent throughout this area, an irrigation scheme anywhere within this zone will inevitably consist of fragmented areas of ridgeline and lesser sloped fields. Other land at more remote locations may also be suitable. More detailed evaluation of land irrigation areas would be advisable if the land irrigation option proceeds beyond the concept stage.

Harrison Grierson (2010) also looked at options for the location of the new treatment plant. Options north and south of Akaroa township were again considered. Sites south of the township were identified as problematic due to difficult, rolling terrain requiring additional pumping stations to get all the wastewater to the treatment plant and the risk of ongoing negative effects on the culturally sensitive land and harbour area around Ōnuku Marae. Remaining at the existing site and upgrading the treatment process was considered but discounted due to public and cultural concerns.

Subsequent to the Harrison Grierson work Council moved forward with consultation and negotiation with landowners in the Akaroa and Takamātua area, both north and south. Through this process they were able to identify and purchase an area of land north of the township that was suitable for construction of the new wastewater treatment plant. Due to the availability of this land, and the issues around social and cultural acceptability previously identified with locating the new treatment plant in the south, the preferred option for the new treatment plant is north of the township.

The possibility of using Council owned land was also considered. Council reviewed land that they owned in and near Akaroa township, including the Recreation Ground. None of this land was considered suitable for either the wastewater treatment plant or land disposal due to the limited land area available and public health issues associated with locations within high populated and publically accessible areas. Council also owns the Misty Peak reserve which is situated on the hills to the south of Akaroa. This land lies within the potable water collection catchment area for the Akaroa water supply system and is high in elevation and so is not suitable for use for wastewater treatment or disposal.

5.3 Constraints Around Suitability of Land

To identify suitable land north of Akaroa township and south of Takamātua Stream where the shortlisted schemes could be constructed, a number of constraints needed to be considered including:

- Slope
- Elevation
- Geotechnical Stability
- Ownership
- Silent files
- Proximity to wastewater treatment plant
- Proximity to residential dwellings
- Consentability

Geotechnical stability is covered in Section 6 and details on consentability are outlined in Section 7. Commentary on the other constraints is set out in the following sections. An overview of these constraints is shown on the site plan in Appendix D.

5.3.1 Land Slope

Good practice dictates that irrigation of treated wastewater to land should be undertaken on land with a slope of 15° or less. Slopes greater than this risk the wastewater running off rather than soaking in. At steeper slopes there is also difficulty in getting machinery in to construct and maintain the equipment.

For the construction of storage ponds, infiltration basins or subsurface wetlands, the flatter the land the better to minimise the amount of earthworks and retaining required. It is possible to construct these devices on hillsides with appropriate benching and retaining but this will increase the technical complexity and cost significantly. In particular if the storage pond has to be constructed on steeper slopes there is the risk that large dam regulations and requirements will be triggered.

Drawing GIS-6517985-20-03 in Appendix D shows areas of suitable slope within a 2 km radius of the treatment plant in green. While a radius is drawn around the treatment plant, as discussed in Section 5.2 the land around the Takamātua headland and Takamātua valley is the most appropriate for consideration for a land based disposal option.

5.3.2 Height Above Sea Level

It is preferable to locate irrigation fields, storage ponds, and the wetland or infiltration basins below or not too far above the level of the treatment plant to minimise pumping costs and the technical complexity of installing pipes that run up and over gullies and hills.

5.3.3 Land Ownership

While the subsurface wetland and infiltration basin options require a relatively small area of land (1.4 – 1.5 ha), the irrigation options require between 17 and 37.6 ha. To obtain this amount of land efficiently, larger land parcel sizes are preferred to minimise the time and cost associated with Council acquiring the land.

The location maps in Appendix E show suitable land in parcels of greater than 1ha that could be added together. Table 5.1 demonstrates the number of landowners involved in acquiring this land, noting that for some blocks the number of owners includes LINZ to attend to areas over paper roads. There is a single large landowner that owns blocks A, B, and C (and the majority of Block E) so if these blocks were purchased together there would possible be only one landowner involved in the negotiations. However at this stage there has been no attempt to narrow options by minimising the number of landowners.

Table 5-1 – Land Parcel Information

Block	Owners	Area
A	1	3.64 ha
B	1	10.02 ha
C	1	1.69 ha
D	1	3.49 ha
E	3	14.35 ha
F	2	9.71 ha
G	1	3.01 ha
H	2	8.19 ha
I	2	3.32 ha
J	2	2.53 ha

5.3.4 Silent Files

The Mahaanui Iwi Management plan indicates the presence of a number of silent file areas in the Takamātua Bay and Childrens Bay area – the proposed siting of activities needs to be undertaken in consultation with Ōnuku Runanga. These are shown approximately on the overview site plan in Appendix D and generally cover the area that is being considered for land disposal. A silent file area indicates a general area within which a waahi tapu site(s) is located. The extent of the “silent file” area is necessary so that the precise locations of certain waahi tapu are not revealed. The extent of the specific waahi tapu site(s) however may be much less in area than that of the “silent file” indicated on the planning maps. Land development is not necessarily precluded from these areas, simply, the proposed siting of activities needs to be undertaken in consultation with Runanga.

5.3.5 Proximity to Wastewater Treatment Plant

Council desires to install a scheme that is efficient and sustainable. Pumping treated wastewater large distances from the wastewater treatment plant to a location for land disposal is inefficient and does not promote sustainability. It is also increases the cost of the scheme significantly.

5.3.6 Proximity to Residential Dwellings

Although the quality of the treated wastewater from the treatment plant will be very high, there may be a perception from the public that there will be risk associated with irrigating or storing wastewater adjacent to residential properties. The more residential dwellings close to the chosen location(s), the greater the likelihood of objections from the public.

5.4 Location Options

5.4.1 Components to be Installed

For each option there are a number of equipment items that need to be installed or constructed. The number and size of these items helped define where the schemes could be located.

5.4.1.1 Option 1 - Year Round Irrigation to Trees

- Pipeline from WWTP to storage basin
- Storage basin
- Irrigation pump station
- Dripline irrigators or K-line spray irrigators – including pipework between pump station and irrigators

5.4.1.2 Option 2 – Year Round Irrigation to Pasture

- Pipeline from WWTP to storage basin
- Storage basin
- Irrigation pump station
- Dripline irrigators or K-line spray irrigators – including pipework between pump station and irrigators

5.4.1.3 Option 3 - Summer Only Irrigation plus Subsurface Flow Wetland or Infiltration Basin

- Pipeline from WWTP to storage basin
- Storage basin
- Irrigation pump station – this pump station will be designed to be dual purpose and can pump out of the storage basin to either the subsurface flow wetland or the infiltration basins when not irrigating, with the

ability to divert a small proportion of the total flow into the wetland periodically to keep the wetland wet when irrigating

- Spray type irrigators – including pipework between pump station and irrigators
- Pipeline from storage basin to either subsurface wetland or infiltration basins
- Pipeline from wetland or basins to coastal infiltration gallery
- Coastal infiltration gallery

5.4.1.4 Options 4 and 5 – Subsurface Flow Wetland and Infiltration Basin

- Pipeline from WWTP to storage basin
- Storage basin
- Small pump installation to pump out of storage basin to either subsurface flow wetland or infiltration basins
- Pipeline from pump installation to either subsurface flow wetland or infiltration basins
- Pipeline from wetland or infiltration basins to coastal infiltration gallery
- Coastal infiltration gallery

5.4.1.5 Option 6 - Non Potable Reuse

- Storage tank or basin
- Reticulated network through Akaroa township – estimated to be approximately 17 km of pipe
- Connections in the roadway from the main to each property
- Installation of piping, storage tanks and taps on each individual property
- Booster pumps for properties above the level of the WWTP

The non-potable reuse system will be installed under existing roads and existing properties – no land acquisition is required.

5.4.2 Location Options

For each option there is a requirement to construct a storage basin and either pump station or wetland/infiltration basins adjacent to this. The summer irrigation plus wetland or infiltration basin options will require a storage basin and a pump station. Two main options have been identified for locating these structures – these are shown in Figure 5.2. Location A is close to the wastewater treatment plant, across the State Highway on relatively flat land at the top of Old French Road. Location B is nearer to the coastline, again on an area of relatively flat land closer to the locations identified for the installation of the coastal infiltration gallery discharge. Specific location maps for each option are given in Appendix E.

Figure 5-2 – Storage Basin, Wetland and Infiltration Basin Location Options

The two locations identified are not the only possible locations for constructing these devices, however from the initial assessment of land in the area they are the optimal locations due to slope, size and proximity to key features. Other possible locations are likely to be less cost effective and more technically complex. The two location options are compared in Table 5.2. Similarly while the coastal infiltration gallery location area has been shown on Figure 5.2, there are other options for locating this, as discussed in Section 4.8. The location shown is the preferred location.

Construction of the larger storage pond for the year round irrigation to pasture option is only technically feasible at a limited number of locations. Approximately 2.5 ha is required for the pond, including embankments. This amount of land is not available at Location B, but there may be further locations (other than A and B) where there is sufficient land at shallow grades. This will be further evaluated at the next phase.

Table 5-2 – Comparison of Storage Basin, Wetland and Infiltration Basin Location Options

Location Option	Advantages	Disadvantages
Option A	Close to treatment plant for operator attendance and provision of services such as power and telecom Relatively flat land and land owner has indicated willingness to sell Good access for construction Smaller diameter pipeline to coastal infiltration gallery due to storage pond buffering	May be visible from State highway – visual mitigation may be needed Relatively close to a number of residential properties
Option B	More remote location overall and not easily visible to the public Relatively flat land and land owner has indicated willingness to sell	Close to new subdivision in Takamātua Access for construction and supply of services such as power and Telecom more difficult A more distant site from the treatment plant for operational staff to visit Longer length of large diameter pipeline to storage basin

For both location options a pipeline connection is required between the treatment plant site and the location of the coastal infiltration gallery discharge. There are two most likely options for the pipeline route that are shown on Figure 5.2. The first option is to follow legal roads, where possible, around the side of the Takamātua hill to the coast. This is a more direct route but some sections go through private land so would require land owner approval, purchase or the creation of easements to install the pipe. By following legal roads the pipeline is more undulating than if a consistent contour was followed the whole way and may require a pump station to overcome high points. The cost of a pump station would have to be evaluated against the cost of forming any necessary easements for laying the pipe more directly but in private land. This can be done at the next design stage.

The alternative option is to run the pipe along legal roads and around the coastline. The last section of pipeline would be built in the coastal foreshore as legal roads do not extend all the way to the proposed location of the coastal infiltration gallery. This route is longer and would require consents for construction works in the Coastal Marine Area but would not involve access to private landowner permissions.

Based on experience with installing polyethylene (PE) pipe in this area for the Akaroa Water Supply Upgrade, it is likely that directional drilling could be used for much of the pipeline installation.

5.4.3 Irrigable Areas

Parcels of land identified as irrigable are shown on the location maps in Appendix D. This drawing indicates the difficulty in finding a contiguous block of land for irrigation due largely to slope and ground conditions. It is still possible to achieve the amount of land required over multiple areas and parcels. However, this does decrease the efficiency of the irrigation system and significantly increases both the capital and operational cost by increasing the length of pipe that needs to be installed, the number of fittings and the size and potentially the number of pump stations.

6 Geotechnical Land Suitability

6.1 Scope

The scope of the geotechnical considerations undertaken as part of the concept design development comprised a desktop study and site walkover on 8 December 2015 to assess the geotechnical stability aspects of the proposed treatment area. The objective of the study and walkover was to help inform where the different treatment options could be positioned. The following options have been considered in relation to the geotechnical aspects:

- Drip line type irrigation
- Infiltration basins
- Subsurface flow wetland
- Storage pond
- Discharge of remaining flow via a coastal infiltration gallery

The subsurface flow wetland, infiltration basins and storage pond options are expected to be artificially lined. Hence the geotechnical aspects have considered the effects of introducing treated wastewater to land (by drip line or spray irrigation) and how the remaining treated wastewater could be transported to a coastal infiltration gallery to coastal waters.

All the storage ponds will be considered as dams under the Building Code 2004. The Building Code 2004 defines a large dam as one which meets the following criteria:

(a) has a height of more than 4 metres, where the height is measured as the greatest distance from the crest of the bund to the base of the bund(s), and

(b) holds more than 20,000 cubic metres volume.

The design of the 30,000 m³ pond for year round irrigation will likely involve earth embankments typically 3 - 3.5 m high with a working water depth of 2.5 m. The pond will be fitted with a continuous plastic liner to prevent water seepage into the underlying soils. The embankments may need to be stabilised using lime assuming that local loess is used as construction material. A leakage detection system will be provided. Geotechnical risks including the risk of tunnel erosion beneath the pond and the risk of striking rock as part of the pond excavation have been allowed for the initial pond cost estimate. The 30,000 m³ pond would be defined as a large dam under the Building Code 2004 if the ground conditions and site location require embankment heights exceeding 4 m. The smaller storage ponds required for other options are unlikely to meet the criteria for a large dam under the Building Code 2004.

Regulations impose certain duties on the owners of all dams. The additional duties on owners of large dams compared with the duties on owners of small dams, include (amongst others):-

- Having to apply for Building Consent for the construction of the dam
- Having the dam classified by a Recognised Engineer (RE) and the classification agreed with the Regional Council
- Have a RE assess the Potential Impact Category (PIC) of the dam
- Developing and implementing a management plan
- If the PIC is medium or high, complete an annual 'warrant of fitness', including inspection(s) by an RE

It is recommended that as part of the design development, and when the design is finalised, due consideration be given to the legislative requirements of the works in relation to their status as either small or large dams.

6.2 Sources of Information

The following information has been considered

- Geology of Akaroa West Area, 1:50,000 scale geological map (Sewell et.al., 1990)
- Preliminary Geotechnical Appraisal of Potential Slope Stability Issues in Relation to the Proposed Wastewater Irrigation Areas of Land Near Akaroa (Geotech Consulting 2010).
- Slope Hazard Susceptibility Assessment – Akaroa Harbour Settlements (Tonkin and Taylor 2008).
- Irrigation of Domestic Wastewater – Akaroa Options (EcoEng 2010).
- Summary of Land Irrigation of Wastewater on Banks Peninsula (Christchurch City Council 2014).
- Akaroa Wastewater Project - Review of Disposal Alternatives - First Stage (CH2M Beca 2015).

6.3 Site Description

The area considered is that around the north side of the Takamātua headland (refer area overview drawing in Appendix D) for the reasons described in Section 5.2.

The headland is undulating to moderately steep, rising to 209 mRL at its highest. Steeper slopes, estimated to be up to 35 m high, face the coast to the north and west. Areas where the topography is less steep (less than 15° and between 15°– 20°) are limited and occur close to the centre of the headland, at higher elevations, away from the coast. The coastal flanks of the headland are incised by a number of valleys and gullies. Generally the land use is pastoral, with areas of trees and regenerating bush typically on steeper or uneven ground. There is a settlement of houses and baches adjacent to the coast on the north side of the headland.

6.4 Ground Conditions

The geology is dominated by loess, which is recorded as being greater than three meters thick on the geological map, but is noted as being significantly thicker in other literature. This overlies Akaroa Volcanic bedrock comprising basalt with tuff, ash, trachyte, breccia and paleosols. Colluvium, composed of weathered volcanic rock and reworked loess, forms significant overlying deposits on some slopes, typically at lower elevations. On the lower coastal slopes the loess and colluvium are typically absent.

Geotech Consulting 2010 identified a significant large ancient landslide, with some active areas within it, at Childrens Bay on the south side of the headland. The movement was suggested to be in the bedrock, with the headscarp and upper areas extending into the study area. Tonkin and Taylor also identified this bedrock landslide in addition to a number of different forms of instability on the north side of the headland. These comprised large Loess bedrock landslides, small Loess landslides and active gullies as shown on Figure 1 in Appendix F (taken from the Tonkin and Taylor report).

6.5 Geotechnical Considerations

The major geotechnical risk associated with introducing treated wastewater to land is instability in the loess and colluvium and reactivation of instability in bedrock. Loess is susceptible to moisture ingress and, when saturated, can be easily eroded and potentially collapse (tunnel gullies). Instability can be triggered on slip surfaces due to erosion of material providing a resisting effect and/or increases in pore water pressures (landslides). During the walkover evidence of both shallow and deeper seated instability on the north facing slopes, with back-tilted blocks at the head of landslides and translational features on the slopes, was noted.

The coastal slopes show evidence of ongoing erosion of the loess and colluvium where they overlay the bedrock. The bedrock itself stands at relatively steep angles to the south west, but less so to the north-west. A small number of local block and wedge failures were noted in the bedrock, being controlled by the discontinuities. The rock generally appears to be relatively competent where it was exposed.

6.6 Preliminary Geotechnical Recommendations

Of the options to introduce the treated wastewater to land, artificially lined wetlands or infiltration basins are preferable to irrigation in relation to the potential slope instability risk.

If further consideration is to be given to irrigating with, or allowing infiltration of, the treated wastewater onto land it is recommended that those areas where no instability has been identified by Geotech Consulting and Tonkin and Taylor and where the slope is not greater than 15° be targeted. It would be advisable not to introduce treated wastewater to areas that are currently, or have historically been unstable. Additionally caution should be used if treated wastewater is to be introduced above the Childrens Bay or other landslides, where it would have potential to infiltrate the landslide and exacerbate any movement.

The risk of inducing ground movement could be mitigated to a degree by reducing the rate of application, particularly during the winter and spring, when the soil is expected to be wetter. Nevertheless the overall effect of applying treated wastewater to land will increase the risk of instability occurring, particularly during heavy rainfall events.

Experience of the loess on the Port Hills is that its strength can drop from a ‘dry’ peak, to around one third of this strength when it is saturated. The effect of the loess having a lower strength is a greater risk of instability, a risk that is increased if the slopes are subjected to seismic loading.

In addition to an increased instability risk, the concentrated discharge of water will increase the risk of tunnel gullies forming. Spray irrigation and drip irrigation systems would need to be configured and constructed to provide an even distribution of water to the soil. The application would need to take account of the topography, preventing flows of water developing in depressions or gullies.

In relation to the risk of ground instability and erosion, evidence of historical ground movement on sloping terrain on the peninsula is noted. For options involving application of wastewater to land, the risk of future ground movement over and above ground movement that will occur naturally can be managed by a range of measures including the following:

- Selection of suitable application sites with a slope of less than 15 degrees
- Avoiding applying wastewater when soils are saturated
- Avoiding applying wastewater during winter (for pasture irrigation option)
- Investigation of site soil profiles and soil moisture holding capacity
- Use of a soil moisture water balance model incorporating field data to plan and operate the land irrigation system

The following further work was suggested by Geotech Consulting - this indicates what would need to be done if an option of introducing water to land is preferred and is to be taken forward.

- *Drilling and installation of piezometers in the most promising and likely areas for future use is a high priority once ground conditions are sufficiently dry to allow drill rig access (January – February is probably the ideal period). Initial water level measurements will be required, as opposed to theoretical computer modelling of the impact of infiltration on existing groundwater levels.*
- *Refinement of existing sub areas and extension of the area mapped at the southern site to include some of the adjacent land further to the south.*

- *A detailed geotechnical report will be required for the consent hearings detailing soil types, depths, rock types, slope angles and geomorphology once the likely initial areas for irrigation have been targeted and investigated by drilling. Some laboratory testing of soil strengths from drilling samples is also recommended. This information is necessary for consenting but will not affect the classification as suitable of the areas chosen here.*
- *Preliminary stability analysis will then be possible to indicate the general order of the current factor of safety of the slope areas prior to any irrigation commencing.*
- *The establishment of a baseline geodetic survey network is also recommended so that future resurveys can be done during irrigation operation to detect and monitor any subtle slope creep (at rates of mm/year, a common precursor to major movement) should slope movement begin to occur as wastewater loads are applied and/or progressively increased.*

To reduce the risk of inducing instability the treated wastewater collected after the subsurface wetland or infiltration basin should not be transported to coastal waters via a creek, but will be passed through a pipe to a coastal infiltration gallery (refer Section 4.10). The steeper sections of the coastal slopes present challenges in relation to constructing and fixing a pipe, hence consideration should be given to locations where the slopes are shallower and/or lower. To traverse these slopes the pipe will need to be anchored, likely either by rock anchors, in a trench or in a drilled hole. It is understood that access restrictions are likely to apply to the small beaches to the west and settlement to the north. Hence options at the north western section of the headland are considered, as presented on Figure 6.1.

Figure 6.1 – Coastal Aspects

Option A follows stable land south westwards to a promontory and then northwards to a small beach. This latter section will need to traverse a 5m to 8m high rock exposure either; above ground and anchored to the rock, or via a directionally drilled hole. The remainder is likely to be able to be buried in a trench, subject to the depth to rock.

Options B and C are similar, the difference being Option B commences on a narrow access track part way down the slope. For either of these options constructing a pipe in a trench and then restricting the ingress of water into the trench is likely to be challenging. A pipe could be constructed above ground or placed in a directionally drilled hole.

Option D is similar to Options B and C, although it commences from a lower elevation and is likely to pass through less competent rock.

Careful detailing and construction will be required if a pipe is to be placed in a trench, including the placement of waterstops at regular intervals across the trench to reduce the risk of providing a preferential pathway for groundwater. It is considered feasible to anchor a pipe on the ground surface to the rock, although access may make this difficult and there would be visual impacts. The option of directionally drilling a pipe from the level ground above the coastal slope to sea level is likely to come at a cost premium, but could warrant further consideration.

Varying ground conditions (loess, colluvium and rock) can make drilling difficult and positioning a drilled hole such that it daylights at the required elevation is likely to require the skills of a specialist contractor. Hence, if ground anchors or directional drilling are to be considered further it is recommended that the advice of specialist contractors be sought.

7 Consenting Requirements and Risks

7.1 Overview

This section considers:

- Resource consents that may be required from the Christchurch City Council in respect of the Banks Peninsula District Plan and the proposed Replacement District Plan as well as from Environment Canterbury, in respect of various regional plans.
- Other consents/authorisations that may be required.
- A preliminary assessment of actual and potential effects on the environment.
- A risk assessment of the consenting process.

7.2 Resource Consents - District Plan and Regional Plan Requirements

The site, which for the purposes of this assessment is the Takamātua headland and environs, is subject to a number of provisions in the relevant district plan and regional plans.

In terms of the district plan, the site is zoned Rural in the operative Banks Peninsula District Plan (Operative Plan) and Rural Banks Peninsula in the proposed Replacement District Plan (pRDP)[5]. The site is also subject to a number of overlays in the respective district plans including:

- A Coastal Natural Character Landscape Overlay covering the southern side of the headland in the Operative Plan. This area is proposed to be a High Natural Character Area under the pRDP.
- A Rural Amenity Landscape Areas over the remaining area of the headland under the operative plan. This area is proposed to be a Significant Landscape Overlay under the pDRP.
- A Significant Ridgeline on an east-west axis on the headland in both the Operative and PRDP plans.
- Silent File Areas 27 and 28 which cover a large majority of the headland in both the Operative and PRDP plans.

These landscape areas are shown in Appendix G.

In terms of regional plans, the following plans are of relevance:

- Canterbury Land and Water Regional Plan (LWRP)
- Canterbury Regional Coastal Environment Plan (RCEP)
- Canterbury Natural Resources Regional plan(NRRP) - Chapter 3 Air Quality
- Proposed Canterbury Regional Air Plan (pCARP) [6]

In the RCEP, Takamātua Bay is identified as an Area of Significant Natural Value (ASNV). The water quality classes are identified as Contact Recreation (CR) for Takamātua Bay and Childrens Bay. The remaining areas of waters in the harbour are classified as Shellfish Gathering (SG). These areas are shown in Appendix G.

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[5] The pRDP is required to be had regard to although the rules do not have effect until the plan is made operative. For completeness however, the rules are assessed in Appendix H.

[6] The rules in the pCARP have immediate effect.

The resource consents that are likely to be required for Options 1 (year round irrigation to trees), 2 (year round irrigation to pasture), 3 (summer only irrigation plus infiltration basin or subsurface wetland), 4 (subsurface flow wetland) and 5 (infiltration basins) under the district and regional plans are identified in Appendix H. It is assumed resource consents are not required for Option 6 (non-potable reuse)

In summary, the following is noted:

7.2.1 District Plans

In terms of the district plans, the activities are likely to be considered as “utilities” which are permitted subject to compliance with various standards. For the options including a storage pond, an infiltration basin or subsurface wetland, it appears that standards relating to earthworks in terms of volumes may not be met and accordingly, resource consent as a restricted discretionary activity would be required.

Pipes which are underground are however generally a permitted activity. Any pipeline in private land (i.e. not owned by Council) should be protected by appropriate easement.

If the planting of trees for the uptake of wastewater, as proposed for one of the year round irrigation options, is considered as “forestry” (and this is not certain) the activity would require resource consent as a discretionary activity. If the planting occurs in a Coastal Natural Character Landscape Overlay, resource consent would be required as a non –complying activity. However, this latter option is considered unlikely as the area of the overlay is not preferred because of soil instability issues.

Earthworks within Silent File areas require resource consent as a restricted discretionary activity, although it appears this may not apply to earthworks for utilities.

Overall, as a minimum, resource consent for a discretionary/limited discretionary activity will be required for all disposal options.

7.2.2 Regional Plans

In terms of the regional plans:

- Resource consent as a discretionary activity for the discharge of treated wastewater to ground would be required under the LWRP (Options 1-4).
- Resource consent as a discretionary activity for the discharge of contaminants to air from irrigation or other wastewater treatment would be required under the NRRP Chapter 3 and the pCARP (Options 1-4).
- Resource consent as a discretionary activity for the discharge of wastewater to the Coastal Marine Area (CMA) would be required under the RCEP (Options 2-4).
- Resource consent as a discretionary activity for the disturbance, placement and occupation of a structure in the CMA would be required under the RCEP (Options 2-4).

Overall, as a minimum, resource consent for a discretionary activity would be required for all disposal options. These requirements are summarised in the table in Appendix H.

7.2.3 Summary

Resource consents would be required from both the Christchurch City Council and Environment Canterbury. If it can be established that the adverse effects are minor and the written approval of affected parties is obtained, the application could be processed as non-notified. Given the low likelihood that all potentially affected parties can be consulted, and that their approval is obtained in writing, it is anticipated that resource consent applications would be publicly notified.

7.3 Other Consents/Authorisations

7.3.1 Notice of Requirement

As an alternative to applying for resource consents from Christchurch City Council, Council as the applicant could choose to designate the site for wastewater purposes by issuing a Notice of Requirement (NOR). The designation effectively means a landowner cannot undertake activities that are contrary to the designation without Council permission and generally implies that Council will acquire the land. However, regional resource consents (as noted above) would still be required.

7.3.2 Archaeological Authority

Section 42 of the Heritage New Zealand Pouhere Taonga Act (2014) states that unless an Archaeological Authority is granted from Heritage New Zealand, no person may modify or destroy an archaeological site. An "*archaeological site"* is defined as "a place that was associated with human activity that occurred before 1900". Potentially, the earthworks associated with construction of infiltration basins or subsurface wetland could result in a requirement to apply for an Archaeological Authority and this is considered likely given that a significant part of the headland is covered by Silent File areas.

7.4 Preliminary Assessment of Actual and Potential Effects on Environment

This section provides a preliminary assessment of the likely effects on the environment of the land based disposal options recommended in this report. The assessment is only preliminary at this is stage because no detailed baseline studies or investigations have occurred.

Generally, the assessment focuses on the land disposal options given that non-potable reuse is unlikely to require resource consents.

7.4.1 Positive Effects

Positive effects may accrue from passing the wastewater through land, either prior to discharge to the harbour, under options 3, 4 and 5; or by avoiding the discharge to the harbour under Options 1 and 2. The Ngāi Tahu parties have advised that year round irrigation to pasture or trees are the only options that are acceptable to them. The Council will undertake community consultation in April - May 2016 to understand community concerns around scheme options, with a goal of optimising the positive effects of the scheme.

7.4.2 Landscape/Visual Effects

Option 1 - Pond storage with year-round irrigation of trees

All year round irrigation to trees requires the establishment of a plantation of trees of approximately 25 ha for irrigation purposes and storage facilities of approximately 0.7 ha. The District Plan generally requires resource consent for "forestry" (and it is has not yet been assessed whether the proposed plantings are "forestry') in excess of 1 ha as well as constraints in respect of proximity to the coastline and the silent file areas. The sensitivity of the Takamātua Headland area is reflected by the various overlays in the District Plan relating to landscape, significant ridgelines, silent files and character areas. Accordingly, any planting should be carried out as sensitively as possible with mitigation measures including planting along contours, avoidance of straight edges and ridgelines and use of native vegetation where possible.

The visual effect of trees located in other areas such as the valley floors is not considered to be as critical because these sites would not be as visible. Natural undulations on the headland would provide effective screening.

Earthworks associated with storage facilities (a wetland/storage pond of say approximately 0.5 ha x 2.5m deep), could be sensitively undertaken by locating below ridgelines, minimising batter slopes, and implementing appropriate landscaping. The design of other earthworks such as those for access roads could also be undertaken sensitively. A wetland/pond would be consistent with the rural character of the area although the presence of a floating cover could reduce this “naturalness”. Such a pond may be more acceptable in a remote location.

Option 2 - Pond storage with year-round irrigation of pasture

For year round irrigation to pasture the same comments on the pond storage apply, but the visual effects associated with planting of trees will not apply. The irrigation to pasture may result in “greening” of areas in summer - this is not considered to be a significant visual effect as the existing landscape is already variable in terms of colours and landuses.

Earthworks associated with the larger storage facilities required for this option (a wetland/storage pond of approximately 2.5 ha including earth embankments and with 2.5 m working water depth), could also be sensitively undertaken by minimising batter slopes and with appropriate landscaping. Suitable options for locating this pond are very limited. The design of other earthworks such as those for access roads could also be undertaken sensitively. A wetland/pond would be consistent with the rural character of the area. Such a pond may be more acceptable in a remote location and further evaluation of locational options taking into geotechnical risks, potential costs and landscape and visual impact issues will be undertaken in the next phase of the project.

7.4.3 Option 3 - Summer irrigation of pasture with pond storage, wetland or infiltration basin, and coastal infiltration gallery

This option requires summer application to pasture (12 ha), a subsurface wetland plus 12,000 m^3 of storage, or an infiltration basin plus 7,000 m^3 of storage and discharge, when too wet to irrigate, via a coastal infiltration gallery. It is assumed the area of the wetland and storage pond would be approximately 1.4 ha, or 1.5 ha for the infiltration basin plus storage pond. While the irrigation may result in “greening” of areas in summer this is not considered to be a significant visual effect as the existing landscape is already variable in terms of colours and landuses.

In terms of wetlands/basins, care should be taken in the design by having regard to the mitigation measures identified for the year round irrigation option. It is noted that subsurface wetlands and infiltration basins would be located at ground level which would mitigate visual effects. Locally-sourced plants on top of a subsurface wetland (with root systems into the underlying media), would facilitate additional wastewater polishing before discharge.

The coastal infiltration gallery would consist of an underground pipe from the wetland/infiltration basin that could discharge direct to the shoreline. After construction, there would be no visual evidence of the coastal infiltration gallery.

Due to the high clarity of the treated wastewater (normal and wet weather), after passage through the wetland/infiltration basin, the discharge from the coastal infiltration gallery would not be conspicuous (and unlikely to be visible).

7.4.4 Option 4 - Pond storage, infiltration basin and coastal infiltration gallery

This option requires storage of 7,000 m^3, infiltration basins of 1.1 ha, and final discharge via a coastal infiltration gallery. After construction, visual effects would be minimal. Some locally-sourced planting could be carried out around the edges of the pond and/or infiltration basin and such a facility would not be out of place in a rural environment.

Comments on the visual effects of the coastal infiltration gallery and storage ponds above would also apply to this option.

7.4.5 Option 5 - Pond storage, subsurface wetland and coastal infiltration gallery

The subsurface wetland option is similar to the infiltration basin option and would require storage of 12,000 m³, subsurface wetland of around 0.7 ha, and discharge via a coastal infiltration gallery. A key component of the wetland would be the inclusion of locally-sourced plants on the surface of the wetland. Such a facility would not be out of place in a rural environment.

Comments above on the visual effects of the coastal infiltration gallery and storage ponds would also apply to this option.

7.4.6 Non-potable reuse

This option would involve reticulation of a portion of wastewater flows from the WWTP via new separate pipework to residential and commercial properties in Akaroa Township. The treated wastewater would be available for activities such as toilet flushing, landscape watering and boat washing.

Apart from the temporary visual effects of constructing the new underground pipelines, no other landscape/visual effects would apply.

7.4.7 Natural Hazard Effects

All options (apart from non-potable reuse) would require consideration of natural hazards such as geotechnical instability in the area given the erodible nature of loess soils and evidence of historic slips in the area. The southern portion of the headland has been excluded from land disposal for this reason. It is understood that appropriate engineering design and location on moderate slopes can overcome difficulties of instability in respect of the treatment, storage and coastal infiltration gallery facilities.

Above-ground pond storages would need to be sited, designed and constructed to minimise any risks of bund failure (e.g. from seismic activity). The preference will be to locate them on relatively flat land so that these risks can be readily mitigated.

7.4.8 Effects on Soils, Groundwater and Surface Waters

The treated wastewater quality from the normal operation of the WWTP will be suitable for land application and none of the individual contaminants are likely to affect soil structure. The wastewater is from domestic/commercial sources and will be treated to a relatively high level (i.e. very low concentrations of solids, organic matter, fats, oils and grease and trace metals; relatively low nutrients and micro-organisms). The wastewater would easily meet New Zealand guidelines for land application of wastewater (e.g. Department of Health, 1992, NZ Land Collective, 2000).

For the irrigation options, treated wastewater would be applied to land at rates that meets the assimilative capacity of site vegetation and soils. Generally, sustainable land application systems are operated on a soil deficit basis to ensure that no ponding or runoff to surface waters occurs. The provision of an appropriate volume of storage would be essential when soil conditions are unsuitable for the year-round land application option.

Site vegetation will take up nutrients contained in the wastewater for the irrigation and subsurface flow wetland options. The land application system would be sized for both hydraulic and nitrogen loads. Depending on land area and nitrogen load, removal of biomass (e.g. by cut and carry) may not be necessary.

The low permeability soils of the headland will restrict losses to groundwater. Groundwater depth is likely to be deep and any effects from an appropriately-designed and operated land application system would be minor. In addition, pond storages, infiltration basins and wetlands would be lined (HDPE or similar) to minimise seepage, with the wastewater piped to the coastal infiltration gallery. It is also understood that residential properties in the vicinity rely on a reticulated system or rainwater for potable water supply rather than groundwater bores. Therefore, it is likely that there would be a minimal risk of contaminating potable water supplies.

The condition and capacity of existing waterways on the headland (and their suitability for receiving wastewater discharges from a coastal infiltration gallery), has not been assessed. However, any discharge into streams that then entered Takamātua Bay or Childrens Bay results in potential adverse effects given these areas are used for swimming (with their waters having a classification in the Canterbury Regional Coastal Plan of "Contact Recreation"). The effects of discharges to other watercourses that reach the coast outside of these bays may be acceptable for wastewater discharge, given the relatively high level of treatment under most circumstances and the likely additional dilution in waterways during times of high wastewater flow.

The effects on natural waterways of receiving and conveying wastewater in respect of ecosystems and amenity would need to be fully assessed if this option was progressed.

7.4.9 Effects on Cultural/Historic Values

The headland site is affected by Silent Files 27 and 28 with an indication that the areas of the silent files are larger than those shown in the district plan.[7] Clearly early engagement with Ōnuku Rūnanga will be necessary to identify any sensitive areas that may affect the preferred disposal option so that concerns can be addressed. By their nature the silent files do not specify sites so early and ongoing meaningful consultation with Ōnuku Rūnanga is essential and is being undertaken as part of this process.

Land within the Silent File areas would not be necessarily precluded from use for land application, but would require the approval of Ōnuku Rūnanga as well as consent from Council.

There are no European sites of value identified at this stage. However, an Archaeological Authority may be required from Heritage New Zealand if a site that is to be modified is associated with human activity pre-1900.

Ōnuku Rūnanga and Wairewa Rūnanga of Ngāi Tahu are kaitiaki of the harbour. Effects of any shoreline discharge on meeting shellfish gathering standards and not degrading the quality of kaimoana would be relevant. Public health effects are discussed below.

7.4.10 Effects on Recreation

There is likely to be minor effects of establishing treatment facilities on existing recreational activities on the headland as the pipework/ land disposal/storage facilities are likely to be located on Council – owned land (with no public access) or private land to which the Council has rights of access. It is noted that there are

[7] Cultural Values Report: Takamātua to Takapuneke (Dyanna Jolly Consulting, July 2009)

unformed public roads on the headland which the public have access to and the Childrens Bay walkway is located in the vicinity. Appropriate fencing and warning signage would be required to advise the public of the treatment facilities.

Wastewater disposal activities are unlikely to result in adverse effects on other land-based recreation activities in the vicinity of the site. The discharge of any wastewater into existing waterways that enter either Childrens Bay or Takamātua Bay is has the potential to result in adverse effects given these areas are popular with bathers and the waters retain a water quality CR classification. Similarly an engineered discharge to the shoreline in these areas also has the same potential adverse effects.

It is anticipated that activities such as swimming and boating in the harbour outside of Takamātua Bay and Childrens Bay would not be adversely affected by options discharging via a coastal infiltration gallery given the high level of treatment at the WWTP (for most flows) and the likely additional treatment through the wetland or infiltration basin. There would be no effects on swimming or boating from irrigation, as there would be no discharge to the harbour.

Accordingly discharge points, outside of Takamātua Bay and Childrens Bay, such as at the western end of the headland, are likely to be more acceptable.

The balance of Akaroa Harbour is classified for shellfish gathering (SG) purposes in the Coastal Plan. A discussion on the likely effects of a coastal infiltration gallery at the western end of the headland is included below.

7.4.11 Noise

The general noise environment on the headland is typical of rural areas. The construction of pipelines and the excavation of ponds and wetlands would produce a temporary localised increase in noise levels but it is expected that any effects on neighbours would be minimal due to the natural contours and expected separation distances. Apart from K-line and fixed irrigators (which are low sources of noise), ponds and wetlands are largely passive systems with only a small transfer pump required at each site to pump between the pond and the irrigation area, wetland or infiltration basin. As a result, there will be minimal potential for noise nuisance on the headland from the disposal options.

7.4.12 Effects on Terrestrial Ecology

Any effects on terrestrial ecology from earthworks activities (e.g. from direct disturbance or from dust deposition) would need to be appropriately minimised/managed. However at this stage, no at-risk plant or animal species have been identified from available literature, which appears to reflect the modified nature of the headland site.

7.4.13 Effects on Marine Ecology

The ecology of the shoreline, intertidal and subtidal areas around the Takamātua headland has not been investigated in any detail. However, Cawthron (2014) notes that the inner bays and shorelines of the harbour consist of alternating sandy/muddy bays (eg Childrens Bay and Takamātua Bay) interspersed with rocky headlands, many of which have shore platforms. Water depth along the Takamātua headland increases relatively quickly from the shoreline (i.e. approximately ~5 m at 100 m from the shoreline south of Lushington Bay). Water depths within Childrens Bay, Lushington Bay and Takamātua Bay increase more gradually (i.e. approximately 5 m depth at 800 -1,000 m from shore). Significant portions of these bays are exposed at low tide.

It is likely that the shoreline and subtidal areas around the headland contain rocky shore, reef and kelp environments diverse in flora and fauna and supporting a range of food chain and kaimoana species including algaes, mobile invertebrate communities and adult and juvenile shellfish (eg mussels). Fish species along the rocky shore and reefs are likely to include wrasse, butterfish and moki. The harbour is nationally important due to the populations of Hectors dolphin and penguins. The occasional presence of these animals around the headland is presumed.

Summer only irrigation, wetland and infiltration basin options would require the discharge of treated wastewater through a coastal infiltration gallery. Such a discharge could occur through a coastal infiltration gallery embedded within beach gravels (or graded materials specifically brought to the site). This infiltration gallery would be constructed to allow the steady diffusion of wastewater into coastal waters below the beach surface. The wastewater would then be diluted and dispersed by currents within the harbour.

The effects of a shoreline discharge on site marine ecology would need to be fully assessed by field studies, as part of a design and consenting process, and then regularly monitored over the life of the project. However, it is likely that the discharge of all or some portion of the high quality wastewater to the shoreline would have minimal effect on aquatic communities. Wastewater concentrations of potentially toxic substances such as ammonia, heavy metals and organic compounds will be low and will undergo significant dilution within a relatively short distance from the discharge. A mixing zone (zone of noncompliance) would be required as part of consent conditions but this is likely to be limited to a small area around the discharge point.

Monitoring of the current WWTP single port outfall discharge into the rocky shoreline at Redhouse Bay provides some indication of the likely ecological effects of a shoreline discharge at the Takamātua headland. While this discharge extends approximately 100 m into the rocky bay, the wastewater quality is lower than will be produced at the proposed WWTP.

The existing WWTP at the Takapūneke Reserve is recognised as having adverse effects on the cultural values of Ōnuku Rūnanga. However, ongoing monitoring of the discharge shows no significant ecological impacts on the intertidal or benthic environments that can be attributable to the outfall. Cawthron (2014) notes that the 2006 ecological assessment of the current outfall site (Golder, 2007), is particularly relevant as the shallow near-shore location represents a worst-case for benthic exposure to wastewater contaminants. Golder found no evidence of accumulation of metals within 150 m of the outfall. No significant effects on benthic ecology were found during the 2006 study, although it was noted that there were a greater number of taxa, including some that are more tolerant of organic enrichment, within 25 m from the outfall.

Based on the expected high wastewater quality from the proposed WWTP under normal flow conditions and the lack of adverse effects from the existing WWTP outfall, into a similar shoreline environment, it is unlikely that a headland discharge through shoreline gravels would have any more than minor effects on marine ecology.

Infrequent bypassing of flows in large wet weather events will result in a lower quality wastewater discharged from the WWTP. However, the subsequent passage of this wastewater through land would reduce contaminants such as suspended solids, BOD, metals and priority organic pollutants, such that any short term discharge to the shoreline would be unlikely to have any significant effects on marine ecology. It is noted that wetlands can also reduce nitrogen (nitrate) and phosphorus. However, the lack of aerobic conditions in subsurface wetlands limits the reduction in ammonia.

The likely performance of a subsurface flow wetland under different wastewater quality and flows conditions would need to be fully assessed.

7.4.14 Effects on Public Health

The effects of a shoreline discharge (particularly during wet weather) and its effect on public health would be a key consenting issue.

7.4.14.1 Land-based System

The likely public health effects of year round irrigation and the land-based components of the other alternatives have been discussed earlier. As was noted, there would be very little opportunity for public exposure to wastewater during irrigation. The public would be specifically excluded from irrigation areas as well as storage, infiltration basin and wetland sites. No more than very low levels of noise, odour or aerosols would be produced by the operation of these systems including the storage pond once appropriate mitigation devices are installed.

7.4.14.2 Shoreline Discharge

Summer only irrigation, wetland and infiltration basin options would require the ultimate discharge of treated wastewater via a natural or engineered pathway to the shoreline. It is likely that such a discharge would be designed to occur along the western shoreline of the Takamātua headland because this area is generally inaccessible from land, not suitable for swimming and remote from the higher use areas of Childrens Bay and Takamātua Bay.

The rocky shoreline and adjacent reefs at the western end of the headland may provide some opportunity for boat access and activities such as shellfish gathering and diving. A key issue would therefore be to reduce the public health risk of any shoreline discharge to shellfish gatherers and other users.

All of the harbour waters, apart from selected bays (including Childrens Bay and Takamātua Bay which are classified for contact recreation), are classified for shellfish gathering purposes in the Canterbury Coastal Environment Plan. This affords the highest level of public health protection under the plan.

The presence and abundance of shellfish in the vicinity of the headland has not been investigated. However, it is assumed that the rocky shore, reef and kelp environments of the area contain adult and juvenile shellfish (e.g. mussels) and these may be accessible to gatherers. A field investigation of existing shellfish communities, as well as ongoing monitoring of shellfish tissue (micro-organisms and heavy metals) would be required as part of the consenting and operation of any future shoreline discharge.

Monitoring of the existing WWTP single port outfall discharge into the rocky shoreline at Redhouse Bay provides some indication of the likely effects of a shoreline discharge at the Takamātua headland on shellfish gathering. The treated wastewater from the existing WWTP contains higher concentrations of micro-organisms (particularly during the summer months), than will be present in the treated wastewater from the proposed WWTP. The proposed membrane filtration system has high reliability and will effectively remove all larger organisms (i.e. bacteria and protozoa), and a significant portion of smaller organisms (viruses) under a normal flow scenario, including peak summer holiday flows. Therefore any impacts on shellfish quality at the Takamātua headland are unlikely to be measurable.

7.4.14.3 Disinfection Through Wetlands

The effect of a shoreline discharge (particularly during wet weather) and its effect on public health would be a key consenting issue and so the quality of the treated wastewater likely to be exiting this discharge has been investigated by looking at the disinfection possible through the upstream treatment.

A limited literature review was undertaken to assess the disinfection performance of other subsurface wastewater treatment wetlands currently operating overseas. The results of this review provide an indication of the likely performance of a similar system downstream of the Akaroa WWTP – i.e. before discharge via a coastal infiltration gallery to the shoreline. A summary of the results from overseas facilities is attached as Appendix I.

The results of this limited review suggest that that with an appropriately-designed subsurface wetland (i.e. well-mixed, vegetated, with a retention time of at least 3 days), 90 to >99% (i.e. 1 to >2 log order) reduction in both viruses and bacteria could be achieved. The results suggest the vegetated sub surface flow wetlands perform better than unvegetated or surface flow wetlands. Performance appears to be unaffected by seasonal conditions.

These results, indicate that infrequent wet weather flows passing through a suitably-sized and designed subsurface flow wetland may not require additional mechanical disinfection (i.e. apart from the disc filter and UV at the WWTP), before discharge through the engineered pathway.

The disinfection performance of additional natural treatment systems (such as subsurface wetlands or infiltration basins), is acknowledged by the results from other operating facilities.

7.4.14.4 Normal Flows (including peak summer)

Monitoring of the existing Akaroa WWTP influent virus concentrations in December 2013 and January 2014 shows median concentrations of 10,000 genome copies per litre which is typical of a small community with seasonal tourist peaks. The proposed WWTP membrane filtration system would be operated to provide a 3-4 log reduction in viruses (i.e. to concentrations of less than 10-100 genome copies per litre).

There are also a number of natural disinfection processes operating within the, subsurface wetlands, and infiltration basins that would continue to reduce virus concentrations to very low levels before final discharge. The extent to which these processes could be utilised depends on design considerations (i.e. appropriate flow conditions and sufficient retention time is provided.

Assuming an additional 1-2 log reduction through the wetlands/infiltration basins and beach materials, the effects on public health (e.g. shellfish quality) would likely be minimal under normal flow and peak summer flow conditions. The discharge would be expected to meet harbour shellfish gathering standards before, or close to the discharge point.

The requirements for an appropriate mixing zone around the discharge point, as well as signage and ongoing monitoring of shellfish flesh quality, would need to be confirmed after field studies, a public health risk assessment and design considerations were completed.

7.4.14.5 Wet Weather Flows

Full treatment through the WWTP will not be possible under high wet weather flows. In this case, excess screened flows would bypass the main treatment process and receive very fine c=screening using a disc filter and UV disinfection and before being discharged from the WWTP. This scenario is predicted to occur only once or twice a year for one to two days each time.

Under the high wet weather flow scenario, wastewater microorganism (bacteria and viruses) concentrations from the WWTP would be slightly higher. While UV disinfection will be provided on these bypassed flows, micro-organism concentrations (as measured by faecal coliforms) may range (i.e. 1000-10,000 cfu/100mL). UV is a less effective disinfection method than membrane filtration for a number of enteric viruses. This means that the log reduction of viruses before discharge from the WWTP will be slightly less than for the normal operating conditions scenario (i.e. expected 2.7 log removal as opposed to 3.0 log removal during dry weather and fully membrane treated flow, including the impact of reduce flow rate post- wetland or infiltration basin).

As noted above, an additional 1-2 log reduction through storage ponds, wetlands/infiltration basins and beach materials, could be achieved, if sufficient retention time is provided. However, under wet weather conditions, the higher flows would mean reduced wastewater quality, less overall retention time and therefore lower disinfection potential. Regardless, wetlands and infiltration basins would need to be designed to minimise short circuiting so that, as far as possible, all wastewater received equal exposure to the natural disinfection processes operating within the system.

Assuming an additional 1-2 log reduction in microorganisms could be achieved during passage through the wetlands/infiltration basins and beach materials, the likely effects on public health would also be minimal under wet weather flow conditions. The discharge would also be expected to meet harbour shellfish gathering standards before, or close to the discharge point. The low frequency of the bypass scenario means that any discharge of higher concentrations to the marine environment would be short-lived. As such, there would be little opportunity for significant accumulation of microorganisms within shellfish before natural die-off and depuration occurred.

7.4.15 Effects of Odour and Spray Drift (Aerosols)

The potential for odour creation in wastewater systems is generally a function of the concentration of organic material (BOD), as well as residence time (e.g. in pipework) where organic material can decompose under anaerobic conditions. The treated wastewater will have a low BOD concentration (design mean BOD concentration of 20 g/m^3) under normal operating conditions and a relatively short residence time in the delivery pipe to the storage pond. Retention within the storage pond will be relatively short and therefore not conducive to the development of anaerobic conditions.

However the storage of wastewater that has not been fully treated during times of high weather flows has the potential to become anaerobic and create odour. Given this, consideration should be given to locating the storage pond on a remote part of the headland well-separated from sensitive development rather than say in proximity to the WWTP if it is not possible to adequately mitigate any odour that may be formed. The Guideline for Design, Construction and Operation of Oxidation ponds (MWD, 1974) recommends a 300 m buffer between treatment ponds and urban areas and a 150 m buffer to isolated dwellings and this could be applied to the storage pond if it contains untreated high weather flows. These separation distances appear achievable on the western part of the headland.

Alternatively, processes to remove the solids component from the wet weather flows would assist in reducing odour. Any odour creation is likely to be short term given that storage of wet weather flows will be for 2-3 days and only likely to occur 1-2 times per year. Another alternative would be to cover the pond, and pass any air discharged from the pond through an odour treatment device.

The potential for odour creation from irrigation to land would be minimal given the high wastewater quality (i.e. normal flows) and application over a relatively large area. Any land application system would be well-buffered from other sensitive land uses.

All surface wetlands have a “musty” odour associated with the natural biological processes. However, both subsurface wetlands and infiltration basins operate below ground level and would not be significant source of odour.

Non potable use of wastewater (especially for outdoor use), is unlikely to be a source of odour due to the high wastewater quality.

Aerosols are spray droplets, and treated wastewater aerosols can contain potentially pathogenic micro-organisms. Downwind transport of aerosols from irrigators is dependent on irrigator type, droplet size and wind strength. The concentration of micro-organisms in the wastewater under normal flows will be very low as a result of disinfection at the WWTP (annual median faecal coliforms concentration of 500 cfu/100 mL). This is well below the Public Health guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land (Department of Health, 1992) for application of wastewater to pasture (<10,000 faecal coliforms/100 mL) and irrigation of forest and treelots (no quality restrictions, no public access for 48 hours after irrigation).

The Constructed Wetlands Treatment of Municipal Wastewaters (USEPA, 2006) suggests that with secondary treated wastewater, risks from aerosols beyond 30 m from a treated wastewater irrigation site are low as bacteria and viruses are quickly destroyed by the processes of solar UV and desiccation. The addition of buffer plantings significantly reduces the risk of aerosol transport.

Irrigation of land on the headland is likely to be by surface driplines (under trees) or low pressure K-line or fixed ground sprinklers to (pasture). None of these systems is conductive to aerosol creation.

7.4.16 Effects on Amenity

The amenity values of the Takamātua Peninsula and surrounding areas are not anticipated to be significantly affected by land disposal or treatment. These facilities are considered not to be out of place in a rural environment and factors affecting amenity such as noise, odour and spray drift are anticipated to be minimal (see discussion above).

However, there may be a public perception that amenity would be adversely affected by the discharge of wastewater to land/water, particularly if nearby residents (such as in Takamātua), consider themselves affected in some way. It will be necessary to confirm with stakeholders, through appropriate modelling, field investigations and design, that this would not be the case. The possible negative effect of land discharge systems on adjacent property values is often cited in opposition to such schemes.

The effects can be mitigated by a robust consultation and information sharing process with stakeholders and the public and this will be undertaken once this report is finalised.

7.4.17 Wastewater Disposal Alternatives

A number of wastewater alternatives are considered in this report. Consideration of alternatives is critical given the provisions of the Resource Management Act including Section 105 (which relates to discharges) and Section 168A (which relates to designations) as well as various policies in the New Zealand Coastal Policy, the Canterbury Regional Policy and the RCEP relating to alternatives for the discharge of wastewater into the coastal area. There is also case law on the necessity to give adequate consideration to alternatives including the discharge of wastewater, particularly having regard to Maori matters set out in Section 6(e), Section 7(a) and (e) and Section 8 of the Act.

Council has considered a large number of possible disposal and reuse options (refer to Section 3 of this report) and after analysis and consultation with the Ngāi Tahu parties has narrowed these options to the shortlisted options described in this report. In this respect year round irrigation and non-potable reuse would not result in any wastewater discharge to the harbour, although non-potable reuse would only use approximately 20% of the wastewater. The other options would result in a shoreline discharge to the harbour, and although the wastewater would pass through land prior to entering the harbour this does not satisfy the full range of cultural values of the Ngāi Tahu parties.

7.5 Risk Assessment of Consenting Process

This assessment of the likely consenting risk process is based on the identified planning issues and the high level assessment of effects. As noted above, the assessment is preliminary only and has been undertaken without the benefit of detailed investigations.

In terms of resource consents, the relevant activities do not have prohibited activity status in either the district or regional plans. The Coastal Natural Character Landscape has the most stringent controls. However provided the activities do not occur on sensitive landscapes within the Coastal Natural Character Landscape, they are likely to have a discretionary/limited discretionary status under the various overlays in the District Plan relating to landscape, significant ridgelines, silent files and character areas rather than the more restrictive non complying activity status under the Coastal Natural Character Landscape. Regulatory authorities can however still refuse to grant consent under a discretionary/limited discretionary status.

The likely consenting risks have been assessed below in Table 7.1 based on the following: high (red), medium (orange) or low (green).

Table 7.1 – Likely Consenting Risks

Adverse Effect	Option	Risk	Comment
Landscape/Visual – Trees	Year round irrigation to trees	Medium	Assumes trees are not located in high sensitivity areas of the Coastal Natural Character Landscape which would have non-complying status. Under other District Plan overlays planting of trees likely to be discretionary. Use of natives likely to improve amenity.
Landscape /Visual – storage pond, wetland, and infiltration	All land disposal options	Low	A location by SH75 could elevate the risk and conversely a more remote location (such as on the headland) is likely to carry less risk. Overall the risk is assessed as low and effects can be mitigated by careful design in respect of such matters as contours and landscaping.
Natural Hazards	All land disposal options	Low	Unstable soil areas avoided and facilities engineered to avoid bund failure. Consent may be required from Regional Council for storage pond considered a “large dam”.
Soils, Groundwater and Surface Waters	All land disposal options	Low	High quality wastewater, storage systems, uptake by plantings and lining of facilities reduces risk.
Noise	All land disposal options	Low	Little or no noise generated.
Recreation - land based	All land disposal options	Low	Limited land-based recreation at present.
Recreation - harbour based	Summer only irrigation, wetland and infiltration basin options	Medium	It is proposed any discharge would avoid areas classified as CR. Risk to shellfish gathering likely low but performance of wetlands needs further investigation.
Cultural/Historic Values	All land disposal options	Medium	Location of activities in Silent File areas means this remains a risk until further consultation is undertaken with Ōnuku Rūnanga. Year round irrigation to pasture or trees is strongly supported by the Ngāi Tahu parties; options which retain a coastal discharge are not supported.
Terrestrial Ecology	All land disposal options	Low	No at-risk species identified at present.

Adverse Effect	Option	Risk	Comment
Marine Ecology	Summer only irrigation, wetland and infiltration basin options	Low	Likely low risk based on effects of existing WWTP discharge and proposed high quality wastewater.
Public Health – land	All land disposal options	Low	Public will be excluded from treatment and storage facilities and irrigation areas.
Public Health – shoreline discharge	Summer only irrigation, wetland and infiltration basin options	Medium	While any discharge is able to avoid areas classified as CR further investigation to determine presence of shellfish in vicinity of headland is required and whether the effects from high weather flows can be mitigated by wetlands polishing.
Odour and Spray Drift	All land disposal options	Low	The use of a cover and/or location of the storage pond in a remote location will reduce the risk from odour during storage of high weather flows. No aerosols would be generated by drip irrigation (for irrigation under trees), and the use of k-line irrigation systems with buffer areas around the irrigation areas would mitigate any risk from aerosols from spray irrigation of pasture.
Amenity	All land disposal options	Medium	While the actual or potential effects do not appear to be significant there may nevertheless be a public perception that amenity will be adversely effected given the location of facilities in relative proximity to developed areas.

The preliminary assessment suggests that consenting risks for the land-based treatment and disposal options are likely to be low or medium. The reduction of medium risks to a low status will require ongoing stakeholder engagement and undertaking site-specific investigations. Issues relating to the accommodation of wet weather flows as it relates to odour, public health and shellfish gathering; development in Silent File areas; and public perception of amenity effects could result in elevated risk.

However, at this stage no high risk or “fatal flaws” are identified and it is considered all the options would be consentable. A high level review by ECan of this section of the report is included in Appendix K.

8 Cost Estimation

Costs have been estimated for the following options:

1. Year-round irrigation under trees
2. Year-round irrigation to pasture
3. Summer-only irrigation to pasture with subsurface flow wetland or infiltration basin
4. Subsurface flow wetland
5. Infiltration basin

Each option will require a storage pond, with two possible locations - A or B as shown on Figure 5.2 with the exception of Option 2 which requires the larger storage pond that initial investigations indicate can only be located at or near Location A. Option 3 includes a subsurface flow wetland or infiltration basin in addition to irrigation. Options 3 - 5 discharge to a coastal infiltration gallery.

8.1 General Assumptions

The estimates have assumed current market rates and sums based on a traditional procurement route, i.e. fully designed with competitive tendering from at least three suitable selected tenderers / sub trades for the work as a lump sum tender. The estimate assumes economy of working and procurement based upon continuity of work.

The estimate assumes the proposed work can be consented.

The estimate is based upon rates and prices current as at 1st Quarter 2016 and no allowance has been included for increases in labour, materials or plant beyond this date.

8.2 On Costs

On Costs cover project costs that are in addition to the physical construction, supply and installation of the works.

- The estimate allows 12% for Preliminary and General and Contractor's Margin.
- Risk Contingency has been allowed at 30%. This reflects the stage of the design and the potential for scope change.
- The estimate allows 13% for professional fees.
- The estimate allows a lump sum allowance of $200,000 for costs associated with the resource consent process.

8.3 Specific Assumptions

8.3.1 Storage Ponds

Each disposal option includes the construction of a storage pond, ranging from 7,000 m^3 to 30,000 m^3. The storage pond construction has been allowed at $8/$m^3$ for basic earthworks construction, with additional allowances for HDPE liner and covers, carbon filters, and pipe inlet and outlet structures. The larger pond will not need to be covered.

The estimates allow for two different locations for the storage pond – A and B. The estimate assumes location A is within 200 m of the proposed treatment plant, and location B is within 2.5 km of the proposed treatment plant. The exact location may vary, subject to engineering and design, geotechnical and land purchase constraints.

8.3.2 Treatment Site Locations

The estimate assumes that year-round irrigation sites for Option A are generally within a 2.5 km radius from the WWTP, with the storage pond at location A. Initial analysis suggests the required irrigation area might be spread over up to seven different sites. Options using location site A assume the irrigable areas require approximately 2.5 km of pipeline to pump water the various year-round sites. Option B assumes wastewater will be conveyed by gravity pipe down to the storage pond at location B, before pumping it back up to the irrigation sites (approximately 4 km of additional pipeline).

The subsurface wetland and infiltration basins sites are assumed to be located as close as practical to the storage pond locations at either location A or B.

8.3.3 Provisional Sums

The estimates include provisional sum allowances for the following items:

- Additional earthworks for sloping site for storage pond construction - \$10,000 - \$50,000
- Tunnel erosion risk \$12,000 to \$30,000 for 12,000 m^3 - 30,000 m^3 ponds only
- Rock excavation \$64,000 to \$160,000 for 12,000 m^3 - 30,000 m^3 ponds only
- Bypass Treatment system - \$200,000 (based on indicative costs for a disc filter at \$155,000)
- Irrigation site – reconfigure site fencing \$12,000 and reconfigure site access \$10,000 each
- Power supply to the pump station sites \$100,000
- Coastal infiltration gallery - \$50,000 for delivery of plant and materials / access to the site (e.g. by barge or similar)
- Shelter belt planting for year round irrigation to pasture - \$50,000

These allowances are provisional only and subject to further engineering design and cost estimation.

8.3.4 Land Purchases

Land purchase costs are based on approximate areas required for treatment sites. Actual areas purchased may be larger as treatment sites may only cover a portion of a parcel/lot of land – the current cost estimates are based on only purchasing the amount of land required for the land treatment option. No costs have been allowed for purchasing larger blocks of land and sub-dividing and reselling sections of the land.

8.3.5 Year-round Irrigation to Trees

The estimate assumes year-round irrigation will take the form of drip line irrigation laid on the ground beneath trees. Dripline irrigation has been allowed at \$2,000/ha and assumes 19 mm polyethylene (PE) pipe or similar laid on ground at 1 – 1.5 m spacing.

The estimate makes a total allowance of \$1,000/ha to establish the plantation, including supply and planting of seedlings (assumed equal mix of radiata pine/eucalyptus/natives), fertilising and post-plant weed control spraying. The estimate excludes further plantation management post-planting (pruning, thinning etc.).

The estimate assumes the year-round irrigation will dispose of all the wastewater on site – i.e. no discharge to a coastal infiltration gallery is required.

8.3.6 Year-round Irrigation to Pasture

The estimate assumes year-round irrigation will take the form of K-line spray irrigation onto existing pasture land. The estimate allows for a relatively high rate of $3,000/ha to establish the K-line system, as it is assumed the design will call for more pods than for a typical agricultural application to reduce the need for moving the pods on a regular basis. The estimate assumes pasture on site is suitable for use and excludes pasture renewal costs.

A provisional sum has been added for the establishment of shelter belts that may be needed close to residential properties.

The estimate assumes the year-round irrigation will dispose of all the wastewater on site – i.e. no discharge to a coastal infiltration gallery is required.

8.3.7 Summer-only Irrigation

Summer irrigation is priced as K-line type irrigation to pasture. The estimate allows for a relatively high rate of $3,000/ha to establish the K-line system, as it is assumed the design will call for more pods than for a typical agricultural application to reduce the need for moving the pods on a regular basis. The estimate assumes pasture on site is suitable for us and excludes pasture renewal costs.

The summer-only irrigation option will need additional treatment, either a subsurface wetland or an infiltration basin. The wetland or infiltration basin will discharge to a coastal infiltration gallery.

8.3.8 Subsurface Flow Wetland

The subsurface flow wetland has been estimated at $405,000. This cost assumes suitable granular materials for construction can be found on site or sourced from Road Metals' Yaldhurst quarry. If suitable materials can be sourced from Birdlings Flat, there could be a cost saving. The wetland plants are assumed to be sourced from the DOC nursery at Motukarara.

8.3.9 Infiltration Basins

The cost of infiltration basins have been estimated at $1.2 million. This cost assumes suitable granular materials for construction can be found on site or sourced from Road Metals' Yaldhurst quarry. If suitable materials can be sourced from Birdlings Flat, there could be a cost saving. An allowance has been made for planting and the plants are assumed to be sourced from the DOC nursery at Motukarara.

8.3.10 Non-Potable Reuse

The costing of $10.9M for the non-potable reuse scheme includes a new supply main from the treatment plant to the township, and a 17km polyethylene pipe reticulation network serving the 1095 connected properties within Akaroa township. For each property the costing allows for a connection and toby box, a 2,000 L onsite storage tank, and plumbed connection to a toilet cistern.

8.4 Cost Estimate Summary

The current capital cost estimates for the proposed land disposal options range from **$3.6 million** to **$7.3 million** as shown in Table 8.1. These costs include land purchase, construction cost, equipment cost and allowances for fees, consents and Preliminary and General costs. The costs do not include the cost for the new treatment plant and trunk main and pump station changes in Akaroa. These costs estimates are accurate to within +/- 30%.

Table 8.1 – Capital Cost Estimate Summary

Option	Description	Capital Cost Estimate
1A Trees	Year-round irrigation under trees – location A	**$4.5M**
1B Trees	Year-round irrigation under trees – location B	**$6.1M**
2A Pasture	Year-round irrigation to pasture – location A	**$7.3M**
3.1A	Summer irrigation with subsurface wetland – location A	**$4.9M**
3.1B	Summer irrigation with subsurface wetland – location B	**$5.1M**
3.2A	Summer irrigation with infiltration basin – location A	**$5.6M**
3.2B	Summer irrigation with infiltration basin – location B	**$5.8M**
4A	Subsurface flow wetland - location A	**$3.6M**
4B	Subsurface flow wetland - location B	**$4.0M**
5A	Infiltration Basin – location A	**$4.3M**
5B	Infiltration Basin – location B	**$4.8M**
6	Non-potable reuse	**$10.9M**
	Harbour outfall	**$6.7M**

Note that all values within this report and included in the attached estimates are GST exclusive.

Note that the capital cost for non-potable reuse would need to be added to one of Options 1 – 4 cost as it is not a standalone option.

Note that these estimates are indicative and are intended to be used only for options appraisal.

A qualitative assessment of operational costs is provided in Table 8.2.

Table 8.2 – Operating Cost Estimate Summary

Option	Description	Operating Cost Factors
1A	Year-round irrigation under trees – location A	Irrigation pump station located close to treatment plant. Pump station operation and maintenance costs. Need to prune, harvest, spray, maintain trees Repair/maintenance of irrigation system
1B	Year-round irrigation under trees – location B	Irrigation pump station a remote site from treatment plant – larger pumps. Higher pump station operation and maintenance costs. Need to prune, harvest, spray, maintain trees Repair/maintenance of irrigation system
2A	Year-round irrigation to pasture – location A	Irrigation pump station located close to treatment plant. Pump station operation and maintenance costs. Need to maintain pasture (cut and carry) and shelter belt Move of K-line sprinklers Repair/maintenance of irrigation system
3.1A	Summer irrigation with subsurface wetland – location A	Irrigation pump station located close to treatment plant. Pump station operation and maintenance costs. Need to periodically relocate irrigators if using K-line spray irrigators Cut and carry costs – operation and sales of pasture Repair/maintenance of irrigation system Cost of application of lime/fertiliser to maximise pasture growth
3.1B	Summer irrigation with subsurface wetland – location B	Irrigation pump station a remote site from treatment plant – larger pumps. Higher pump station operation and maintenance costs Need to periodically relocate irrigators if using K-line spray irrigators Cut and carry costs – operation and sales of pasture Repair/maintenance of irrigation system Cost of application of lime/fertiliser to maximise pasture growth
3.2A	Summer irrigation with infiltration basin – location A	Irrigation pump station located close to treatment plant. Pump station operation and maintenance costs. Need to periodically relocate irrigators if using K-line spray irrigators Cut and carry costs – operation and sales of pasture Repair/maintenance of irrigation system Cost of application of lime/fertiliser to maximise pasture growth
3.2B	Summer irrigation with infiltration basin – location B	Irrigation pump station a remote site from treatment plant – larger pumps. Higher pump station operation and maintenance costs Need to periodically relocate irrigators if using K-line spray irrigators Cut and carry costs – operation and sales of pasture Repair/maintenance of irrigation system Cost of application of lime/fertiliser to maximise pasture growth
4A	Subsurface flow wetland - location A	Every 10 years replace wetland plants/media Minor operational costs for pump
4B	Subsurface flow (SSF) wetland - location B	Every 10 years replace wetland plants/media Minor operational costs for pump
5A	Infiltration Basin – location A	May need to periodically replace media Minor operational costs for pump
5B	Infiltration Basin – location B	May need to periodically replace media Minor operational costs for pump

Note that all values within this report and included in the attached estimates are GST exclusive.

Note that these estimates are indicative and are intended to be used only for options appraisal.

8.5 Changes to the Wastewater Treatment Plant for Irrigation to Pasture

An assessment of the possible reduction in capital cost from changes to the wastewater treatment plant for irrigation to pasture as discussed in Section 4.2 has been made. The revised capital cost has been based on changing the treatment process from BNR technology to a more conventional process consisting of:

- A single biological trickling filter (BTF) 10 m in diameter
- An Imhoff tank of approximately 200 m^3 capacity
- Two clarifiers each of 6 m diameter

If these changes are made then there is an opportunity to reduce the capital cost of the wastewater treatment plant by up to $2M. This saving may be offset against the higher capital cost of implementing the irrigation to pasture options.

9 Evaluation of Options

The criteria used to evaluate the shortlisted options included criteria established in the first stage of the investigations, with an additional item of consentability added. Descriptions of how each criteria were evaluated are given below.

9.1 Cultural Acceptance

Cultural acceptance commentary has been provided by the Ngāi Tahu parties and is included in the evaluation assessments in Section 9.10.

9.2 Comparative Capital Cost

The concept level cost estimates prepared are outlined in Section 8. Only the cost estimate for irrigation year round to pasture with storage at Location A was found to be more than the previous cost estimated for the harbour outfall. However it must be noted for the irrigation to pasture option there is an opportunity to change the wastewater treatment plant type to a biological trickling filter based plant. It is estimated that this would reduce the capital cost of the treatment plant by about 25% or $2 million, and would reduce operating costs by up to $150,000 per year. Consequently for overall scheme comparison $2 million could be deducted from the irrigation to pasture costs.

9.3 Comparative Operational Cost

Operational costs have been compared on a qualitative basis assessing the cost of operating the equipment (cost of power, chemicals etc.), likely maintenance and replacement costs and likely operator input and travel time.

9.4 Land Availability and Suitability

The land availability criteria refers to the availability of suitable land for the proposed scheme. Suitable is defined as being of the necessary slope and ground conditions. Available is defined as not being already used for residential dwellings or commercial properties. The options that were considered to have good land availability and suitability require an area of land which is either already owned by Council or would be able to be purchased without invoking the Public Works Act and is of workable slope. The all year round irrigation options do not rank as well in this category as to achieve the amount of land required numerous disparate parcels would need to be purchased.

9.5 Timeliness

Timeliness estimates whether the option will be able to be installed/constructed before the Council's consent to use the existing outfall expires in June 2020. Those options requiring land acquisition of multiple parcels are considered to rank poorly for timeliness as this process would likely be time consuming, particularly if compulsory land acquisition under the Public Works Act is invoked.

9.6 Environmental Impact

This criteria makes an assessment on how the proposed scheme will affect the receiving environment.

9.7 Social Acceptance

Social acceptance is assessed with the frame of reference being the acceptance of interested stakeholders, such as the residents of Akaroa and Takamātua. The assessment is based on the degree of opposition that may be expected from interested stakeholders.

9.8 Public Health

This criteria looks at whether the proposed scheme has any associated public health risks from food or contact recreation, such as residual viruses being present in the wastewater.

9.9 Consentability

The consentability of each option has been assessed in section 7. The options are assessed against the number and nature of consents that will be required.

9.10 Evaluation

The following sections summarise the findings of evaluating each option against the criteria described.

9.10.1 Option 1 – Year Round Irrigation to Trees

Year round irrigation to land (either trees or pasture) is the only option regarded by the Ngāi Tahu parties as consistent with their cultural values. The amount of land required for year round irrigation to trees means it rates less well than other options in terms of land availability and timeliness. Because a number of properties from different landowners will need to be purchased, this affects the programme for the works. It is unlikely that this scheme could be completed before June 2020 when the existing consent expires. Although this option scores well for public health as it offers no point discharge to the receiving environment, it may be problematic socially as a significant portion of the Takamātua headland and possibly Takamātua valley will need to be converted to wastewater irrigation area and the appearance of the landscape will change. The year round irrigation to land options are considered to have the highest operational costs due to the pumping costs associated with the irrigation pump stations required (particularly if the irrigation fields are spread over a large area), pruning and maintaining forestry and shelterbelts and fertilising and spraying where necessary.

9.10.2 Option 2 – Year Round Irrigation to Pasture

Year round irrigation to pasture is regarded by the Ngāi Tahu parties as consistent with their cultural values. The amount of land required for year round irrigation to pasture is more than required for other options. To obtain the larger land area a number of properties will need to be purchased from different landowners and this is likely to extend the overall programme for the works. It is unlikely that this scheme could be completed before June 2020 when the existing consent expires. Although this option scores well for public health as it avoids a point-source discharge to the receiving environment, it may be problematic socially as a significant portion of the Takamātua headland and possibly Takamātua valley will need to be converted to wastewater irrigation area. A large storage pond will need to be constructed and suitable options for locating this pond are very limited. The size and continuous use of the storage pond could affect public perceptions about the scheme. Cattle can be grazed on pasture at times although there may be a stand down period between irrigation and grazing depending on a range of factors. Irrigation pumping cost, costs associated with cut and carry tasks and moving sprinklers and cattle and maintaining shelterbelts mean this option will also have the highest operational costs.

9.10.3 Option 3 – Summer Only Irrigation + Wetland or Infiltration Basin

Summer only irrigation is considered to be more socially acceptable as the land treatment area required is smaller and can be confined to a specific area. However as wastewater will have to pass through a coastal infiltration gallery into the receiving environment during winter, this option is considered to score less well for environmental impact and public health. The Ngāi Tahu parties have reservations in respect of this option (for the reasons set out in relation to Options 4 and 5), but would be prepared to consider it as part of a transition to year-round irrigation. Operational costs associated with summer only irrigation plus either wetland or infiltration basin will lie somewhere in the middle with less pumping and irrigation field costs than the year round schemes but more operational costs that the wetland or infiltration basins by themselves.

9.10.4 Options 4 – Subsurface Flow Wetland

The amount of land required for the subsurface flow wetland is relatively small – there are multiple places where the scheme could be located including on the property of one landowner who has already indicated their willingness to sell to Council. Therefore this option scores well for capital cost, land availability and timelines. While it may be more socially acceptable than year round irrigation due to the small, contained area of treatment there may still be some opposition from neighbouring property owners. As wastewater will have to pass through the a coastal infiltration gallery into the receiving environment, this option does not score as well as irrigation to land for environmental impact and public health and is not consistent with Ngāi Tahu cultural values. The smallest ongoing operational costs would be associated with the subsurface wetland or infiltration basins which require only periodic replacement of either plants or media.

9.10.5 Option 5 – Infiltration Basins

Options 5 is assessed as being similar to Option 4. While the land required is slightly larger and the capital cost slightly more these differences were not considered significant enough to affect the overall assessment. The Ngāi Tahu parties do not perceive there to be a material difference between Options 4 and 5, from a cultural perspective.

10 Projects Risks and Opportunities

10.1 Year Round Irrigation to Trees

Year round irrigation to trees represents an opportunity to completely eliminate the discharge of wastewater to the receiving waters. Year round irrigation to trees is supported by the Ngāi Tahu parties as it satisfies their full range of cultural values, including public health risks and environmental impacts. Balancing these positives are significant risks around land access and land procurement given that extensive irrigation fields are required. The dispersed nature of the irrigation fields, spread across at least three separate areas, could increase community opposition as numerous landowners will be affected directly or indirectly. These factors combined may lead to extended timelines for scheme implementation. Year round irrigation are amongst the highest capital cost land treatment options, exceeded only by summer irrigation plus infiltration basin.

10.2 Year Round Irrigation to Pasture

Year round irrigation to pasture has the benefits of not needing to plant trees and wait for a canopy to establish, and potential income benefits from cut and carry pasture operation. However irrigation to pasture requires a greater land area and has increased risk of creating land erosion and instability if not well managed. This option requires the largest pond storage requiring more extensive earthworks and retaining. There is likely to be greater public resistance to the construction of such a large pond above residential properties. For spray irrigation time is required to establish a shelter belt before the irrigation can commence. Irrigation to pasture options include the highest capital cost, there is opportunity to offset some of this cost by changing the wastewater treatment technology used.

10.2.1 Grazing of Irrigated Land

Cattle will be able to be grazed on pasture irrigation systems but cattle would not be included in the forestry year round irrigation option. The frequency that the cattle can be grazed and the withholding period between irrigation and grazing will depend on a number of factors including:-

10.2.1.1 Nutrient Uptake Requirements

The application of treated wastewater to land will add nutrients (nitrogen and phosphorus in particular). Some of the added nutrients are taken up by the plants and some are potentially lost through the soil to the underlying groundwater. The greatest uptake of nutrients occurs where the land is managed as "cut and carry", that is where the crop is grown and harvested to be fed to animals at another location. Lower nutrient uptake occurs in grazed pasture systems (sheep or cattle) due to the return of nutrients, particularly nitrogen, in the urine and dung. The acceptable amount of nutrients leached through the soil profile will depend on whether the groundwater is utilised in any way and the impact of the nutrients from the groundwater as it emerges into any surface water bodies. The most appropriate land use and associated nutrient balance can only be determined when the environmental impacts of the particular options are investigated in more detail.

10.2.1.2 Potential Risk of Transfer Of Diseases Common to Cattle And Humans

Historically human wastewater has been treated to a level where diseases can potentially be irrigated onto pasture. If cattle graze the irrigated pasture too soon after the irrigation then there is the potential to transfer the diseases from humans to cattle. The main concern was around the beef tape worm (taenia saginata). The withholding period for when stock could not enter a paddock irrigated with human wastewater was typically around 30 days.

At Akaroa the proposal is to use an advanced treatment system which will prevent most diseases (and in particular the cysts of the beef tapeworm) from being present in the treated wastewater to be irrigated. This presents the opportunity to consider reducing the withholding time between irrigation and grazing.

The use of the land by any type of stock and any withholding requirements will be considered further as options are considered in more detail.

10.2.1.3 Risk of Damaging Soil Profile

Irrigation of treated wastewater to maximise the application of the wastewater means that the soil is kept moist for longer than would normally be the situation. Grazing cattle on soils when the soil is too moist risks damaging the soil (and the plants growing in it). The consequence is compaction of the soil with a reduced infiltration rate, potentially higher runoff and reduced nutrient uptake as the plants are not able to grow efficiently.

The details of the number and type of stock that may utilise the irrigation area will be considered as the design is progressed.

10.2.1.4 Soil Type and Land Slope

The potential sites for irrigation have not been investigated. Each site will have differing soil profiles and land slopes. These will influence the design at each location and what is the best combination of farming practices to coincide with the wastewater irrigation.

10.3 Summer Only Irrigation + Wetland or Infiltration Basin

Summer only plus wetland or infiltration basin involves a simpler and smaller irrigation scheme combined with a wetland or infiltration basin and engineered pathway. Opportunities within this scheme include easier implementation and lower cost as well as elimination of wastewater discharge to the harbour during summer; the time when most fishing, food gathering and recreational use takes place. The Ngāi Tahu parties would consider supporting this option as a transitional step to year-round irrigation, despite reservations in respect of the wetland and infiltration basin elements as noted below. Community opposition may be less than for a year round scheme as the irrigation area is smaller and may be relatively remote from most (but not all) rural residential properties. Capital costs are moderately high to high as both irrigation and wetland/infiltration basin components need to be constructed. The combination of summer only irrigation plus infiltration basin is amongst the highest capital cost options. Environmental and public health risks are slightly higher compared to year round irrigation to land as treated wastewater flows to the harbour in winter after passing through land.

10.4 Subsurface Flow Wetland

The subsurface wetland provides passage through land within a confined area in a wetland rather than over an extensive area of land. The Ngāi Tahu parties do not support this option, as it does not utilise natural processes to restore the mauri of the wastewater, and continues discharge of it into the harbour. The opportunity is for a simpler scheme that may be supported by the wider community because of the reduced land impact and smaller number of affected parties, will be easier to operate, with low public health and environmental risks. Land requirements are also minor (1.4 ha) and the scheme may be implemented within a relatively short time frame, after resource consents have been secured.

This option effectively takes the same treated wastewater as for the harbour outfall and passes it through further system components, to try and achieve a culturally acceptable land treatment. These components have significant additional cost but the quality of the treated wastewater is largely unchanged and the proposed new discharge from the scheme does not dilute the treated wastewater as effectively as the harbour outfall.

10.5 Infiltration Basin

The infiltration basin scheme is similar in terms of opportunities and risks to the subsurface wetland. The Ngāi Tahu parties do not support this option, as it does not utilise natural processes to restore the mauri of the wastewater, and continues discharge of it into the harbour, and do not perceive a significant difference between the wetland and the infiltration basin options. The infiltration basin is also a relatively simple scheme, although more costly than a subsurface wetland, that may be supported by the wider community for the same reasons as the subsurface wetland, will be easier to operate, with low public health and environmental risks. Land requirements are minor (1.5 ha) and the scheme may be implemented relatively quickly, after resource consents have been secured.

This option effectively takes the same treated wastewater as for the harbour outfall and passes it through further system components, to try and achieve a culturally acceptable land treatment. These components have significant additional cost but the quality of the treated wastewater is largely unchanged and the proposed new discharge from the scheme does not dilute the treated wastewater as effectively as the harbour outfall

10.6 Use of Treated Wastewater by Local Farmers

There is an opportunity for the Council to approach local landowners with regard to usage of treated wastewater for irrigation purposes on their land. All the options require the installation of a pipe route that generally goes past multiple farms – it would be possible and relatively simple to provide take-off points from these mains to facilitate this process. The Ngāi Tahu parties strongly support this as complementary to an irrigation option.

11 Conclusions

The key conclusions of this investigation of conceptual designs for land treatment of wastewater from Akaroa after are as follows:

11.1 Option 1 – Year-Round Irrigation to Trees

Option 1, based on year-round irrigation under trees, would consist of 25 ha of land planted in trees with surface drip lines and a further 0.7 ha for storage and 2.5 ha for buffer zones. There would be no measurable effects on the receiving environment under this scheme. Indicative capital costs for this option are $4.5 - $6.1M in addition to the cost of the treatment plant and reticulation modifications in Akaroa, depending on storage pond location.

Year round irrigation under trees represents an opportunity to completely eliminate the discharge of wastewater to the receiving waters and is one of the only options considered that is consistent with Ngāi Tahu cultural values. However there are significant risks around land access and land procurement given that extensive irrigation fields are required. The dispersed nature of the irrigation fields, spread across at least three separate areas, could increase community opposition as numerous landowners will be affected directly or indirectly. These factors combined may lead to extended timelines for scheme implementation.

11.2 Option 2 – Year-Round Irrigation to Pasture

Option 2, based on year-round irrigation to pasture based on a soil moisture balance with storage of wastewater during winter. The scheme would consist of 27 ha of land in grass or lucerne with K-line spray irrigators and a further 2.5 ha for storage and 8.1 ha for buffer zones. There would be no measurable effects on the receiving environment under this scheme. The indicative capital cost for this option is $7.3M in addition to the cost of the treatment plant and reticulation modifications in Akaroa, based on a storage pond location at or around location A. However there is an opportunity for capital cost savings at the treatment plant as a high level of denitrification is not required for irrigation to pasture and so the treatment plant can be detuned.

Year round irrigation to pasture represents an opportunity to completely eliminate the discharge of wastewater to the receiving waters and is one of the only options considered that is consistent with Ngāi Tahu cultural values. However there are significant risks around land access and land procurement given that extensive irrigation fields are required. The dispersed nature of the irrigation fields, spread across five separate areas, could increase community opposition as numerous landowners will be affected directly or indirectly. There is an increased risk of land stability and erosion if the scheme is not well managed. These factors combined may lead to extended timelines for scheme implementation, but this implementation should be quicker than the year-round irrigation to trees option.

11.3 Option 3 – Summer Only Irrigation plus Wetland or Infiltration Basin

Option 2 involves land irrigation in summer and in winter land passage through a subsurface wetland or infiltration basin before wastewater flows through a coastal infiltration gallery. The scheme would require of 12 ha of land for irrigation, plus 1.4 ha for a storage pond and wetland, or 1.5 ha for a storage pond and infiltration basin. Both options require 3.6 ha of land for buffer zones around the irrigation area. The quality of wastewater discharging via the engineered pathway will be slightly improved over the BNR plant discharge proposed for the harbour outfall, which already achieves a very high standard.

The infiltration gallery would be built into the shoreline in the intertidal zone at the head of Takamātua Peninsula. In the winter, and after passage through the subsurface wetland or infiltration basin, wastewater flows via the coastal infiltration gallery. Indicative capital costs are $4.9 - $5.1M for the wetland option and $5.6 - $5.8M for the infiltration basin option, depending on storage pond and wetland or infiltration basin location.

Summer only plus wetland or infiltration basin involves a simpler and smaller irrigation scheme combined with a wetland or infiltration basin and coastal infiltration gallery. Opportunities within this scheme include easier implementation and lower cost as well as elimination of wastewater discharge to the harbour during summer; the time when most fishing, food gathering and recreational use takes place. Community opposition may be less than for a year round scheme as the irrigation area is smaller and may be relatively remote from most (but not all) rural residential properties. Environmental and public health risks are slightly higher compared to a year round irrigation to land as wastewater flows to the harbour in winter after passing through land. Although the Ngāi Tahu parties have significant reservations about this option (for the reasons described in relation to Options 4 and 5), they are prepared to consider this option as a transitional step to year-round irrigation to land.

11.4 Option 4 – Subsurface Flow Wetland

Under this option wastewater passes through a subsurface wetland, some of the wastewater is reused in the wetland and the remaining wastewater flows to the harbour via the coastal infiltration gallery. The scheme would require 0.7 ha of land for a storage pond plus 0.7 ha for a wetland. In summer the flow will be reduced by water uptake by wetland plants. Indicative capital costs are $3.6 - $4.0M depending on storage pond and wetland location.

The subsurface wetland provides passage through land within a confined area in a wetland rather than over an extensive area of land. The opportunity is for a simpler scheme that is likely to be supported by the wider community, will be easier to operate, with low public health and environmental risks. Land requirements are also minor (1.4 ha) and the scheme may be implemented within a relatively short time frame, after resource consents have been secured. This option is not supported by the Ngāi Tahu parties.

11.5 Option 5 – Infiltration Basin

The infiltration basin option is similar to the subsurface wetland scheme, except the passage through land occurs vertically downwards through the infiltration basin rather than horizontally within a wetland. The scheme would require 0.4 ha of land for a storage pond plus 1.1 ha for the infiltration basins. Indicative capital costs are $4.3 - $4.8M depending on storage pond and infiltration basin location.

The infiltration basin scheme is similar in terms of opportunities and risks to the subsurface wetland. The infiltration basin is also a relatively simple scheme, although more costly than a subsurface wetland, that is likely to be supported by the wider community, will be easier to operate, with low public health and environmental risks. Land requirements are minor (1.5 ha) and the scheme may be implemented relatively quickly, after resource consents have been secured. This option is not supported by the Ngāi Tahu parties.

11.6 Option 6 – Non-potable reuse

Non-potable reuse describes a system where the treated wastewater is reticulated to households for use in toilet flushing, garden watering, boat washing etc. Non-potable reuse cannot dispose of all the treated wastewater with certainty. Hence non-potable reuse would function as an add-on to Options 1 – 4. It is estimated that 20% of the wastewater flow could initially be reused in summer (in toilet flushing) and approximately 10% in winter. The cost for Option 6 is estimated at $10.9M.

In addition to, or instead of domestic reuse, there is an opportunity for the Council to offer treated wastewater to farmers for reuse in farm irrigation. All the options require the installation of a pipe route that generally goes past multiple farms – hence it would be possible and relatively simple to provide take-off points from these mains to facilitate this process. This option is strongly supported by the Ngāi Tahu parties, though they acknowledge its costs and limitations.

12 References

Department of Health (1992) “Public health guidelines for the safe use of sewage effluent and sewage sludge on land”; (Public Health Services, 1992)

NZ Land Treatment Collective (2000) “NZ Guidelines for utilisation of sewage effluent on land”, Pub. NZ Land Treatment Collective and Forest Research

Cawthron (2014) “Baseline benthic ecological survey for a proposed wastewater treatment plant outfall in Akaroa harbour”. Report no. 2486, Cawthron June 2014.

Ministry of Works (1974) “Guidelines for the design, construction and operation of oxidation ponds”

Partridge, T. (2016) Tree Canopy Establishment - Akaroa Wastewater Irrigation to Land. Internal CCC memo.

USEPA (2006) “Constructed Wetlands Treatment of Municipal Wastewaters”.US Environmental Protection Agency, Cinn, Ohio 152pp

Hunter, I.R. and Hunter, J.A.C. (1991) “Apparent Phosphorus Uptake and Change in in Nitrogen Content of Pinus Radiata Growing on Soils of Different Phosphorus Retention, Treated with Superphosphate and A-Grade Rock Phosphate”. New Zealand Journal of Forestry Science.

Franklin, H.M. (2014), “The Interaction of New Zealand Native Plants with Nitrogen in Canterbury’s Agricultural Landscapes”

Kadlec, R.H. (2009), “Treatment Wetlands 2nd Ed “, Boca Raton Florida, CRC Press

Harrison Grierson (2010), “Akaroa Wastewater Options and Risk Analysis Report”

Sewell et.al (1990), “Geology of Akaroa West Area”, 1:50,000 scale geological map

Geotech Consulting (2010), “Preliminary Geotechnical Appraisal of Potential Slope Stability Issues in Relation to the Proposed Wastewater Irrigation Areas of Land Near Akaroa”

Tonkin and Taylor (2008), “Slope Hazard Susceptibility Assessment – Akaroa Harbour Settlements”

EcoEng (2010), “Irrigation of Domestic Wastewater – Akaroa Options”

Christchurch City Council (2014), “Summary of Land Irrigation of Wastewater on Banks Peninsula”

CH2M Beca (2015) “Akaroa Wastewater Project - Review of Disposal Alternatives - First Stage”

Dyanna Jolly Consulting (2009), “Cultural Values Report: Takamatua to Takapuneke”

Blumenthal, J. et al (2000), “Guidelines for the Microbiological Quality of Treated Wastewater used in Agriculture: Recommendations for Revising WHO Guidelines”

WHO (2006), “Guidelines for the Safe Use of Wastewater, Excreta and Greywater: Volume 2 Wastewater Use in Agriculture”

Appendix A

Overview of Scheme in Consent Application

Appendix B

Peer Review and Response to Peer Review

Appendix C

Hydrogeological Report

Appendix D

Area Overview Drawing

Appendix E

Location Maps

Appendix F

Geotechnical Figures

Appendix G

Planning Maps

Appendix H

Resource Consents Required

Appendix I

Disinfections Through Wetlands

Appendix J

Wainui Wastewater Scheme Monitoring Reports

Appendix K

Environment Canterbury Review

CH2M Beca