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Report

Akaroa Wastewater Summary of Disposal and Reuse Options

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

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Revision History

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4			
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Document Acceptance

Action	Name	Signed	Date
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on behalf of	CH2M Beca Ltd		

Executive Summary

CH2M Beca Ltd (Beca) is assisting Christchurch City Council (Council) in developing alternative disposal and reuse options for treated wastewater from Akaroa. This work commenced in 2015 with desk top studies and a longlist of possible options, progressing through concept design, options shortlisting, physical site testing and stakeholder engagement.

Stakeholder engagement has been a continuous theme, with ongoing exchange of ideas and development of scheme options through input from Iwi, a wastewater working party, the wider community, statutory agencies and other parties. This engagement has taken various shapes including formal public consultations, hui with the Ngāi Tahu Parties, working party meetings, public meetings, dissemination of information on the Council website and one-on-one discussions with landowners and potentially affected parties.

Activities documented in the report include:

- Description of wastewater flow and loads
- Description of options longlisting and shortlisting
- Outline of irrigation land selection and optioneering
- Overview of four shortlisted options
- Summary of generic scheme features including network upgrade and treatment plant
- Summary of stakeholder engagement
- Carbon accounting for shortlisted options
- Cost estimates
- Risk assessment
- Summary evaluation and conclusion

Throughout the period of scheme option assessment, a number of options have advanced while others have been excluded. The shortlist of overall scheme options that has been reached through this process is as follows:

- Inner Bays Irrigation Scheme
- Goughs Bay Irrigation Scheme
- Pompeys Pillar Irrigation Scheme
- Mid-harbour Outfall

A drilling investigation was undertaken to confirm if deep bore injection of treated wastewater was a viable method for disposal of Akaroa wastewater. The investigation found that the ground conditions near the proposed new wastewater treatment plant were not suitable for deep bore injection. Wastewater injection into the ground in other locations closer to Akaroa for managed aquifer recharge has been ruled out by Council based on the potential risk to public water supply for Akaroa and Takamātua.

The four options at a glance are summarised below.

Parameter	Scheme Option			
	Inner Bays Irrigation Scheme	Goughs Bay Irrigation Scheme	Pompeys Pillar Irrigation Scheme	Harbour Outfall Scheme
Capital cost range ($M)	$54m to $63m	$61m to $71m	$66m to $76m	$45m to $52m
Operating cost (per year)	$510,000	$580,000	$580,000	$470,000
Carbon impact (over 35 years)	8,900 tonnes stored	4,500 tonnes stored	8,300 tonnes stored	1,300 tonnes emitted
Distance from treatment plant (approximate kilometres)	5.6km	11km	13km	4km

The baseline option of the harbour outfall is the least cost, but emits more greenhouse gases over 35 years than any other option. Irrigation of native trees at Pompeys Pillar is the most costly option. Both the Pompeys Pillar and the Inner Bays irrigation schemes offer carbon capture amounting to more than 8,000 tonnes over 35 years while Goughs Bay, which has a smaller irrigation area, captures somewhat less.

There are a range of non-potable reuse options that have been investigated - from a fully reticulated system to all properties, to irrigation of public green areas only. A non-potable reuse purple pipe network to irrigate public parks and flush public toilets within Akaroa would cost an additional $2.7 M that is not included in the costs shown above. A fully reticulated non-potable reuse network has not been used before in New Zealand and is not currently supported by the Ministry of Health and the Canterbury District Health Board. These additional costs would apply to all options except the harbour outfall where the pipeline is shared and so the additional cost for non-potable irrigation of public parks and flushing toilets is $500,000.

This report captures all assessments made to date and provides a summary evaluation of the shortlisted options against the well-being and sustainability requirements of the Local Government Act 2002.

Contents

Appendices

1 Introduction

1.1 Background

CH2M Beca Ltd (Beca) is assisting Christchurch City Council (Council) in developing alternative options and locations for wastewater management for Akaroa. The Council has been investigating long term options for management of Akaroa's wastewater since 2009. Following initial conceptual design work by Harrison Grierson and other parties Beca was commissioned to design, consent and implement a scheme based on disposal to the middle of Akaroa Harbour in 2013.

The Council applied to ECan and the Christchurch City Council for resource consents for a new treatment plant, a new pump station, changes to the Akaroa reticulation network and a new wastewater outfall and discharge to the harbour in 2014. In June 2015 the Hearing Commissioners granted resource consents for the treatment plant and reticulation changes. However, they declined the resource consent application for discharge of wastewater to the harbour. This was due to the cultural effects of a direct discharge of treated wastewater to the harbour and an assessment that the application had not sufficiently investigated alternative locations and options for disposal of treated wastewater.

With respect to the harbour disposal option, Ngāi Tahu advises that "Ngāi Tahu rights and interests associated with Akaroa Harbour are strongly focused on mahinga kai (food gathering practices). Discharge of treated wastewater to the harbour is culturally offensive and incompatible with the harbour as mahinga kai. As tāngata whenua, Ngāi Tahu have kaitiaki rights and responsibilities to actively protect natural resources in Akaroa for future generations. Protecting and enhancing the mauri (life force) of the harbour requires the elimination of wastewater discharges to Akaroa Harbour. The Mahaanui Iwi Management Plan (2013) provides further detail on Ngāi Tahu objectives and policies for managing wastewater in Akaroa to protect customary fisheries."

After the June 2015 decision to decline the harbour outfall consents, Beca was commissioned to investigate land-based alternatives. This report describes the options investigations and assessment.

The Council will be making a Local Government Act (LGA) decision on which wastewater discharge option it will pursue. Under section 14.1 of the LGA:

> *(c) when making a decision, a local authority should take account of—*
>
> *(i)* *the diversity of the community, and the community's interests, within its district or region; and*
>
> *(ii)* *the interests of future as well as current communities; and*
>
> (iii) *the likely impact of any decision on each aspect of well-being referred to in section 10:*

The well-beings referred to are the social, economic, environmental, and cultural well-being of communities. Section 14.1 of the LGA goes on to say:

> *(h) in taking a sustainable development approach, a local authority should take into account—*
>
> *(i)* *the social, economic, and cultural well-being of people and communities; and*
>
> *(ii)* *the need to maintain and enhance the quality of the environment; and*
>
> (iii) *the reasonably foreseeable needs of future generations.*

Under Section 77 of the LGA:

(1) A local authority must, in the course of the decision-making process,—

(a) seek to identify all reasonably practicable options for the achievement of the objective of a decision; and

(b) assess the options in terms of their advantages and disadvantages; and

(c) if any of the options identified under paragraph (a) involves a significant decision in relation to land or a body of water, take into account the relationship of Māori and their culture and traditions with their ancestral land, water, sites, waahi tapu, valued flora and fauna, and other taonga.

The option must also be consentable as sustainable management under the Resource Management Act 1991 (RMA). While Council has lodged, and subsequently withdrawn, an appeal against the 2015 declining of the outfall consents Council, staff consider that there are some discharge to land options that are more efficient, effective, feasible and appropriate than the Council originally considered in 2009.

The Council has been working with Ōnuku Rūnanga, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Rūnanga o Ngāi Tahu (the Ngāi Tahu parties to the appeal) to explore land-based alternatives to the harbour outfall. The Council kept the consent authorities – Environment Canterbury and the Christchurch City Council in its regulatory capacity – involved in that process as they were respondents to the Environment Court appeal. However, that appeal was withdrawn in 2019.

The Council has also been working with the Akaroa Treated Wastewater Reuse Options Working Party, which was set up by the Banks Peninsula Community Board to assist the Council in exploring land-based alternatives to a harbour outfall. The wastewater working party has provided invaluable input, guidance and feedback on various proposals over the duration of the scheme investigations. The Council sought feedback from the wider public through two previous rounds of public consultation. This report documents the consultation activity, the key themes identified, and the changes in project proposals that have been incorporated in response.

1.2 Purpose

The purpose of this report is to document the options assessment process for disposing or reusing Akaroa's treated wastewater, since the outfall consents were declined in 2015.

1.3 Scope

The scope of this report includes investigations into land-based disposal and reuse of treated wastewater from Akaroa that have been investigated since 2015. This includes initial long listing of land-based options, short listing of options, and specific development including concept designs, cost estimates, risk assessment, stakeholder engagement and decision-making processes that have led to a short list of scheme options.

1.4 Statutory Overview

Consideration of alternatives is critical for both the LGA decision making process described above (which requires assessment of reasonably practicable options) and for the resource consent application that follows the Council's decision under the LGA to seek resource consents for a preferred option.

The purpose of the RMA, which underlies all decisions on resource consent applications, is "to promote the sustainable management of natural and physical resources". **Sustainable management** means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while:

a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and
b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and
c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Section 6(e) of the RMA requires that, as a matter of national importance, all persons deciding on resource consent applications must (among other matters) recognise and provide for the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, wāhi tapu, and other taonga.

Section 7 of the RMA also requires that decision makers have particular regard to matters that include kaitiakitanga, the ethic of stewardship, the efficient use and development of natural and physical resources, the maintenance and enhancement of amenity values and the maintenance and enhancement of the quality of the environment.

Applications for resource consent must include an assessment of the proposed activity's effects on the environment. The RMA requires that if it is likely that the activity will result in any significant adverse effect on the environment, the application must include a description of any possible alternative locations or methods for undertaking the activity (RMA Schedule 4, clause 6(a)).

Section 105 of the RMA was a particular focus of the hearing commissioners in 2015 when they declined resource consent for discharge of treated wastewater into the harbour. It provides that the consent authority deciding a resource consent application for discharge into water must have regard to:

a) the nature of the discharge and the sensitivity of the receiving environment to adverse effects; and
b) the applicant's reasons for the proposed choice; and
c) any possible alternative methods of discharge, including discharge into any other receiving environment.

Decision making by a consent authority on a resource consent application must have regard to any relevant provisions of planning instruments made under the RMA including the New Zealand Coastal Policy Statement (NZCPS), the Canterbury Regional Policy Statement, the Land and Water Regional Plan and the Regional Coastal Environment Plan (RCEP), and the Christchurch District Plan. Section 23(2) of the NZCPS sets out the following policy on human sewage discharges:

"In managing discharge of human sewage, do not allow:

a. discharge of human sewage directly to water in the coastal environment without treatment; and
b. the discharge of treated human sewage to water in the coastal environment, unless:
  i. there has been adequate consideration of alternative methods, sites and routes for undertaking the discharge; and
  ii. informed by an understanding of tāngata whenua values and the effects on them"

Policy 8.3.9 of the Regional Policy Statement affirms NZCPS policy 23(2) explicitly as follows:

8.3.9 Direct discharge of sewage into the coastal marine area

To ensure that human sewage is not discharged directly into the coastal marine area without treatment and where:

1. Alternative methods, sites and routes for undertaking the discharges have been considered; and
2. There has been consultation with Ngāi Tahu as tāngata whenua and particular regard had for their values and the effects of discharges on those values; charges on those values;

the human sewage is treated in a manner appropriate to the receiving environment.

Policy 7.5 of the Regional Coastal Environment Plan also informs consent decision making for discharges of human sewage as follows:

Only grant a resource consent to discharge human sewage into water, or onto or into land in the Coastal Marine Area, without it passing through land or a specially constructed wetland outside the Coastal Marine Area, where:

a. the discharge better meets the purpose of the Act than disposal through land or a wetland outside the Coastal Marine Area; and

b. there has been consultation by the applicant with Tāngata whenua in accordance with Tikanga Māori and due weight has been given to sections 6, 7 and 8 of the Act; and

c. there has been consultation by the applicant with the community generally; and

the discharge is not within an Area of Significant Natural Value, unless the applicant satisfies Environment Canterbury that exceptional circumstances justify the discharge in such an area.

The Ministry for Environment (MfE) 2010 publication *"Making Good Decisions Workbook ME679 Part D*" also notes key factors for consideration under Part 2 of the RMA which include the following:

- "Māori have a special relationship with New Zealand's environment and recognising this relationship contributes to good environmental outcomes.
- Parliament pronounced a number of provisions to integrate Māori values and world views into the administration of the RMA. Key provisions are contained within Part 2 of the RMA, which sets out the overriding sustainable management purpose.
- These are strong directions, to be borne in mind at every stage of the planning process.
- This framework allows the weighing and balancing of considerations – their scale and degree and relative significance.
- The RMA provisions require substantive and procedural recognition of Māori values. In most, if not all cases, substantive recognition will require procedural input."

Applying the framework for decision making requires the weighing of considerations – including their scale and degree and relative significance. In this context the evidence presented by the Ngāi Tahu Parties at the 2015 hearing into the council application to discharge treated wastewater to Akaroa Harbour is salient. Notable in this evidence were the following points[1]:

- The kaimoana of the harbour is the mana kai of the many hapū of Ōnuku. They no longer provide from the food basket at their front door and have to bring in seafood from outside of the area.
- The continued disposal of human effluent to the harbour, with no plan for alternative disposal, could constitute a "further grievance"
- To the Ngāi Tahu submitters, the continuation of discharge to the marine environment at any quantity would be culturally offensive.
- Iwi speakers indicated that the cultural impacts of the discharge would not be satisfied until all the effluent made contact with Papatūānuku (land) before entering any water body.
- Ngāi Tahu also advocated on behalf of the mauri (life essence) of the Akaroa Harbour. Discharge of sewage into Akaroa Harbour is seen as degrading the mauri of the coastal environment, which is linked to the health and accessibility of their local food resource.

The submissions of the Ngāi Tahu parties show potential for significant adverse cultural impacts from continuing discharge of treated sewage to the Akaroa Harbour. These effects are multi-dimensional and include the impact on food gathering, on the mana kai, and on the mauri of the Akaroa Harbour. They

[1] ECan Decision of Hearings Commissioner in the matter of CRC150046, 150047, 150048, 150049, 150050 and 152814 dated 9th July 2015.

provide strong direction for council to develop and implement a land-based treatment scheme through which all effluent makes contact with Papatūānuku before entering water. The regulatory policies set out above also support this direction.

2 Design Flows and Loads

2.1 Population Projections

A range of scheme options were investigated for disposal and reuse of treated wastewater from Akaroa. These included irrigation to land schemes and a harbour outfall. All scheme options are designed for year 2052 projected flows and loads, being approximately 30 years from when the new WWTP and wastewater scheme could be built and commissioned.

The design populations for 2018 and 2052 were determined using population data and forecast growth rates provided by the Council. The data provided used outputs from the Council population growth model, which is based on the medium Statistics NZ projections. Akaroa welcomes a large number of tourists, particularly in the summer over Christmas and New Year. As the number of visitors was unknown, the peak summer population was derived based on measured wastewater loads (biochemical oxygen demand, BOD) over the peak summer period in December 2018 - January 2019. A summary of design population is given in Table 2-1. It can be seen that the predicted number of permanent residents is modest, and that most of the increase in population is from visitors.

Table 2-1 Akaroa Design Population

Season	Source	2018	2052
Winter	Domestic Visiting Total	668 97 765	728 112 840
Summer	Domestic Visiting Total	668 1,409 2,077	728 1,620 2,348
Peak Summer	Domestic Visiting Total	668 3,331 3,999	728 3,829 4,557

2.2 Design Wastewater Flows

Wastewater flows were derived by integrating a range of data sources into several computer models. The data inputs include flow monitoring data from flow meters on the wastewater network (installed in mid-2017 after the wastewater treatment plant flow meter was found to be faulty), rainfall data, influent wastewater quality monitoring data, water metering data and GIS (geographical information system) asset information. A schematic diagram of this approach is provided in Figure 2-1.

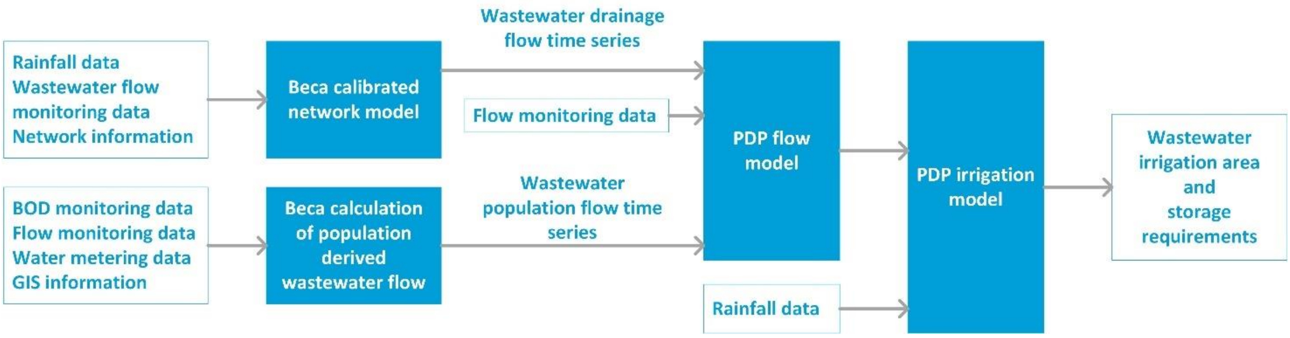


Figure 2-1 Schematic Diagram of Irrigation Modelling Approach

Within the modelling approach adopted there are two contributors to flow and load:

- A wastewater drainage flow time series
- A wastewater population flow time series

The wastewater drainage flow time series is derived using outputs from the wastewater network model, which was built and calibrated in 2018 using flow and rainfall data from mid-2017 to 2018 – refer to Appendix A for the model build and calibration reports. The model was used to calculate how much rain and groundwater derived inflow and infiltration flows into the wastewater network each day over the 46 year period for which local rainfall records were available (1972 – 2018). The wastewater drainage flow time series is calculated as a drainage only flow with no contribution from wastewater produced by people.

The wastewater population flow and load time series was calculated separately from the drainage flow time series because the network model cannot cope with the varying population that occurs in Akaroa. Akaroa typically receives significant visitor numbers in summer and has a much smaller population in winter. A population model was therefore created as a simple spreadsheet calculation with the year divided into periods for winter, summer and peak summer, each with its own assumed population. This reflects observed changes in human-sourced wastewater contributions throughout the year based on 20 months of flow monitoring from 2017 to 2018.

A combined wastewater flow dataset was generated by Pattle Delamore Partners (PDP), a subconsultant to Beca, by adding the drainage flow time series to the population flow time series – the methodology for doing this is described in detail in Appendix B. The modelled flow estimates for 2018 and for 2052 are summarised in Table 2-2.

Table 2-2 Modelled Flow Estimates based on 1972 – 2018 Rainfall Data

PDP Modelled Flow Estimate Based on 1972 – 2018 Data		
	Current Population 2018	Future Population 2052
Average flow (m^3/day)	627	652
Maximum flow (m^3/day)	7,609	7,626
Minimum flow (m^3/day)	212	229
Average Annual Volume (m^3)	229,000	238,000

The model assumes that the maximum capacity of the proposed new treatment plant is 1,200 m^3/day, based on the consented design. This is the maximum volume that can pass through the plant membrane filters in a 24-hour period, based on a peak design flow of 14 L/s. Any flow above this limit would be diverted to a raw wastewater storage pond until later when treatment capacity becomes available.

The model does not take account of network overflows however it can help predict them. The model shows the current network overflow frequency to be between a 1:2 year and 1:5-year event. From the model results for the reversed network, and including recent pipe renewal works, the overflow frequency is predicted to be between 1:5 year and 1:10 year event. The predicted overflow volumes to the harbour for the 1:10 year event are small and it is likely these can be prevented by targeted network upgrades.

The Council provided information indicating that 38 overflows have occurred between 2012 and 2019. Reconfiguring the wastewater network as part of the wastewater scheme will reduce the frequency and volume of these overflows, and reduction in inflow and infiltration in the network will also reduce overflows.

The Council has yet to apply for a wastewater network overflow consent, however for the purposes of concept design it has been assumed that:

- Overflows would occur, on average, once every 10 years in the revised network, upstream of the new wastewater treatment plant. Except in extremely large storms this will be only at a constructed overflow point to Grehan Stream from the new Terminal Pump Station, so the overflowing wastewater will have undergone primary treatment (screening and grit removal) prior to discharge.
- The raw wastewater storage pond at the new WWTP site would be sized to contain all remaining flow that is pumped from the Terminal Pump Station to the wastewater treatment plant.
- The inner harbour option has additional wetland treatment at the new WWTP site. This wetland will receive a small flow of treated wastewater from the WWTP continuously to support wetland ecology. However, the wetland will only overflow once every 5 years. The infrequent wetland-treated discharge will flow into Children's Bay Stream and will ultimately be released into Akaroa Harbour.
- Discharge of treated wastewater from the wastewater treatment plant to the receiving environment in excess of a controlled discharge through additional wetland treatment will occur approximately once every 10 years. This uncontrolled overflow would occur when the wetland overtops, and the flow would discharge into the stream on the property and run down the hill into Childrens Bay.
- For the eastern bays options of Goughs Bay and Pompeys Pillar no overflows of treated wastewater from the WWTP site are planned, with the intention to pump all treated wastewater up to the 1:10 year flow to the storage ponds at the irrigation site. If the raw wastewater pond becomes full, then the Terminal Pump Station will stop pumping and overflows would occur at the Terminal Pump Station.
- A reduction in inflow and infiltration of 20% will be achieved across the network.

The total flow, along with the flow derived from population and inflow and infiltration (I&I) (i.e. drainage) is shown in Table 2-3 for 2052 modelled flows.

Table 2-3 Modelled 2052 Population and Drainage Flows Based on 1972-2018 Rainfall Data

Parameter	Population based annual volume	Groundwater Inflow and Infiltration	Rain-Derived Inflow and Infiltration	Total Annual Volume
Average (m^3/yr)	93,338	102,975	41,846	238,159

The data in Table 2-3 shows that in an average year, groundwater infiltration contributes 43% and rain derived inflow and infiltration contributes 18% of the total flow.

2.2.1 Reduction in Inflow and Infiltration

As groundwater infiltration represents a significant proportion of total flow, reducing groundwater infiltration has the potential to significantly reduce overall wastewater flows. The PDP irrigation model was used to look at the effect of reducing I&I on the land area required for land-based disposal of treated wastewater and the treated wastewater storage volume required for land disposal via irrigation schemes. Irrigation to land schemes typically need to store treated wastewater in winter when the land is too wet for irrigation, by reducing the winter wastewater volumes the storage required is reduced.

The results from the modelled scenarios show that the maximum storage volume required is sensitive to reductions in I&I (refer to Appendix B for details). The peak storage volume required generally occurs during the winter period and after a series of significant rainfall events which cause large I&I flow into storage. Therefore, reducing I&I has the potential to reduce the storage volume required.

The Council contracted Citycare to pinpoint sources of I&I in Akaroa using Distributed Temperature Sensing (DTS) as well as reviewing work on I&I reduction by other councils in New Zealand. Based on the outcome of

I&I improvement work elsewhere, and taking into account the results of the DTS, the Council selected a 20% I&I reduction as likely to be achievable for the Akaroa wastewater network. It may be possible to reduce I&I by more than 20%, however the exact percentage improvement is unknown at this stage and will only become clear as the I&I improvement works are implemented.

An I&I reduction of more than 20% has reportedly been achieved recently at Inglewood in Taranaki through a targeted remediation programme based on DTS. The Inglewood project achieved the following reductions in flow:

- 40% reduction in average flow
- 70% reduction in average dry weather flow (ADWF)
- 30% reduction in peak wet weather flow (PWWF)

Applying the Inglewood scenario to Akaroa reduces the required storage to 16,000 m^3 for an irrigable area of 34.5 ha (refer to PDP letter report, Appendix B). This is a significant improvement over the 19,000 m^3 of storage required for 40 ha of irrigable area achieved through a 20% reduction of I&I. While the Inglewood scenario is aspirational it is unlikely this level of improvement can be achieved through remediating the existing network at Akaroa. This is due to differences in the networks and in the comparative contributions to flow from I&I and population. The rationale for this view is outlined as follows:

- At Akaroa the primary factor in ADWF is population-based flow. The worst case ADWF case occurs in peak summer when the population also peaks. The contribution of I&I as a proportion of ADWF is lowest in summer due to lower groundwater levels and the dominant influence of population-based flow. Therefore, reduction in ADWF resulting from I&I improvements is likely to be minor.
- Reductions in PWWF may be achieved at Akaroa by I&I management. Groundwater-derived I&I is the dominant feature of I&I in Akaroa. Using the flow splits in Table 2-3 the reduction in groundwater I&I needed to attain a net reduction of 30% in PWWF is 70%. It will be very difficult and costly to reduce groundwater derived I&I in Akaroa to this extent. A key consideration is that most of this infiltration occurs in low lying and older parts of the network located near the coastline. These parts of the network may be at or below the level of shallow groundwater which is also tidally influenced. It has been found at other similar locations (e.g. Motueka) that fixing individual infiltration points causes shallow groundwater levels to rise slightly until the groundwater finds another place to leak into the sewer. Within this setting it would be erroneous to assume that a 30% reduction in PWWF can be practically achieved for Akaroa.
- For the reasons outlined above it is considered that the level of I&I improvement attained at Inglewood is not practically achievable through remediation of the existing Akaroa network. It is recommended that a 20% reduction in I&I is retained as a reasonable basis for network improvements.
- As an alternative to remediating the existing network, the entire wastewater network could be completely replaced, either using pressure sewer or a combination of gravity plus pressure sewer. This would involve extensive construction works affecting every household connection in every street, and may also require a financial commitment from landowners as leakage from privately owned laterals is a contributor to overall I&I. This scenario would be prohibitively expensive as well as disruptive and so has not been incorporated into scheme proposals thus far.

2.3 Design Wastewater Loads

Average Dry Weather Flow (ADWF) for Akaroa is based on the model results as shown in Table 2-2. The maximum capacity of the treatment plant is limited to 1,200 m^3/day which equates to 14 L/s. Any flow above this limit would be diverted to a raw wastewater storage pond until capacity becomes available.

The design load basis is:

- The BOD load is based on the standard population load of 74 g/p/d

- The total suspended solids (TSS) load is based on the standard population load of 84 g/p/d
- The total Kjeldahl Nitrogen (TKN) load is based on a high strength population load of 20 g/p/d to match historical monitoring

The BOD and TSS standard population loads (also used in deriving the peak summer population) come from *Wastewater Treatment in NZ: Evaluation of 1992/93 Performance Data* (Hauber, 1995). Using these design basis inputs the design flows and loads are given in Table 2-4.

Table 2-4 Akaroa WWTP Design Flows and Loads

Season	Parameter	2017		2052	
Winter	ADWF	496m³/d		513m³/d	
	units	kg/d	g/m³	kg/d	g/m³
	BOD	57	114	62	121
	TSS	66	133	72	141
	TKN	15	31	17	33
Summer	ADWF	785m³/d		845m³/d	
	units	kg/d	g/m³	kg/d	g/m³
	BOD	154	196	174	206
	TSS	179	228	202	239
	TKN	42	53	47	56
Peak Summer	ADWF	1,000m³/d		1,123m³/d	
	units	kg/d	g/m³	kg/d	g/m³
	BOD	292	292	337	300
	TSS	344	344	392	349
	TKN	81	81	92	82

A typical diurnal flow pattern was established by averaging hourly flow data during dry weather from 1 December 2017 to 13 May 2018 (see Figure 2-2 Diurnal Flow Pattern). Based on this a diurnal hourly peaking factor of 1.7 will be adopted.

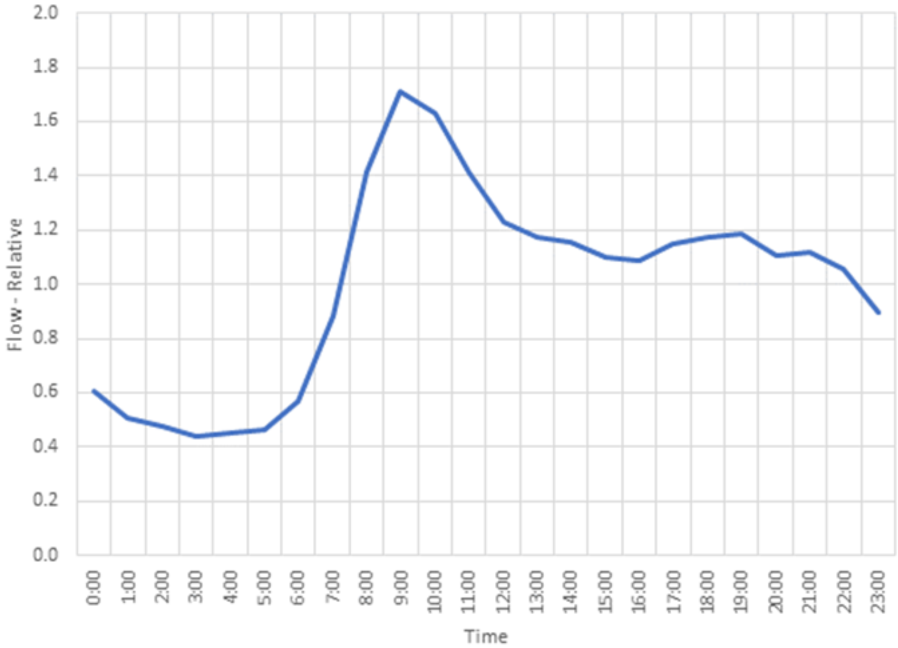


Figure 2-2 Diurnal Flow Pattern

From 11 December 2013 to 7 February 2014 influent monitoring was carried out three times per week. Results of this monitoring are given in Table 2-5 . However, as the results are from time weighted composite samples rather than flow weighted, they are slightly lower than the design values given in Table 2-4. The relative ratios e.g. BOD/COD are still likely to be representative.

Table 2-5 Design Influent Quality

Parameter		Median	Peak Summer Day
TSS (total suspended solids)	mg/L	130	210
VSS (volatile suspended solids)	mg/L	120	180
COD (carbonaceous oxygen demand)	mg/L	355	500
sCOD (soluble carbonaceous oxygen demand)	mg/L	180	300
BOD_5 (five-day biological oxygen demand)	mg/L	135	200
$sBOD_5$ (soluble five-day biological oxygen demand)	mg/L	75	120
Amm-N (ammoniacal nitrogen)	mg/L	36	54
NO_2-N (nitrite nitrogen)	mg/L	0.06	0.22
NO_3-N (nitrate nitrogen)	mg/L	0.01	0.02
sTKN (soluble total Kjeldahl nitrogen)	mg/L	40	60
TN (total nitrogen)	mg/L	46	64
TP (total phosphorus)	mg/L	6.6	8.4
Alkalinity	$mgCaCO_3/L$	225	270
Faecal coliforms	cfu/100mL	5,000,000	7,500,000
Enterococci	cfu/100mL	500,000	1,000,000
Ratio of TSS (total suspended solids) / VSS (volatile suspended solids) ratio		92%	88%
Ratio of COD (carbonaceous oxygen demand) / BOD_5 (five-day biological oxygen demand)		2.6	2.5
Ratio of sCOD (soluble carbonaceous oxygen demand) / COD		51%	60%
Ratio of $sBOD_5$ (five-day biological oxygen demand) / BOD_5		56%	60%
Ratio of sTKN (soluble total Kjeldahl nitrogen) / TN (total nitrogen)		87%	94%
Ratio of Amm-N (ammoniacal nitrogen) / TN		78%	84%

2.3.1 Design Treated Wastewater Quality

A key requirement for the Akaroa wastewater scheme is that the quality of treated wastewater is adjusted to meet the assimilative capacity of the receiving environment. In the initial phase of scheme development, Akaroa Harbour was the proposed receiving environment. The treatment plant design considered a number of factors including:

- The Council's 2011 resolution to produce the "best quality wastewater available"
- Specification of a membrane treatment, which removes suspended solids and BOD to very low levels
- A nitrogen standard that at least met the nitrogen removal performance of the existing treatment plant, which discharges to Akaroa Harbour, and would also avoid or minimise any cumulative nutrient effects on Akaroa Harbour waters

The decline of the harbour discharge consent application and pursuit of land disposal and reuse based alternatives has spurred an assessment of the assimilative capacity of these alternative pathways. The assimilative capacity of pasture is different from native trees. Pasture has higher assimilative capacity as the pasture is either “cut and carried” or consumed by stock. By either process the applied nutrients are removed from the soil and pasture system. Refer also to Professor Brett Robinsons reports on application of treated wastewater to pasture and native plantings in Banks Peninsula in Appendix C.

In the case of native trees the nutrients uptake diminishes as the trees mature. Nutrients are not substantially reduced within the arboreal system unless the trees are regularly trimmed and the trimmings taken away. Further discussion on this topic is provided in Section 4.2. Working back from the receiving environment, the wastewater quality was determined for irrigation to native trees, balancing nutrient load on the land with the amount of nutrients needed to facilitate tree growth. The was found to be approximately the same as the wastewater quality previously determined for a harbour discharge, so the same quality limits were adopted for both harbour discharge and irrigation to native trees. The proposed wastewater quality is set out in Table 2-6.

Table 2-6 Proposed Wastewater Quality Standards

Wastewater Quality Parameter		Proposed Average Summer Treated Wastewater Quality – Harbour Discharge and Irrigation of Native Plantings
Total suspended solids	mg/L	2
Carbonaceous BOD_5	mg/L	5
Ammonia nitrogen	mg/L	1 (5[1])
Total nitrogen	mg/L	15 (30[1])
Total phosphorus	mg/L	7
E. coli	cfu/100mL	10
Enterococci	cfu/100mL	10

Note 1. Short term peak from 26 December to 5 January each year

For more information about the wastewater treatment plant, please refer to Section 9.2.

3 Longlist Options

3.1 Overview

A wide range of alternatives to a harbour outfall have been considered over the five-year period of investigations from 2015 to 2020. The process of longlisting and then producing a shortlist for further evaluation typically involves a number of steps; starting with preparing a list of all potentially feasible options, then establishing criteria for initial screening, then taking a shortlist forward to the next stage of investigation where options with initially favourable attributes are studied in more detail.

In the case of the Akaroa Wastewater Scheme the longlist to shortlist process has not been done in a single step, as the needs of the project have evolved over the course of the investigation. The longlist started with attempting to identify solutions that would primarily address cultural concerns of Ngāi Tahu. The driver for this approach was a direction from the hearing commissioner to the 2015 application for consent for harbour discharge that cultural impacts associated with the discharge, and alternatives that would address such impacts, were not adequately considered.

The initial longlisting and screening process identified a range of options, generally involving beneficial reuse of wastewater by application to land, that have been carried through into the preferred land-based schemes as set out in this report. Additional options were identified by various stakeholder throughout the project evolution, generally in response to constraints and barriers that have emerged through the option development process. The overall chronology of longlisting and shortlisting is set out below.

Throughout this process the harbour discharge option has been retained as a baseline option for comparison.

3.2 Initial Longlist Screening in 2015

In July 2015, in response to Environment Canterbury declining the Council application for consent to discharge to Akaroa Harbour via an outfall, Council initiated an investigation into alternatives for disposal and reuse of Akaroa treated wastewater other than discharging via a new harbour outfall.

The first step in this work was to develop a long list of 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 baseline of a harbour outfall option 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 earlier resource consent application. The options listed relate to methods of disposal of the treated wastewater from the proposed new wastewater treatment plant.

Table 3-1 Longlist Options Initially Assessed in 2015

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)

An initial semi-qualitative evaluation of the options was undertaken by Council staff and Beca, with inputs from the Ngāi Tahu parties, on the listed options using selected criteria. For each criterion the option was given a ranking from best to worst using a three-point scale.

The evaluation criteria and rating scales are shown in Table 3-2.

Table 3-2 Shortlisting Evaluation Criteria and Rating Scale from 2015

Criteria	Best (Score = 3)	Neutral/Medium (Score =2)	Worst (Score = 1)
Cultural acceptance	Favourable	Moderately favourable	Unfavourable
Cost	Less than outfall cost	Approximately same as outfall cost	Greater than outfall cost
Land availability	Suitable, publicly available land within 2km	Suitable land within 2km. Requires land acquisition	No suitable land within 2km
Timeliness	Complete by June 2020 (as for outfall option)	Complete between June 2020 and June 2022	Complete after June 2022
Environmental Impact	Positive or no effects on the environment	Minor adverse effects on environment	Significant adverse effects on environment
Social Acceptance	Community likely to support	Mixed response from community	Community likely to oppose
Public Health	Low risk for shellfish collection and recreational contact	Occasional shellfish collection or public health risks	Significant shellfish collection and/or public health risks

Longlist options were evaluated against the criteria. These criteria were selected by Council staff with input from Beca technical and planning specialists. The purpose of establishing criteria for selection of options for further investigation, taking into account the four well-beings referred to in Sections 10,14 and 101 of the Local Government Act 2002 (The LGA), was to avoid any possibility of predetermining the outcome of the investigation process. The criteria reflect specific aspects of the four LGA well-beings.

For each criterion the option was categorised as either favourable (green), moderately favourable (orange), or unfavourable (red). The evaluation criteria and summary scores are shown in Table 3-3.

Table 3-3 Summary of Options Comparison

Scheme Option	Sub-option	Assessment Factor							
		Cultural Acceptance	Cost	Land Availability	Timeliness	Environmental Impact	Social Acceptance	Public Health	Score
Outfall	A1 - Discharge to outfall	1	2	3	3	3	3	3	**18**
	A2 –Rakahore chamber to outfall	2	2	3	3	3	3	3	**19**
No outfall	B1 - Irrigation to land	3	3	2	2	3	2	3	**16**
	B2 – Passage through land	3	3	2	2	3	2	3	**18**
	B3 – Non-potable reuse	2	2	3	2	3	2	2	**15**
	B4 – Potable reuse	1	1	3	1	3	1	3	**13**
Coastal waters or outfall	C1 – Wetland to coastal waters	3	3	2	2	2	2	2	**15**
	C1 – Wetland to harbour outfall	3	3	2	2	3	3	3	**17**
	C2 – Overland flow to coastal waters	3	3	2	2	2	2	2	**16**
	C2 – Overland flow to harbour outfall	3	3	2	2	3	3	3	**17**
Other	D1 – Tanker to CWTP	2	2	3	3	1	2	3	**15**
	D2 - Pump to CWTP	2	2	2	2	1	2	3	**13**

The Council Infrastructure Transport and Environment (ITE) Committee undertook a preliminary consideration of the options ranking 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.

Council presented these options and the initial evaluation 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.

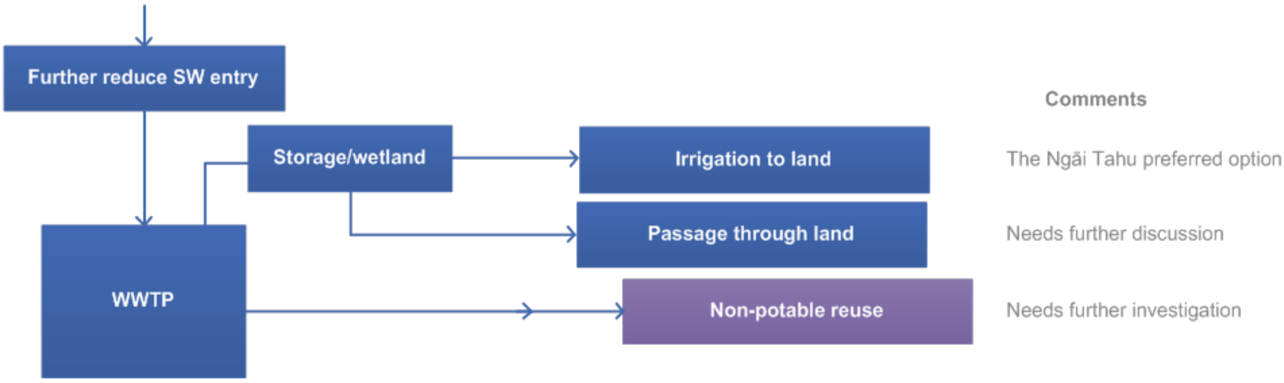


Figure 3-1 Ngāi Tahu Preferred Pathways for Wastewater Disposal at Akaroa

3.2.1 Options Not Initially Progressed

The following options from Table 3.1 were not preferred based on feedback from the Council ITE Committee and/or the Ngāi Tahu parties and so were not progressed through to the next stage of design. The basis for this selection is set out below.

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 by the Council ITE Committee that it would not be publicly 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.

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. 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.

Council staff considered that this option was unsuitable due to cultural concerns identified by the Ngāi Tahu parties within the context of the direction provided by the Environment Court. Therefore, this option was not progressed.

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 discharged directly into a local waterway or coastal marine environment.

Council staff considered that this option was unsuitable due to cultural concerns identified by the Ngāi Tahu parties within the context of the direction provided by the Environment Court. Therefore, this option was not progressed.

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. The additional wastewater load would be unlikely to have a significant impact on CWTP in terms of treatment performance.

The option would have potential for odour nuisance from the storage of raw wastewater at Akaroa and the possibility of raw wastewater spills in the tanker loading area.

At the time of consideration there was an assumed average flow of 230 cubic metres per day, which has since proven to be a significant underestimate. Assuming a typical tanker volume of 12 cubic metres, approximately 20 tanker loads per day would be needed. This would require four tankers performing five loads a day each (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. Early estimates considered this to be, operationally, a very expensive option. This option would also have a negative environmental effect due to emissions from the vehicles and would have a negative impact on the traffic flows in and around Akaroa, particularly during the peak tourist season.

For these reasons Council staff determined not to progress this option.

Pumping Wastewater to Christchurch Wastewater Treatment Plant

Under this scenario 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 main roadway were to be followed. Alternatively a 50km pipeline with a crossing under Lyttelton Harbour was considered. In both cases multiple pump stations would be needed to pump the flow to the Christchurch network.

Due to the length of time the raw wastewater would spend in the pipeline and undergoing anaerobic processes there is significant potential for septicity causing corrosion and odour nuisances at 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 were considered by Council staff 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 Council staff determined that this option should not be progressed.

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. After treatment via the Rakahore chamber, the water would be released via the outfall at the harbour mid-point.

The Ngāi Tahu parties do not consider a harbour outfall in any form a culturally acceptable option and so this option was not progressed any further.

Discharge to Harbour Outfall (as per consent application)

This option involves a 2.5 km long harbour outfall as per the current consent application. 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 the harbour outfall option 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 was also supported by some sectors of the community based on the small number of submissions received during the 2015 hearing process and early 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 was the basis of the Council's consent application (at that time) this option was retained as the baseline with which to compare the other shortlisted options as the investigation progressed.

Discharge to Ocean Beyond the Akaroa Harbour Mouth

This option would involve laying a marine pipeline from Akaroa to the harbour heads, allowing an ocean outfall to be created. The marine pipeline would be approximately 11km long near the heads and descend to a depth of 40m.

This option was considered prohibitively expensive by Council staff due to the technical risks and the total distance.

3.3 Shortlisted Options in October 2015

In parallel with the concept options review by the Council ITE Committee, and in response to Environment Court mediation action involving Council and Ngāi Tahu, the Ngāi Tahu parties were engaged in several hui and site walkovers over a three-month period in 2015. This culminated in a hui with the Ngāi Tahu parties on 21st October 2015 at which the following options shortlist was agreed:

- 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.

3.4 Developed Shortlist January 2016

Through a collaborative process involving the Ngāi Tahu parties and Council, the project team took the shortlisted options from October 2015 and developed these into specific schemes with consideration of possible irrigable land. The developed shortlist was documented in a draft report issued 29th January 2016. An outline of the report options is provided below. The requirements for land area and storage noted were based on the understanding of wastewater flows at that time, and so differ from the current scheme requirements presented later in this report.

Option 1 – Year Round Irrigation to Trees

This year-round irrigation option was 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 5 m buffer zones giving a total land requirement of 28.2 ha. Suitable land areas were 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.

Option 2 – Year Round Irrigation to Pasture

This year-round irrigation option was based on 37 ha of land in pasture with K-line spray irrigators and a further 2.5 ha for storage. The same land that would be suitable for irrigation to trees would be suitable for irrigation to pasture. The scheme incorporated the consented 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 would be no discharge of wastewater to the harbour for this option.

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 (i.e. to the harbour). The scheme also incorporated 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

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. Retention time in the wetland is at least 2 days in summer and 3 days in winter. Land could be obtained from a single landowner. 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.

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.

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 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.

3.5 Refinement of Shortlist in March 2016

A hui with the Ngāi Tahu parties was held on 2nd of March 2016. The investigative work by Council and Beca was presented and discussed. Ngāi Tahu provided a clear response that options 3, 4 and 5 as outlined above were culturally unacceptable. Key issues for Ngāi Tahu were:

Options 3 and 4 (Subsurface Wetland and Infiltration Basin)

- In the case of a subsurface wetland and infiltration basin, wastewater still ends up in the harbour, so if we are true to cultural values then these options could not be supported by Ngāi Tahu.
- Wastewater does not go through a natural process through the land. These options use the materials of Papatūānuku but are imperviously lined (possibly with a synthetic material) and are a constructed process rather than natural. There is less mixing opportunity than for the harbour outfall and there is a reluctance to move the discharge from Onuku to somewhere else where it would be someone else's problem but with the same issues.

Option 2 (Summer Only Irrigation Plus Subsurface Wetland or Infiltration Basin)

- Similar concerns to Options 3 and 4.

Based on the feedback from the Hui on 2nd March 2016, subsurface wetland and infiltration options were eliminated from further consideration. The option of summer only irrigation combined with wetland and/or infiltration basin was also eliminated following the same logic.

3.5.1 Refined Shortlist

The refined shortlist that was taken forward from the March 2016 Hui was as follows:

- Year-round irrigation to trees
- Year-round irrigation to pasture
- Non-potable reuse as a complementary feature of year-round irrigation to pasture or trees

Discharge to Akaroa Harbour continued to be retained as a baseline option for comparison with land-based schemes.

3.6 March 2016 to March 2017

The refined shortlist of options of year round irrigation were moved forward between 2016 and 2017 to identify suitable sites, followed by site specific investigations to confirm they were technically appropriate.

A short list of suitable sites was then issued for public consultation in March 2017.

3.7 Design Basis Change Due to Flowmeter Error

In early 2017 a comparison by Beca of potable water inflows to Akaroa against wastewater outflows suggested discrepancies with the flow monitoring data collected at the Akaroa Wastewater Treatment Plant. Council staff investigated this issue and determined that the flow meter being used was faulty. New flow meters were installed, and the new flow data indicated that actual flows were more than twice the previously reported flows. The flow error, and implications for the scheme, were reported to Ngāi Tahu at a hui on 2nd of August 2017, and also to the Akaroa Wastewater Working Party on 20th November 2017.

With the increase in total wastewater volume, more land would be needed for a land-irrigation scheme not envisaged by previous investigations. This led to a new round of investigations and initiatives to find new areas of land beyond Takamatua Valley.

3.8 Deep Bore Injection

In light of the increased flows and challenges around land disposal a new option considered was deep bore injection as a potential pathway for disposal of Akaroa wastewater that could be acceptable to Ngāi Tahu. The Council conducted a drilling investigation near the site of the proposed wastewater treatment plant to assess the feasibility of deep bore injection.

A number of sites to investigate were considered in consultation with the community working party and known geotechnical factors taken into account, as well as proximity to public water supply sources. A site on the hill between Akaroa and Takamatua near the planned WWTP was considered an appropriate investigation location and two trials bores were drilled and flow tested.

The Beca interpretive report on the investigation, dated 21st December 2018 (refer Appendix E), found that deep bore injection at the proposed wastewater treatment plant site was not feasible Due to the lack of open connected fractures and low permeability ground conditions, the exfiltration bore capacity was very low and not feasible for deep bore injection.

Based on the results of the deep bore drilling investigation, and the considerable cost of conducting further investigations at other sites with no indication of likely success, a decision was taken by Council staff to discontinue bore injection as a possible wastewater disposal option.

3.9 Managed Aquifer Recharge

In 2019, the Akaroa Treated Wastewater Reuse Options Working Party asked that managed aquifer recharge (MAR) be investigated. This is similar to deep bore injection, except that the injection of the treated wastewater into the ground is for some sort of beneficial use (e.g. adding water to an aquifer for potable use, increasing stream flows, holding back saline intrusion of groundwater).

Council commissioned a review of possible applications of Managed Aquifer Recharge (MAR) for Akaroa by WGA (see Appendix F for a copy) and Beca independently undertook a review of the applicability of MAR (see Appendix F for a copy).

Whilst the work identified a potential to inject highly treated wastewater into a groundwater under Akaroa, Council staff determined that potential connectivity between the groundwater injection and groundwater abstraction for potable supply, presented a significant risk to water supply security in Akaroa, and determined that the option should not be considered further. (see Appendix F for a copy of the staff letter outlining the staff position)

3.10 Combined Duvauchelle – Akaroa Wastewater Scheme

While investigations into Akaroa wastewater management developed, a similar investigation has also been underway at Duvauchelle. An assessment was undertaken to determine if there were any potential benefits in combining the Akaroa and Duvauchelle wastewater schemes. This has been reported on in a Beca letter dated 13th July 2020 (refer to Appendix D). This assessment assumes that Duvauchelle wastewater will be spray irrigated onto the Akaroa Golf Course land for most of the year, with winter flows treated in a wetland prior to discharge to Pawsons Stream. A summary of possible combined land-based scheme options is presented in Table 3-4.

Table 3-4 Akaroa and Duvauchelle Combined Wastewater Scheme Options

Scheme	Baseline Scheme Option	Combined Scheme Option
Inner Bays	Akaroa wastewater irrigated to land at Robinsons Bay, and other small parcels of land. Storage at Robinsons Bay. Treated wastewater discharge to Children's Bay Stream via a wetland for a 1:5 year rainfall event. Duvauchelle wastewater irrigated at Akaroa Golf Course and discharged to surface waters (Pawsons Stream) via wetland in winter. Storage on the golf course.	Schemes interconnected via pump station and pipeline from Robinsons Bay to Duvauchelle. Required irrigation land area is unchanged. Minor volumes of Akaroa wastewater may be irrigated to Akaroa Golf Course in summer to supplement Duvauchelle wastewater irrigation. Akaroa wastewater unlikely to be able to discharge to Pawsons Stream in winter due to limited assimilative capacity. Hence no reduction in storage in Robinsons Bay likely to be achieved.
Outer Bays	Akaroa wastewater irrigated at Pompeys or Goughs. Storage at the site of irrigation. Duvauchelle wastewater irrigated at Akaroa Golf Course and discharged to land via wetland in winter. Storage at Duvauchelle.	Schemes interconnected via pump station and pipeline from Duvauchelle to Akaroa. Combined wastewater pumped from Akaroa to Outer Bays and irrigated onto native vegetation. Storage at site of irrigation.

The work found that, for the inner bays scheme there was no useful reduction in storage or the required irrigation area for the Akaroa scheme. For an outer bays combined scheme, combined costs are likely to be significantly higher cost than for two separate schemes. There were no clear synergies or efficiencies to be gained by combining Akaroa and Duvauchelle in a combined inner bays scheme.

Council staff determined that with no clear benefits in combining the schemes this option would be discontinued.

3.11 Summary Options Longlist

The summary assessment of longlist options is set out in Table 3-5. The criteria shown in the table represent all of the criteria that have been adopted throughout the investigation, by Council staff and Beca technical specialists, to reach the conclusions. Where the performance of a given option against any criteria has not been established this is reported as “unknown”. For example, not every longlist option has been tested with the community, and so for these options the social acceptability is simply stated as “unknown”.

It should be noted that no weighting has been applied to the different criteria in Table 3-5.

Table 3-5 Summary Assessment of Longlist Options

Scheme Option	Cultural effects	Capital cost	Operational cost	Consentability	Social acceptance	Environmental effects	Public health risk	Technical feasibility	Shortlisted
Discharge via rakahore chamber to mid-harbour outfall					unknown				No
Deep bore injection					unknown	unknown			No
Managed aquifer recharge					unknown	unknown			No
Year round irrigation to land									Yes
Year round irrigation to land (occasional peak rainfall events go to harbour via subsurface wetland)									Yes
Summer irrigation with discharge to harbour via infiltration gallery in winter						unknown			No
Summer irrigation with discharge to harbour in winter									No
Potable reuse									No
Non-potable reuse									Yes, but not a standalone option
Wetland treatment with 2 day retention time and discharge						unknown	unknown		No

Scheme Option	Cultural effects	Capital cost	Operational cost	Consentability	Social acceptance	Environmental effects	Public health risk	Technical feasibility	Shortlisted
to mid-harbour outfall									
Overland flow to harbour					unknown	unknown	unknown		No
Overland flow to coastal waters at Eastern Bays					unknown	unknown	unknown		No
Tankering wastewater to Christchurch Wastewater Treatment Plant				N/A	unknown				No
Pumping wastewater to Christchurch for treatment and disposal				N/A	unknown				No
Discharge to mid-harbour via outfall									Yes
Discharge sea at Eastern Bays via outfall					unknown	unknown			No
Discharge to sea at the heads of Akaroa Harbour via outfall					unknown	unknown			No
Combined Duvauchelle and Akaroa land-based scheme									No

A commentary on the longlisting presented in Table 3-5 is as follows:

- Discharge to Akaroa Harbour via a rakahore chamber – rejected due to significant cultural effects as the rakahore chamber would provide no further treatment before discharge to the harbour
- Deep bore injection – rejected as not technically feasible, after drilling investigations near the new treatment plant site found the volcanic rock to have very low permeability (see section 3.8 for more explanation and Appendix E for factual and interpretive reports on deep bore injection investigations)
- Managed aquifer recharge – rejected as it would pose too great a risk to the potable water supply for Akaroa, significant cultural effects due to the mixing of treated wastewater with groundwater (see section 3.9 and Appendix F for further details)
- Summer irrigation with discharge to harbour via infiltration gallery in winter – rejected due to significant cultural effects of the direct discharge of treated wastewater to harbour, not supported by the community in public consultation in 2016
- Summer irrigation with discharge to Akaroa Harbour – rejected due to significant cultural effects of the direct discharge of treated wastewater to harbour, not supported by the community in public consultation in 2016
- Potable reuse – not culturally acceptable and based on experience elsewhere is likely to receive a mixed response from the community, although this idea has not been formally tested with the community. Approvals from Ministry of Health would be unlikely to be granted (see Appendix G for communications from the Canterbury District Health Board on this matter).
- Wetland treatment with short retention time and discharge to mid-harbour outfall – rejected due to the short retention time in the wetland not providing sufficient treatment to address the cultural effects, not supported by the community in public consultation in 2016
- Overland flow to harbour – rejected due to overland flow not providing sufficient treatment to address the cultural effects, technically challenging due to topography and erodible soils
- Overland flow to coastal waters at Eastern Bays – rejected due to significant cultural effects of moving water from one takiwā to another, technically challenging due to topography and erodible soils
- Tankering wastewater to Christchurch wastewater treatment plant – rejected due to negative social and environmental impacts from significant truck movements, technically challenging with high operational costs
- Pumping wastewater to Christchurch wastewater treatment plant – rejected due to problems with odour and septicity of wastewater due to long retention times, negative social and environmental impacts, technically challenging and prohibitively expensive
- Discharge to sea at Eastern Bays via outfall – rejected due to significant cultural effects of a direct discharge of treated wastewater to water, not cost-effective compared to a mid-harbour outfall
- Discharge to sea to the heads of Akaroa Harbour via outfall – rejected due to significant cultural effects of a direct discharge of treated wastewater to water, prohibitively expensive and technically challenging to construct

3.12 Final Longlist Options

The finalised longlist of options at December 2019 was as follows:

1. A mid-harbour outfall similar to that applied for in 2015 (though with further improvement to water quality through no wet weather bypassing of the WWTP)

2. Year round irrigation to land with occasional peak rainfall events going to harbour via subsurface wetland.

3. Year round irrigation to land with no harbour discharge

4. Non-potable reuse as a complementary feature of other options.

4 Irrigation to Land Options

4.1 Selection Criteria for Irrigable Land

Potential sites for irrigation and wastewater storage outlined in this report were selected using a GIS (geographical information system) model that was developed by CH2M Beca in 2017. Due to the important role that GIS-based site selection has played in the identification of potential irrigation and storage sites for the Akaroa wastewater scheme, the applicable GIS criteria are summarised in Table 4-1 and Table 4-2.

Two types of irrigation were looked at – spray irrigation to pasture using either K-line spray head or fixed pole mounted spray heads, or dripper irrigation to trees. In the case of pasture, spray irrigation is the most cost-effective irrigation method, but drip irrigation would also be possible. K-line or fixed type irrigation is most likely to be used for pasture due to the shape of the areas that are suitable for irrigation. Dripper irrigation has been adopted as the preferred irrigation type for irrigation of native trees. These two types of irrigation are shown in Figure 4-1 and Figure 4-2.

Figure 4-1 K-line spray irrigation of reclaimed water to pasture at Blenheim

Figure 4-2 Drip irrigation of reclaimed water to trees at Wainui

Figure 4-2 shows what the dripper lines may look like when first installed, over time the lines will naturally become covered by leaf litter and will be less visible. The dripper lines are not visible from afar.

Table 4-1 Pasture Irrigation Site Selection Criteria (Spray Application)

Selection Criteria	K-Line spray irrigation option	Basis for Criteria Selection
Land Stability	In accordance with Process Design Manual for Land Treatment of Municipal Wastewater (USEPA, 2011); Exclude land with slope of greater than 15 degrees for irrigation area Exclude land with slope of greater than 15 degrees for land downslope to coastline Exclude land with identified instability within or downhill of area Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	To minimise risk of land instability resulting from irrigation
Minimum land parcel	2 ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	Tonkin & Taylor (T&T) erosion zones excluded (refer to Appendix H for T&T slope hazard maps)	To minimise risk of land instability resulting from irrigation
Residential setback	Exclude residential zone land parcels. In addition, potentially irrigable land within 25 m of any adjacent land ownership area	It is assumed that rural dwellings require a complying on-site wastewater system. The Canterbury Land and Water Regional

Selection Criteria	K-Line spray irrigation option	Basis for Criteria Selection
	has been excluded. For any potentially irrigable property parcel containing a dwelling, 1 ha of land has also been subtracted to allow for the dwelling and land for onsite wastewater disposal	Plan Rule 5.8 requires a 4 ha site for onsite wastewater disposal as a permitted activity. However, subject to resource consent, this land area could be reduced to 1 ha providing the on-site wastewater system complies with AS/NZS1547:2012.
Stream setback	25 m to centreline of continuous flowing streams. 10 m setback to ephemeral streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25 m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.
Landscape effects setback	Exclude land identified as High Natural Character or Outstanding Natural Landscape in the District plan, plus a 50 metre buffer zone	To avoid possible negative landscape effects

Table 4-2 Tree Irrigation Site Selection Criteria (Dripper Application)

Selection Criteria	Dripper Irrigation Option	Basis for Criteria Selection
Land Stability	In accordance with Process Design Manual for Land Treatment of Municipal Wastewater (USEPA, 2011): Exclude land with slope of greater than 19 degrees for irrigation area Exclude land with slope of greater than 15 degrees for land downslope to coastline Exclude land with no identified instability within or downhill of area Exclude land that, if it became unstable, could pose risk to downslope residences and infrastructure	To minimise risk of land instability resulting from irrigation.
Minimum land parcel	1 ha	To exclude plots that are too small to contribute significant irrigable area
Erosion zones	T&T map erosion zones excluded	To minimise risk of land instability resulting from irrigation
Residential setback	Exclude residential zone land parcels. In addition, potentially irrigable land within 5 m of any adjacent land ownership area has been excluded For any potentially irrigable property parcel containing a dwelling, 1 ha of land has also been subtracted to allow for the dwelling, ancillary buildings and the land needed for onsite wastewater disposal in compliance with the AS/NZS1547:2012	Subject to resource consent, the minimum land area of 1 ha has been calculated based on a 3,000 m^2 irrigation field area for a rural residence plus a 3,000 m^2 reserve area. Allowing for house site, driveway, and outbuildings the minimum site has been set at 1ha. A 5 m buffer around the 1 ha is also provided.

Selection Criteria	Dripper Irrigation Option	Basis for Criteria Selection
Stream setback	25 m to centreline of continuous flowing streams. 10 m to centreline of ephemeral streams	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into surface water courses.
Coastline setback	25 m	To minimise the potential for nutrients in irrigated wastewater to migrate through shallow groundwater into coastal waters.
Landscape effects setback	Exclude land identified as High Natural Character or Outstanding Natural Landscape in the District plan, plus a 50 metre buffer zone	To avoid possible negative landscape effects

4.2 Design Basis for Land Irrigation

PDP has developed an irrigation model to calculate the required area for irrigation of wastewater to land, and the associated storage pond volume, for the Akaroa scheme. An overview of the model is described in Appendix B. As noted in Section 2.2, a conventional wastewater network model is not capable of accommodating varying population and the impact of this on wastewater flows. Akaroa population varies considerably between weekdays, weekends and holiday periods.

To overcome this problem, the two contributions to wastewater flow – groundwater and stormwater entering the wastewater network (drainage derived flow), and the contribution from people (population derived flow) were calculated in two separate models and then added together in a combined flow model for the purposes of calculating irrigation land area.

4.2.1 Population-derived Flow

Figure 4-3 shows the current and future (2052) population derived flow over the year based on the population data presented in Table 2-1.

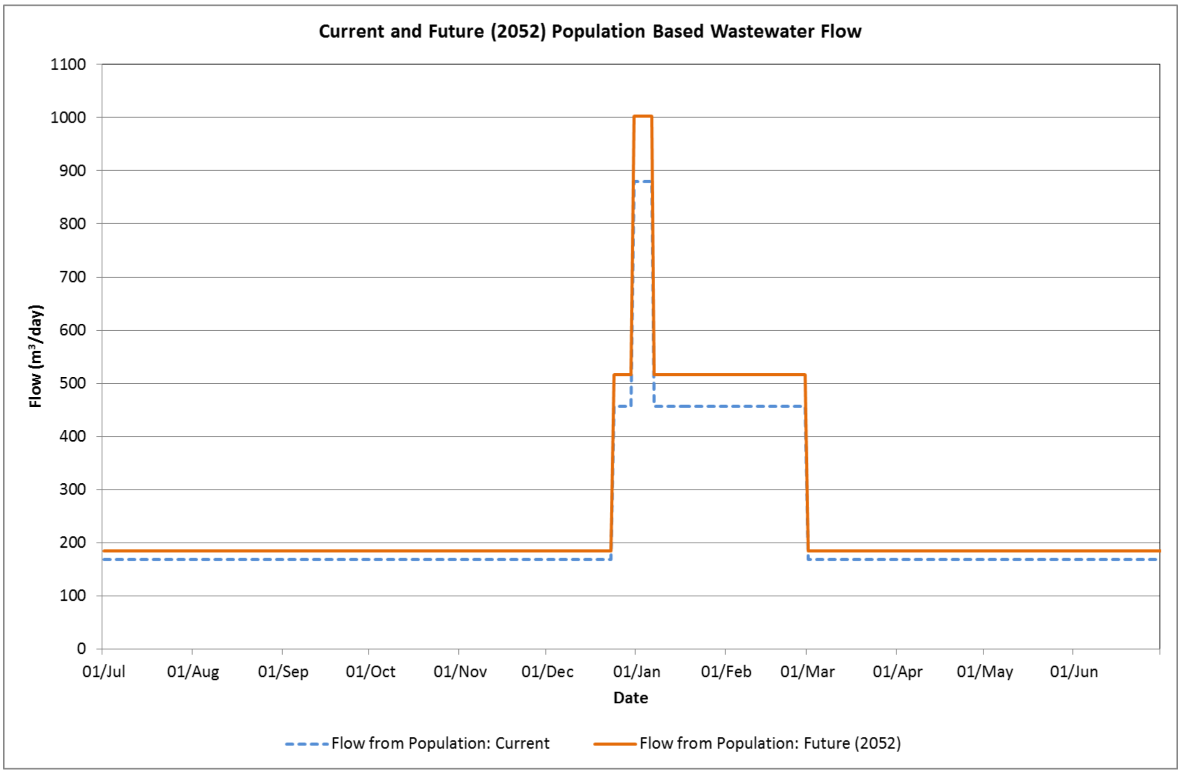


Figure 4-3: Current and Future (2052) Population Based Flow

4.2.2 Drainage-derived Flow

The drainage derived flows were calculated using a separate model. This model uses a linear trendline to relate rainfall to inflow and infiltration (I&I). The resulting trendline relationship was then applied to a long term rainfall record (from NIWA virtual climate station network (VCSN) station 20249) to calculate inflow and infiltration (I&I) for each rainfall event from 1972 to 2018. The VCSN record was developed by NIWA using interpolation of surrounding weather stations to develop a consistent long-term record. The VCSN data includes adjustments for altitude. PDP has reviewed some of the rainfall records available and the VCSN data is consistent with those rainfall records with adjustments for altitude.

As noted in Section 2.2 I&I contributes a large portion of the total flow. The effect of reducing the total flow through reducing population-based flow (through water conservation) and reducing I&I has been assessed. The model has been run with various percentage reductions. Using upper Robinsons Bay as the example site, typical results to show the potential effect of I&I reduction are presented in Table 4-3. Full detail of the analysis is given in Appendix B. As outlined in Section 2.2.1 a design basis of 20% I&I reduction has been assumed for design of land irrigation schemes.

Table 4-3 Effect of I&I Reduction on Irrigation Storage Volume

Reduction in I&I	Maximum Storage Volume Required (m³) for Corresponding Irrigation Area		
	30 ha	40 ha	60 ha
0%	463,000	36,000	21,000
20%	40,000	24,000	16,000
40%	21,000	14,000	12,000
60%	10,000	9,000	9,000

The model assumes that the maximum capacity of the WWTP is 1,200 m^3/day. Any flow in excess of this is diverted to an untreated wastewater storage pond, before passing through the WWTP once capacity becomes available. After the WWTP, flow is either irrigated or diverted to treated wastewater storage.

4.2.3 Irrigation of Native Trees via Dripper Irrigation

For irrigation to native trees, drip irrigation is assumed with the wastewater applied to the land irrespective of soil moisture conditions. The following key assumptions were made based on field assessments where available, and soil mapping and descriptions including information from the DSIR Soil Maps of the South Island (1967) and on Canterbury Maps. Refer to Appendix B for further detail on the parameters and numbers used:

Irrigation demand threshold:	Irrigation occurs regardless of the plant available water (P[2]AW), even if PAW is at field capacity
Extreme rainfall cut-off:	If rainfall > 50 mm/day then irrigation ceases
Irrigation season:	All year round
Irrigation efficiency:	100% efficiency
Maximum irrigation application (mm/day):	Dec–Feb: 2.75 mm/day
	Mar–May 2.15 mm/day
	Sep–Nov: 2.15 mm/day
	Jun–Aug: 1.5 mm/day

The maximum irrigation application per day is less than the Long-Term Acceptance Rate of the soils and is selected to avoid surface ponding when the PAW is at field capacity. The LTAR is based on field testing and soil descriptions as given in the infiltration testing results in Appendix L, Appendix Y and Appendix Z.

4.2.4 Irrigation of Pasture via Impact Sprinkler

For irrigation to pasture it was assumed that impact sprinklers (such as K-line or fixed pole mounted sprinklers) would be used and the wastewater would be applied to the land based on a soil moisture balance (i.e. Irrigation is only applied when the soil moisture content is assessed to be less than the maximum Plant Available Water). The following key assumptions were made based on field assessments where available, and soil mapping and descriptions including information from the DSIR Soil Maps of the South Island (1967) and on Canterbury Maps. Refer to Appendix B for further detail on the parameters and numbers used:

Irrigation Demand Threshold:	Irrigation based on daily soil moisture balance up to a maximum Profile Available Water
Irrigation Season:	All year round, Dec to Mar for south facing land (15.3 ha) at Goughs Bay

[2] Plant Available Water (PAW) is the available water for plant uptake in the soil profile over the fixed rooting depth. This is different from the total water holding capacity of the soil, which is typically greater but the water held in the layer below the rooting zone will not be lost to evapotranspiration but will slowly drain out by gravity.

Maximum irrigation application rate: 7 mm/day

Irrigation Efficiency: 85% efficiency

Soils and Rainfall

The following soils and rainfall parameters have been assumed for the irrigation areas:

Soil Profile Available Water (PAW)

Goughs Bay	Pasture: 36 mm
Robinsons Bay	Pasture: 48 mm, Trees: 85 mm
Pompeys Pillar	Pasture: 48 mm
Rainfall	
Goughs Bay	NIWA VCSN 20379 and Long Bay Road AWS
Robinsons Bay	NIWA VCSN 20249 and Akaroa EWS
Pompeys Pillar	NIWA VCSN 20380

The full methodology for this assessment is outlined in Appendix B. The irrigable land areas and storage volumes required are described in the individual sections related to each option.

4.2.5 Phosphorous Uptake by Trees

Phosphorus uptake by mature New Zealand native vegetation is not well understood. An assessment by Professor Brett Robinson, from the School of Physical and Chemical Sciences, University of Canterbury, for two local soils referred to as Pawson Silt Loam (PSL) and Barry's Soil (BSL) concluded that irrigation of treated wastewater onto NZ native vegetation at specified applications rates would have the following impacts (refer to Appendix C for the full report):

- Total average phosphorus concentrations in the top 300 mm of soil would remain within the range of total phosphorus concentrations found in New Zealand's agricultural soils
- Olsen-P (a measure of plant-available phosphorus) would significantly increase in both soils but still remain within ranges considered optimal for a high-fertility soil (the PSL), and within a low-fertility soil (BSL)
- Phosphorus leaching below the top 300 mm of topsoil would increase. However, most of this phosphorus would be retained in the subsoil before it reaches waterways. Given that New Zealand native vegetation would decrease surface runoff and soil loss, the increase in phosphorus leaching would be more than offset by the reduction of phosphorus entering waterways through erosion and overland flow: There is likely to be less phosphorus lost by irrigation of treated wastewater to New Zealand native vegetation than an intensively grazed pasture.

This assessment was based on a range of phosphorus in the treated wastewater from 5 to 15 mg/L. The predicted average phosphorus in the Akaroa treated wastewater is 7 mg/L based on a typical average influent of 6.6 mg/L and a peak summer concentration of 8.4 mg/L.

Based on this assessment and the proposed treated wastewater quality, no phosphorous removal is proposed at the WWTP for the irrigation to trees option.

4.2.6 Nitrogen Loading for Irrigation to Pasture

As discussed in Section 2.3, for irrigation of treated wastewater to pasture, no nitrogen removal at the treatment plant is proposed. For a WWTP with BOD removal only the predicted nitrogen in the treated wastewater is 34 mg/L. At this effluent concentration the nitrogen loading rates for various irrigation areas are given in Figure 4-4. The standard nitrogen loading rate for pasture used for beef cattle is 150 kg/ha/yr. Professor Brett Robinson showed that loading rates between 125 - 172 kg/ha/year will result in negligible (<2 kg/ha/year) nitrogen leaching for cut-and-carry pasture.

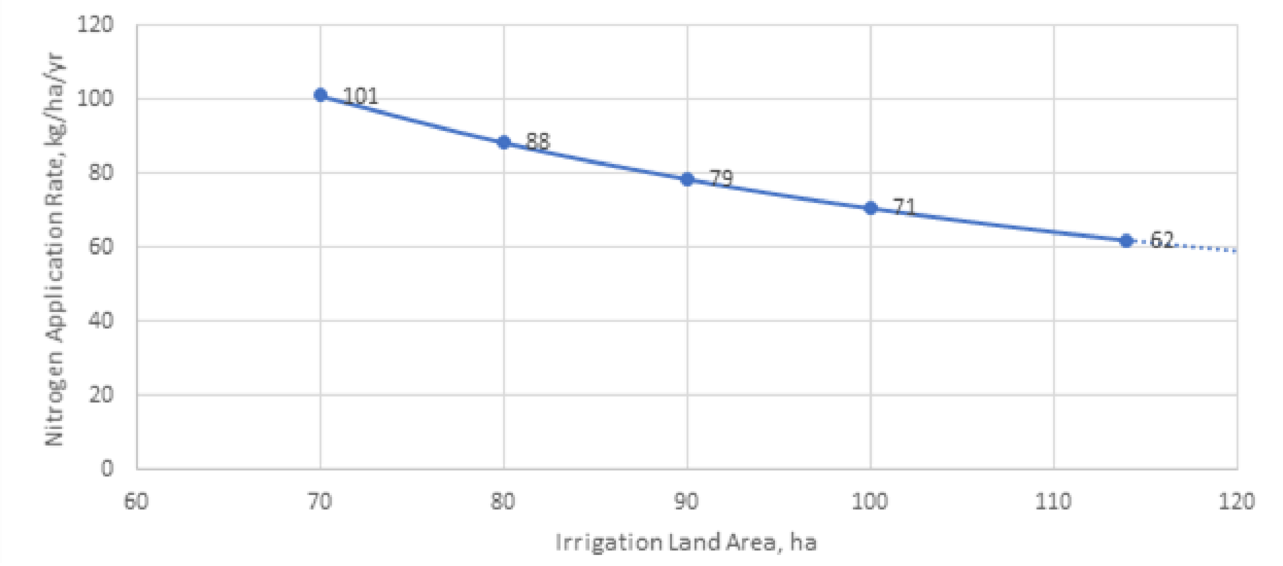


Figure 4-4 Relationship between Nitrogen Loading Rate and Irrigation Land Area

4.2.7 Preferred Means of Land Irrigation

After assessing the different modelled scenarios for irrigation to trees and irrigation to pasture, the preferred means of land irrigation was found to be irrigation to native trees, as this requires less irrigation area and storage volume. Overall this so is lower cost, plus has biodiversity, recreation and carbon benefits.

4.3 Selection Criteria for Storage Pond Sites

GIS selection criteria for storage pond sites were developed in a way similar to the GIS criteria for potential irrigation sites. These criteria were selected in two distinct phases in 2016 and 2017 by technical specialists at Beca and PDP in consultation with Council staff, to address recommendations of recognised guidelines (specifically the USEPA Process Design Manual for Land Treatment of Municipal Wastewater Effluents 2006) and to address potential environmental, cultural and social risks that were identified by the project team as scheme options were developed.

The storage selection criteria are outlined in Table 4-4.

Table 4-4 Storage Pond / Storage Wetland Selection Criteria

Factor	Criteria	Basis for Criteria Selection
Waterways	Exclude 25 m buffer on either side to centreline of waterway	To avoid impinging on stream floodplains and to reduce risks of storage pond or wetland embankment erosion due to flooding.
Road	Exclude 25 m buffer on either side to centreline of road	To provide protection against visual impacts from a storage pond which may incorporate above ground embankments.
Residential Dwelling	Exclude 100 m buffer around residential dwellings	Odour risks associated with the pond operation are considered to be low based on assessment provided in the Beca report of 31 March 2017. The 100 m buffer is proposed to manage other potential nuisance effects from the pond including noise from an aeration bubble curtain compressor and midge populations.
Plot size	Exclude all land plots 1 ha or less including a 100 m buffer around the plot	Plots of less than 1 ha are assumed to contain a residential dwelling.
Groundwater and seal level rise	Exclude land less than 2 m above Mean High Water Spring (MHWS)	Shallow groundwater within this area poses significant risks for pond design and construction. Accounts for future sea level rise.
Elevation	Exclude consideration of land above 200 m (with specific exceptions shown)	Pumping treated wastewater to a pond located above 200 m would be comparatively costly. Pond construction costs above 200 m are also likely to be higher due to the limited depth of loess and higher risk of encountering rock at shallow excavation depth.
Planning	Included all planning overlays including Silent File Areas	To take into account of land planning status and other protections in the selection of potential pond sites
Property boundaries	Include property boundaries	To understand where pond sites cross property boundaries and how many land parcels would be involved in a given scheme configuration.
Geotechnical Assessment	T&T map erosion zones excluded	Geotechnically unstable areas are unsuitable for pond construction and carry high risk.
Land slope	Exclude land greater than 4 degrees slope	Land greater than 4 degrees slope requires more extensive ground works resulting in higher costs

4.4 Design Basis for Wastewater Storage

Wastewater storage requirements were also determined in the PDP irrigation model. To assess the storage requirement the model compares the daily wastewater flow to the volume that can be irrigated for every day in the time series from 1972 to 2019. For any day when all of the wastewater is not able to be irrigated, based on the maximum application rates set out in Section 4.2, the surplus wastewater goes to storage. The stored volume typically increases in the winter and as a result of heavy rainfall.

For irrigation to native trees, on heavy rainfall days (50 mm and above), and on the following consecutive days of rainfall, zero wastewater is applied to land and all wastewater flow must be stored.

Analysis of the storage model results found that a small number of very infrequent events over the 47 year modelling period had a significant influence on the required storage volume. Through a process of consultation with key stakeholders it was agreed that a subsurface treatment wetland may be introduced to a scheme such that fully treated wastewater could be diverted into this wetland and discharge into surface waters during rainfall events exceeding a 1:10 year average return interval. Modelling shows that the wetland would discharge wastewater for a total of 48 days over the 47 year period in 10 separate events.

The benefit of the wetland is a reduction in required treated wastewater storage volume by about 25%. Reducing the storage simplifies the design and reduces the cost of the scheme. This benefit is greatest for the inner harbour land irrigation scenario due to the space constraints that apply at this location. The subsurface treatment wetland is included in the Inner Bays irrigation option but not for the Goughs Bay and Pompeys Pillar irrigation options where the benefits of the wetland are less because additional storage is more readily able to be constructed at the irrigation site. The total amount of wastewater discharged to surface waters through the wetland for the Inner Bays Irrigation option is a few thousand cubic metres every ten years. In other words, a very small percentage of the 2.3 million cubic metres of wastewater generated over the same period.

4.5 Longlist of Irrigation Sites

Irrigation to land in Eastern Banks Peninsula has been identified by the Ngāi Tahu parties as a potentially acceptable wastewater management option. A range of potential sites were identified using several stages of GIS modelling using the methodology outlined in Section 4.1.

An early step involved high level GIS screening of potential sites in Eastern Banks Peninsula. The work commenced with a GIS analysis to identify areas of rural land with an aggregate area of approximately 50 ha, either contiguous or within a locality, with suitable slope that could potentially be irrigable. The 50 ha area was identified based on initial assessment of irrigation land requirements. Initial screening did not take into account land parcel size or "edge effects" that diminish irrigable area when land is broken into numerous small parcels. Figure 4-5 shows the areas identified as having potential for irrigation based purely on providing sufficient land area within a locality, and meeting slope and downslope criteria (as outlined in Section 4.1).

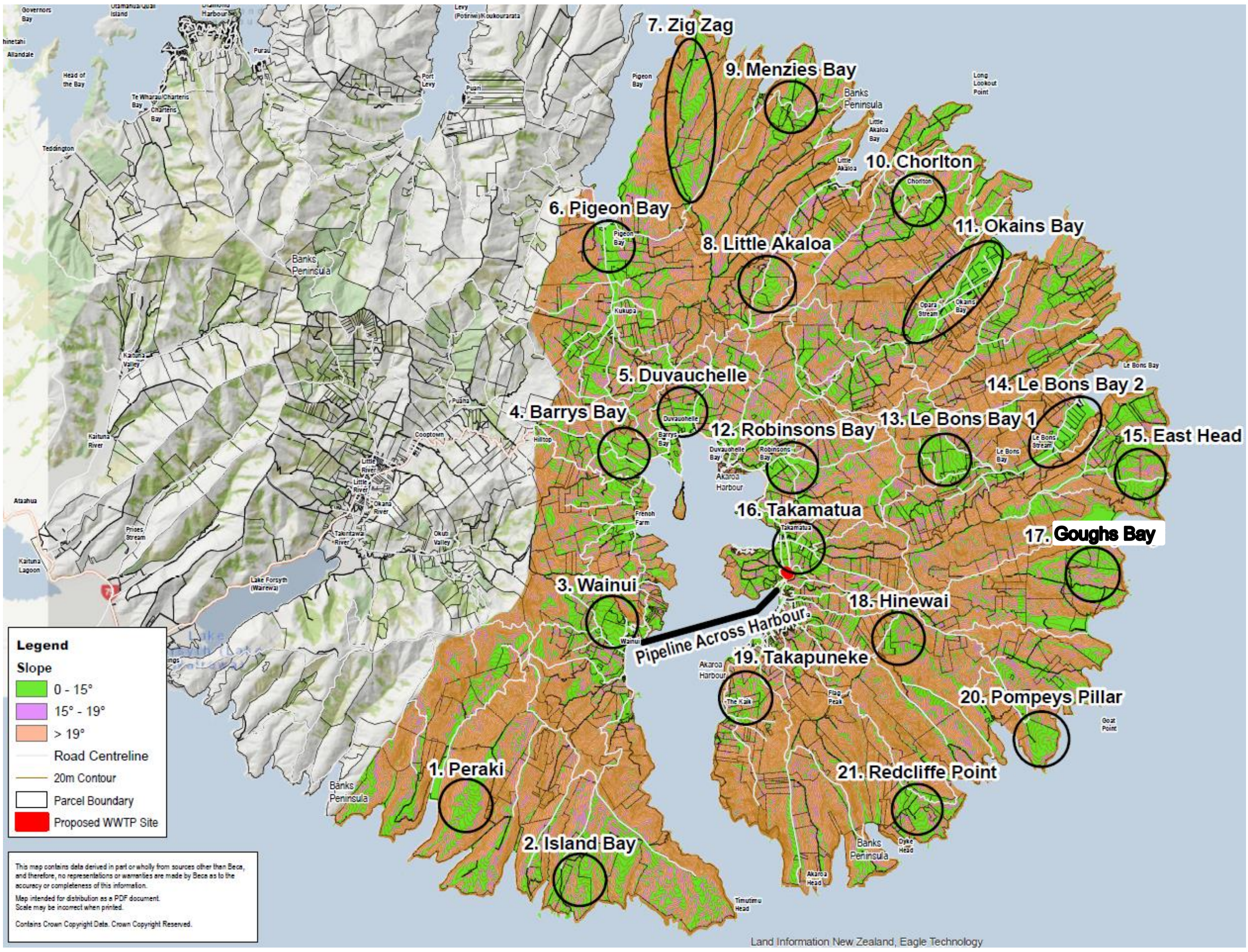


Figure 4-5: Potentially Irrigable Areas Identified by High Level Screening

Screening criteria were identified by Beca and PDP technical specialists in February 2017 to allow the sites to be compared to each other. The screening criteria are primarily focused on sufficient land area (preferably a contiguous area sufficient to irrigate all wastewater), and land stability, but also consider distance from the treatment plant. Distance from the treatment plant was applied as a criteria as increased distance translates to higher capital cost and higher operational costs. Increased distance to the irrigation area also translates to lower overall resilience as long conveyance pipelines are at risk from land slips and other natural hazards. The selection criteria are summarised in Table 4-5.

Table 4-5: Irrigation Site Screening Criteria

Assessment Criteria	Comparative Performance Definitions		
	Favourable	Moderately favourable	Unfavourable
Land area and slope stability	Sufficient land, continuous irrigation area and slope less than 19 degrees	Land area sufficient but discontinuous. Site slope less than 19 degrees	N/A
Downgradient slope	Downgradient slopes less than 15 degrees, and low risk to infrastructure or property	Downgradient slopes greater than 15 degrees, and low risk to infrastructure or property	Downgradient slopes greater than 15 degrees, and significant risk to infrastructure or property (**SITE EXCLUDED**)
Distance from treatment plant	Less than 5 km from WWTP by road (or cross harbour pipeline)	5 – 10 km from WWTP by road (or cross harbour pipeline)	More than 10 km from WWTP by road (or cross harbour pipeline)

Potential irrigable areas identified, and initial screening results (indicated by the ticks and crosses) based on the criteria set out in Table 4-5, are shown in Figure 4-6.

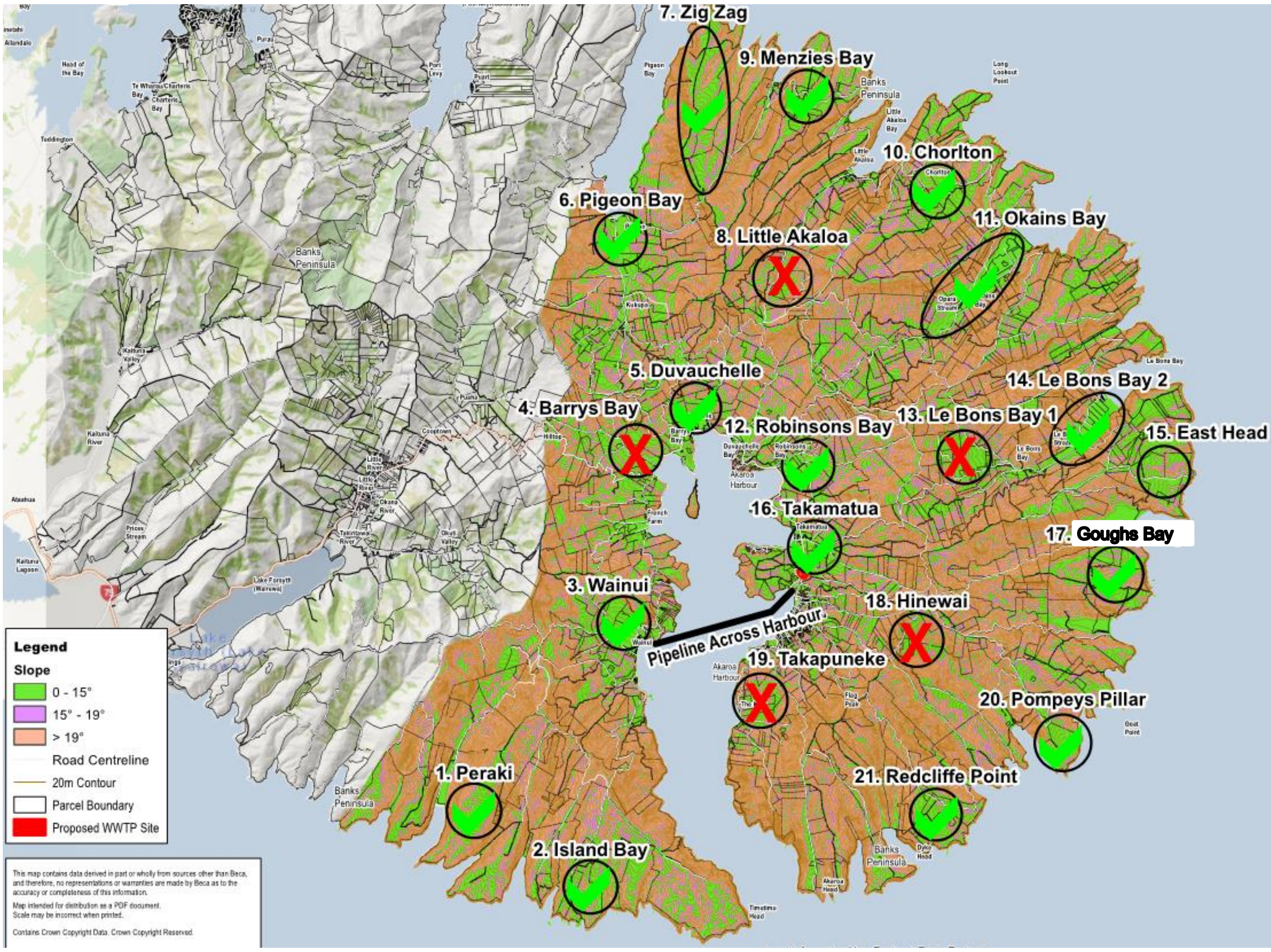


Figure 4-6: Results of Screening of Irrigation Sites on Eastern Side of Banks Peninsula

Based on the initial screening five sites were excluded (Barrys Bay, Le Bons Bay 1, Little Akaloa, Hinewai and Takapūneke). These sites offer sufficient land area but have been excluded due to downslope geotechnical risk. Sixteen sites were found to be potentially suitable based on the specified criteria. Evaluation of these sites against the criteria specified is summarized in Table 4-6.

Table 4-6: Initial Site Screen Assessment

No.	Site	Land Area and Slope	Downgradient slope and risk	Distance from treatment plant[1] (km)	Commentary
1	Peraki	Favourable	Moderately favourable	32	Not shortlisted initially due to long distance from treatment plant
2	Island bay	Favourable	Moderately favourable	32	Not shortlisted initially due to long distance from treatment plant
3	Wainui	Favourable	Favourable	22	Not shortlisted initially due to long distance from treatment plant
4	Barrys Bay	Moderately favourable	Unfavourable	10	Excluded due to downslope geotechnical risk
5	Duvauchelle	Favourable	Favourable	7	Not shortlisted initially as site earmarked for irrigation of Duvauchelle wastewater
6	Pigeon Bay	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
7	Zig Zag	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
8	Little Akaloa	Favourable	Unfavourable	13	Excluded due to downslope geotechnical risk
9	Menzies Bay	Favourable	Moderately favourable	24	Not shortlisted initially due to long distance from treatment plant
10	Chorlton	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
11	Okains Bay	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
12	Robinsons Bay	Favourable	Favourable	4	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk and moderate distance to treatment plant
13	Le Bons Bay 1	Favourable	Unfavourable	10	Excluded due to downslope geotechnical risk
14	Le Bons Bay 2	Favourable	Favourable	16	Not shortlisted initially due to long distance from treatment plant
15	East Head	Favourable	Moderately favourable	21	Not shortlisted initially due to long distance from treatment plant
16	Takamātua	Moderately favourable	Favourable	1	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk and moderate distance to treatment plant
17	Goughs Bay	Favourable	Moderately favourable	11	Not shortlisted initially due to increased distance from treatment plant
18	Hinewai	Favourable	Unfavourable	7	Excluded due to downslope geotechnical risk
19	Takapūneke	Favourable	Unfavourable	4	Excluded due to downslope geotechnical risk
20	Pompeys Pillar	Favourable	Moderately favourable	10	Recommend further investigation due to sufficient and potentially suitable land area, low geotechnical risk to infrastructure and property, and moderate distance to treatment plant
21	Redcliffe Point	Favourable	Moderately favourable	12	Not shortlisted initially due to long distance from treatment plant

Initial screening conducted in March 2017 identified Pompeys Pillar as preferred over Goughs taking into account the distance to site, which was calculated as 10km to Pompeys Pillar and 11km to Goughs Bay. In other words, Pompeys was preferred because it was closer to the treatment plant and Goughs was not shortlisted (refer to Table 4-6).

Subsequently another potential Goughs Bay site was found by Council staff, owned by Keith Townsend. The Townsend land extends beyond the initial Goughs Bay zone shown in Figure 4-6 and includes land at a lesser distance from the treatment plant; hence the long section of the pipeline to the Townsend land at Goughs Bay shown in Figure 6-4 and given in Appendix K shows it to be shorter than the pipeline to Pompeys.

4.6 Shortlist of Irrigation Sites

Based on the screening exercise conducted, and a range of subsequent investigations, the following land-based irrigation scheme options were shortlisted and discussed at a hui on 2nd of August 2016 attended by Council, Ecan, Beca and PDP representatives. The scenarios discussed at the hui included the Townsend land at Goughs bay on the shortlist. This site was identified after the initial screening in March 2017 but before the hui in August 2017. The outcome from the hui was that four localities were shortlisted for further investigations:

- Site 12 - Robinsons Bay Valley
- Site 16 - Takamātua Valley
- Site 20 - Pompeys Pillar
- Site 17 - Goughs Bay

It should be noted that Hinewai (site 18 in Table 4-6), which was identified initially as unfavourable in 2017, was reconsidered as an option in 2020 at the suggestion of the working party. A site walkover and further geotechnical assessment was undertaken in February 2020. This review confirmed the unsuitability of this site for irrigation and wastewater storage due to a number of factors. A copy of this review is provided in Appendix I.

The following sections describe the design basis and assumptions for each shortlisted scheme option.

5 Option 1 – Inner Bays Irrigation to Trees

5.1 Outline of Scheme Option

The Inner Bays Irrigation Scheme combines irrigation of suitable areas within the inner bays of Akaroa Harbour (Robinsons Bay Valley and Takamātua Valley) with network inflow and infiltration (I&I) reductions in Akaroa, non-potable reuse and a subsurface wetland to provide additional storage and additional treatment of occasional discharges to the harbour (approximately once every 5 years).

The main irrigation area and main storage ponds for this scheme would be at a property located at 11 Sawmill Road in Robinsons Bay Valley. Three other properties would also be included in the irrigation scheme: a part of the neighbouring property at 88 Sawmill Road, a property at Hammond Point (6528 Christchurch Akaroa Road) and a property in Takamātua Valley (6683 Christchurch Akaroa Road). If this option was chosen, the Council intends to purchase these properties.

A concept design for the Inner Bays option with irrigation to native trees was developed incorporating the following components, as illustrated in Figure 5-1. Refer to Appendix J for the overall scheme map.

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m^3, located on land opposite the new treatment plant on Old Coach Road (owned by the Council), to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Treated wastewater storage pond with a volume of 1,000 m^3, located on land opposite the new treatment plant on Old Coach Road
- Subsurface wetland of approximately 3,800 m^2 as an ecological restoration feature on the site opposite the treatment plant, for evapotranspiration and additional treatment of wastewater, and on rare occasions to facilitate a discharge to the harbour as needed
- 4.8 km long gravity pipeline from the treated wastewater storage pond to the irrigation areas, with the route along State highway 76 (Christchurch Akaroa Road) and paper roads once the pipe reaches Robinsons Bay Valley (refer to Appendix K for a long section drawing of the pipeline)
- 40 ha of irrigated mixed native plantings on land made up of 34 ha at 11 and 88 Sawmill Road, 3.1 ha at Hammond Point (6528 Christchurch Akaroa Road) and 2.9 ha at Takamātua Valley (6683 Christchurch Akaroa Road)
- Two treated wastewater storage ponds with a volume of 9,500 m^3 each, located at 11 Sawmill Road
- Irrigation pump station, distribution pipelines and irrigation system at the three irrigation areas, all based on dripline irrigation to native trees
- Non-potable reuse network for irrigation of public parks and flushing of public toilets in Akaroa including UV treatment and possibly chlorination of non-potable reuse flow

For more detail on the network upgrades, wastewater treatment plant and non-potable reuse components, please refer to Section 9.

Beca conducted an initial investigation in 2017 into the feasibility of irrigating this land (see Appendix L for the geotechnical assessment and infiltration testing for the inner bays sites and Appendix M for information on the Hammond Point site).

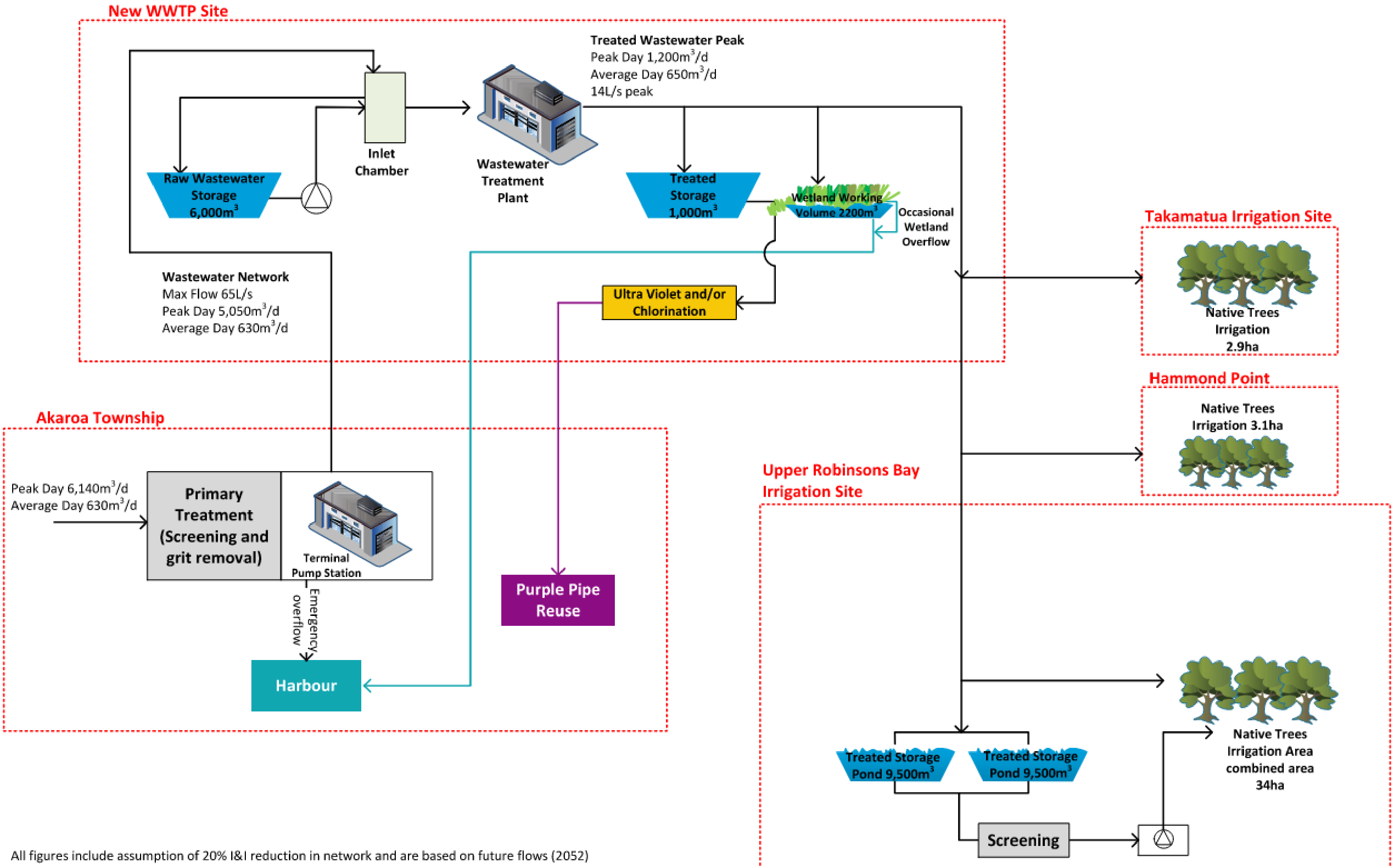


Figure 5-1 Schematic of Inner Bays Irrigation and Reuse Scheme

5.2 Subsurface Wetland

The Inner Bays irrigation scheme includes a subsurface treatment wetland on the land opposite the treatment plant on Old Coach Road. The subsurface wetland was been proposed as a result of collaborative discussions between the Council and the Ngāi Tahu parties, who originally suggested the concept. It is also supported by the working party. The purpose of the wetland is to:

- Reduce storage pond volumes at Robinsons Bay (approximately a 10% reduction)
- Provide an alternative disposal option for treated wastewater flows increasing the resilience of the scheme
- Address cultural concerns relating to infrequent discharges to harbour of treated wastewater by allowing flows to pass through the sub-surface wetland to provide additional treatment and restore the mauri of the water before being discharged to the harbour
- Provide amenity for the community and general public through environmental enhancement.

Debbie Tikao from the Ngāi Tahu parties has produced a landscape concept for how the property opposite the treatment plant could be developed to provide public amenity. Figure 5-2 shows an overview of the concept, where item number 1 is the wetland and item 4 is the proposed wastewater treatment plant. Please refer to Appendix N for the full drawing and legend.

Figure 5-2 Ngāi Tahu Parties Landscape Concept for Site Opposite WWTP

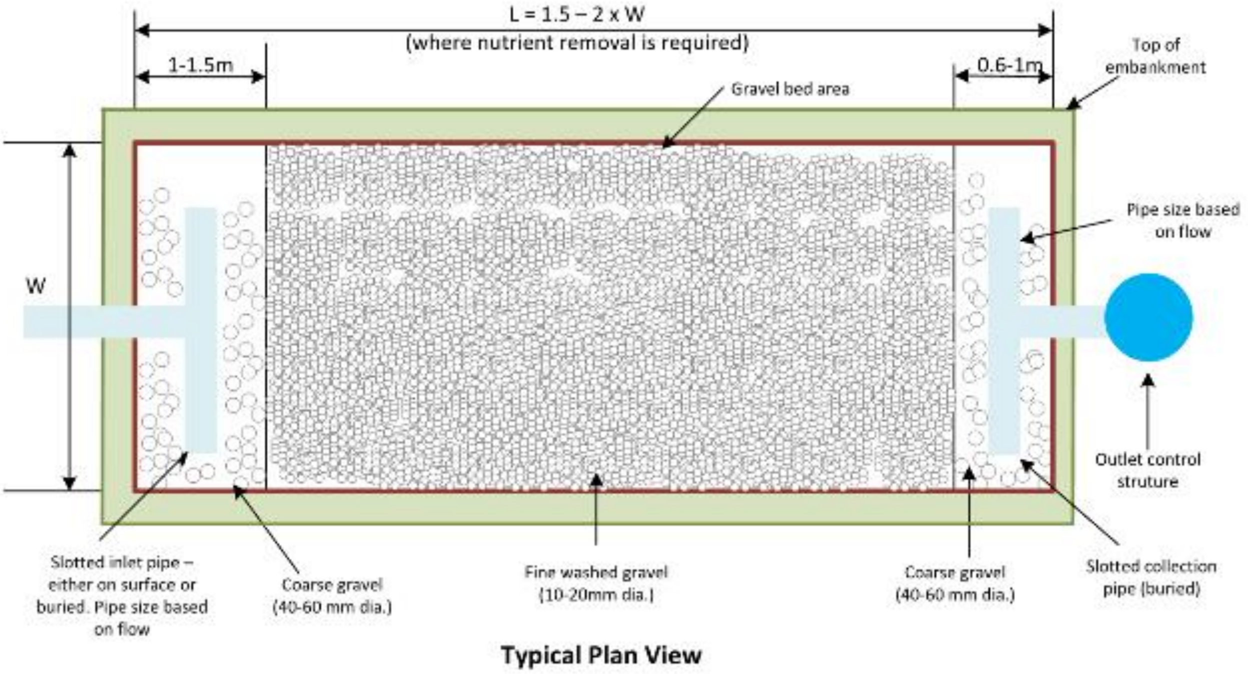
To build the subsurface wetland a basin would be constructed and lined, then filled with media and planted with wetland plants on the surface. The operational philosophy of the subsurface wetland is that on a day-to-day basis a small volume of treated wastewater will be diverted from the treated wastewater storage pond into the subsurface wetland to keep the plants alive and to allow a portion of the wastewater to be lost through evapotranspiration. The intention is the daily volume sent to the sub-surface wetland would be roughly equivalent to the volume lost by evapotranspiration, with no discharge from the wetland under normal conditions.

In prolonged rain events, the storage ponds in Robinsons Bay would be filled to capacity first. Only after these have reached their limit would treated wastewater be diverted from storage to the wetland which, once filled to a groundwater level 300 mm above the surface, would release treated wastewater at approximately 2 L/s via a low level outlet and pipe to discharge into the stream near the wetland.

Modelling indicates that the Robinsons Bay ponds would be full, and the wetland would receive more wastewater than could be transpired over 48 days in 10 separate events over the 47 year rainfall record. Of these there are five events totalling 27 days where the wetland surcharges and a flow of greater than 2 L/s (and up to the full flow of the treatment plant of 14 L/s) is allowed to leave the wetland and discharge to the harbour. Discharge to the harbour of greater than 2 L/s will be from an overflow pipe from the wetland. This pipe would be directed from the wetland, into the creek on the property opposite the WWTP, and down the hill to Childrens Bay.

During the other events (5 events and 21 days in total) the discharge to harbour from the wetland is approximately 2 L/s and this flow will be via a smaller (sized to control the flow to 2L/s or less), lower level pipe from the wetland (refer Figure 5 2). This smaller pipe will connect into the main overflow pipe.

The sub-surface wetland concept is shown in Figure 5-3.



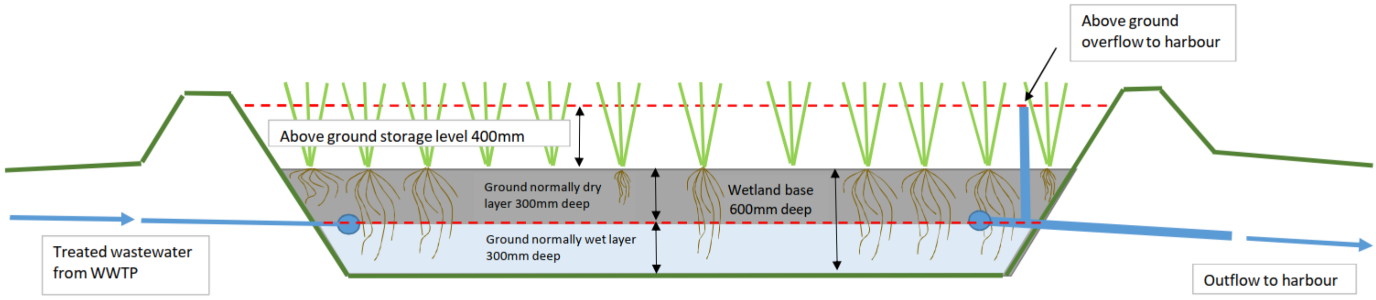


Figure 5-3 Concept Design for Sub-Surface Wetland

As shown in Figure 5-3 the wetland will have a total gravel depth of 600 mm with a porosity of 0.3. There will be approximately 300 mm of permanent water maintained in the wetland beneath the surface to retain root health, another 300mm of normally dry ground and 400 mm of freeboard on top of the media for additional storage. The overall surface area of the wetland is estimated to be 3,800 m², and the available wetland storage volume when utilising the above ground storage level is approximately 2,200 m³. When the wetland freeboard is exceeded, the wetland overflows to the harbour at an unrestricted rate via the overflow pipe.

PDP has undertaken an assessment of what additional treatment might be achieved by the sub-surface wetland for different flowrates through the wetland. Literature indicates that while there is unlikely to be any measurable reduction in phosphorous, there could be up to 45 – 80% removal of nitrogen, depending on the time of the year. The full assessment is included in Appendix O.

Figure 5-4 and Figure 5-5 show the construction of a sub-surface wetland in Abel Tasman and an indication of what it would look like once established.

Figure 5-4 Construction of a Subsurface Flow Wetland (at Abel Tasman courtesy of Cameron Gibson and Wells Ltd)

Figure 5-5 Planted Subsurface Flow Wetland at Abel Tasman (Cameron Gibson Wells Ltd)

The Council has purchased land opposite the treatment plant where the wetland would be located. Ground conditions are known to consist of loess soils, which are susceptible to erosion and so a geotechnical site visit and high level desktop review was undertaken to assess the feasibility of different potential wetland locations on the property, in conjunction with the storage ponds for raw and treated wastewater.

5.3 Assessment of Potentially Irrigable Area

Modelling by PDP found that 40 ha of irrigable land and a storage volume of 19,000 m^3 would be optimal for the Inner Bays scheme (refer to Appendix B). In addition to the GIS selection criteria in Section 4.1, aerial photography was reviewed to assess areas of erosion and/or instability outside of the Tonkin & Taylor mapped area of land instability, and site visits were undertaken by a geotechnical engineer. Full details of the assessment method, criteria used, and results are provided in Appendix P. The resulting map is shown in Figure 5-6.

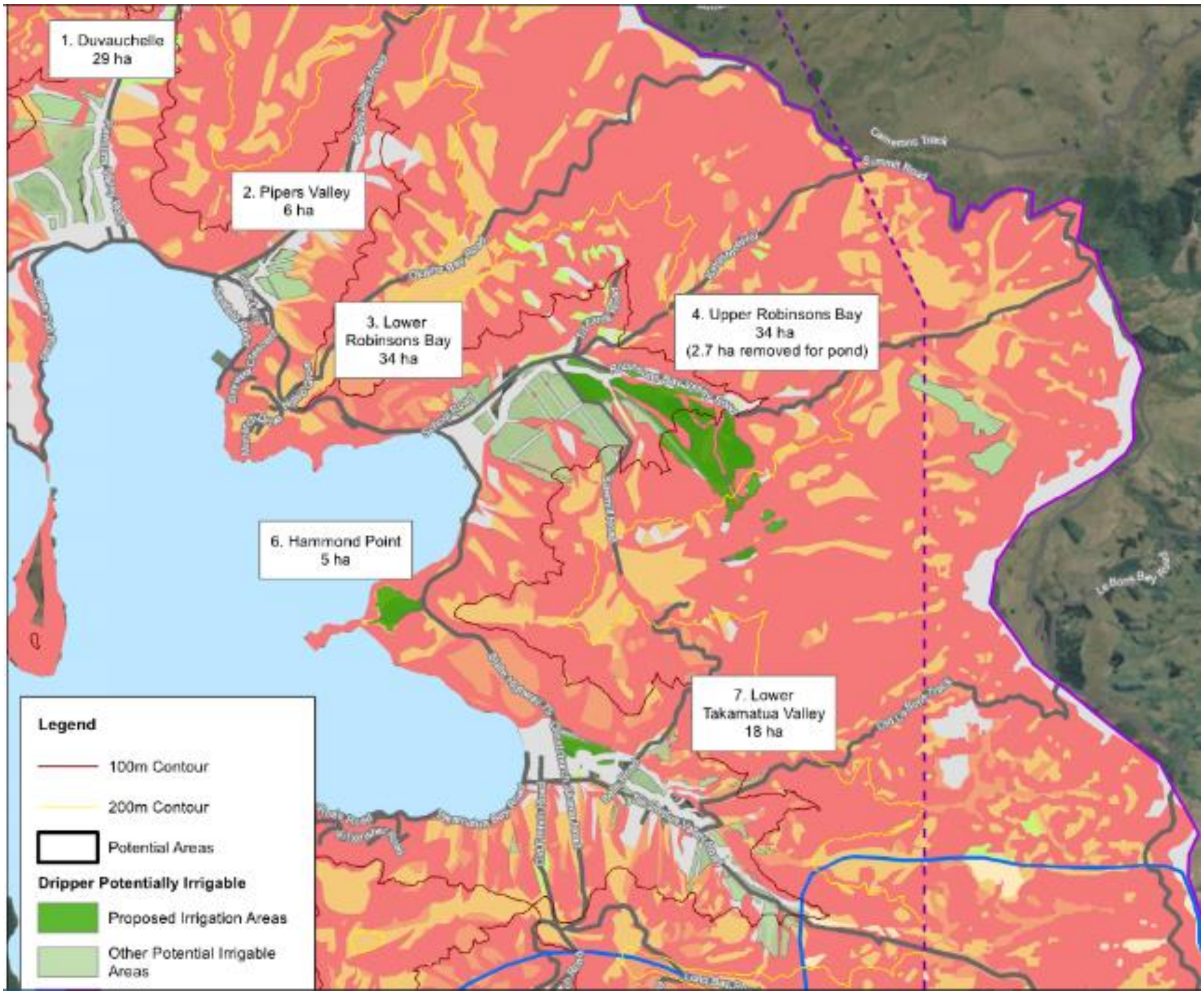


Figure 5-6 GIS Screening of Irrigable Sites in Inner Bays

The 34 ha of irrigable land in Upper Robinsons Bay shown in Figure 5-6 is the cornerstone of the Inner Bays Scheme due a number of positive features; it is a large area of favourably sloping land with proven irrigation potential, with a suitable storage site, and that meets GIS selection criteria. It is also suitably close to the treatment plant, can be supplied by gravity from the treatment plant, and has a willing landowner.

This area on its own is not sufficient to accept the total annual wastewater volume. The minimum total land area required is 40 ha. Some additional land totalling about 6 ha is needed to complete the scheme. A number of possible sites may be suitable to complement the 34ha area in Upper Robinsons Bay. Criteria that have been identified by Council staff for selecting a complementary site or sites are as follows:

- Meet GIS site selection criteria for dripper land irrigation as per Table 4-2
- Preferably 4-5 ha in size
- Preferably located close to the pipeline supplying wastewater to Robinsons Bay
- Consentable and suitable for planting and irrigating native trees while minimising any potential adverse effects
- Preferably with a willing landowner

Figure 5-6 identifies a number of potential complementary sites. Two sites have been identified as preferred by Council staff to date from the possibilities shown in this figure:

- 5.2 ha of land at Hammond Point (6528 Christchurch Akaroa Road).
- 2.9 ha of land in lower Takamātua (6683 Christchurch Akaroa Road)

The land at Hammond Point is a preferred complementary site due to its conformance to irrigation suitability criteria, proximity to the proposed pipeline route to Robinsons Bay, and the landowner indication that they may be interested in selling.

The land in lower Takamātua Valley is preferred for similar reasons. A difference with the Takamātua property is that the owner has indicated they are not interested in selling.

The land identified as potentially irrigable at Hammond Point sits largely within Coastal Environment and Coastal Landscape planning zones. While this doesn't necessarily preclude irrigation at this site, it does introduce additional risk with consenting of such activities. Refer to Section 5.7.3 for the planning evaluation of the land at Hammond Point. A geotechnical desktop study and site walkover of the Hammond Point land was completed to confirm the irrigation feasibility, and the amount of irrigable area. The letter summarising this work is provided in Appendix M.

Land in Duvauchelle has been reserved for the Duvauchelle wastewater scheme, and land in Pipers Valley is not preferred as it would require significant additional pipework and possibly pumping.

GIS mapping of 11 Sawmill Road and site-specific geotechnical assessments has confirmed land areas that are suitable for irrigation (refer to Appendix J) and a summary map in Figure 5-7. A total of 2.7 ha has been removed from the identified irrigable area for pond storage and associated exclusion zones. While some localised areas do not meet the 15º downslope screening criteria, a site-specific geotechnical assessment has revealed no evidence of downslope instability, and these areas are considered suitable for irrigation.

An overview of the preferred irrigation sites in the Robinsons Bay locality is shown in Figure 5-7

- 2.9 ha is proposed for irrigation on the flat land in Takamātua Valley adjacent to State Highway 75 (6683 Christchurch Akaroa Road)
- 5.2 ha of land of which 3.1 ha is proposed for irrigation at Hammond Point (6528 Christchurch Akaroa Road).

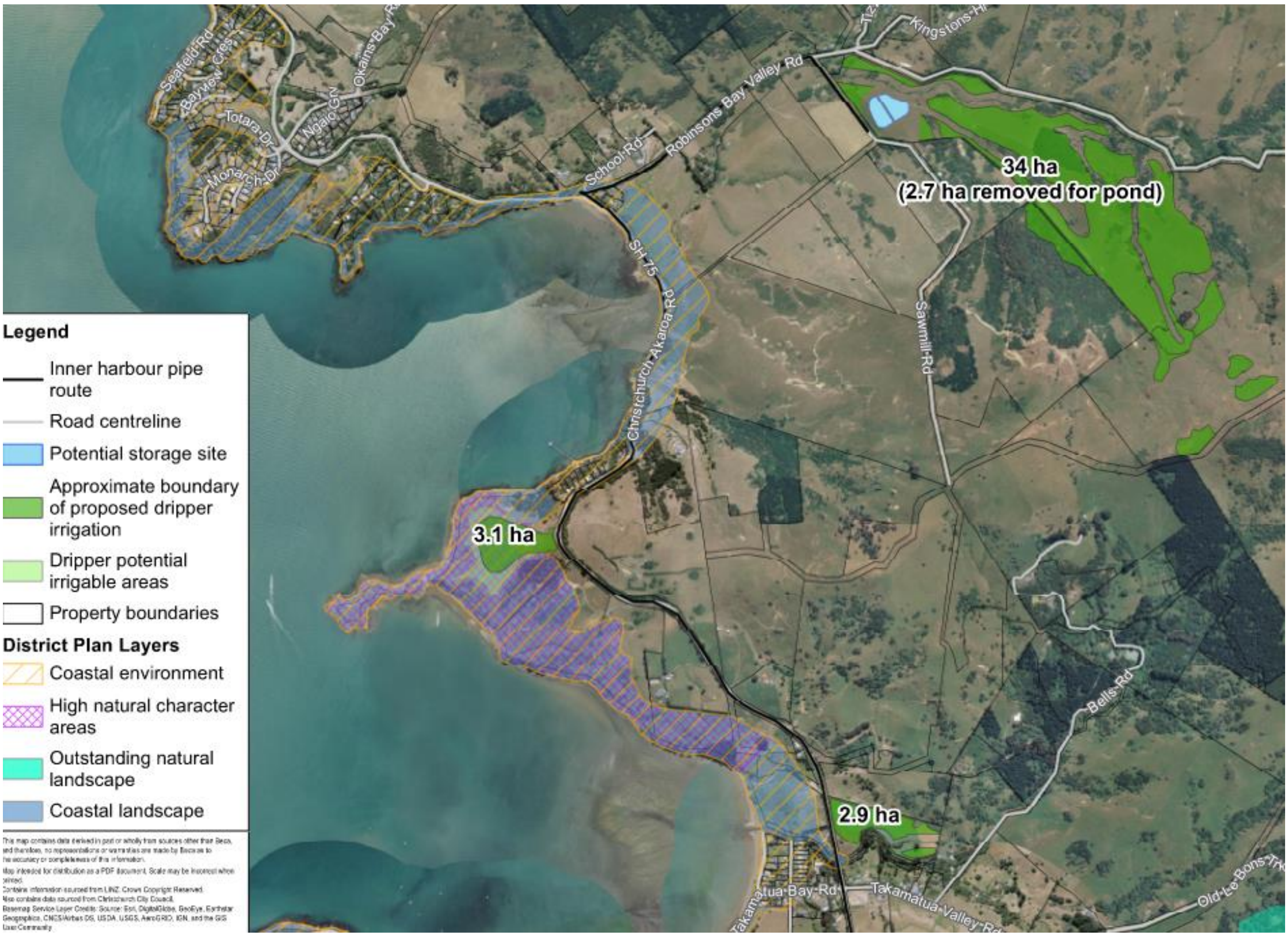


Figure 5-7 Overview of Inner Bays Irrigation Scheme

As stated above a minimum of 40 ha is required for a practical and workable inner bays irrigation scheme. The total potential irrigable area identified in Figure 5-7 is 42.1 ha. To meet the total of 40 ha would require inclusion of both Hammond Point and the property in Lower Takamātua Valley.

5.3.1 Required Irrigation Area and Storage Volume

For the purposes of determining the storage volume required for the Inner Bays irrigation scheme for drip irrigation to trees, the following assumptions were made by PDP in their irrigation model:

- 40 ha of irrigable land available, irrigated by drip irrigation to trees. Irrigation application rates range between 168 – 610 mm per year depending on soil type.
- Available sub-surface wetland wastewater storage volume of 2,200 m^3 when water level within the wetland increases by 400 mm from media level to overflow level (refer to Section 5.2) in a storm event
- When the storage ponds at 11 Sawmill Road are 100% full, all treated wastewater from the treatment plant is instead diverted to the sub-surface wetland located on the opposite side of the road from the treatment plant. Once the level in wetland reaches more than 300 mm, flow would discharge at 2 L/s.
- The wetland will continue to fill, utilising the additional 300 mm of normally dry ground and the above ground storage or freeboard of 400 mm as shown in Figure 5-3 until the wetland freeboard is exceeded. After the above ground freeboard is exceeded the wetland would overflow to the harbour at an unrestricted rate. Up until the freeboard is exceeded the flow to harbour will be 2 L/s, controlled by the size of the first outflow pipe.

- The modelling indicates that the wetland receives more wastewater than can be transpired over 48 days in 10 separate events over the 47-year data history and a discharge to harbour occurs.
- Of these 10 events there are five events totalling 27 days when the wetland receives more wastewater than can be accommodated by the above ground freeboard, and a discharge of greater than 2 L/s (and up to the full treated wastewater flow of 14 L/s) would result.

The required storage volume for an Inner Bays irrigation scheme for this scenario was found to be 19,000 m^3. Multiple iterations of various irrigation areas and pond volumes were trialled, and this combination was found to be the most practical and cost effective.

5.4 Treated Wastewater Storage Ponds

This option includes 19,000 m^3 of treated wastewater storage in two ponds of approximately 9,500m^3 each at 11 Sawmill Road. There is only one site at 11 Sawmill Road with suitable area and land slope to facilitate construction of these ponds. A potential layout of the storage ponds at 11 Sawmill Road is shown in Figure 5-8.

As the ponds would be uncovered, some form of filtration system would be required for the irrigation outlet to prevent blockages of the irrigators by things such as algae and debris that could blow into the ponds.

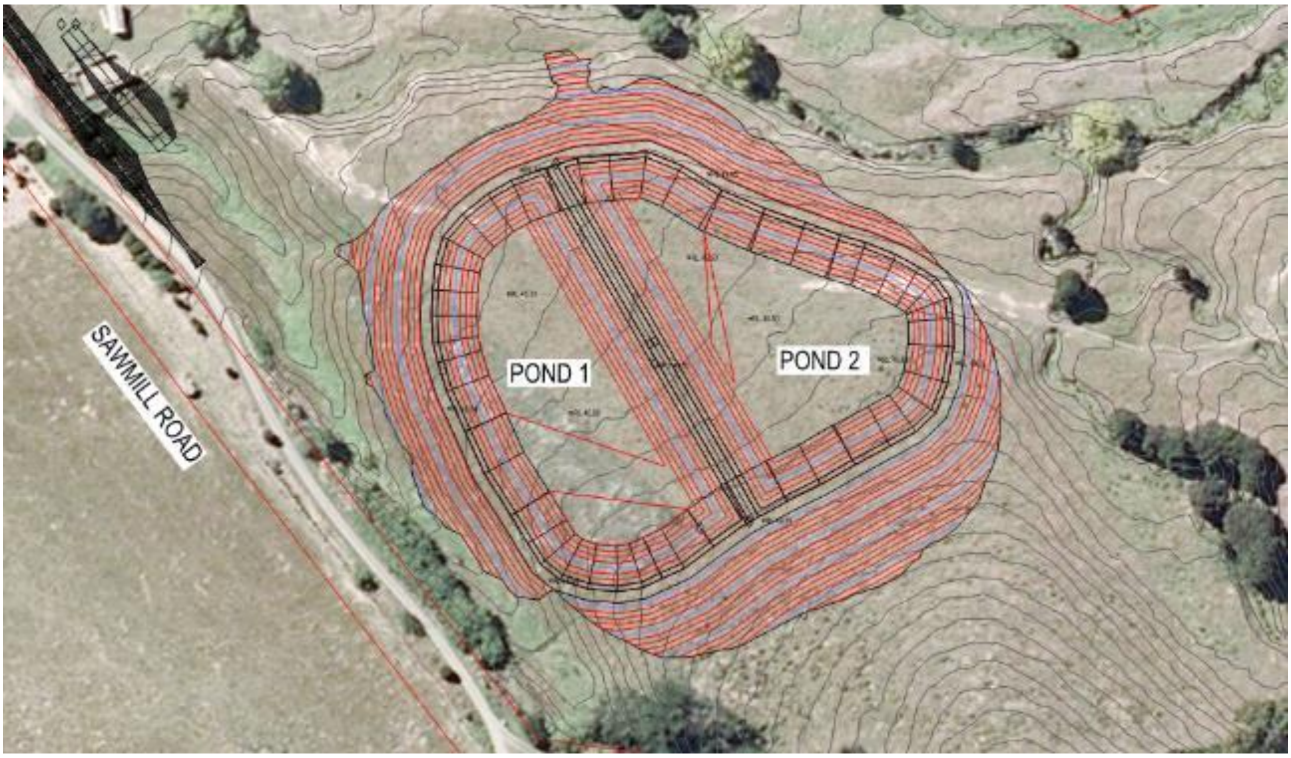


Figure 5-8 Possible Storage Pond Layout

The storage ponds would be set out as a cut-to-fill configuration with embankments on the downhill (north) side of the ponds. The stored volume in the ponds would vary throughout the year and would be influenced by the following factors:

- Rainfall, and hence I&I, in the reticulation network in Akaroa. It is assumed that work is completed in the Akaroa catchment to reduce I&I by 20%, hence reducing the treatment, irrigation area and storage capacity required.

- Direct rainfall on the treated wastewater storage pond on Old Coach Road (opposite the treatment plant site)
- Direct rainfall on the treated wastewater storage ponds in Robinsons Bay
- Drip irrigation of the storage volume at Robinsons Bay which fluctuates seasonally.

5.4.1 Dam Break Analysis

There are a number of dwellings down valley of the proposed storage ponds at 11 Sawmill Road. A risk of inundation of downgradient properties was identified in the event of failure of the storage pond. To investigate this risk, a two-dimensional flood model of the lower Robinsons Bay Valley was developed to provide a concept-level dam break assessment of the effects of a breach in the storage pond embankment. The dam break analysis used inputs including a developed concept design for the storage pond embankments.

The developed concept design of the storage pond embankment is shown in Figure 5-9 and described in detail in Appendix Q.

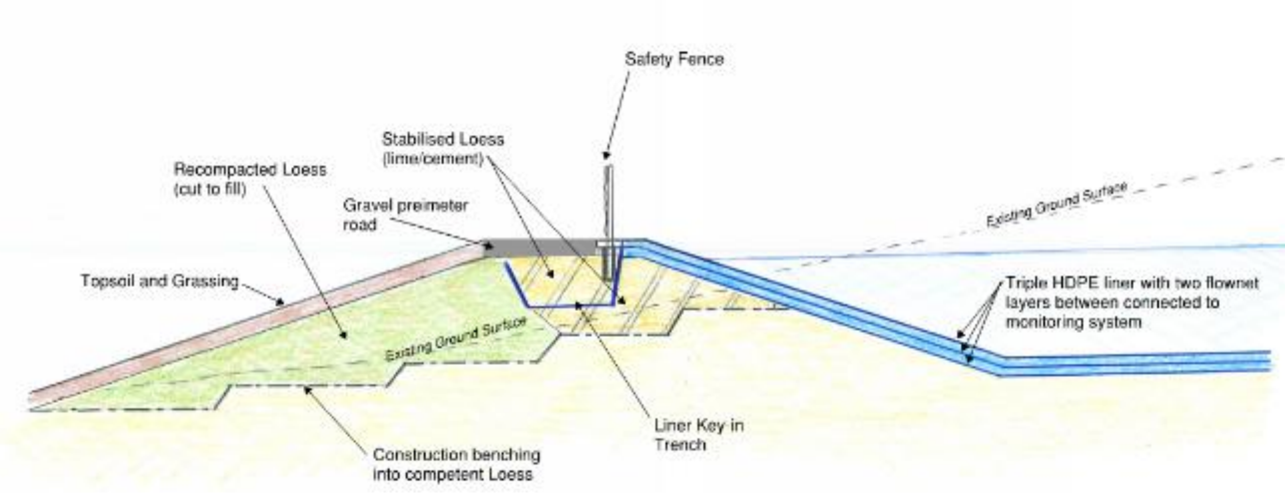


Figure 5-9 Concept Design of Embankment

The local soil type is loess. A stability analysis based on known loess soil properties showed that the embankment performance is acceptable for static and seismic load cases for typical dry to wet soil moisture conditions. The performance of the dam is influenced by moisture levels in embankment soils, with static and seismic stability adversely affected with saturated soil conditions. Furthermore, loess is vulnerable to piping failure due to its dispersive nature. Taking these risk factors into consideration the following key design features are proposed:

- The embankment would be made of compacted local loess with a stabilised core
- Due to the importance of controlling moisture a triple liner with trench key and two stages of leakage monitoring is proposed. The triple liner provides redundancy, and allows for early warning and response
- The embankments should be grassed (not planted in shrubs or trees) to allow for leak observation (i.e. greening)
- Two spillways will be provided to avoid bank overtopping
- No penetrations through the liners will be permitted.

The intention is that leakage monitoring would be reported over the Council SCADA network via telemetry. The SCADA is monitored continuously 24 hours per day at the Christchurch network control room at the Christchurch wastewater treatment plant. Response plans would be developed for leakage detection events. If leakage was detected, the affected pond would need to be drained and the liner repaired.

The dam break modelling results are provided in Appendix R. Initial dam break modelling of the storage pond as a single large volume showed that this presented a downstream flooding risk that could not be easily mitigated. It was therefore decided to split the storage into two ponds. The likelihood of the two ponds breaching at exactly the same time is considered very low and so the dam break assessment has been undertaken for the case of a single pond at 12,500 m^3 volume.

Since the dam break modelling has been conducted the sizing of the ponds has further reduced to 9,500 m^3 for a single pond. Hence the dam break modelling is conservative as it is based on a larger pond than the sizing now proposed.

Further work would be conducted at the design stage to provide an engineered solution that minimises the risk of the two ponds failing simultaneously.

The dam break analysis was based on a “worst case” volume, with the pond filled to overflowing. A breach period of 10 minutes was assumed. Flood extents were mapped for two dam breach locations and it was found that a breach to the west created the most potential risk to neighbouring properties, therefore western breaches were considered for the analysis. It was found that even with small pond volumes there was a potential flooding risk to nearby properties. As a potential mitigation measure a bund and channel were tested in the model runs to divert flows away from adjacent and downgradient occupied properties. The bund and channel were found to be effective and so have been included in the storage pond concept design for the site.

A series of scenarios were modelled including a “sunny day” breach, and a breach coinciding with wet weather events (1 in 5 year, 1 in 10 year, 1 in 20 year, 1 in 50 year, 1 in 100 year return periods). Figure 5-10 shows the comparison of a sunny day breach of a 12,500 m^3 working volume (15,000 m^3 maximum volume) with a 5 year and 10 year return period storm events.

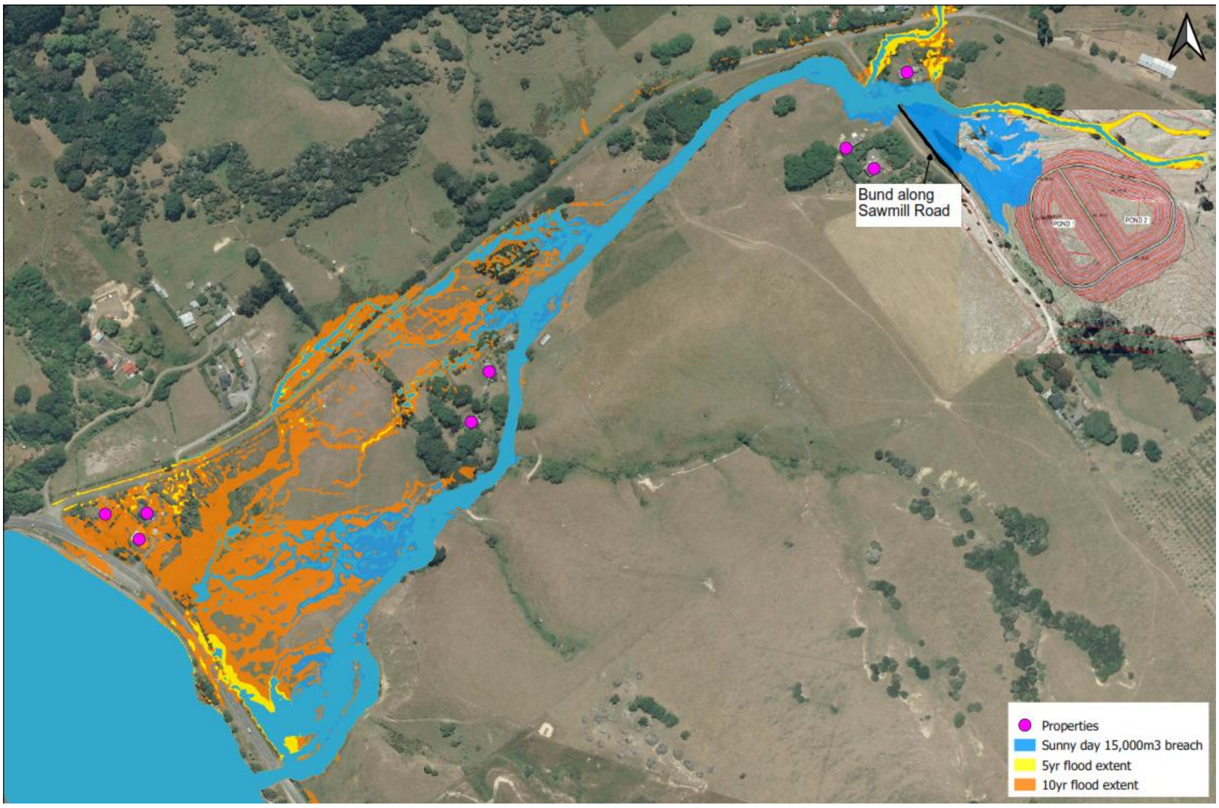


Figure 5-10 Comparison of Sunny Day 15,000 m^3 Breach with 5 and 10 Year Return Period Storm Events

The conclusion from the dam break assessment at 11 Sawmill Road is that a pond split into two 12,500 m^3 cells, paired with a bund and channel designed to direct dam break flows into the stream upstream of Sawmill Road, would not result in an increase in flood risk to properties in the vicinity of Sawmill Road. A dam break of this scale would result in a greater flood extent further down in the catchment than for a 5-year storm event, but less than for a 10-year storm event. Letters outlining the details of the modelling and results for all scenarios considered are included in Appendix R.

5.4.2 Midge Control

The storage ponds have potential to support insect populations, including midges. Experience elsewhere suggests that if the wastewater is treated to a very high standard, then a natural balanced ecology system will establish, and midges are less likely to breed uninterrupted and become a nuisance to neighbours. Where possible trees will be planted or retained around the ponds, which will act as a screen and discourage any midges from leaving the immediate pond environment. Midge larvae survival is also susceptible to water depth variation, the fluctuating volume of treated wastewater stored across the year will therefore be beneficial.

The storage ponds will have a deep profile, up to four metres in depth. However, as the capacity of the storage ponds is designed for the highest flow event in the 47 year data set and typically the storage will only fill up during winter months, the water depth in the ponds will be less than this for much of the year.

In summary, the variation in water depth, highly treated wastewater and screening with trees, are mechanisms that are proposed to minimise midges and mosquitoes.

5.5 Landscape Amenity

The detailed design of the scheme would be developed with input from interested groups to bring to together a landscape amenity plan that suits the needs of the community, the environment, and at the same time the irrigation activities required to be performed at the site. A preliminary landscape plan has been produced to show how this might be implemented and this is included in Appendix S and shown in Figure 5-11.

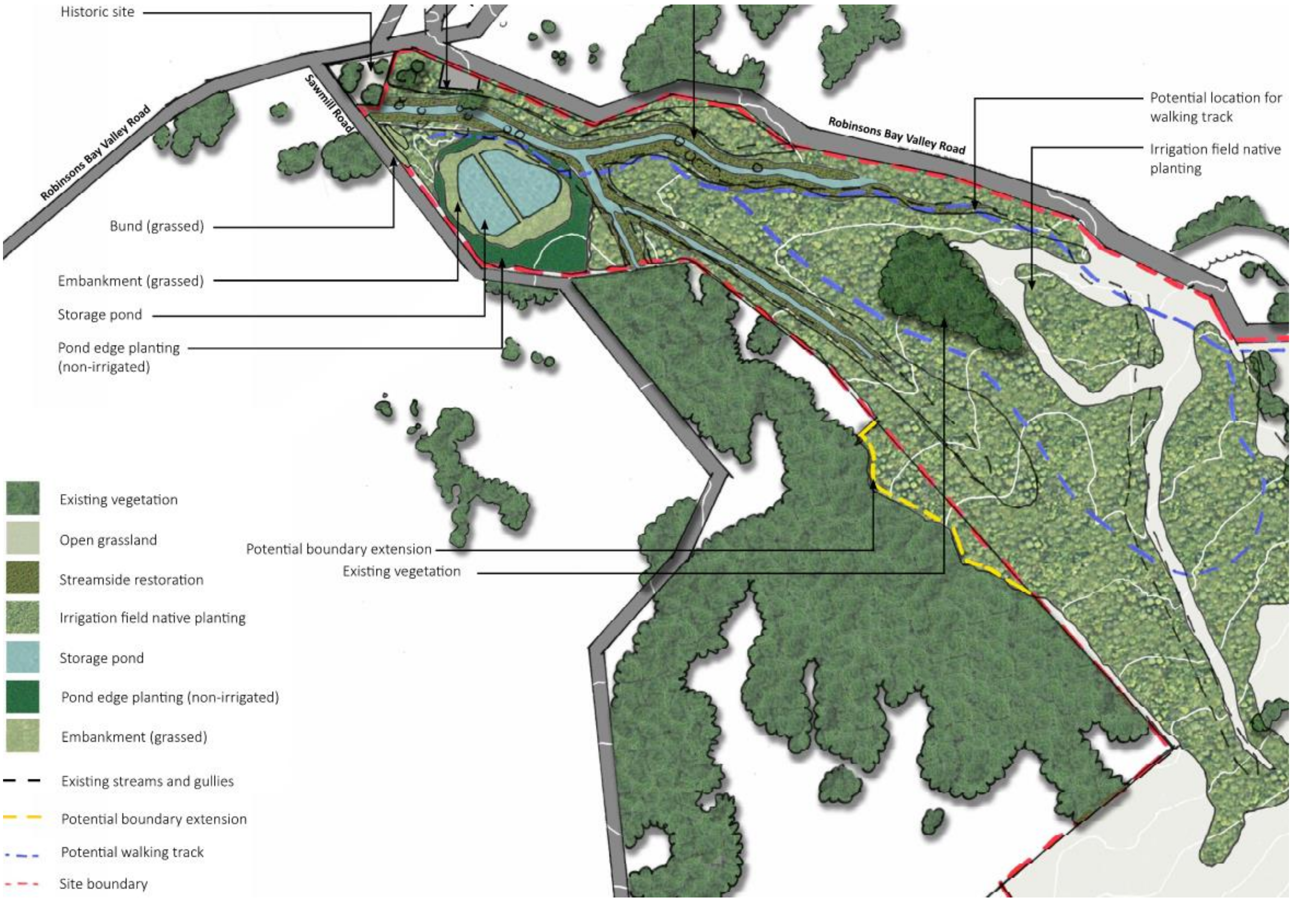


Figure 5-11: Landscape Concept for 11 and 88 Sawmill Road Irrigation Scheme

11 Sawmill Road is currently used predominately for grazing cattle. The landscape amenity could be altered to incorporate the following features:

- Stream side restoration of the Robinsons Bay Stream. In many places at present the stream side is not protected by fences, which allows stock access to the waterway. The intent is to remove stock and provide a native vegetation buffer zone and thereby restore the streamside. This will have the benefit of locally improving the stream conditions and can be used as a demonstration of the benefits of such restoration projects.
- Ephemeral gully restoration would include native plantings to reduce direct run off from the hills which would provide a benefit to the wider catchment and potentially lowering flood heights in the lower valley. The ephemeral gullies would not be irrigated to limit the possibility of drip irrigation systems being directly in the active water path during storms. Consequently, the plant species and growth rates may differ from the irrigated zones.
- Irrigation of native vegetation would be undertaken through the irrigation fields. The species mix would be diverse and would undertake a restorative approach, rather than one of irrigation solely.
- The existing oak plantation would be left as it currently stands, with drip irrigation added to this block, in addition to other existing bush areas that are suitable for irrigation, based on the site specific investigations.
- As can be seen from the landscape plan large areas of 11 Sawmill Road are anticipated to remain as open vegetation, especially higher altitude steeper areas. There remains the option, in time, to also plant these areas with native plantings if this is considered to be more consistent with the intended future use of the land.

The source of funding for amenity landscaping has not been confirmed; at this stage these costs have been excluded from project capital cost estimates in this report.

5.5.1 Irrigated Vegetation

It is envisaged that species selected for irrigation areas would draw on the trials irrigating native trees with treated wastewater from the Duvauchelle wastewater treatment plant in Pipers Valley Road (refer *Final Report (June 2017): A lysimeter experiment and field trail to determine options for the beneficial reuse of water from Duvauchelle and Akaroa, Banks Peninsula,* Brett Robinson, University of Canterbury[3]) where irrigation to a variety of native species has shown strong success. The plants with the greatest positive response to irrigation with treated wastewater were L*eptospermum scoparium* (mānuka), *Olearia paniculata* (akiraho), *Coprosma robusta* (karamu), *Podocarpus cunninghamii* (Hall's totara), *Cordyline australis* (tī kōuka/cabbage tree) and *Phormium tenax* (harakeke/flax).

Dr Hugh Wilson, botanist and manager of Hinewai Reserve, has also provided the Council with a comprehensive list of native species that would be suitable for irrigating with treated wastewater, including trees and shrubs for flat and sloping sites (see Appendix T for a copy). The planting report provides a very diverse list of species suitable for the range of situations on the Upper Robinsons Bay site. The intention would be to select species not just for their suitability for irrigation, but also for restoration and ecosystem enhancement. The list of plants suggested could be used to establish a revegetation methodology for the site.

The lysimeter testing and native tree trials undertaken by the university have not shown any negative effects in terms of soil aggregate instability or nitrate leaching for application rates of up to 2,000 mm per year, which is far in excess of that being considered for the inner bays irrigation option, which range between 168 – 610 mm per year.

5.5.2 Public Access

The scheme for 11 Sawmill Road would include provision for public access. The public access could include the following elements:

- Small public car park accessed off Sawmill Road.
- Information signage and interpretation panels to highlight the historical features of the site and former uses, including former use as a sawmilling operation. There is already some historical signage in place, refer Figure 5-24, that could be utilised. Signage to describe the mixed use of the site as a treated wastewater irrigation area, including descriptions of the vegetation restoration and irrigation treatment features. Wayfinding signage could also be included.
- It is envisaged that a walking track would loop throughout parts of the property and could take in views of the following features:
  - Robinsons Bay Stream
  - Historic sites
  - Irrigation systems
  - Various native species restoration copses
  - Oak plantation
  - Views of Akaroa harbour.

[3] http://www.kiwiscience.com/duvauchelle.html accessed 11 November 2019

The walking loop would be restricted to the south side of the Robinsons Bay Stream. Small bridges or similar would be used to traverse the ephemeral water ways.

Due to the nature of the land it is unlikely that wheelchair or push chair access would be possible across all of the hiking route, as steps would likely be required in a number of locations, especially on the steeper zones. Notwithstanding this it is possible that a large portion of the lower valley floor could be wheelchair accessible.

5.6 Heritage Features

The Robinsons Bay area has a rich history and there are a number of accounts of historic human activity in the area. Of particular interest at 11 Sawmill Road is a historic sawmill site that was known to exist on the land in the nineteenth century. This is a significant historical aspect for the area in terms of deforestation and development into a pastoral environment. Remnants of this activity that can still be seen on the ground today, although much of the infrastructure is now lost. Adjacent to 11 Sawmill Road is Pavitt Cottage which lies at 5 Sawmill Road (at the intersection of Sawmill Road and Robinsons Bay Valley Road) and is a heritage listed feature – refer Section 5.7 for further commentary.

An oak plantation lies on the lower slopes of 11 Sawmill Road in addition to an abandoned homestead. It is intended that the oak plantation will remain. A farm shed and stockyards lie close to the Sawmill Road entrance, these are likely to be removed.

The majority of the infrastructure proposed for this scheme lies away from the known artefacts of the nineteenth century infrastructure. It is recommended that an archaeological study should be undertaken to confirm this, and an authority may be required for disturbance of artefacts. A discovery protocol should be put in place for the works for and any unforeseen discoveries of koiwi and/or taonga.

5.7 Planning Evaluation

The planning considerations for the proposed development of the ponds and wetland on Old Coach Road Pond opposite the treatment plant, upper Robinsons Bay (11 and 88 Sawmill Road), Hammond Point and Takamātua Valley are discussed below, including the relevant overlays/zones, planning provisions and a high level consideration of the potential effects. The assessment also considers the planning requirements associated with the potential reuse of non-potable water in Akaroa. It is noted that the purpose of this assessment is to identify the key planning considerations only and a more detailed planning assessment will be undertaken once the preferred option is selected. Refer to Appendix U for maps showing the different planning overlays that apply to each site.

5.7.1 Treatment Plant Pond and Wetland Site on Old Coach Road

The pond and wetland site is located adjacent to SH 75 and Old Coach Road, Akaroa (6864 Christchurch Akaroa Road) opposite the treatment plant. Figure 5-12 shows the potential development of the site and relevant Christchurch District Plan (CDP) overlays. The development of the site includes storage ponds for the wastewater treatment plant, a sub-surface wetland, a utility building housing a pump station for the Goughs Bay and Pompeys Pillar options (approximately 7.5 m x 10 m with an internal height of 3.5 m), and associated pipes and ancillary equipment. The raw wastewater storage pond would be covered, with the air extracted and treated to remove odours. The utility building partly would be set into the slope of the site. There will be occasional discharge of highly treated wastewater from the sub-surface wetland to the Childrens Bay stream.

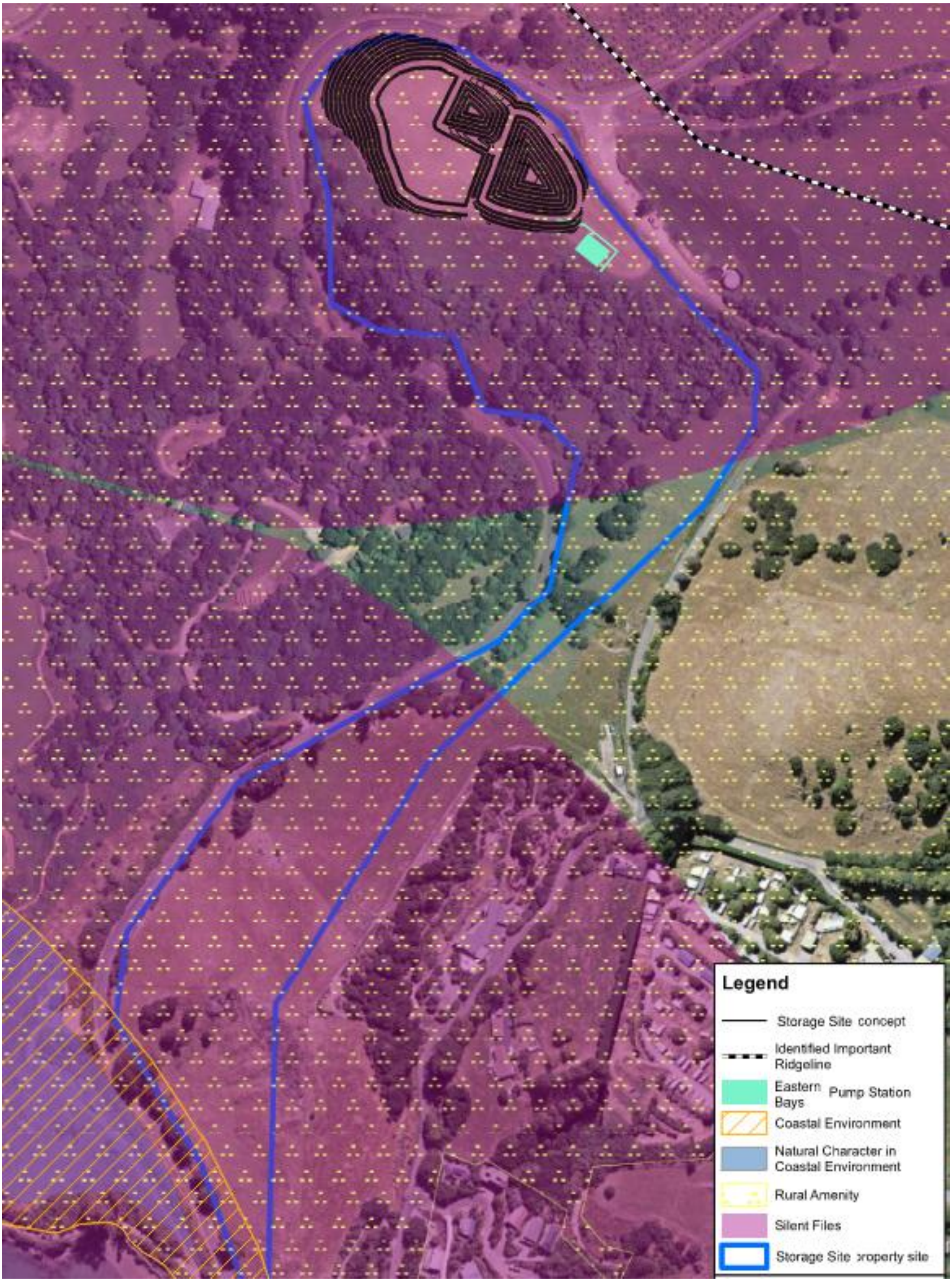


Figure 5-12 Treatment Plant Pond and Wetland Site Provisional Layout and Christchurch District Plan Overlays

5.7.1.1 Christchurch District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and falls within the rural amenity landscape Rural Amenity Landscape (RAL)1.0 Banks Peninsula in the CDP, as shown on Figure 5-12.

The proposed activities associated with wastewater disposal are a "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

Utilities Rule 11.8.1 P2 states that the "Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator" are permitted activities provided the activity complies with the Built Form Standards for the Rural Banks Peninsula Zone. In terms of the Built Form Standards for the Rural Banks Peninsula Zone, the standards in large part refer to bulk and location of buildings (which includes the storage ponds). These are discussed briefly below.

- A minimum set back of 30 m from SH 75 or 15 m from another road (Built Form Standard 17.4.2.5)
- Setbacks of 10 m from internal boundaries (Built Form Standard 17.4.2.7)
- Site coverage of buildings shall not be greater than 10% of the site area or 2,000 m2 whichever is the lesser (Built Form Standard 17.4.2.9)
- The maximum building footprint shall be 300 m2 (Built Form Standard 17.4.2.10).

Given that the standards relating to matters such as site coverage and building footprint for the development of the site are unlikely to be met by the proposal, resource consent as a restricted discretionary activity under Rule 17.4.1.3 would be required. The Council's discretion is limited to:

- The Built Form Standards that are not met;
- Significant features and rural amenity landscape (as set out in 9.2.8.2);
- Site of Ngāi Tahu cultural significance (as set out in 9.5.5)
- Identified important ridgelines (as set out in 17.11.1.10).

In terms of other provisions in the CDP affecting the site the following are of relevance:

- Appendix 9.5.6.1 Schedule of Wāhi Tapu / Wāhi Taonga – Silent File 14b (located within the areas referred to as Silent File 027 in the Mahaanui Iwi Management Plan 2013). The intended alignment of the pipeline from the storage site back into Akaroa for the purple pipe and the harbour outfall is through the site so it will also intersect Silent File 15b.
- Earthworks relating to development of the site will require resource consent as a restricted discretionary activity in terms of Earthworks Rule 8.9.2.3 RD5 as the earthworks are within a Silent File identified in Appendix 9.5.6.1. The general earthworks and earthworks to create the access tracks also require consent for a restricted discretionary activity pursuant to Utilities Rule 11.4.3 RD5, as the access track is to be created within a site identified in Appendix 9.5.6.1. Such applications are not required to be publicly notified under Rules 8.9.1 and 11.3 (j).
- Rule 17.4.2.3 Identified Important Ridgeline states all buildings shall be located at an elevation at least 20 vertical metres immediately below the height of any adjoining Important Ridgeline identified on the planning maps.
- The site adjoins the Identified Important Ridgeline as shown on Figure 5-8 and the proposal does not satisfy Rule 17.4.2.3 given that the contours on the site and surrounding area do not allow the 20 vertical metres to be achieved. As a consequence resource consent as a restricted discretionary activity under Rule 17.4.1.3 RD1 would be required.

5.7.1.2 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance to the proposed development:

- The site is identified as “High Soil Erosion Risk” in the Land and Water Regional Plan (LWRP). Earthworks associated with any storage pond in these areas are likely to require resource consent as a restricted discretionary activity under Rule 5.171 given the earthworks will exceed the specified limits in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Council has been obtained so any earthworks associated with the building are exempt from this rule.
- Rule 7.50 of the Canterbury Air Regional Plan (CARP) provides for the discharge of contaminates into air from the treatment and disposal of less than 50 m^3 per day of human sewage effluent. However, as the discharge will exceed 50 m^3 per day, it will therefore be a discretionary activity under Rule 7.63.
- The storage ponds and wetland would have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds or wetland would not occur. If there was a +discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.
- It is also anticipated that the sub-surface wetland will discharge highly treated wastewater approximately once every 5 years to the Childrens Bay Stream. This discharge will require resource consent under Rule 5.86 of the LWRP which states that the discharge of treated sewage effluent to surface water is a non - complying activity.
- In any event, the use of land for a community wastewater treatment system will require consent as a discretionary activity under Rule 5.84.

5.7.1.3 Preliminary Assessment of Effects

In terms of effects the site is relatively well separated from sensitive uses with the nearest dwelling approximately 100 m from the site. The Landscape and Visual Effects Review (refer to Appendix V) noted that the site is not visible from SH75 and views are limited from other vantage points. The site can be viewed from Long Bay Road, however this is predominantly of a transient nature for road users. The site is relatively level which will reduce the amount of potential earthworks and its location in proximity to the WWTP is a logical one, concentrating utility type developments in one locality. Potential odour from the pond is not considered to be a significant issue given the raw wastewater pond will be covered and the air extracted and treated. The highly treated wastewater in the treated wastewater storage pond and subsurface wetland will not have objectionable or offensive odours.

Overall, subject to final design which can incorporate appropriate mitigation such as landscaping to naturalise the ponds and wetland, adverse effects can be managed in an acceptable manner.

As indicated, planting for naturalisation and screening purposes on the perimeter and between the ponds and wetland will assist to mitigate any adverse visual effects. Plantings should be undertaken in natural patterns and groupings as much as possible and appear as an extension of and link in with surrounding vegetation. While the buildings may not achieve significant reduction below the identified Important Ridgeline, the ridgeline in this location is broad and not sharply defined meaning any intrusion is less obvious, particularly as the ponds would have a low elevation and the utility building would be located further down the site and set into the slope.

Noise effects from the operation pump station are anticipated to be minor and comply with CDP noise provisions. Noise will be mitigated by measures such as insulation and the separation distances to sensitive uses.

Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.

In respect of the site being located in a Silent File area, Ōnuku Rūnanga are aware of potential development of the site and have confirmed that there do not appear to be any issues in relation to earthworks within this Silent File area. However, a cultural monitor should be present during excavations and an accidental discovery protocol put in place.

5.7.2 Upper Robinsons Bay

11 and 88 Sawmill Road in upper Robinsons Bay Valley are shown in Figure 5-13 which shows development areas and relevant CDP overlays (refer to Appendix U for full drawing). The development of the site includes irrigated areas, utility buildings, and associated pipes and ancillary equipment.

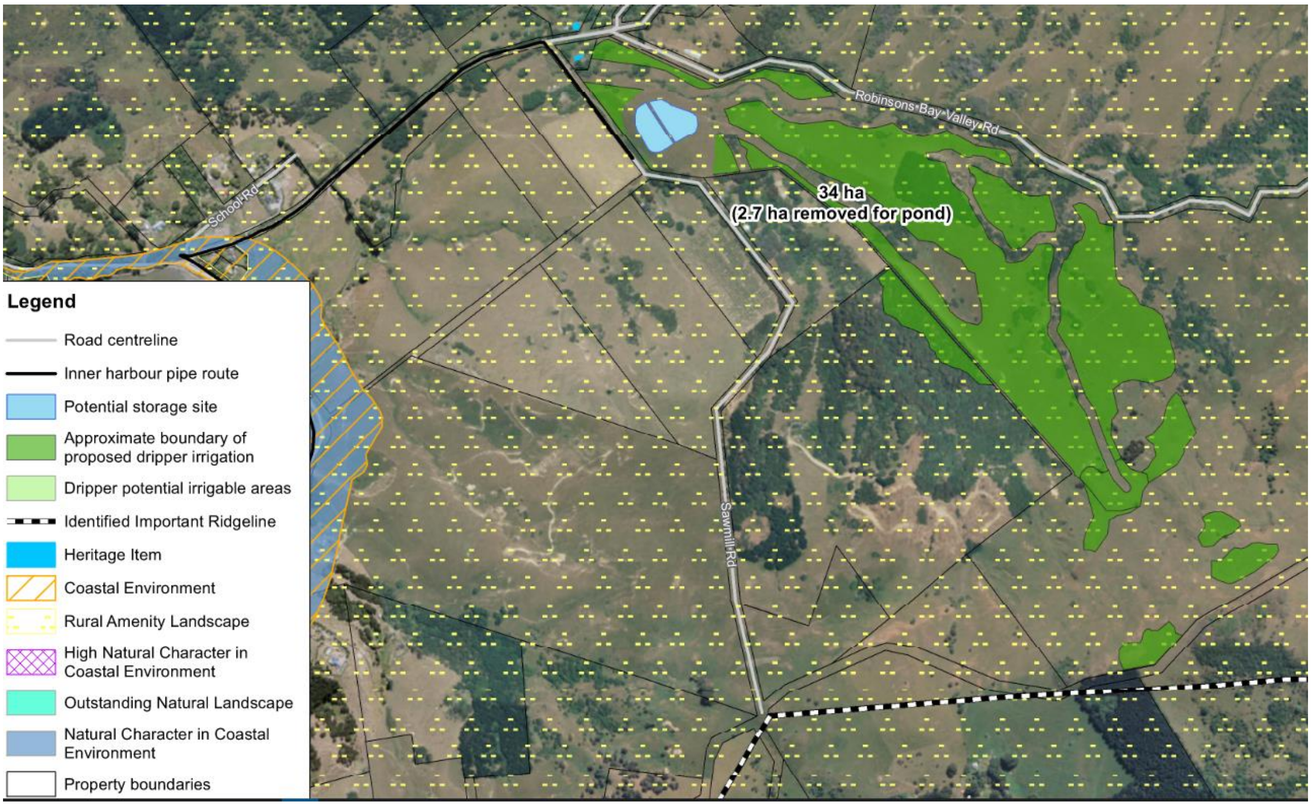


Figure 5-13 Upper Robinsons Bay Irrigation Sites – Christchurch District Plan Overlays

5.7.2.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and falls within the rural amenity landscape RAL1.0 Banks Peninsula in the CDP.

The proposed activities associated with wastewater disposal area are a "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

Utilities Rule 11.8.1 P2 states that the "Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator" are permitted activities provided the activity complies with the Built Form Standards for the Rural Banks Peninsula Zone. In terms of the Built Form Standards for the Rural Banks Peninsula Zone, the standards in large part refer to bulk and location of buildings (which includes the storage ponds). These are discussed briefly below.

- A minimum set back of 15 m from roads (Built Form Standard 17.4.2.5)
- Setbacks of 10 m from internal boundaries (Built Form Standard 17.4.2.7);
- Site coverage of buildings shall not be greater than 10% of the site area or 2,000 m^2 whichever is the lesser (Built Form Standard 17.4.2.9); and,
- The maximum building footprint shall be 300 m^2 (Built Form Standard 17.4.2.10).

Any utility buildings are likely to be of a modest scale which may not infringe any of the built form standards. As such resource consent is not likely to be required for the buildings. If resource consent is required, then Rule 17.4.1.3 Restricted Discretionary Activity applies.

However, the use of the land for irrigation of wastewater to trees is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is considered a utility that requires resource consent as a discretionary activity under Rule 11.4.3.

The ponds are considered as buildings under the CDP and subject to build form standards such as setbacks, site coverage and building footprint. It appears that not all of these standards will be met and resource consent as a restricted discretionary activity is therefore required. When considering the proposed streamside restorative planting, “bank enhancement works” are generally a permitted activity under Rule 6.6.

The storage pond is in proximity to a former sawmill site (Robinsons Sawmill). While the site is not identified in the CDP as a heritage item, and the pond does not appear to encroach directly on the site, an Archaeological Assessment (refer Appendix W) has been undertaken for the area which recommends that an Archaeological Authority from Heritage New Zealand Pouhere Taonga is applied for in respect of works on the site (refer to Section 5.77 of this report).

Pavitt Cottage and its setting, located at 5 Sawmill Road, Robinsons Bay is identified in the CDP as a Significant Heritage Item 1171 (dwelling) and 145 (setting) in Appendix 9.3.7.2 Schedule of Significant Historic Heritage (see Figure 5-14).

Figure 5-14 Pavitt Cottage and Setting (Christchurch District Plan)

The CDP notes the item "*has historical and social significance as a 19th century dwelling associated with an early sawmill and linked to several well-known local families. The dwelling has architectural and aesthetic significance as an example of a colonial dwelling from the 1860s that was extended soon after construction. 5 Sawmill Road has technological and craftsmanship significance for its ability to demonstrate vernacular construction methods from 19th century Banks Peninsula… The dwelling and its setting are of archaeological significance because they have the potential to provide archaeological evidence relating to past building construction methods and materials, and human activity on the site, including that which occurred prior to 1900.*"

Rules apply to activities that may affect the dwelling such as new structures, or modification or demolition of existing structures within the setting. The purpose of these rules is to avoid effects such activities may have on the setting. These rules do not apply to activities outside of the defined setting.

The proposed ponds at 11 Sawmill Road are located more than 100 m from the cottage and its setting (see Figure 5-15 – blue line is 100 m separation distance from the maximum pond water level) and given this buffer distance it is anticipated there will be minimal effects on the cottage. However, the location of the cottage would be noted in any Construction Management Plan (CMP) so that contactors are aware of its presence.

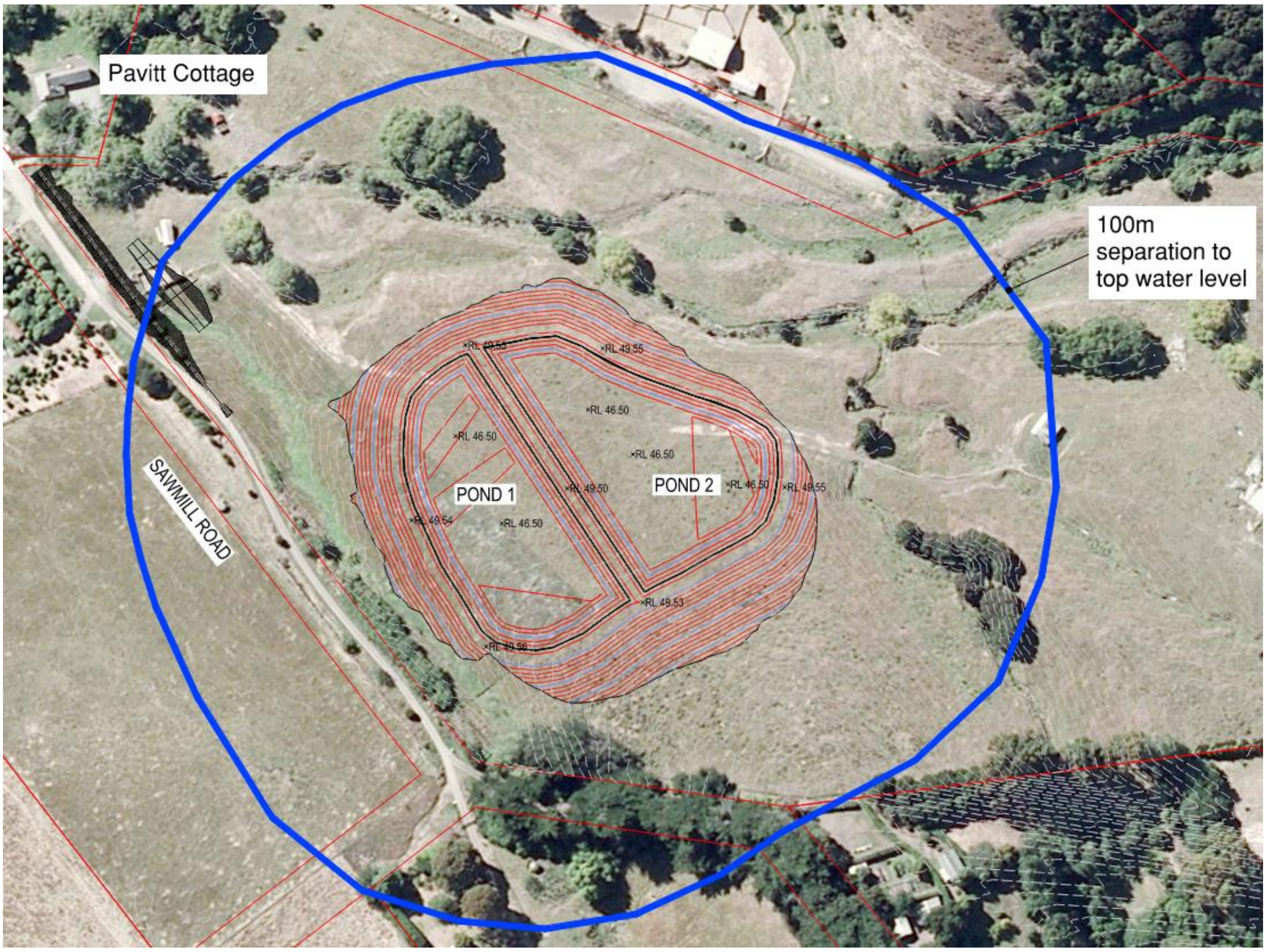


Figure 5-15 Setback of Proposed Upper Robinsons Bay Ponds from Adjacent Structures

Opposite Pavitt Cottage, on the other side of Robinsons Bay Valley Road, is the Former School Master's House which is Significant Heritage Item 1173 (dwelling) and 539 (setting) in Appendix 9.3.7.2 Schedule of Significant Historic Heritage in the CDP (see Figure 5-13). This item is located further north from the ponds than Pavitt Cottage and so again minimal effects are anticipated.

Figure 5-16 Former School Master's House and Setting (Christchurch District Plan)

No other rules in the CDP are applicable to the site as there are no overlays that trigger resource consents such as those relating to landscape or coastal matters.

5.7.2.2 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance:

- The site is identified as “High Soil Erosion Risk” in the Land and Water Regional Plan (LWRP). Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171 if the earthworks exceed the specified limits (more than 10 m^3 and cut and fill is greater than 0.5 m) in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Council has been obtained so any earthworks associated with a building are exempt from this rule.
- Part of the valley floor site is identified as over an unconfined or semi-confined aquifer in which Rule 5.75 of the LWRP requires any excavation to maintain 1 m separation between the base of any excavation and the aquifer and 50 m separation from a waterbody in order to be a permitted activity. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.
- Rule 5.154 of the LWRP states that the impounding and storage of water outside of a bed of a river or natural lake is permitted if the volume is less than 20,000 m^3 or the maximum depth of water is less than 4 m. Accordingly, if the depth is less than 4 m then resource consent does not appear to be required. The current estimated depth of each pond is 4 m, on this basis resource consent would be required as a discretionary activity
- Under Rules 5.167- 6.169 of the LWRP the removal of vegetation or earthworks as part of any restorative planting could trigger the requirement for resource consent as a restricted discretionary activity if specified thresholds are exceeded.
- Rule 5.84 of the LWRP provides for the use of land for a community wastewater treatment system and the discharge of treated sewage effluent into or onto land as a discretionary activity.
- Rule 7.50 of the CARP provides for the discharge of contaminates into air from the treatment and disposal of less than 50m^3 per day of human sewage effluent as a permitted activity, provided certain

conditions are met. However, as the discharge will exceed 50 m^3 per day, resource consent would be required as this would be a discretionary activity under Rule 7.63.

5.7.2.3 Preliminary Assessment of Effects

The landscape review (see Appendix V) determined that all of the possible irrigation sites identified within the wider Robinsons Bay landscapes have the potential to accommodate the proposed irrigation area (pasture or planted) with low to moderate impacts on the existing character or general amenity of the area. This is because both landscapes already consist of a patchwork of various land cover and land uses and the introduction of a new land use would be easily absorbed within this context. 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. Accordingly, the above can apply to 11 and 88 Sawmill Road sites.

An artist's impression of what the inner bays irrigation scheme might look like is shown in the following images:

- Upper Robinsons Bay artists impression Figure 5-18, with the before photograph shown in Figure 5-17
- Hammond Point artists impression Figure 5-20, with the before photograph shown in Figure 5-19
- Takamātua artists impression Figure 5-22 with the before photograph shown in Figure 5-21

Figure 5-17 Original Image Upper Robinsons Bay

Figure 5-18 Artist's Impression of Irrigation to Native Trees Scheme in Upper Robinsons Bay

Figure 5-19 Original Image Hammond Point

Figure 5-20 Artist's Impression of Irrigation to Native Trees Scheme at Hammond Point

Figure 5-21 Original Image Takamātua

Figure 5-22 Artist's Impression of Irrigation to Native Trees Scheme in Takamātua

Geotechnical risks are low for all shortlisted sites since geotechnically unstable land has been excluded from further consideration (see Appendix L for further information). Appropriate engineering design would minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity). The storage ponds would be located on relatively flat land so that these risks can be readily mitigated.

In terms of other potential effects it is noted:

- The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure.
- Treated wastewater would be applied to land at rates that meets the assimilative capacity of site vegetation and soils.
- The location of two domestic water bores in Robinsons Bay valley (near the State Highway) and other private water supplies identified by the Working Party in the area should be confirmed, and consideration of alternative waters supplies be undertaken if required.
- The condition of existing waterways at the sites has not been assessed. However, Council is currently undertaking a freshwater ecological assessment of Crown Island Stream and the findings from this will be considered once available. Any discharge into streams including those that then enter coastal areas, would require assessment of the potential to cause adverse effects. However, the possible locations for irrigation areas were determined using setback distances selected to minimise the risk of discharge into waterways. The use of drip lines for irrigation would avoid the production of aerosols. Planting of vegetation in the buffer areas would also provide effective mitigation.
- In terms of heritage and cultural effects there are not any identified significant adverse effects. Ōnuku Rūnanga have not identified any specific matters of concern and two identified heritage sites (dwellings) in the vicinity of Robinsons Valley Road will not be affected. An archaeological assessment would be undertaken to ascertain any potential adverse effects on the Robinsons Bay Sawmill site.
- The risk of irrigation odours is considered low, given that the pond will contain highly treated and lightly loaded wastewater and the use of drippers to disperse wastewater at or below the ground surface, particularly with the proposed buffer distances to residences which will also assist to manage potential nuisance effects.

- Land based recreation activities are unlikely to be adversely impacted given the absence of public recreation facilities and activities.
- Noise effects from sources as irrigation equipment and pump stations is anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.
- Akaroa treated wastewater will meet very a high standard and will present very low risks to public health.
- Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.

The use of the site by the public for recreation and amenity purposes will have positive effects. All schemes will have “unrestricted” public access to the irrigation area including the provision of walkways. The use of land treatment areas by the public for recreation was assessed against the Australian Guidelines for Water Recycling (AGWR) which given the high level of treatment enables access without risk to public health

A range of different measures are applied to manage public health risks associated with irrigation of treated wastewater to land around New Zealand. In the case of the proposed Akaroa wastewater scheme the treated wastewater will meet very a high standard and will present very low risks to public health when drip irrigated to native trees. Refer to Section 9.2.6 for further detail on this. Accordingly, it appears that the risk to public health arising from public access and recreation activities can be appropriately managed.

The views and concerns of community stakeholders raised to date have been considered in the preliminary assessment of effects. The preparation of the AEE for any final selected scheme option will be accompanied by further stakeholder consultation and it is anticipated that proposed activities will be refined as appropriate to avoid, remedy or mitigate potential adverse effects including potential effects on local communities.

5.7.3 Hammond Point

The Hammond Point site (6528 Christchurch Akaroa Road) is located between Robinsons Bay and Takamātua. An area of 5.23 ha is proposed for drip irrigation to trees. There are a number of dwellings to the north of the site along Christchurch Akaroa Road which are in relative proximity to the irrigation area, with the nearest dwelling being approximately 95m from the irrigation area. Figure 5-23 shows the site in the north, as well as the Takamātua site in the south, and the relevant CDP overlays. Refer to Appendix U for the full map.

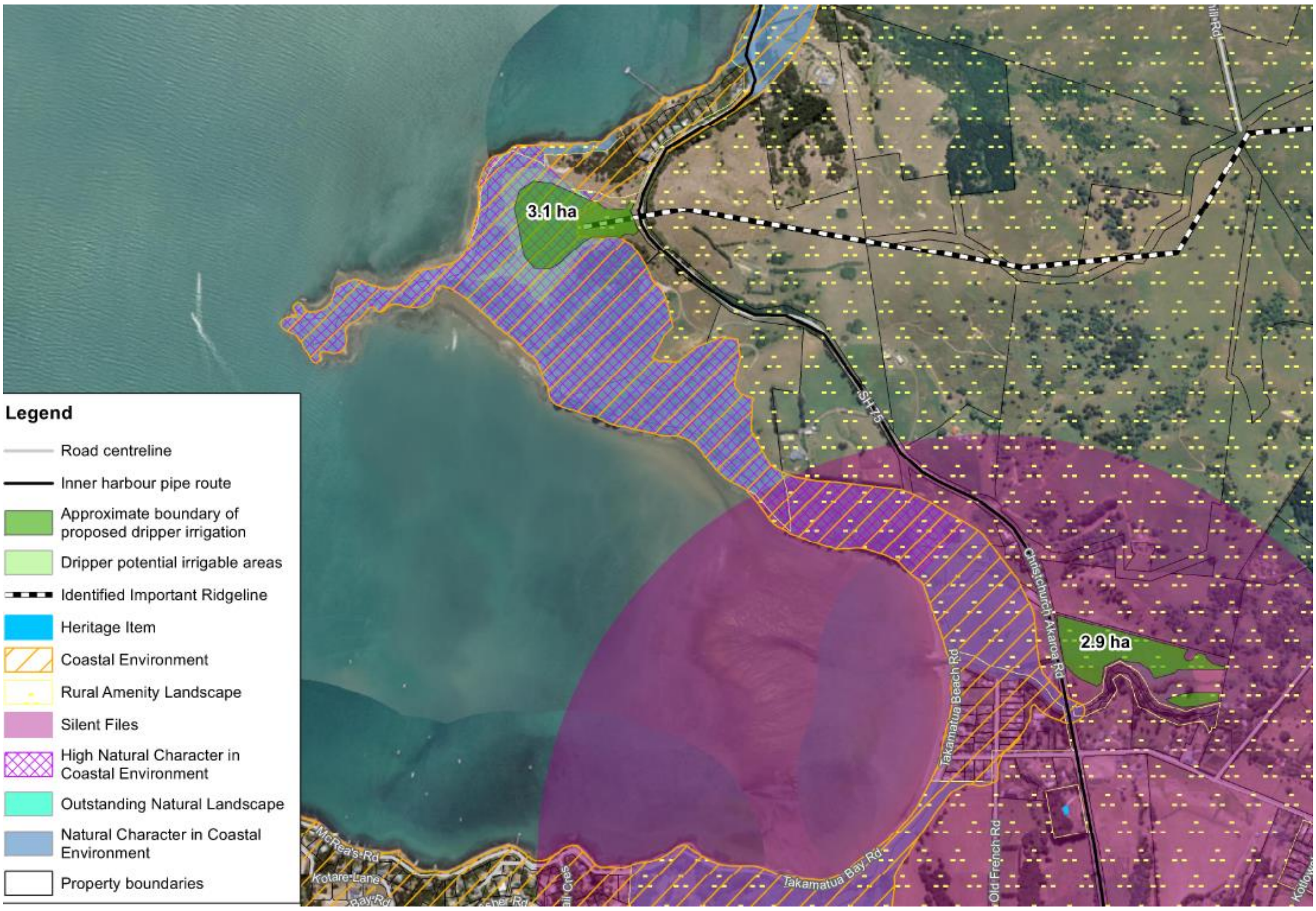


Figure 5-23 Christchurch District Plan Overlays for Hammond Point and Takamātua Irrigation Areas

5.7.3.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and much of the site falls within the Coastal Environment and High Natural Character in Coastal Environment overlays in the CDP. A small area of the site is in the Rural Amenity Landscape overlay. An Identified Important Ridgeline extends from the summit of the Banks Peninsula hills to the eastern portion of the site. A 'Remainder of Port Hills and Banks Peninsula Instability Management Area' Overlay is located over the site.

The proposed activities associated with wastewater disposal are a "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

The use of the land for irrigation of wastewater is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of requires resource consent as a discretionary activity under Rule 11.4.3.

While the site is located within an area of High Natural Character of the Coastal Environment, the rules within Chapter 9 Natural and Cultural Heritage of the CDP do not apply to utilities, except as matters for discretion when consent is triggered for the utility itself (9.2.8.3).

5.7.3.2 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance to the proposed development:

- The use of land for a community wastewater treatment system and discharge of treated wastewater from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP and includes the irrigation of wastewater to land.
- Parts of the site are identified as “High Soil Erosion Risk” in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171 if the earthworks exceed the specified limits (more than $10m^3$ and cut and fill is greater than 0.5 m) in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Council has been obtained so any earthworks associated with a building are exempt from this rule.
- Rule 7.50 of the CARP provides for the discharge of contaminates into air from the treatment and disposal of less than $50m^3$ per day of human sewage effluent. However, as the discharge will exceed $50m^3$ per day, this would be a discretionary activity under Rule 7.63.

5.7.3.3 Preliminary Assessment of Effects

In terms of natural hazards, a site walkover was completed to review by a geotechnical engineer to assess slope risks, the report from this walkover is included in Appendix M. Geotechnically unstable land identified in the assessment has been excluded from further consideration. There are no ponds proposed for the Hammond Point site, only dripper irrigation to trees is proposed.

- In terms of effects of other potential effects it is noted:
  - The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure.
  - Treated wastewater would be applied at rates that meets the assimilative capacity of site vegetation and soils.
  - An initial search of the ECan groundwater well database indicated that there are no active bores for domestic or stock water supply in proximity to the site, with the nearest domestic water bores located in Robinsons Bay valley. It is possible there are further properties that rely on groundwater, but these are not recorded in the database. These would need to be located by site walkovers and landowner advice. An assessment of effects on these water supplies would be required, and alternatives considered.
- The risk of irrigation odours causing an adverse effect is considered low given that the nearest dwelling is approximately 95 m from the irrigation area.
- In terms of heritage and cultural effects Ngāi Tahu have not identified any specific matters of concern or sites of significance to date.
- Akaroa treated wastewater will meet a very high standard and will present very low risks to public health, which is further mitigated by the absence of close neighbours.
- Noise effects from sources such as irrigation equipment and pump stations are anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.
- Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.

The April 2020 Landscape and Visual Assessment – Pompeys Pillar, Goughs Bay and Hammonds Point report (copy provided in Appendix V) provides a high-level assessment of the potential landscape character and visual amenity matters at the Hammond Point site. In relation to the site, the report considers the potential landscape and visual effects to be low overall and notes the following:

- A complex existing vegetation pattern will help absorb the change in land use from pasture to vegetation
- Native forest will increase biodiversity
- Given the site is predominantly within the Coastal Environment - Outstanding Natural Landscape and Coastal Environment - High Natural Character planning overlays, the return of the landscape from pasture to native forest is a positive effect
- The site is highly visible from many vantage points
- Vegetation cover will erode the legibility of the underlying volcanic landform which is distinctive.

5.7.4 Takamātua Valley

The site (6683 Christchurch Akaroa Road) is located inland of Takamātua Bay, north of the Takamātua Stream Esplanade Reserve and comprises an area of 2.9 ha for drip irrigation. Figure 5-23 (above) shows the development areas and relevant CDP overlays.

5.7.4.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and falls within the rural amenity landscape RAL1.0 Banks Peninsula CDP.

The proposed activities associated with wastewater disposal are a “utility” under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

The use of the land for irrigation of wastewater is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is defined as a utility and requires resource consent as a discretionary activity in terms of Rule 11.4.3.

In terms of other provisions in the CDP affecting the site the following are of relevance:

- Appendix 9.5.6.1 Schedule of Wāhi Tapu / Wāhi Taonga – Silent File 14a (located within the areas referred to as silent file 027 in the Mahaanui Iwi Management Plan 2013).
- There are two protected trees on the site (T517 and 518), although these are outside the area proposed for irrigation and are unlikely to be affected.
- Despite the site’s location within a Liquefaction Management Overlay, the rules relating to natural hazards do not affect the proposal as they relate only to subdivision and residential development.

5.7.4.2 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance to the proposed development:

- The use of land for a community wastewater treatment system and discharge of treated wastewater from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP and includes the irrigation of wastewater to land.
- Parts of the site are identified as “High Soil Erosion Risk” in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171 if the earthworks exceed the specified limits (more than 10 m3 and cut and fill is greater than 0.5 m) in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Council has been obtained so any earthworks associated with a building are exempt from this rule.
- Rule 7.50 of the CARP provides for the discharge of contaminates into air from the treatment and disposal of less than 50 m3 per day of human sewage effluent as a permitted activity provided certain conditions are met. Current estimates of the discharge are slightly below 50 m^3 per day and an

assessment against the conditions would therefore be required to determine whether the activity is permitted. The relevant conditions include:

- The treatment system and any surface irrigation of effluent is at least 20m from the boundary of the property of origin
- Spray irrigation, and storage of effluent in uncovered vessels, including oxidation ponds, occurs at least 50m from the boundary of the property of origin and at least 150m from any sensitive activity or wāhi tapu, wāhi taonga or place of significance to Ngāi Tahu that is identified in an Iwi Management Plan. Given that the site is located within a Silent File, the conditions of Rule 7.50 cannot be met and the activity must be considered under Rule 7.63 as a discretionary activity.

5.7.4.3 Preliminary Assessment of Effects

- The landscape consists of a patchwork of various land cover and land uses and it is considered the introduction of a new land use can be absorbed within this context.
- In terms of natural hazards, the land is flat and so there is no risk of land instability. The site located within a Liquefaction Management Area overlay. However, the relevant rules from Chapter 5 only apply to subdivision and residential development.
- In terms of other potential effects, the following is noted:
  - The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure.
  - Treated wastewater would be applied to land at rates that meets the assimilative capacity of site vegetation and soils.
  - An initial search of the ECan groundwater well database identifies a number of bores for domestic or stock water supply in proximity to the site. The Akaroa Working Party has also provided information about springs in the Takamatua area. It is possible there are further properties that rely on groundwater, but these are not recorded in the database. These would need to be located by site walkovers and landowner advice. An assessment of effects on these water supplies would be required.
  - The condition of Takamātua stream has not yet been assessed. However, a Council review of the stream is underway and the findings from this review will be taken into account. The location of the irrigation area has been determined using setback distances to minimise the risk of discharge into the waterway. In addition, low pressure type irrigators or drip lines do not produce aerosols and/or planting of vegetation by the stream will provide mitigation.
- The risk of odours from irrigation causing an adverse effect is considered very low as it will be subsurface drip irrigation.
- Although the site falls within Silent File 14a, early engagement with Ōnuku Rūnanga has identified that there are no sensitive areas that may affect irrigation at this site.
- Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.

The two significant Kahikatea trees within the property are on the opposite (seaward) side of the State highway and are not within the area identified for irrigation.

5.7.5 Reuse of Non-Potable Water

Reuse of treated wastewater for is being considered for non-potable uses in Akaroa such as supply to:

- Irrigate public parks and flushing of public toilets
- Toilet flushing and garden watering in commercial and residential properties

For further detail, please refer to Section 9.5. The use and discharge of treated sewage effluent from a community wastewater treatment system to land (be it public parks or private properties) is a discretionary activity under Rule 5.84. Accordingly, resource consent would be required.

However, the discharge onto land within a Community Drinking Water Protection Zone is a prohibited activity under Rule 5.85. There are a number of these zones over the northern part of Akaroa which means that no parks or private properties in this area could be irrigated with the wastewater. It is understood the zones relate to groundwater bores that are no longer in use and that the Council will request that these protection zones are removed, meaning the discharge would no longer be a prohibited activity and resource consent could instead be sought under Rule 5.84.

In respect of the use of the treated wastewater for flushing toilets, resource consent for a discharge for this activity would not be required because the wastewater would be contained within a piped system.

In respect of the reuse of treated wastewater in Akaroa for irrigation of public parks, the consenting risk is anticipated to be relatively low provided the risks are managed appropriately. The Canterbury District Health Board (CHDB) has advised on the need to control spray drift so as to avoid airborne drift into residential areas as well as restricting access of the public to parks while spraying is occurring and for a suitable period of time after spraying has occurred. It is also assumed that any odour will not be offensive or objectionable and the discharge is applied land at rates that meets the assimilative capacity of the vegetation and soils.

It is noted that there is wide community support for the irrigation of public parks using treated wastewater. In relation to the use of treated wastewater on private gardens and for use in private properties, the initial feedback from the CDHB is that the use of non-potable reuse for private property use is not acceptable practice under the current NZ regulatory framework (refer 9.5 Non-potable Reuse (Purple Pipe) of this report and Appendix G). Accordingly, obtaining resource consent for this activity is likely to be difficult at present.

Pipeline to Robinsons Bay Site

It is proposed that the pipeline from the treatment plant to the irrigation sites would be installed along legal road including State highway 75 and then paper roads to the site at 11 Sawmill Road. Approvals will need to be obtained from NZTA for installation of a pipe in the highway corridor, and for installing a pipe crossing below a state highway. Roads in the CDP are zoned Transport and the installation of utilities is generally a permitted activity in this zone.

5.7.6 Archaeological Sites

The Heritage New Zealand Pouhere Taonga Act 2014 makes it unlawful for any person to modify or destroy, or cause to be modified or destroyed, the whole or any part of an archaeological site without the prior authority of Heritage New Zealand. The Heritage New Zealand Pouhere Taonga Act 2014 defines an archaeological site as a place associated with pre-1900 human activity, where there may be evidence relating to the history of New Zealand.

Both the treatment plant pond site and the Takamātua irrigation site fall within Silent File areas. Advice from Ōnuku Rūnanga is that there are no issues in relation to the proposed activities. Ōnuku Rūnanga would manage any excavation required for this project in the same manner it does with any other excavation that occurs within a silent file, which is to have a cultural monitor present and to have the accidental discovery protocol in place. Notwithstanding these identified sites, earthworks associated with any of the proposed study sites could potentially result in a requirement to apply for an Archaeological Authority. As part of the cultural impact assessment (CIA) completed by Ōnuku Rūnanga, the Rūnanga have requested that an archaeological authority is obtained prior to the commencement of any earthworks.

In respect of Robinsons Sawmill an Archaeological Assessment has been carried out on the site (refer Appendix W) The report states "*the result of this assessment is also that the surrounding archaeological landscape of the 19th century sawmill is of medium to high archaeological value, and it has thus been recorded as an archaeological site (N36/260)"*. At present N36/230 is not on the formal New Zealand Heritage List/Rārangi Kōrero retained by Heritage New Zealand Pouhere Taonga but the assessment confirms that pre-1900 activity took place and so the area can be defined as an "archaeological site."

A Heritage New Zealand signboard (Figure 5-24) at Sawmill Road also provides details of the sawmill's history.

Figure 5-24 Robinsons Bay Sawmill Signboard

The Archaeological Assessment recommends that "*Before any demolition of historic structures or ground disturbance is to take place on Lot1, DP 82749, and bordering properties that are part of the surrounding archaeological landscape which includes the old sawmill site, the landowners should make an application to Heritage New Zealand for an authority to damage, modify, or destroy Archaeological Site Number N36/260."*

The guidelines for archaeological sites on the Heritage NZ website provides the following commentary around tree planting:

> *Effects on the values of the sites should be explicitly considered, not just effects on the physical features of the site. It is important to be aware that the recovery of information is a method of mitigating the loss of archaeological information, not for the loss of the site itself. Site destruction, although preceded by archaeological investigation, will result in the destruction of any contextual, educational or landscape values the site may have possessed. Conversely, planting trees on a site may not greatly affect surface features, but has the potential to disturb stratigraphy, hence affecting*

the future condition and information potential of the site. It may also reduce visibility, hence affecting interpretative and landscape values.

Based on the archaeological assessment and the guidelines referred to above an application for an Archaeological Authority will be required for works at Sawmill Road in Upper Robinsons Bay. Any requirement and/or constraints identified by the Archaeological Authority (such as not undertaking earthworks or tree planting on identified features) can be addressed and incorporated in the next stages of design. Figure 5-25 has overlaid the historic features identified in the assessment in Appendix W with the current proposed irrigation areas.

It is noted that the “well domestic supply” identified, is not on the ECan list of registered bores and so is assumed to be historic or not in use.

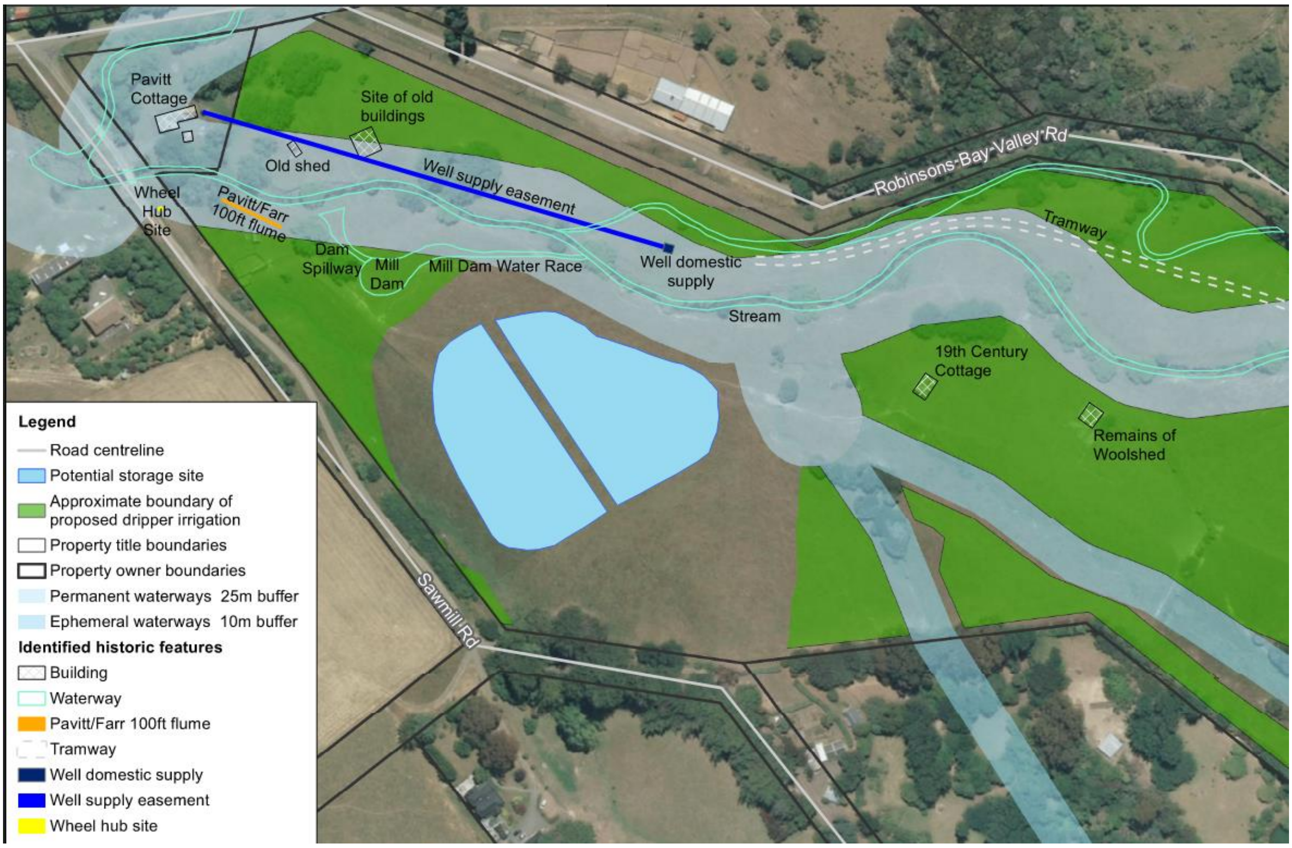


Figure 5-25 Sawmill Road Features Identified by Archaeological Assessment

5.7.7 Planning Summary

The planning assessment is high level and preliminary only and has been undertaken without the benefit of detailed investigations. Resource consents from both Environment Canterbury and Christchurch City Council are likely to be of discretionary and restricted discretionary status. The following table provides a summary of the likely consenting risks:

Table 5-1 Likely Consenting Risks

Adverse Effect	Site	Risk	Comment
Landscape /Visual – storage pond/access/trees	All Sites	Low	Effects can be mitigated by careful design in respect of such matters as contours and landscaping in terms of earthworks. Planting of native trees will have positive effects on biodiversity, natural character and amenity. This has been weighed against some negative landscape effects resulting from physical impacts (e.g. earthworks).
Noise	All Sites	Low	Little noise is anticipated to be generated during operation. Construction noise is expected to comply with CDP standards and will be managed through resource consent conditions and construction management plans.
Recreation	All Sites	Low	Limited recreation activities occur at present in the vicinity of the sites. Allowing public access to the upper Robinsons Bay site would result in a positive recreation effect.
Cultural/Historic Values	All Sites	Medium	The treatment plant pond site and the Takamātua site are located within Silent File Areas. Advice from Ōnuku Rūnanga is that there are no issues in relation to the proposed activities. Ōnuku Rūnanga would manage any excavation required for this project in the same manner it does with any other excavation that occurs within a silent file, which is to have a cultural monitor present and to have the accidental discovery protocol in place. While the Robinsons Sawmill is not a registered archaeological site or on the Heritage New Zealand heritage list, an archaeological assessment undertaken indicates it is likely to be an archaeological site and an Archaeological Authority should be applied for. The next stage of design will address any constraints as a result of the authority. Other sites are considered a low risk.
Ecology	All Sites	Low	No at-risk species identified at present. Council is currently undertaking a freshwater ecological assessment of Crown Island Stream and the findings from this will be considered once available
Odour	All Sites	Low	Odour modelling has shown that the risk of odour is low. No aerosols would be generated by drip irrigation under trees.
Amenity	All Sites	Low	While the actual or potential amenity effects appear to be minor or minimal some people may perceive that amenity will be adversely affected. Conversely the public may perceive the establishment of additional native forest as a benefit to region. It is not considered that perception, in the absence of an actual effect, poses a risk to the consenting process.

The preliminary assessment suggests that adverse effects of the treatment and disposal options are likely to be low or medium at the sites. The reduction of medium risks to a low status will require ongoing stakeholder engagement and undertaking site-specific investigations. Based on the investigations completed to date no high or significant risks are identified.

In respect of the reuse of non-potable water in Akaroa, the risk is anticipated to be low given the wide community support for this activity although this assumes odour will not be offensive or objectionable and the discharge is applied land at rates that meets the assimilative capacity of the vegetation and soils.

6 Option 2 – Goughs Bay Irrigation to Trees

6.1 Overview of Scheme Option

In January 2017 a screening evaluation of potential irrigable sites over the entire eastern Banks Peninsula area was undertaken using the criteria in Section 4.1. Included in the list of potential sites was an area of land between Goughs Bay and Hickory Bay. Subsequently, the Council contacted landowners in this locality. One of these landowners indicated that he would be interested in irrigating treated wastewater on his land (which is located at 461 Goughs Road, henceforth known as the Goughs Bay site). In parallel with landowner discussions, this site had also been identified by GIS screening as potentially viable (refer to Section 4.5). This landowner has previous experience with irrigating treated wastewater on a farm in Ashburton, from which his family undertakes cut and carry operations, and he therefore viewed this scenario as favourable for his farming practice. However, in discussions with the Council in January 2020 the landowner confirmed he is no longer interested in participating in the wastewater scheme.

Removal of landowner support at Goughs Bay has caused the Council to change the irrigation design for this site from pasture to native trees. Goughs Bay was originally planned as an irrigated pastoral scheme as this was a prerequisite of the landowner and respected his intentions to continue farming. However, it is now assumed that the farm (or at least part of it) would need to be purchased by the Council for wastewater scheme purposes if this option was chosen. Irrigation would be to native trees rather than pasture, as it offers advantages over pasture irrigation in terms of reduced wastewater storage, reduced irrigation area, reduced scheme costs, improved carbon sequestration, and ecological benefits this approach is considered to more effectively address the environmental, cultural, social and economic well-beings of the Local Government Act.

The location of the Goughs Bay site is shown in Figure 6-1.

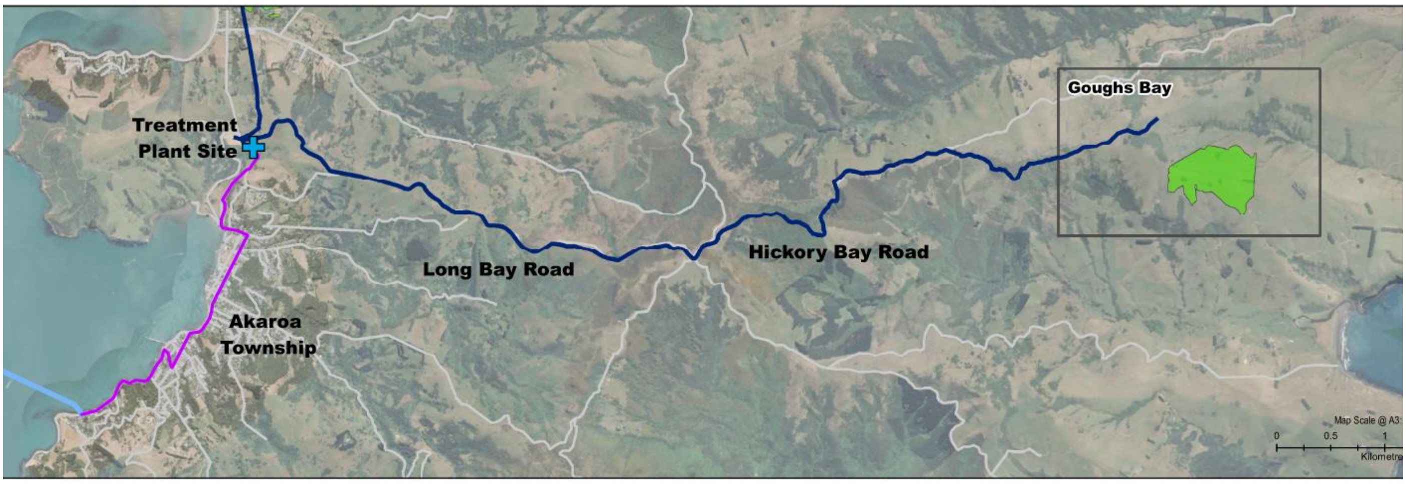


Figure 6-1 Overview of Goughs Bay Irrigation Scheme

A Goughs Bay irrigation scheme would be made up of the following components (see Section 4 for a description of these):

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m³ across the road from the treatment plant site on Old Coach Road, to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Treated wastewater pump station near the storage pond at the treatment plant
- 11 km long pipeline from the treatment plant to the Goughs Bay irrigation site, with the route along Long Bay Road and Hickory Bay Road and then paper roads to reach the site.
- Treated wastewater storage ponds (totalling approximately 30,000 m³) at 461 Goughs Road
- Dripper irrigation of 33 ha of mixed native plantings at 461 Goughs Road
- Non-potable reuse network for the most populated areas of Akaroa including UV treatment and possibly chlorination of non-potable reuse flow.

For more detail on the network upgrades, wastewater treatment plant and non-potable reuse components, please refer to Section 9.

An indicative layout of the Goughs Bay irrigation scheme is given in Appendix J and is shown in Figure 6-2 Overview of Irrigation Scheme at Goughs Bay Site.

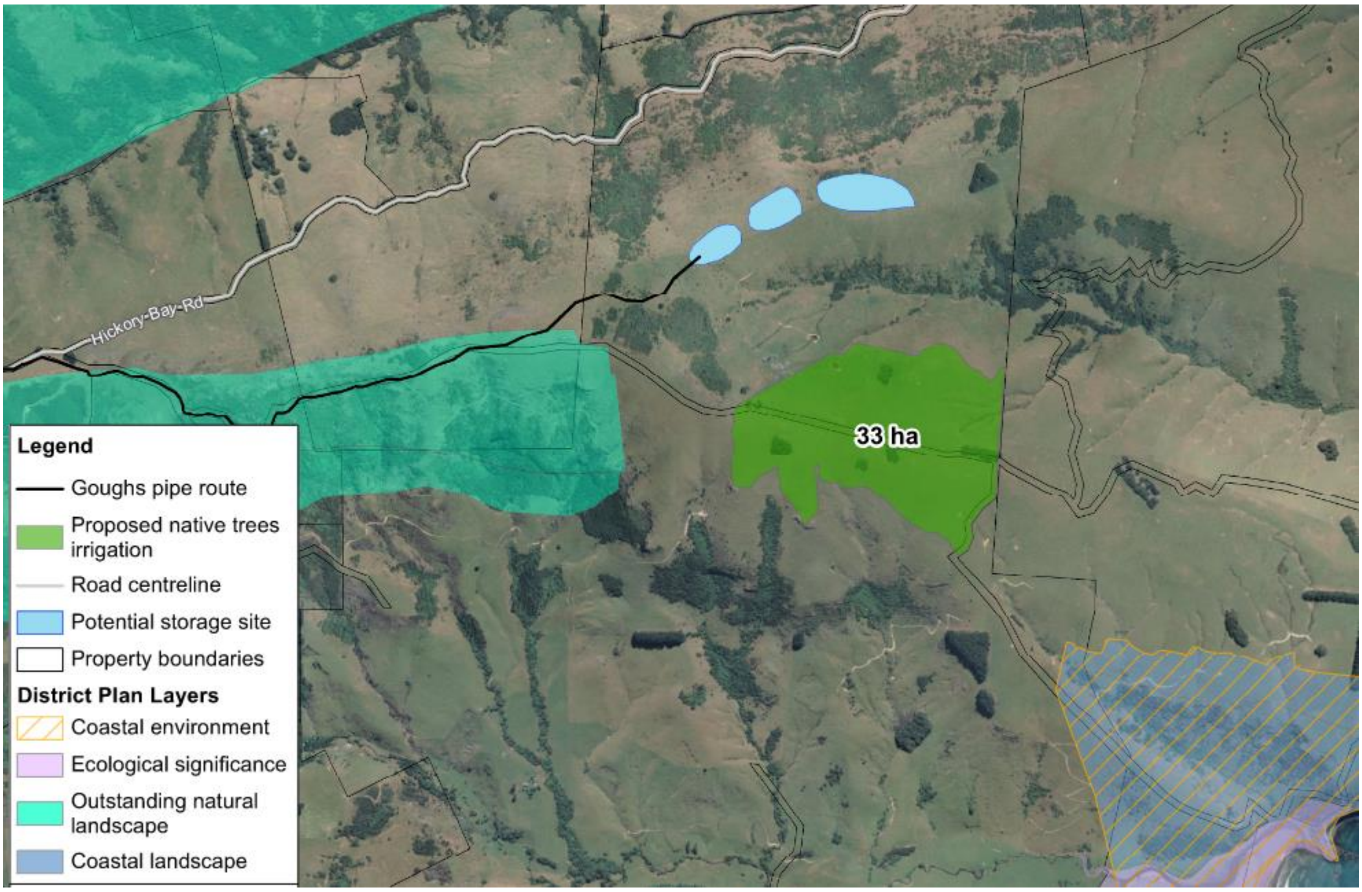


Figure 6-2 Overview of Irrigation Scheme at Goughs Bay Site

6.2 Assessment of Potentially Irrigable Area

The Council organised to capture survey information for the proposed irrigation area at 461 Goughs Road via airborne LiDAR (light detection and ranging). The site was flown in May 2018.

A site walkover was also undertaken by representatives from Council, civil and geotechnical engineers from Beca and an irrigation advisor from PDP to assess slope stability and irrigation potential on 24 May 2018. The walkover found that although the site was rocky in places, with limited topsoil, the potentially irrigable area could be extended to steeper slopes as there was a reduced risk of slope instability (see Appendix X for a full outline of the findings of the site walkover).

During the site walkover the possibility of irrigating the farm closer to the coast was introduced. This area had not been included in the area covered by airborne LiDAR and had not been walked over during the first site visit and so a second site visit to the lower land was conducted on 28 June 2018. Notes from this site visit are also included in Appendix X. After this visit the potentially irrigable area map was updated based on the findings. A potentially irrigable area of approximately 112 ha on the property at 461 Goughs Road (excluding paper roads and storage pond areas) was identified.

In May 2019 infiltration testing was carried out on the proposed irrigable areas on the Goughs Bay site. The field investigations indicated the presence of three different soil types, not all of which were suitable for year-round irrigation. As a result, parts of the property were identified as being suitable for irrigation only in summer, as shown in Figure 6-3. The PDP report on the Goughs Bay site infiltration testing and analysis of this is included in Appendix Y.

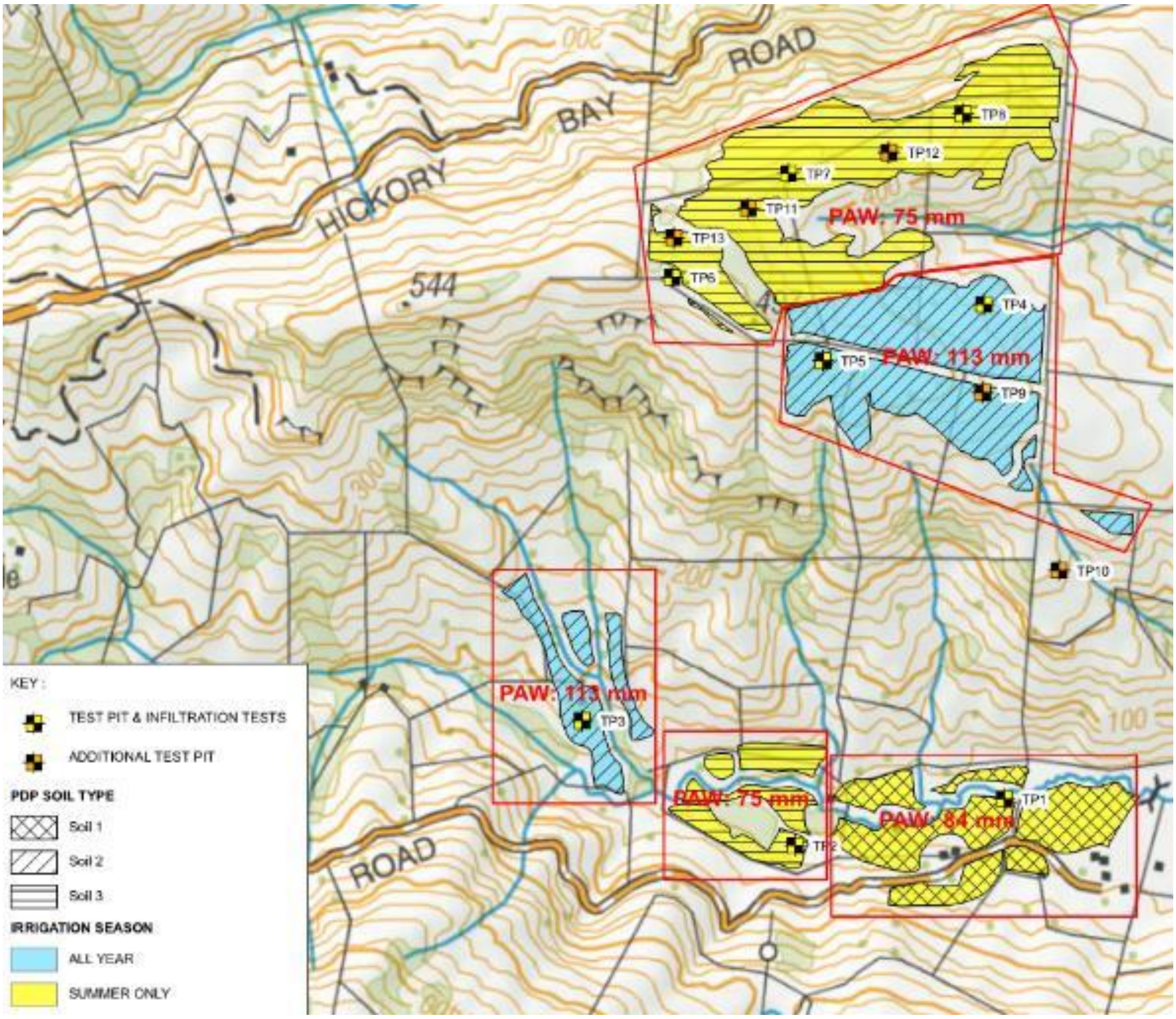


Figure 6-3 Outcomes from Goughs Bay Site Infiltration Testing (PDP, 2019)

6.2.1 Required Irrigation Area and Storage Volume

Using information obtained from the physical infiltration testing of the land and the GIS modelling, the available irrigation area at the Goughs Bay site was assessed to be approximately 113 ha (approximately 18% of the farm, which has a total area of 614 ha). PDP modelled a range of different combinations of storage volume and irrigation area for an irrigation to native trees scheme. The optimum combination selected by Council was an irrigation area 33 ha (approximately 5% of the farm) and storage pond volume of 30,000 m³. The irrigation modelling assumptions are set out in Section 4.2.

PDP were asked to select the 33 ha that should be used for a native trees scheme, this is shown on Figure 6-2. This area was selected as it had the right soil conditions to be able to be irrigated all year around and excluded small 'islands' which would be less economic to irrigate because of the additional pipe length and elevation range.

6.3 Pipeline to Goughs Bay

For irrigation at Goughs Bay, treated wastewater must be conveyed to the irrigation site from the storage pond site opposite the treatment plant. A high-pressure pump station and pipeline would be required to pump water up Long Bay Road to a height of 630 m above sea level. The intention would be to pump to the pipeline high point in a single lift, with a pump station located adjacent to storage pond at the treatment plant. The pump station would be subject to approximately 580 m static head due to the pump station height being 50 m above sea level. Total pump head including frictional losses is 640 m total dynamic head (TDH).

Although operating at a much higher pressure than other Council owned pump stations, the design configuration and operation of the station would be similar to other Council stations.

The design of this pipeline was considered in two discrete sections:

- Uphill pipeline from Old Coach Road along Long Bay Road to the top of the hill (the Cabstand on Summit Road)
- Downhill pipeline from the top of the hill along Hickory Bay Road to Goughs Bay site

A range of material specifications for the pipeline from Old Coach Road to the top of Long Bay Road were reviewed for pricing purposes. The preferred material of construction is cement-lined ductile iron (CLDI) with a pressure rating of 1000 kPa and a surge rating of 1200 kPa. The high-pressure rating is required to deal with static and surge pressure that arise in the pipeline. The preferred material of construction for the downhill pipeline is HDPE. The pipelines would follow public roads where possible, with some sections run on paper roads. Pressure vents in the form of stand-pipes would will be incorporated in the downhill pipeline to allow air to be drawn in and expelled at regular intervals and reduce the working pressure of the pipeline. These stand-pipes are preferable to air valves as they are maintenance free. The indicative pipeline route is shown in Figure 6-4 and a long section for the pipeline can be found in Appendix K.

Figure 6-4 Pipeline Route to Goughs Bay Irrigation Site (image courtesy of Google Earth)

6.4 Goughs Bay Storage Concept

The current concept for treated wastewater storage at Goughs Bay is based on forming ponds by excavating and, where necessary, blasting into rock on a shallow ridgeline within the property (refer to Figure 6-2 and the irrigation scheme map in Appendix J).

Test pits along the ridgeline indicate there may be up to 2 m of free digging soil, although visual findings from the site walkover was of extensive exposed rock in this area and there is a risk that rock may be closer to the surface and more variable than what has been found in the test pits. The ponds would be constructed by excavation as far as possible, and then precision blasting techniques. During the blasting process, there would likely be some overbreak of the rock which would require infilling before liner placement. Furthermore, the liner would need to be protected from the sharp rock and a cushioning layer would be required. Rock bolting may also be required depending on the geology and results of the blasting. Waste rock would be disposed of on the Goughs Bay site, potentially within a valley, in order to minimize the cost of removal from site.

Between one and three ponds with a combined capacity of 30,000 m^3 would be required. Two or more ponds are preferred to allow for operational flexibility and also to facilitate construction of a smaller pond at the highest position on the site (i.e. around RL 450 m) to allow gravity irrigation to the majority of the irrigation zone. Depending on topography on the site the pond may require a small 1-2 m high bund on the downslope side, or a deeper pond (i.e. cut at the upslope end).

The ponds would be lined with an HDPE liner system. The uppermost HDPE liner would have a limited life, due to exposure to the elements (UV) and it is estimated it may need to be replaced every 10 years. Replacement may include welding a new layer onto the old one. Maintenance/repair inspection would be required to be undertaken frequently, and at the very least annually to monitor UV degradation. These ponds would likely to be positioned in high wind zones and would need to be protected with anchors to stop the liners being sucked out.

As the ponds would be uncovered, some form of filtration system would be required for the irrigation outlet to prevent blockages of the irrigators by things such as algae and debris that could blow into the ponds. It is possible that a pump station would be required downstream of the irrigation ponds to provide the necessary head to the irrigation areas that lie above the floor of the ponds, depending on the final positioning of the ponds relative to irrigation areas. This would be confirmed at the next stage of design.

A dam break analysis has not been undertaken as yet, however should irrigation to native trees at Goughs Bay be selected as the preferred option then this work will be completed.

6.5 Planning Evaluation

Relevant planning considerations for the proposed development on the Goughs Bay site (461 Goughs Road) including the relevant overlays/zones, planning provisions and a high level consideration of the potential effects is provided below. It is noted that this assessment is to identify the key planning considerations only and a more detailed planning assessment will be undertaken once the preferred option is selected. Refer to Figure 6-5 for an overview of the map showing the different district planning overlays for this site – the full map can be found in Appendix U.

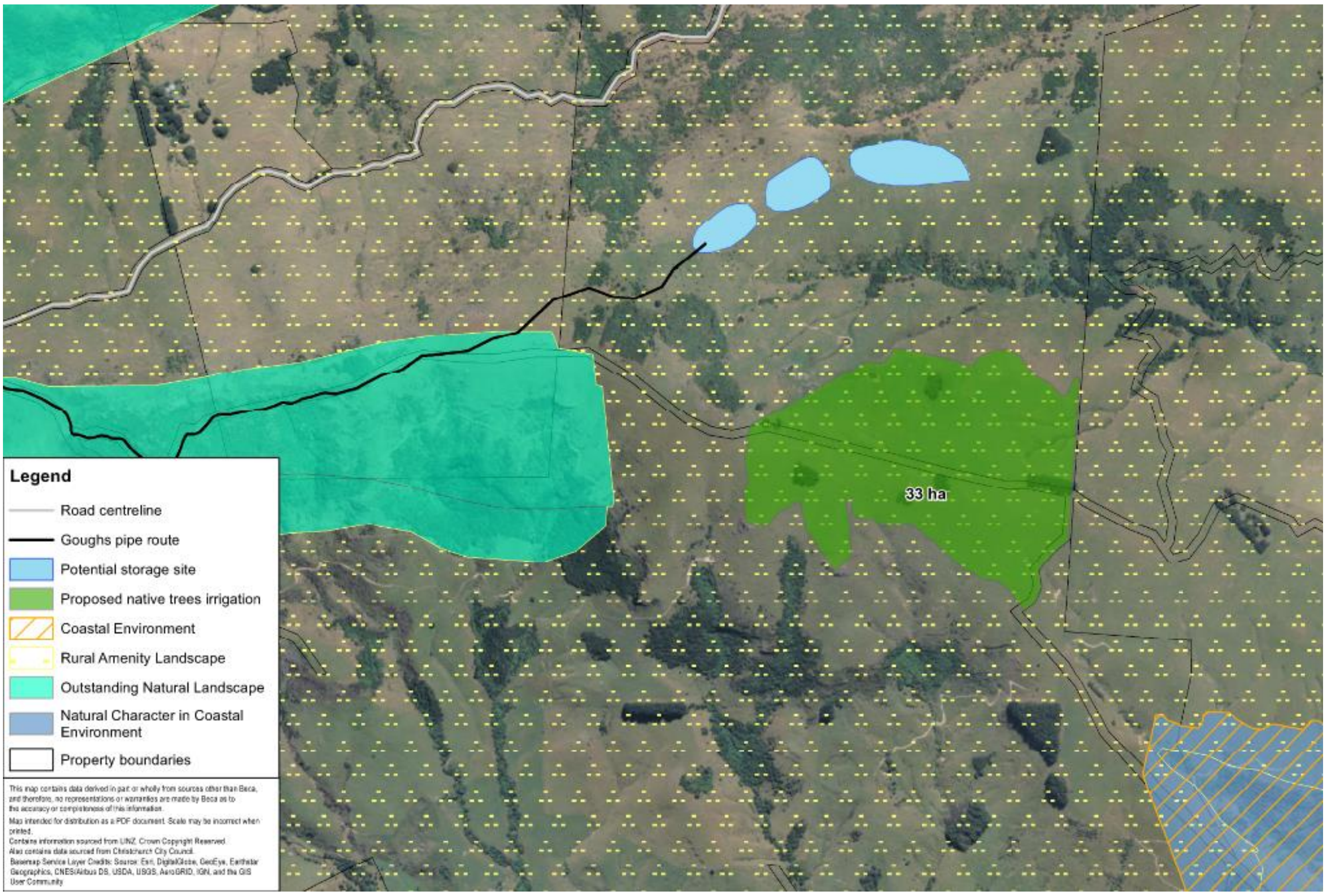


Figure 6-5 Christchurch District Plan Overlays for Goughs Bay Site

6.5.1 Treatment Plant Pond and Wetland Site on Old Coach Road

Refer to Section 5.7.1 for a planning evaluation of the treatment plant pond and wetland site.

6.5.2 Goughs Bay Irrigation Site

The Goughs Bay site (461 Goughs Road) is located on the eastern side of Banks Peninsula in an area between Goughs Bay and Hickory Bay. The site comprises 33 ha of irrigation area, above the ridge area. The total area of the property is approximately 614 ha. Figure 6-5 shows the development areas and relevant CDP overlays. The general site is an isolated one with access available from Goughs Road and Hickory Bay Road which are narrow and steep no exit gravel roads.

The development of the site includes irrigation to native trees, three storage ponds that would be formed by cutting down into existing bedrock, a utility building to house a pump station near the storage ponds, and associated pipes and ancillary equipment.

6.5.3 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and falls within the rural amenity landscape RAL1.0 Banks Peninsula in the CDP. The site falls within the Remainder of the Port Hills / Banks Peninsula Slope Instability Management Area.

The proposed activities associated with wastewater disposal are a "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

- Utilities Rule 11.8.1 P2 states that the "Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator" are permitted activities provided the activity complies with the Built Form Standards for the Rural Banks Peninsula Zone. In terms of the Built Form Standards for the Rural Banks Peninsula Zone referred to in Rule 11.8.1 P2 for utilities, the standards in large part refer to bulk and location of buildings (which may include the storage ponds depending on their construction). These are discussed briefly below.
- A minimum set back of 15 m from roads (Built Form Standard 17.4.2.5);
- Setbacks of 10 m from internal boundaries (Built Form Standard 17.4.2.7);
- Site coverage of buildings shall not be greater than 10% of the site area or 2,000 m^2 whichever is the lesser (Built Form Standard 17.2.3.9)
- The maximum building footprint shall be 300 m^2 (Built Form Standard 17.2.3.10).

If development of the site results in a breach of these Built Form Standards resource consent as a restricted discretionary activity under Rule 17.4.1.3 would be required.

It is noted the utility building housing the pump station would likely to be of a modest scale which may not infringe any of the Built Form Standards. It is anticipated that the storage ponds would exceed the building footprint threshold at least, which would require resource consent.

However, the use of the land for irrigation of wastewater to trees is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is defined as a utility and requires resource consent as a discretionary activity in terms of Rule 11.4.3.

No other rules in the CDP are applicable to the site as there are no overlays on the site that triggers resource consents. An Outstanding Natural Landscape (ONL) overlay is located to the west of the storage ponds on the ridge and irrigated areas but does not apply to the site.

6.5.4 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance to the proposed development:

- The use of land for a community wastewater treatment system and discharge of treated wastewater from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP and includes the irrigation of wastewater to land.
- Parts of the site are identified as "High Soil Erosion Risk" in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171 if the earthworks exceed the specified limits (more than 10 m^3 and cut and fill is greater than 0.5 m) in Rule 5.170 (k) of the LWRP. It is noted that Rule 5.170 does not apply to works for which a building consent from Council has been obtained so any earthworks associated with a building are exempt from this rule.
- Rule 5.154 of the LWRP states that the impounding and storage of water outside of a bed of a river or natural lake is permitted if the volume is less than 20,000 m^3 or the maximum depth of water is less than

4 m. These thresholds would be exceeded for the proposed storage ponds, and on this basis resource consent would be required as a discretionary activity under Rule 5.155.

- Rule 7.50 of the CARP provides for the discharge of contaminates into air from the treatment and disposal of less than 50 m^3 per day of human sewage effluent. However, as the discharge would exceed 50 m^3 per day, this would be a discretionary activity under Rule 7.63.

6.5.5 Preliminary Assessment of Effects

The Council commissioned a Cultural Impact Assessment (CIA) for the Pompeys Pillar site in 2017 and this was updated to include the Goughs Bay site in 2018. The CIA concluded that Te Rūnanga o Koukourārata may not oppose the proposals provided that the activities are subject to a number of requirements, including the ability for Rūnanga representatives to have ongoing involvement in the project, irrigation is to pasture only and not to stands of native trees or surface waterbodies, additional indigenous planting is established wherever possible, and an archaeological authority is obtained prior to any earthworks (amongst other matters). There is a discrepancy between the 2017 and 2018 CIAs in that the 2017 CIA does not oppose irrigation to native vegetation. This will need to be discussed with Rūnanga in more detail.

With regard to the Goughs Bay proposal specifically, Te Rūnanga o Koukourārata note that the proposed irrigation is in an area of multiple recorded archaeological sites of Māori origin and they have highlighted, in particular, a pā site. In respect to the pā site it is requested that no land within the boundary, or within 200 m of the boundary is irrigated. The proposed irrigation area is well set back from the pā site with the edge of the irrigation area is approximately 550 m from the pā site.

Land based recreation activities are unlikely to be adversely impacted given the site has no public access. While Hickory Bay and to a lesser extent Goughs Bay are known surfing beaches, the area does not receive high visitor numbers given its isolation and lack of ready beach access (the access roads are not formed all the way to the beaches). In any event the area that would be irrigated is located a substantial distance from the beaches.

In terms of the proposed storage ponds it is envisaged these will largely be below natural ground level, although some low bunding may be necessary. Groundwater may be intercepted as part of the construction activities – even though the proposed pond positions are at high level there are a number of local springs. Further investigations around groundwater level would be completed at the next stage of design to inform this. The ponds would be lined to stop any discharge to ground and avoid land instability.

In terms of access, upgrades to existing farm tracks may be required, although they would be likely to have a gravel finish which would be in keeping with the rural character of the site and its surrounds.

The Landscape and Visual Assessment – Pompeys Pillar, Goughs Bay and Hammonds Point report (Appendix V) provides a high-level assessment of the potential landscape character and visual amenity matters at the Goughs Bay site. In particular the following is noted:

- The site required for proposed vegetation and irrigation consists of predominantly pasture with some volcanic rocky outcrops to the south and areas of scrub to the west and north. Small areas of mature exotic tree plantings and shelterbelts break the skyline. The site is prominent in the landscape due to its relative height. Nearby valleys and steeper slopes comprise large swathes of native bush and open pastures with small volcanic outcrops. The proposed dripper irrigation areas and storage ponds sit on the flatter upper slopes of the spur on the northern side within areas of open pasture and scrub.
- The site is largely obscured from public vantage points, however the southern reaches fold over the hill giving partial views from Paua Bay Road and Goughs Road as well as from 2-3 vantage points on the upper reaches of Hickory Bay Road.

Overall the report considers that the potential landscape and visual effects are low for the following reasons:

- Existing large areas of native bush to the west, some of which sits within an ONL resulting in the proposed native vegetation being seen as part of a wider pattern of regenerating forest
- Native forest will increase biodiversity
- This is a remote site with limited visibility
- Although discrete, the establishment of storage ponds will require local change to the landform negatively impacting the unmodified and legible volcanic structure.
- Given the site sits near an ONL planning overlay, the return of the landscape from pasture and scrub to native forest is a positive effect.

An artist's impression was generated to show how an irrigation to native trees scheme at Goughs Bay might look from a publicly accessible viewpoint. This is shown in Figure 6-7, with the original photo shown in Figure 6-6.

Figure 6-6 Original Image of Goughs Bay Site

Figure 6-7 Artist's Impression of Irrigation to Native Trees at Goughs Bay Site

In terms of other potential effects, the following is noted:

- The treated wastewater quality from the normal operation of the treatment plant will be suitable for land application and none of the individual contaminants are likely to affect soil structure.
- Treated wastewater would be applied at rates that meets the assimilative capacity of site vegetation and soils.

- There are no identified water takes within 2 km of the site and accordingly water supply should not be affected by irrigation to trees. If there are other takes consideration of alternative water supplies can be undertaken.
- The condition of existing waterways at the sites is currently underway by Council, the findings from this assessment will be taken into account once received. Discharge into streams that then enter coastal areas would require assessment of the potential to cause adverse effects. However, the possible locations for storage ponds and irrigation areas were determined using setback distances that have been selected to minimise the risk of discharge into waterways.
- The risk of pond/irrigation odours causing an adverse effect is considered low given the high treated wastewater quality and the distance to the nearest dwellings.
- In terms of natural hazards, while the land is a steeper and higher altitude site than other potentially irrigable sites evaluated, the land stability risks are considered to be lower than at other sites based on identified soil depth and lack of slips observed. Geotechnically unstable land has been excluded from further consideration and appropriate engineering design will minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity).
- Akaroa treated wastewater will meet a very high standard and will present very low risks to public health, which is further mitigated by the remote location.
- Noise effects from sources such as irrigation equipment and pump stations are anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.
- Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.

6.5.6 Pipeline to Goughs Bay Site

It is proposed that the pipeline from the treatment plant to the Goughs Bay site would be installed along legal road including Long Bay Road and then Hickory Bay Road. Roads in the CDP are zoned Transport and the installation of utilities is generally a permitted activity in this zone.

6.5.7 Archaeological Sites

The Heritage New Zealand Pouhere Taonga Act 2014 makes it unlawful for any person to modify or destroy, or cause to be modified or destroyed, the whole or any part of an archaeological site without the prior authority of Heritage New Zealand. The Heritage New Zealand Pouhere Taonga Act 2014 defines an archaeological site as a place associated with pre-1900 human activity, where there may be evidence relating to the history of New Zealand.

Te Rūnanga o Koukourārata note that the Goughs Bay site is in an area of multiple recorded archaeological sites of Māori origin and they have highlighted, in particular, a pā site. Earthworks associated with any of the proposed study sites could potentially result in a requirement to apply for an Archaeological Authority. As part of the cultural impact assessment (CIA) completed by Te Rūnanga o Koukourārata, the Rūnanga have requested that an archaeological authority is obtained prior to the commencement of any earthworks.

Any requirements and constraints identified by archaeological assessments and authorities can be addressed and incorporated in the next stages of design of the preferred option.

6.5.8 Reuse of Non-Potable Water

Please refer to section 5.7.5 for the planning assessment for non-potable reuse water.

6.5.9 Planning Summary

The planning assessment is high level and preliminary only and has been undertaken without the benefit of detailed investigations. Resource consents from both Environment Canterbury and Christchurch City Council are likely to be of discretionary and restricted discretionary status. The following table provides a summary of the likely consenting risks:

Table 6-1 Likely Consenting Risks

Adverse Effect	Risk	Comment
Landscape /Visual – storage pond/access/trees	Low	Effects can be mitigated by careful design in respect of such matters as contours and landscaping in terms of earthworks. Planting of native trees will have positive effects on biodiversity, natural character and amenity. The site itself is remote with limited visibility. This has been weighed against some negative landscape effects resulting from physical impacts such as earthworks for the storage ponds.
Noise	Low	Little noise is anticipated to be generated during operation. Construction noise is expected to comply with CDP standards and will be managed through resource consent conditions and construction management plans.
Recreation	Low	The site has no public access and limited recreation activities occur at present in the vicinity of the sites. Although Hickory Bay in particular is a known surf beach, access is difficult.
Cultural/Historic Values	Medium	A cultural impact assessment was completed for both the Goughs Bay and Pompeys Pillar sites. The overall findings of the CIA were that the Rūnanga generally weren't opposed to the proposals, provided a number of conditions were met. Te Rūnanga o Koukourārata note that the proposed irrigation is in an area of multiple recorded archaeological sites of Māori origin and they have highlighted, in particular, a pā site. In respect to the pā site it is requested that no land within the boundary, or within 200 m of the boundary is irrigated. The currently proposed irrigation area is approximately 550 m from the pā site. Further clarification is required regarding the Rūnanga's stance on irrigation to native vegetation as this is unclear. The Council would work with the Rūnanga to agree and satisfy these conditions if this option is selected.
Ecology	Low	No at-risk species identified at present. Council is currently undertaking a freshwater ecological assessment and the findings from this will be considered once available
Odour	Low	Odour modelling has shown that the risk of odour is low. No aerosols would be generated by drip irrigation under trees.
Amenity	Low	While the actual or potential effects appear to be minor or minimal some people may perceive that amenity will be adversely affected. Conversely the public may perceive the establishment of additional native forest as a benefit to region. It is not considered that perception, in the absence of an actual effect, poses a risk to the consenting process.

The preliminary assessment suggests that adverse effects of the treatment and disposal options are likely to be low or medium at the sites. The reduction of medium risks to a low status will require ongoing stakeholder engagement and undertaking site-specific investigations. Based on the investigations completed to date no high or significant risks are identified.

In respect of the reuse of non-potable water in Akaroa, the risk is anticipated to be low given the wide community support for this activity although this assumes odour can be adequately managed and the discharge is applied land at rates that meets the assimilative capacity of the vegetation and soils.

7 Option 3 – Pompeys Pillar Irrigation to Trees

7.1 Overview of Scheme Option

In January 2017 a screening evaluation of potential irrigable sites over the entire eastern Banks Peninsula area was undertaken using the criteria in Section 4.1. Pompeys Pillar (the farm at 186 Fishermans Bay Road) was one of the short listed sites, and irrigation to pasture via an arrangement with the farmer was proposed. Further development of the Pompeys Pillar option was conducted between 2017 and 2019. This work included physical investigation of soil infiltration and geotechnical test pits, GIS mapping work, planning evaluation, and modelling of storage and irrigation area requirements.

The location of the Pompeys Pillar site is shown in Figure 7-1.

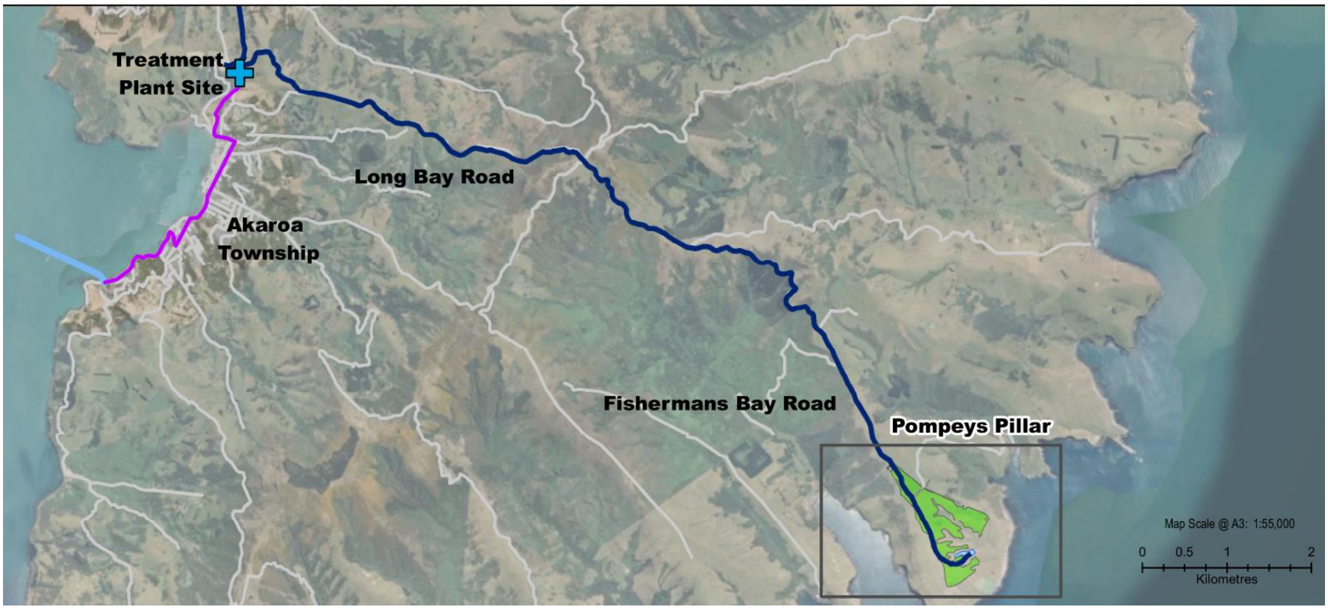


Figure 7-1 Location of Pompeys Pillar Site

In December 2019 Council received formal feedback from the landowner at Pompeys Pillar expressing opposition to wastewater irrigation at Pompeys Pillar. If a scheme at Pompeys Pillar is to be progressed, the Council would need to buy the land. Irrigation would be to native trees rather than pasture, as it offers advantages over pasture irrigation in terms of reduced wastewater storage, reduced irrigation area, reduced scheme costs, improved carbon sequestration, and ecological benefits this approach is considered to more effectively address the environmental, cultural, social and economic well-beings of the Local Government Act. The key components of this scheme include:

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m^3 across the road from the treatment plant site on Old Coach Road, to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Treated wastewater pump station near the storage pond at the treatment plant
- 13 km long pipeline from the treatment plant to Pompeys Pillar, with the route along Long Bay Road and Fishermans Bay Road

- Treated wastewater storage pond with a volume of approximately 36,000 m³ at the irrigation site
- Irrigation pump station and distribution pipelines and irrigation system at Pompeys Pillar based
- Dripper irrigation of 48 ha of mixed native plantings.
- Non-potable reuse network for the most populated areas of Akaroa including UV treatment and possibly chlorination of non-potable reuse flow.

For more detail on the network upgrades, wastewater treatment plant and non-potable reuse components, please refer to Section 9.

An indicative layout of an irrigation scheme at Pompeys Pillar is shown in Figure 7-2 and in Appendix J.

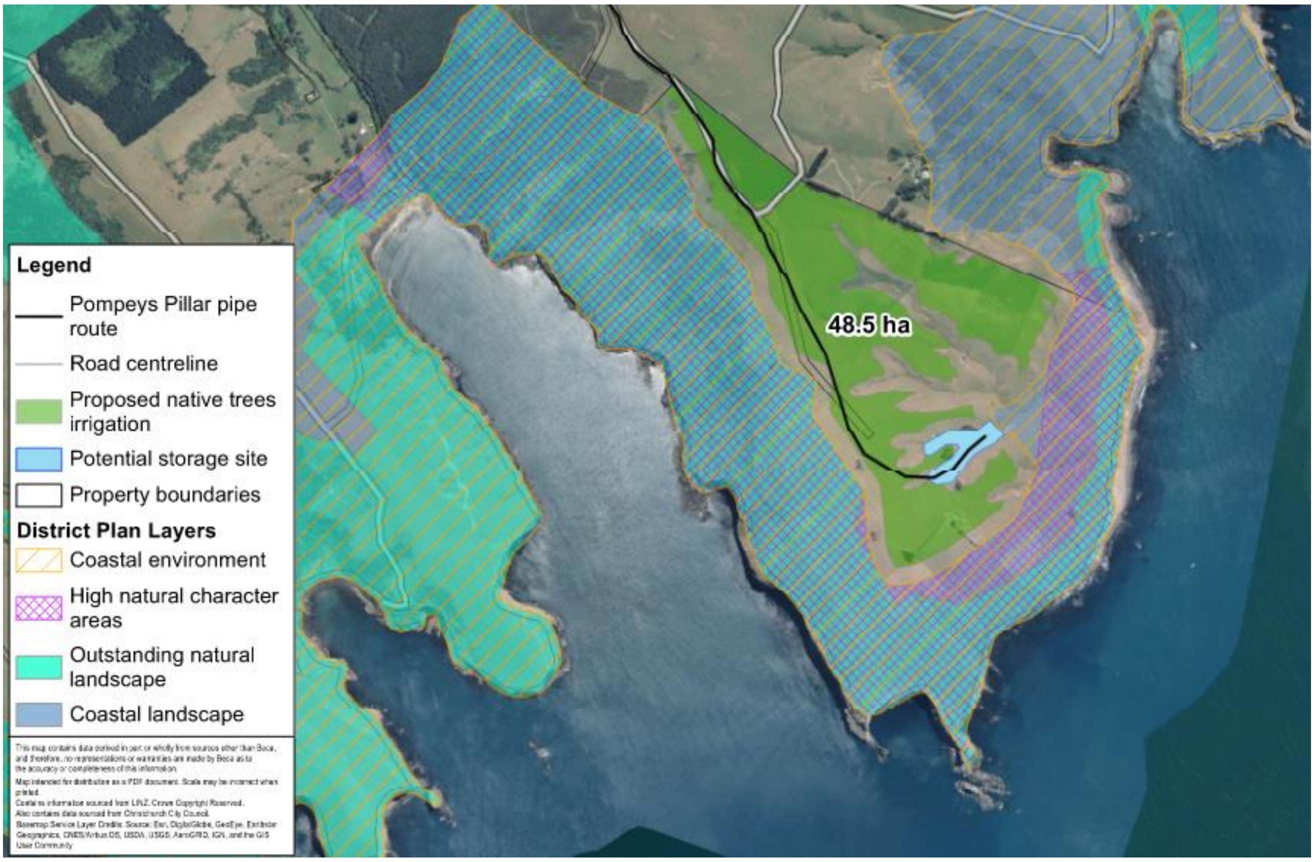


Figure 7-2 Overview of Irrigation Scheme at Pompeys Pillar Site

7.2 Required Irrigation Area and Storage Volume

GIS mapping and site survey and walkover identified 102.6 ha in total of potentially irrigable land at Pompeys Pillar (approximately 58% of the farm, which has a total area of approximately 177 ha). On site geotechnical investigations and infiltration testing were carried out - refer to Appendix Z for full details of the site investigations. The investigations found that the soils at Pompeys Pillar are less free draining, being composed of loess with groundwater at depth, likely within the bedrock. Irrigation may cause localised instability around cliff tops and steeper zones around gullies, so these areas have been excluded from irrigable area. As the soils at Pompeys Pillar exhibited consistently lower permeability than at other sites, more land is needed than at other sites.

Of the total potentially irrigable area at Pompeys Pillar, 54.1 ha is under Christchurch District Plan planning layers for Coastal Environment, High Natural Character and/or Outstanding Natural Landscape. While it may be possible to obtain consent to irrigate in these areas, there is a higher risk profile associated with assuming this. Therefore, for the Pompeys Pillar scheme it was decided to utilise only irrigable land not under planning layers, and with a setback from the planning layers. The irrigable area for the scheme is therefore 48.5 ha (27% of the farm). The storage requirements for 48 ha of irrigation to native trees is 36,000 m^3. This includes allowance for rainfall and freeboard.

7.3 Pipeline to Pompeys Pillar

The pipeline to Pompeys Pillar irrigation site would be 13 km in length. The difference in elevation of the treatment plant and highest point of the pipeline is 520 m. This pipeline and pump station would be similar in design concept to the Goughs Bay pipeline described in Section 6.

The intention would be to pump to the pipeline high point in a single lift, with a pump station located adjacent to storage pond at the treatment plant. Although operating at a much higher pressure than other Council owned pump stations, the design configuration and operation of the station would be similar to other Council stations.

A range of material specifications for the pipeline from Old Coach Road to the top of Long Bay Road were reviewed for pricing purposes. The preferred material of construction is cement-lined ductile iron (CLDI) with a pressure rating of 1000 kPa and a surge rating of 1200 kPa. The high-pressure rating is required to deal with static and surge pressure that arise in the pipeline. The preferred material of construction for the downhill pipeline is HDPE. The pipeline is generally able to follow public roads all the way to the irrigation site. Pressure vents in the form of stand-pipes would will be incorporated in the downhill pipeline to allow air to be drawn in and expelled at regular intervals and reduce the working pressure of the pipeline. These standpipes are preferable to air valves as they are maintenance free. The indicative pipeline route is shown in Figure 7-3 and a long section for the pipeline can be found in Appendix K

Figure 7-3 Pipeline to Pompeys Pillar

7.4 Pompeys Pillar Storage Dam Concept

The concept for storage at Pompeys Pillar is based on forming a 36,000 m³ pond by damming an existing ephemeral waterway in a valley on the site. This valley was identified as the preferred location for the pond based on GIS mapping and a site walkover by a Beca civil engineer. Refer to Appendix Z for the geotechnical assessment of the Pompeys Pillar area. This pond site would be hidden from view from all terrestrial viewing points surrounding the farm. The dam would be an earth bund dam with HDPE liner and concrete structures of dam crest, ramp into dam base and spillway. Some of the key features of the design of the dam are:

- Earth bund dam with HDPE liner
- Stormwater cut off channel to feed around the back of the dam and down into the adjacent gully. This would be around 450 m long, 2 m wide at base, and 2 m deep.
- Emergency spill channel from the dam crest to toe, complete with energy dissipaters. Channel would be 3 m wide, with concrete side walls of 1m height.
- Crest of the dam would be 3 m wide.
- Freeboard allowance of 1.5 m for waves (wind, seismic), etc.
- Low level discharge pipe, 300 mm diameter, through the dam (dewatering purposes, normally closed).
- Pond base to be concrete liner over the HDPE liner to allow movement of maintenance vehicles.
- Permanent weather station and water level monitoring, with continuous communications feedback to Akaroa WWTP
- Stock fencing with gates around the perimeter of the dam
- Upgrade of the access into the site for access of heavy earthmoving equipment, and then ongoing maintenance and operational works such as access to the irrigation pump station.

Imported engineered fill would be needed for the drainage core of the dam. Soil will also need to be harvested from borrow sites. It is assumed there is sufficient borrow on site within a distance of 600 m from the dam site.

A dam break analysis has not been undertaken as yet. However, should irrigation to native trees at Pompeys Pillar be selected as the preferred option then this work will be progressed.

7.5 Planning Evaluation

The Pompeys Pillar site (186 Fishermans Bay Road) is located on the eastern side of Banks Peninsula. The option includes irrigation to native trees over an area of 48 ha, a modest utility building, upgrades to existing farm tracks and a storage pond. The preferred option for a storage pond on the site includes the damming of an ephemeral stream. Figure 7-4 shows the site and the relevant CDP overlays, the full map is in Appendix U.

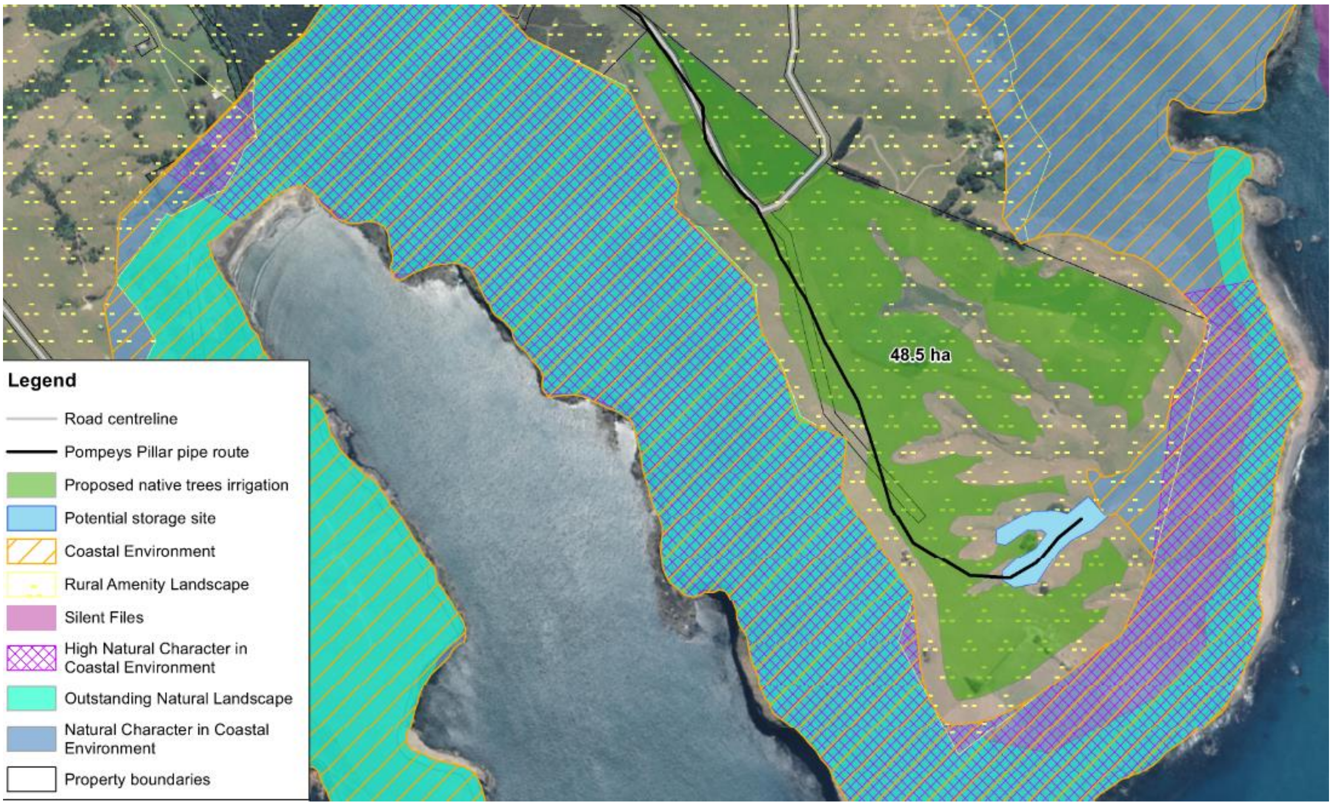


Figure 7-4 Christchurch District Plan Overlays for Pompeys Pillar Site

7.5.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone and falls within the rural amenity landscape RAL1.0 Banks Peninsula CDP. The site is subject to the Remainder Port Hills / Banks Peninsula Slope Instability Management Area.

There are also a number of District Plan overlays which apply to the immediately surrounding environment to the east, south and west, but not the site itself, including an area of Outstanding Natural Landscape (ONL 16.2), the Coastal Environment overlay and the Natural Character in the Coastal Environment 1.0 overlay. While these are in very close proximity to the site, the proposed irrigation area does not encroach on these overlays and therefore the rules relating to these overlays are not applicable.

The proposed activities associated with wastewater disposal are a "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set out in Rules 11.4-11.8.

- Utilities Rule 11.8.1 P2 states that the "Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator" are permitted activities provided the activity complies with the Built Form Standards for the Rural Banks Peninsula Zone. In terms of the Built Form Standards for the Rural Banks Peninsula Zone referred to in Rule 11.8.1 P2 for utilities, the standards in large part refer to bulk and location of buildings (which may include the storage ponds depending on their construction). These are discussed briefly below.
- A minimum set back of 15 m from roads (Built Form Standard 17.4.2.5);
- Setbacks of 10 m from internal boundaries (Built Form Standard 17.4.2.7);
- Site coverage of buildings shall not be greater than 10% of the site area or 2,000 m^2 whichever is the lesser (Built Form Standard 17.2.3.9); and,

- The maximum building footprint shall be 300 m^2 (Built Form Standard 17.2.3.10).

If development of the site results in a breach of these Built Form Standards resource consent as a restricted discretionary activity under Rule 17.4.1.3 would be required.

It is anticipated that the storage pond would exceed the building footprint threshold at least, which would require resource consent.

However, the use of the land for irrigation of wastewater to trees is not considered to be permitted in terms of Rule 11.8.1 P2 as the rule refers to structures only. The use of land for the irrigation of wastewater is defined as a utility and requires resource consent as a discretionary activity in terms of Rule 11.4.3.

7.5.2 Regional Plan Provisions

In terms of Environment Canterbury planning documents, the following is of relevance to the proposed development:

- The use of land for a community wastewater treatment system and discharge of treated wastewater from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP and includes the irrigation of wastewater to land.
- Rule 5.154 provides for the damming of water in the bed of a river as a permitted activity, providing the volume of water is less than 5,000 m^3, the maximum depth is less than 3 m and the dam does not impound the full flow of the river (amongst other matters). These conditions would not be complied with and so resource consent would be required under Rule 5.155 (discretionary activity) or 1.556 (non-complying activity).
- Rule 7.50 of the CARP provides for the discharge of contaminates into air from the treatment and disposal of less than 50 m^3 per day of human sewage effluent. However, as the discharge would exceed 50 m^3 per day, this would be a discretionary activity under Rule 7.63.

7.5.3 Pipeline to Pompeys Pillar Site

It is proposed that the pipeline from the treatment plant to the Pompeys Pillar site would be installed along legal road including Long Bay Road and then Fishermans Bay Road. Roads in the CDP are zoned Transport and the installation of utilities is generally a permitted activity in this zone.

7.5.4 Preliminary Assessment of Effects

The geotechnical report for the site in Appendix Z notes that loess deposits at the top of the cliffs and above locally steep gullies could become destabilised over time. These areas have been excluded from the irrigable area and the remaining area is considered suitable for irrigation. Appropriate engineering design will minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity).

The Council commissioned a Cultural Impact Assessment (CIA) for the Pompeys Pillar site in 2017 and an update in 2018 to include the Goughs Bay site. The CIA concluded that Te Rūnunga o Koukourārata do not oppose the proposals for Pompeys Pillar provided that the activities are subject to a number of requirements, including the ability for Rūnunga representatives to have ongoing involvement in the project, irrigation is to pasture only and not to stands of native trees or surface waterbodies, additional indigenous planting is established wherever possible, and an archaeological authority is obtained prior to any earthworks (amongst other matters). There is a discrepancy between the 2017 and 2018 CIAs in that the 2017 CIA does not oppose irrigation to native vegetation. This, along with the proposed location of the storage pond within the ephemeral stream, would require further discussion and assessment.

The Landscape and Visual Assessment – Pompeys Pillar, Goughs Bay and Hammonds Point (Appendix V) report provides a high-level assessment of the potential landscape character and visual amenity matters at the Pompeys Pillar site. In relation to the site, the report considers the potential landscape and visual effects to be low overall and notes the following:

- Existing pockets of native vegetation in the area will mean that the native vegetation is seen as part of a wider pattern of regenerating forest
- Native forest will increase biodiversity
- Over time the character will change from a rural amenity landscape to something more natural and dominated by native forest. This is seen as a positive effect given the proximity of the site to Outstanding Natural Landscape, Coastal Environment and High Natural Character planning overlays
- This is a remote site with limited visibility
- Although discrete and local, the pond establishment will negatively impact the unmodified and legible volcanic landform.

An artist's impression has been generated to show how an irrigation to native trees scheme at Pompeys Pillar might look from a publicly accessible viewpoint. This is shown in Figure 7-6 with the original image in Figure 7-5.

Figure 7-5 Original Image of Pompeys Pillar Site

Figure 7-6 Artist's Impression of Irrigation to Native Trees at Pompeys Pillar Site

With regards to other potential effects, the following is noted:

- The risk of irrigation odours causing an adverse effect is considered low particularly with the absence of people (other than those living on the site itself) in the vicinity of the site.
- Akaroa's treated wastewater will meet a very high standard and will present very low risks to public health, which is further mitigated by the absence of close neighbours.
- Noise effects from sources such as irrigation equipment and pump stations are anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.
- Effects of construction such as noise, traffic, dust will be appropriately managed through relevant resource consent conditions and construction management plans.
- The lower permeability soils at the Pompeys Pillar site will restrict drainage to groundwater. Further, an initial search of the ECan online GIS does not identify any bores for domestic or stock water supply in proximity to the site. There are no other properties downhill of Pompeys Pillar, so there would be no impact on private water supplies. Council are currently undertaking a freshwater ecology study of streams and findings from this assessment will be taken into account once available.

7.5.5 Archaeological Sites

The Heritage New Zealand Pouhere Taonga Act 2014 makes it unlawful for any person to modify or destroy, or cause to be modified or destroyed, the whole or any part of an archaeological site without the prior authority of Heritage New Zealand. The Heritage New Zealand Pouhere Taonga Act 2014 defines an archaeological site as a place associated with pre-1900 human activity, where there may be evidence relating to the history of New Zealand.

Earthworks associated with any of the proposed study sites could potentially result in a requirement to apply for an Archaeological Authority. As part of the cultural impact assessment (CIA) completed by Te Rūnanga o Koukourārata, the Rūnanga have requested that an archaeological authority is obtained prior to the commencement of any earthworks.

Any requirements and constraints identified by archaeological assessments and authorities can be addressed and incorporated in the next stages of design of the preferred option.

7.5.6 Reuse of Non-Potable Water

Please refer to section 5.7.5 for the planning assessment for non-potable reuse water.

7.5.7 Planning Summary

The planning assessment is high level and preliminary only and has been undertaken without the benefit of detailed investigations. Resource consents from both Environment Canterbury and Christchurch City Council are likely to be of discretionary and restricted discretionary status. The following table provides a summary of the likely consenting risks:

Table 7-1 Likely Consenting Risks

Adverse Effect	Risk	Comment
Landscape /Visual – storage pond/access/trees	Low	Effects can be mitigated by careful design in respect of such matters as contours and landscaping in terms of earthworks. Planting of native trees will have positive effects on biodiversity, natural character and amenity and will be seen as part of a wider pattern of regenerating forest. Although the site is remote with limited visibility, the positive effects have been weighed against some negative landscape effects resulting from physical impacts of the pond on the unmodified and legible volcanic landform.
Noise	Low	Little noise is anticipated to be generated during operation. Construction noise is expected to comply with CDP standards and will be managed through resource consent conditions and construction management plans.
Recreation	Low	There is no public access to the site and limited recreation activities occur at present in the vicinity of the site. Although Hickory Bay in particular is a known surf beach, access is difficult. Potential public access to the upper Robinsons Bay site would result in a positive recreation effect.
Cultural/Historic Values	Medium	A cultural impact assessment has been completed for both the Goughs Bay Irrigation Scheme and the Pompey Pillars site. The overall findings of the CIA are that the Rūnunga generally weren't opposed to the proposals, provided a number of conditions were met. Further clarification is required regarding the Rūnanga's stance on irrigation to native vegetation as this is unclear, as well as Rūnanga's position on the location of a storage pond at the Pompeys Pillar site within the ephemeral stream. The Council would work with Rūnunga to agree and satisfy these conditions if either of this option is selected.
Ecology	Low	No at-risk species identified at present. Council is currently undertaking a freshwater ecological assessment and the findings from this will be considered once available
Odour	Low	Risk of odour is low due to the high standard of treatment and remote setting of the site. No aerosols would be generated by drip irrigation under trees.
Amenity	Low	While the actual or potential effects appear to be minor or minimal some people may perceive that amenity will be adversely affected. Conversely the public may perceive the establishment of additional native forest as a benefit to region. It is not considered that perception, in the absence of an actual effect, poses a risk to the consenting process.

The preliminary assessment suggests that adverse effects of the treatment and disposal options are likely to be low or medium at the sites. The reduction of medium risks to a low status will require ongoing stakeholder engagement and undertaking site-specific investigations. Based on the investigations completed to date no high or significant consenting risks are identified.

In respect of the reuse of non-potable water in Akaroa, the risk is anticipated to be low given the wide community support for this activity although this assumes odour can be adequately managed and the discharge is applied land at rates that meets the assimilative capacity of the vegetation and soils.

8 Option 4 – Inner Harbour Outfall

8.1 Inner Harbour Outfall Route Options

The inner harbour outfall option would involve an outfall pipe to the middle of Akaroa Harbour. Two route options were considered, one launching from Childrens Bay, and the other passing through town to enable non-potable reuse of some of the treated wastewater before launching from Glen Bay. Both options have the diffuser at the end of the outfall pipe located in the same point in the mid-harbour.

8.1.1 Outfall from Childrens Bay

The outfall in this option would consist of a buried pipe laid in the seabed from Childrens Bay out into a mid-harbour position with a total outfall pipe length of 2.5 km. This was the proposal in the 2014 consent application for which consents were declined. A layout plan for this scheme is provided in Figure 8-1.

Figure 8-1 Layout of Childrens Bay Harbour Outfall Option

The outfall in the 2014 consent application was sized for a peak flow of 65 L/s, with a bypass around the treatment plant operating when peak flows exceed 14 L/s. This was the basis for the Assessment of Environmental Effects (Beca, 2014), particularly the quantitative microbial risk assessment by NIWA. The bypassed flow would have received UV treatment but would have been treated to a lesser standard than the main flow. Bypasses are commonly used in treatment plants around New Zealand to allow partially treated sewage to bypass some steps in the process. The main driver for bypassing peak flows is to optimise the size and associated cost of the treatment plant while accepting that, occasionally, a lesser quality wastewater will be discharged.

Feedback from public consultation, the working party and the Ngāi Tahu parties was that all wastewater should be fully treated. As a result, the Council agreed to eliminate the bypass and treat 100% of the flow. Removing the bypass eliminates the disposal of partially treated wastewater to the environment during wet weather. To achieve treatment of peak wet weather flows a raw wastewater storage pond and extra membrane filtration modules in the treatment plant is required.

The concept design for a mid-harbour outfall scheme option incorporating an outfall pipeline from Children's Bay includes the following components:

- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Covered raw wastewater storage with a volume of 6,000 m³ across the road from the treatment plant site on Old Coach Road, to buffer peak flows to the treatment plant
- Pipeline to convey treated wastewater from treatment plant down Old Coach Road with connection to outfall pipe and connection to the purple pipe reuse network within Akaroa township
- 2.5 km long buried 250 OD Polyethylene outfall pipeline from Childrens Bay with a diffuser in the mid-harbour at 8m water depth to mean sea level
- The proposed non-potable reuse network serving parts of Akaroa township would include UV treatment and possibly chlorination of non-potable reuse flow. The treatment requirements will be agreed with the Ministry of Health.

The outfall pipeline at this alignment would be about 2,500 m long and is assumed to be 250 mm outside diameter constructed in polyethylene (PE100). There are two possible methods for constructing the outfall:

- Dig and lay method
- Microtunnelling or horizontal directional drilling (HDD)

Dig and lay involves excavation of a trench on the seabed, typically in sections and then floating and dropping the outfall pipeline into the trench to achieve a 1m depth of cover when finished. In shallow waters (less than 10m depth) the trench can be formed by a long reach excavator working from a barge. The pipeline strings can be assembled at a location with sufficient space and access to the coastline (e.g. Duvauchelle) and floated across the harbour into position. This method was used to construct wastewater pipelines across Lyttelton Harbour in 2018. To get through the intertidal zone a sheet piled trench would be formed. This minimises disturbance to the seabed in the sensitive intertidal zone.

Alternatively, microtunnelling or HDD can be employed. These methods involve drilling beneath the seabed from a coastal location to the diffuser location. The pipeline exits the seabed at the location of the diffuser and the diffuser is then introduced and connected to the outfall pipe. The seabed is then reinstated. This approach minimises disturbance to the coastal marine zone but also has inherent risks around the performance of the drilling machine and the risk of drilling fluids escaping into the receiving environment.

8.2 Outfall from the Glen

In 2019 the concept of an alternative alignment for the harbour outfall, originally suggested in 2014, was put forward. This idea was aimed at taking advantage of the proposal to reticulate non-potable reuse water through Akaroa township in a “purple pipe” network. The treated wastewater pipeline running down Old Coach Road from the treatment plant to Akaroa Township can serve as the purple pipe reuse water main and also as a supply pipeline to the harbour outfall. A much shorter route from the shoreline to the proposed mid-harbour outfall location can be attained if the outfall was launched from Glen Bay, a small bay south of the town. There are potential cost savings in adopting this route compared to the Childrens Bay option, although it is contingent on the non-potable reuse scheme going ahead.

A schematic layout of the Glen Bay outfall alignment is shown in Figure 8-2. This potential alignment was selected based on the following:

- Providing nominal clearance to the rock outcrop at Green Point
- Keeping clear of the small craft moorings to minimise construction issues
- The ability to achieve a gradual curve away from the shoreline to meet the above requirements

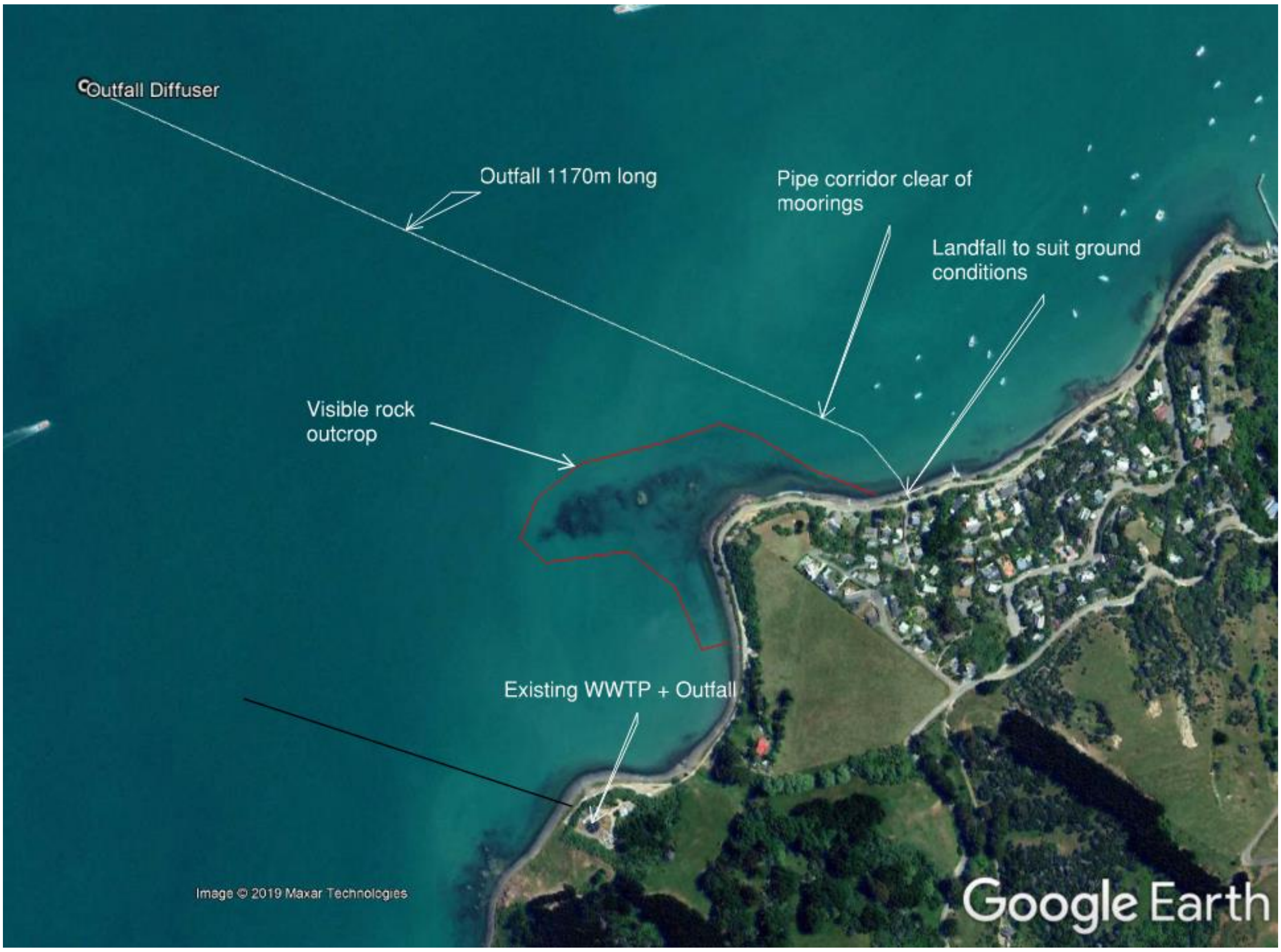


Figure 8-2 Indicative Mid-Harbour Outfall Alignment (image courtesy of Google Earth)

Scheme elements for an outfall at the Glen Bay are the same as for the Childrens Bay outfall configuration. The main difference is that the Glen Bay outfall will be reliant on the purple pipe network to convey treated wastewater from the north end of Akaroa to the south end where it will connect to the outfall terminus as shown indicatively in Figure 8-3.

Figure 8-3 Overview of Pipe Route for Outfall at Glen Bay

Similar construction methods would be employed in construction of the outfall at Glen Bay i.e. either dig and lay method, or microtunnelling or horizontal directional drilling. The presence of rocks at the headland to the south poses a risk to construction. If these rocks extend to the north, they could interfere with outfall construction for either work method. This risk can be manged by seabed probing to confirm the rock physical extent. intersect with the outfall alignment there is uncertainty about whether it will be possible to bury the pipe at this location. If the mid-harbour outfall option is pursued it is recommended that a bathymetric survey of the seabed along the alignment (as was done for the original alignment) be carried out.

A geotechnical assessment at the landfall end would give guidance on any issues around onshore trenching and would inform the selection of the optimum landfall location. It is recommended that geotechnical advice is sought to confirm any further marine geotechnical investigations that would be of value for the new alignment.

The outfall pipeline at this alignment would be around 1,170 m long and is assumed to be 250mm OD diameter polyethylene pipe (PE100). Construction of the Glen Bay outfall option would likely be undertaken using a similar method to Childrens Bay with assembly of the outfall pipe with ballast weights at Duvauchelle, and the pipeline towed by barge to site. Installation of the outfall would be in either a pre-excavated trench or dug into the seabed from a barge mounted excavator. An indicative pipe long section for the pipe through Akaroa and the outfall is given in Appendix K.

Based on the likely smaller line sizing and using costs from the recent Lyttelton wastewater harbour crossing pipe works in 2019, the Glen Bay outfall alignment appears to offer some minor cost saving compared to Children’s Bay outfall alignment. This is subject to further design development and cost review.

8.3 Summary

There are two possible harbour outfall alignment options, Childrens Bay and Glen Bay. The discharge of treated wastewater to the harbour would occur at the same location for both of them. This location is at a mid-harbour position where the depth of water is greatest (about 8m depth at mean sea level) in order to provide the most efficient dilution and dispersion of wastewater released. The potential effects of the discharge to the harbour, which were assessed in the 2014 application for resource consents (although at that time the proposal included a bypass for peak flows which would have been treated to a lesser standard), would be the same for both locational options.

Assuming the purple pipe scheme is incorporated as a core element of the scheme then the costs for both outfall options are likely to be a similar order, although initial concepts indicate that Glen Bay may be slightly lower cost. The construction impacts for the two options on this basis are also considered to be similar. However, if the purple scheme is not adopted as a core element of the scheme then the Children’s Bay scheme would be lower cost and would also be less disruptive to Akaroa Township.

9 Wastewater Scheme Features

There are a number of key design features that have been considered for the Akaroa wastewater scheme. By combining these features overall wastewater scheme options have been developed and evaluated. Each of the main scheme features are described in this section of the report and include:

- Network upgrade and terminal pump station
- Wastewater treatment plant and associated storage
- Non-potable reuse.

9.1 Network Upgrade and Terminal Pump Station

The Akaroa wastewater network will be modified as part of the scheme. Currently wastewater is pumped from north to south through Akaroa to the wastewater treatment plant to the south of the town. The flow direction would be reversed to pump towards to the new wastewater treatment plant to the north of the town on Old Coach Road. This involves upgrades to the pipelines and pump stations in Akaroa, a new terminal pump station in the Childrens Bay boat park and a rising main up to the new treatment plant on Old Coach Road. Initial design of the network upgrade, terminal pump station and rising main was completed in 2014 and documented in the Akaroa Wastewater Preliminary Design Report (Beca, April 2014) and consents were granted for the network upgrades and terminal pump station in 2015.

The core concepts of the 2014 preliminary design are unchanged although minor revisions are required to address increased flows. The scheme has also been modified to significantly reduce the frequency of overflows from the wastewater network.

Some details of the reticulation design have also been adjusted as a result of renewals work that was carried out in Akaroa in 2018 and detailed design work commissioned by Council on these. Required changes have been allowed for in revised costs estimates (refer Section 12).

9.2 Wastewater Treatment Plant and Associated Storage

9.2.1 General

The following preliminary design was developed for the proposed wastewater treatment plant (WWTP) at the top of Old Coach Road.

In 2011 the Council resolved that the wastewater treatment plant would achieve the best wastewater quality available. To achieve this Council has selected a wastewater treatment plant with year-round biological nitrogen removal (BNR) process where nitrogen reduction is required, membrane filtration for solids separation and disinfection, plus additional disinfection with UV and possibly chlorination for non-potable reuse water. The Council has purchased the land for the treatment plant and consents were granted in 2015.

The level of nitrogen in the BNR treatment plant discharge is considered to be suitable for the proposed irrigation of native plantings based on current knowledge of nutrient uptake in this type of vegetation. See Section 4.2.6 for further discussion.

The Council has also committed to a ‘no bypass’ approach to wastewater treatment of peak flows. This requires that all wastewater captured up to the peak design event will be fully treated, either as it is received at the WWTP, or stored for later treatment as described in Section 4.4.

No phosphorus removal is proposed, based on advice received from Professor Brett Robinson from University of Canterbury about the assimilative capacity of irrigated land with pasture or tree coverage (refer Appendix C). Some phosphorus will be removed incidentally by the treatment process due to uptake in treatment plant biomass.

9.2.2 Overview

This section summarises the proposed treatment process. A concept design Process Flow Diagram (PFD) with treatment and hydraulic capacity is shown in Figure 9-1.

Screening to less than 1 mm particle size and grit removal will be provided at the Terminal Pump Station to protect the pumps and no further primary treatment is proposed at the treatment plant.

All flow to the treatment plant will be received into an inlet structure. When flows are in excess of the hydraulic capacity of the treatment plant membranes a high-level outlet in the structure will allow excess flows to be directed to a covered 6,000 m^3 raw wastewater storage pond. The purpose of the raw wastewater storage pond is to:

- Optimise the required capacity of the membrane filters
- Smooth diurnal flow patterns
- Capture the peak inflows for a specified wet weather event.

Normal flows (up to 14 L/s) will bypass the raw wastewater storage and flow directly into the treatment plant.

The treatment plant concept process arrangement remains as Modified Ludzak-Ettinger (MLE) reactors. This is a conventional process for Biological Nitrogen Removal (BNR). The MLE process is an anoxic system followed by an aerobic system, with a high level of recycle from the aerobic zone to the anoxic zone to optimise nitrogen removal. This recycle is combined with Return Activated Sludge (RAS) from the membranes to provide sufficient microorganisms (otherwise known as Mixed Liquor Suspended Solids (MLSS)) to treat the wastewater. To avoid biological inhibition, both carbon (acetic acid) and alkalinity (bicarbonate) will be added to the wastewater as it enters the MLE reactors.

The concept design for secondary treatment is based on using MLE reactors. However, the consent remains open on other BNR processes. This will allow designers to select alternative treatment process, such as:

- Sequence Batch Reactors (SBR)
- Oxidation Ditch
- Mixed Bed Biofilm Reactor (MBBR)
- Integrated Fixed Film Activated Sludge (IFAS)

These options have various advantages which can be considered at the time of procurement.

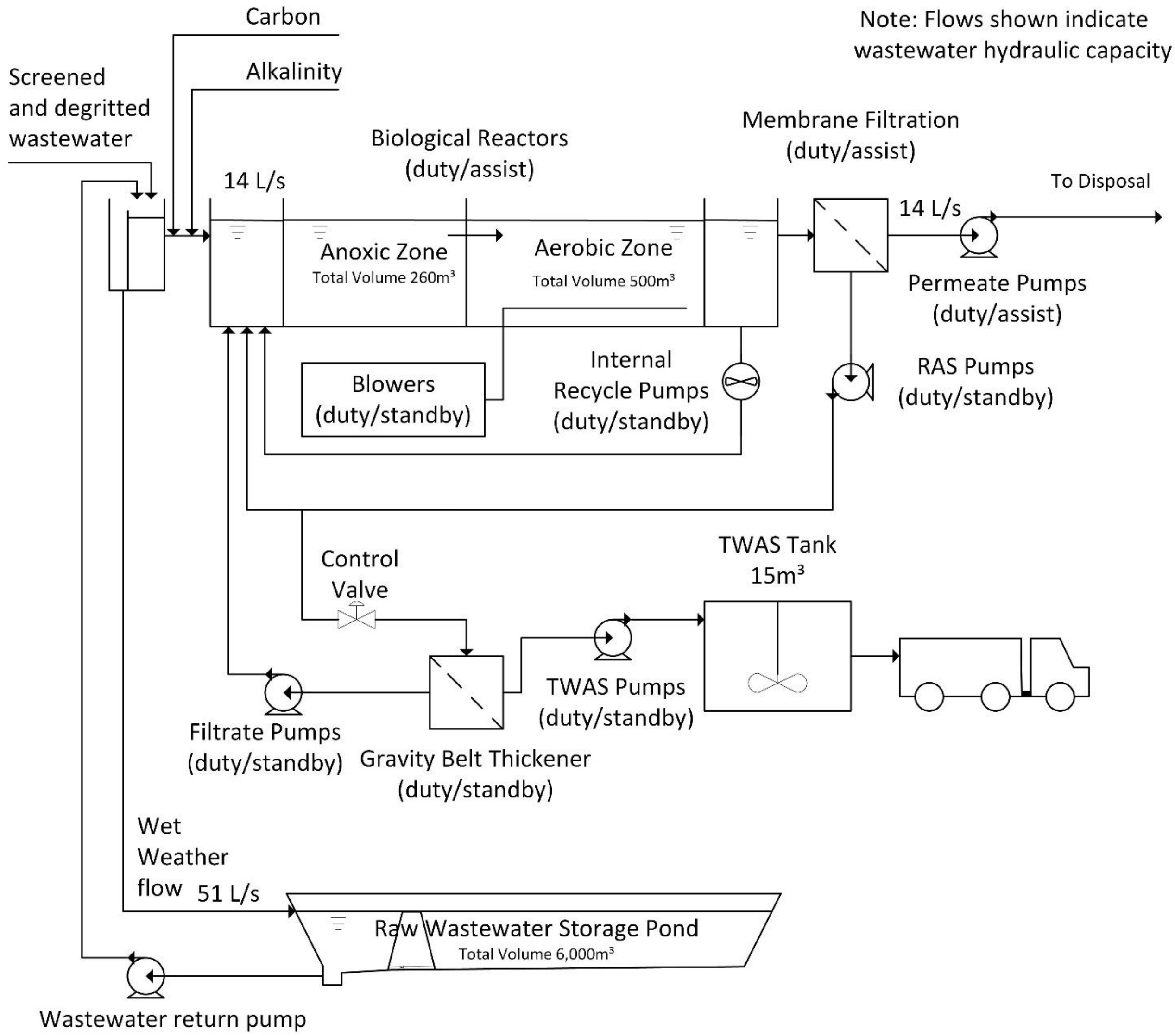


Figure 9-1 Process Flow Diagram for the Akaroa Wastewater Treatment Plant

Waste activated sludge (WAS) will be periodically removed from the return activated sludge (RAS) recycle stream and thickened using a gravity belt thickener and stored in an enclosed tank to form thickened waste activated sludge (TWAS). It is expected that sludge from the tank would be removed weekly and tankered to the Christchurch Wastewater Treatment Plant for processing into biosolids which are then beneficially reused.

The main treatment process units (activated sludge reactors and membrane filters) have been sized for duty/assist operation. Mechanical equipment (i.e. pumps, blowers, gravity belt thickener) has been sized for duty/standby operation.

9.2.3 Biological Treatment

The de-nitrification process requires sufficient carbon to meet the nutritional requirements of the biomass. Because the influent wastewater has a relatively high concentration of total nitrogen compared with biological oxygen demand (BOD), all the influent BOD is required in the MLE reactor. Therefore, no additional primary treatment such as primary sedimentation tanks is proposed.

During the peak summer, the total nitrogen (TN) concentration of incoming flows from Akaroa increases. To allow full de-nitrification to continue additional carbon will be required in the form of methanol or acetic acid or similar. For the peak summer load, it is estimated that 0.25 m³/d of 100% acetic acid would be required to reduce total nitrogen from 15 to 10 mg/L to provide a margin over the average of 15 mg/l given in Table 2-6. A 1 m³ IBC (intermediate bulk container) is proposed to store this carbon source. If the TN limit of 30mg/l during the peak summer is accepted then this dosing may not be required, however it has been allowed for at this stage.

Also, during the peak summer, additional carbonate will be required to prevent inhibition of the nitrification process due to low alkalinity or pH. For the peak summer load, it is estimated that 0.5 m³/day of 10% sodium carbonate (soda ash solution) bicarbonate would be required. A 1 m³ IBC is proposed to store this alkalinity source.

The MLE process has a pre-anoxic zone which means all the carbon is available for the de-nitrification process before it can be consumed in the aerobic zone. It also reduces the overall aeration demand. It does however require a large internal recycle flow to provide sufficient nitrate and nitrite (which is generated in the downstream aerobic zone) for de-nitrification. The internal recycle can be provided by low lift submersible recirculation pumps that recycles mixed liquor from the reactor outlet chamber to the reactor inlet chamber. These pumps can be installed in the wall between these two chambers. Return activated sludge (RAS) is also required to provide sufficient micro-organisms in the reactors.

Preliminary design details for the MLE process and BOD removal only process are given in Table 9-1.

Table 9-1 Preliminary Design Values for the MLE Reactors

Design Parameter		BOD and Nitrogen Removal (MLE process)	BOD removal only
Design treatment flow and load		See Table 2-4	
Total anoxic reactor volume	m³	260	0
Number of anoxic reactors	-	2 (1 duty + 1 assist)	0
Anoxic reactor dimensions	m (l × w × d) each	9.5 × 3.1 × 4.5	n/a
Total aerobic reactor volume	m³	500	300
Number aerobic reactors	-	2 (1 duty + 1 assist)	2 (1 duty + 1 assist)
Aerobic reactor dimensions	m (l × w × d)	9.5 × 5.9 × 4.5	5.7 × 5.9 × 4.5
Design mixed liquor suspended solids (MLSS) concentration	mg/L	5,000	
Peak air flow	m³/s	0.3	0.1
Number of Blowers	-	2 (1 duty + 1 standby)	
Blower size	kW	23	11
Peak internal recycle flow	m³/h	326	n/a
Number of internal recycle pump	-	2 (1 duty + 1 assist)	0
Internal recycle pump size	kW	1.5	n/a
Peak RAS flow	m³/h	65	
Number of RAS Pumps	-	2 (1 duty + 1 assist)	
RAS pump size	kW	1.5	

If alum dosing is required to reduce phosphorus in future, it is estimated that 100 L/d of 47% alum ($Al_2(SO_4)_3.14H_2O$) would be required at peak summer loads. Space is reserved in the concept layout design for a 1 m³ IBC if this is required. The alum would be injected into the reactor where the aluminium would react with phosphate to form the relatively insoluble aluminium phosphate ($AlPO_4$) which would precipitate out and be removed in the WAS stream. This would generate 10% extra sludge and require the reactor MLSS to increase by the same amount to 5,500 mg/L.

9.2.4 Disinfection

Membrane filtration was adopted as a required treatment process in the *Akaroa Wastewater Preliminary Design Report* (CH2M Beca, 2014), and has been specifically included in the concept design. This removes suspended solids and pathogens from the treated wastewater.

Concept design details for the membrane system are based on a duty/assist arrangement to provide some redundancy. Details are given in Table 9-2.

Table 9-2 Preliminary Design Values for the Membrane Filtration System

Design Parameter		Value
Membrane type	-	Hollow fibre ultra-filtration, in tank, low pressure
Membrane nominal pore diameter	µm	0.04
Number of membrane tanks	-	2 (1 duty + 1 assist)
Membrane average hydraulic capacity (each)	m³/d	680
Membrane max. hydraulic capacity (each)	m³/d	870
Membrane internal tank dimension (each)	m (l × w × h)	2.4 × 2.6 × 3.7
Number of blowers and permeate pumps	-	2 (1 per tank)
Blower size	kW	5.5
Permeate pump size	kW	5.5

Disinfection requirements for wastewater irrigation in New Zealand are typically a based on an AEE approach under the RMA. Currently the is no legislation or guidelines in New Zealand for wastewater irrigation. Without undertaking a full AEE disinfection requirements for this have been taken from the *Australian Guidelines for Water Recycling* (2006) (refer to as AGWR). Disinfection requirements, equipment validated log credits, and expected performance are given in Table 9-3. This shown that the proposed process easily meets the requirements even selecting the lowest equipment validation values. Note the term log reduction refers to the decrease in orders-of-magnitude, e.g. a reduction in e. coli from 1000 to 10 cfu/100ml is a 2 log reduction or 99% removal.

Table 9-3 Disinfection requirements for irrigation to trees, equipment validated log credits, and expected performance

Log Reduction	Viruses	Protozoa	Bacteria
Log reduction required for irrigation on Non-food crops – trees (AGWR Table 3.8)	**5**	**3.5**	**4**
Log reduction provided from preventive measure: Drip irrigation of plants/shrubs (AGWR Table 3.5)	4	4	4
Validated log reduction values (LRVs) for equipment/process: ▪ Secondary treatment ▪ Membrane filtration (UF)	 0 – 0.5 2 – 3	 0 – 0.5 4	 0 – 0.5 >4
Total validated log reduction (including preventative measures)	**6 – 7.5**	**8 – 8.5**	**>8**
Typical log reduction performance of treatment ▪ Secondary treatment ▪ Membrane filtration (UF)	 0.5 3.5 – 5	 0.5 – 1 2.5 – 5	 0.5 – 1 >5
Total typical log reduction (including preventative measures)	**8 – 9.5**	**7 – 10**	**>9.5**

9.2.5 Solids Handling and Removal

Waste activated sludge (WAS) will need to be thickened, to produce thickened waste active sludge (TWAS), and stored, before being tankered to the Christchurch Wastewater Treatment Plant for processing into biosolids. Thickening is recommended as this will reduce the number of tanker movements, and to reduce transport costs.

Membrane filtration can thicken the mixed liquor up to around 1.2% dry solids content. A gravity belt thickener (GBT) is proposed to further thicken the sludge to 5% dry solids. The WAS flow is used to control the MLSS to the design in Table 9-1.

Preliminary design details for the solids handling and removal system are given in Table 9-4. By having the GBT feed tank at the same level are the reactors, a control valve can be used to bleed sludge from the Return Activated Sludge (RAS) line to the GBT.

Table 9-4 Preliminary Design Values for the Solids Handling and Removal System

Design Parameter		Value
Gravity belt thickener (GBT) capacity	m^3/h	20
GBT solids capture	%	95
Thickened sludge dryness	% dry solids	5
Number of GBTs	-	2 (1 duty + 1 stand-by)
Overall GBT dimensions	m (l × w × h)	4.0 × 1.2 × 1.5
Overall polymer dosing dimensions	m (l × w × h)	2.1 × 0.85 × 1.6
Operation of GBT		1 to 2 hr/d
Peak TWAS flow	m^3/h	4
Number of TWAS pump	-	2 (1 duty + 1 stand-by)
TWAS pump size	kW	1

Design Parameter		Value
Peak filtrate flow	m^3/h	20
Number of filtrate pumps	-	2 (1 duty + 1 stand-by)
Filtrate pump size	kW	1.5
Sludge tank capacity	m^3	15
Sludge tank dimensions	m (Ø × h)	3 x 3

It is estimated that thickened sludge volumes will be 1.0 m^3/d for average flows and up to 5 m^3/d for peak summer flows.

9.2.6 Enhanced Disinfection for Non-potable Reuse

One of the aspects being considered for wastewater disposal and reuse is beneficial non-potable reuse within Akaroa for flushing of public toilets, irrigation of public parks, and potentially reticulated to higher density areas. See the options Section 5-8 for an outline of the proposed non-potable reuse design.

There are no nationally accepted guidelines in New Zealand that deal specifically with the reuse of treated municipal wastewater in urban areas. Any municipal wastewater recycling scheme is likely to be subject to the requirements of the Health Act and the Local Government Act. Consultation with the Ministry of Health and other Government agencies is needed to ascertain the acceptability of the Australian framework in the absence of New Zealand regulations and guidelines. This could mean a potentially lengthy timeline to confirm the specific requirements for a scheme in Akaroa. Disinfection requirements have been taken from the Australian Guidelines for Water Recycling (AGWR) basing requirements for treatment upon the table below from as there is no current NZ legislation.

Table 9-5 Disinfection requirements for non-potable reuse, equipment log credits, and expected performance

Log Reduction	Viruses	Protozoa	Bacteria
Log reduction required for Dual reticulation, toilet flush, garden use (AGWR Table 3.8)	**6.5**	**5**	**5**
Log reduction provided from preventive measures: None applicable	0	0	0
Validated log reduction values (LRVs) for equipment/process: ▪ Secondary treatment ▪ Membrane filtration (UF) ▪ UV disinfection for non-potable reuse	 0.5 3 3	 0.5 4 4	 >1 >4 4
Total validated log reduction (including preventative measures)	**6.5**	**8.5**	**>9**
Typical log reduction performance of treatment ▪ Secondary treatment ▪ Membrane filtration (UF) ▪ UV disinfection for non-potable reuse	 0.5 – 1 3.5 – 5 3	 0.5 – 1 2.5 – 5 4	 0.5 – 1 >5 4
Total typical log reduction (including preventative measures)	**8 – 10**	**7 – 10**	**>9.5**

The concept design for the WWTP plant would achieve pre-validated log reduction credit of 3.5 log removal for viruses (0.5 log from activated sludge + 3 log from membrane treatment). As shown in Table 9-5, an additional 3 log reduction is required for viruses for non-potable reuse. To attain 3 log UV reduction for the most resistant virus, Rotavirus, a high dose rate is required (≥110mJ/cm²). Concept design details for the UV system are given in Table 9-6.

Initial discussions with UV equipment vendor indicate that a UV system with a high dose rate can be validated for virus removal and hence chlorination may not be required. Confirmation of the need for chlorine dosing will be confirmed at the next phase of design.

Table 9-6 Concept Design Values for the Non-Potable Reuse UV Disinfection System

Design Parameter		Value
UV hydraulic capacity	L/s	14
Design UV transmissivity (UVT)	%	60
Design total suspended solids (TSS)	mg/l	2
Design Rotavirus	log removal	3

9.2.7 Odour Management

Processes that have potential to emit odours (including the raw wastewater storage pond, gravity belt thickeners and sludge storage tank) will be enclosed. The air extracted from these enclosures, and the sludge and membrane building, will be treated in a bark biofilter to remove odour.

Ventilation air from non-odour producing facilities including the blower, laboratory and control room will be discharged directly to the atmosphere. Consents have been granted for the air discharge from the treatment plant.

9.2.8 Operations and Maintenance

The main treatment process (activated sludge reactors and membrane filters) units have been sized for duty/assist operation. For the majority of the time only the duty reactors will be required, with the assist reactor started up prior to the peak load during Christmas/New Year holiday period. The assist membranes may be left in service during the off season, to maximise the treatment of wet weather flows, but would be serviced during this period.

Mechanical equipment (pumps, blowers, gravity belt thickener) has been sized for duty/standby operation. This means the process can continue following the failure of individual items of mechanical equipment. As a cost-saving measure, the gravity belt thickener and thickened WAS pumping could be specified duty only, as they are only required 1 to 2 hours per day, and the process could continue for several days without these units in operation.

For mechanical equipment, sufficient access has been allowed for to maintain the equipment. The membrane building will have a gantry crane for easy removal of the membranes. Crane access to the reactor is from the internal site access road, with the aeration reactor closest to the road.

9.2.9 Hydraulic Design

A preliminary hydraulic profile is shown on Drawing 6517986-GE-042 in Appendix AA.

9.2.10 Civil and Site Layout

The treatment plant site concept site layout is shown in Figure 9-2 and Drawings 6517986-GE-040 and GE-041 in Appendix AA. The layout has been developed with the following concepts in mind:

- The plant has been kept narrow and on the flatter land adjacent to Old Coach Road to avoid the steeper hillside (and higher construction cost and risks associated with increased earthworks volumes and retaining walls)

- The height of the buildings has been arranged so that the higher structures are located to the south east end of the site to maintain maximum vertical separation from the ridgeline
- Site access is via an internal one-way access road
- All the buildings are located just outside the Old Coach Road reserve
- The majority of the equipment is indoors, to reduce noise and visual effects, and to maximise serviceability
- The north east walls of the buildings and tanks are used as retaining walls
- Stormwater will be collected and discharged to the existing table drain on Old Coach Road

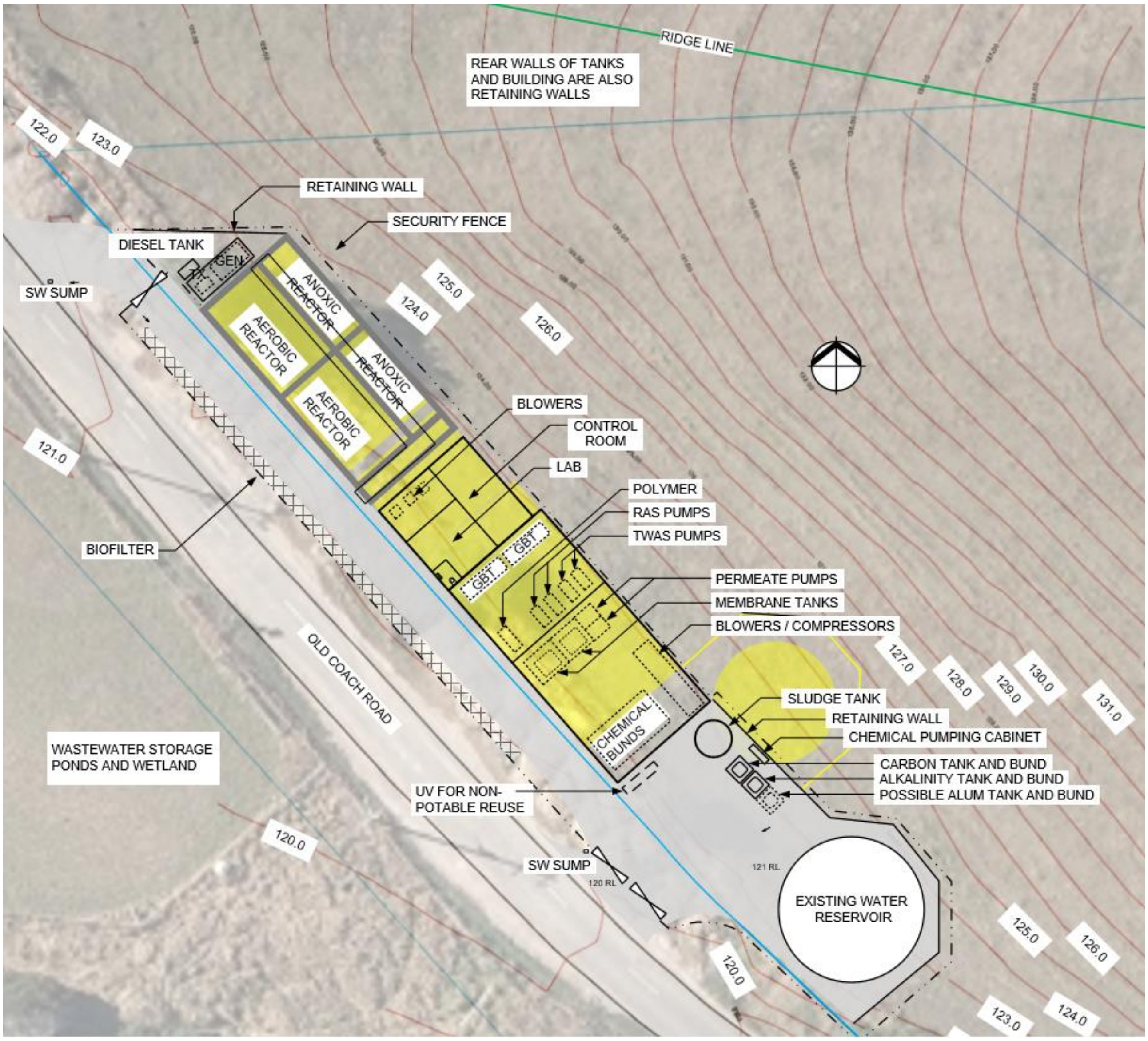


Figure 9-2 Concept Treatment Plant Layout (previous concept in yellow, storage pond not shown)

9.2.11 Wastewater Storage at the Treatment Plant

Based on feedback from public consultation and from the Akaroa Treated Wastewater Reuse Options Working Party and the Ngāi Tahu parties, there is a preference for wastewater to be stored across the road from the new WWTP. Factors in this preference include proximity to the treatment plant, lower landscape impact than for other sites, and well suited position for reticulation of non-potable reuse water to Akaroa and/or to any of the shortlisted irrigation sites. As this site is required for all of the options, the Council bought the property in 2019. This would be used for a raw wastewater storage pond and a treated wastewater storage pond if needed. For the Inner Bays irrigation option a subsurface wetland would also be located on this site.

9.2.12 Requirements for Raw Wastewater Storage

There is a cost trade-off between the hydraulic capacity of the WWTP (specifically the ultrafiltration membranes) and size of the raw wastewater storage pond. Increasing the flow capacity of the treatment plant reduces the volume of raw wastewater storage required and vice-versa. Investigation of this issue found that keeping the membrane capacity as small as possible and providing additional raw wastewater buffer storage is the most cost-effective solution. On this basis, the membrane capacity has been limited to 14 L/s to process the peak summer average daily flow. Flows greater than this (including diurnal peaks during the peak summer) will be stored in the raw wastewater pond and returned to the treatment plant inlet once peak flows have subsided.

It is important to understand what effect the changes to the network and the new scheme components will have on the frequency of overflows. Based on an assessment of Council overflow records to date, there are typically around 2 - 3 events each year where large rain events result in overflow of untreated wastewater to the harbour. The sizing of the raw storage pond influences network overflow frequency. The pump at the terminal pump station will pump until the raw wastewater storage volume is at capacity. Should the raw wastewater storage pond capacity be exceeded by a period of wet weather beyond the design envelope, the pond will not be able to be fully store all raw wastewater, and an overflow from the network will result. This would occur at the terminal pump station after primary treatment (screening and grit removal) and be discharged to Grehan Stream.

The required raw wastewater storage pond volume to prevent an overflow was assessed for various return periods based on a daily volume of wastewater from the recent (14 February 2019) PDP calibrated model. This model uses the Virtual Climate Station Network (VCSN) rainfall data for Akaroa from 1/1/1972 to the end of 2018. In Figure 9-3 these are plotted against the Average Recurrence Interval (ARI) of the rain event based on Council's Waterways, Wetlands and Drainage Guide (WWDG) method. In Figure 9-4, these same events are plotted with a 20% reduction in rain derived I&I.

The determination of the ARI for a given rain event is important in understanding overflow frequency. Excessively large storage would be required to contain an event with an ARI of 1 in 100 years, and for 99.999% of the time this storage would be sitting partially empty. It is therefore not considered cost-effective to design for capture of all rainfall events. Modelling of ARI events and corresponding storage volumes therefore becomes important to understand the most cost-effective scenario.

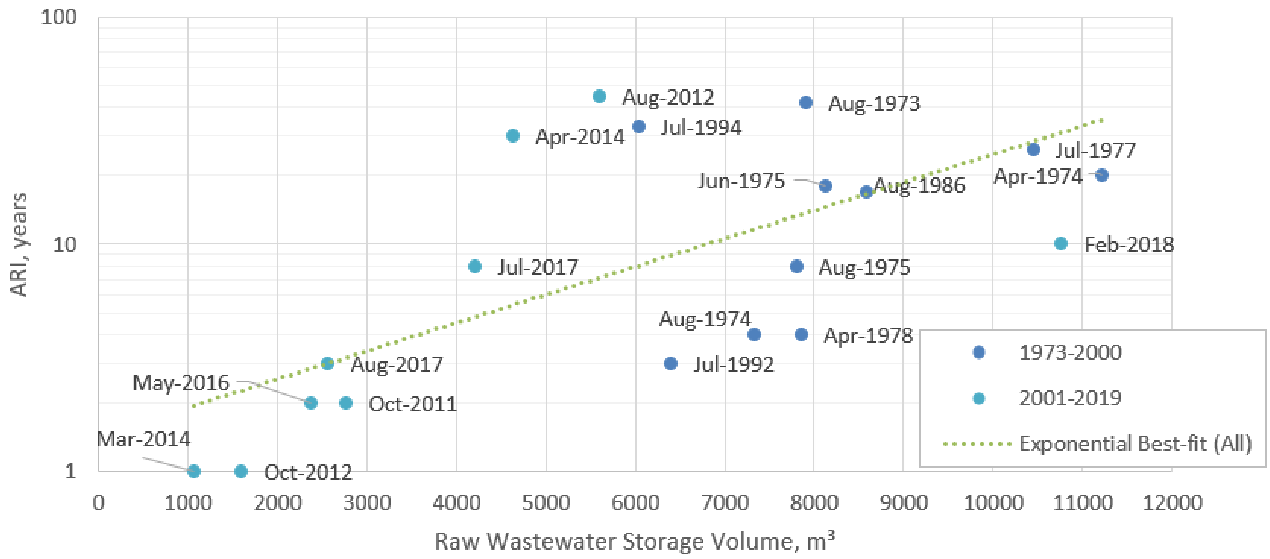


Figure 9-3 Storage Pond Volume Required to Store Historic Significant Wet Weather Events (1972 – 2019)

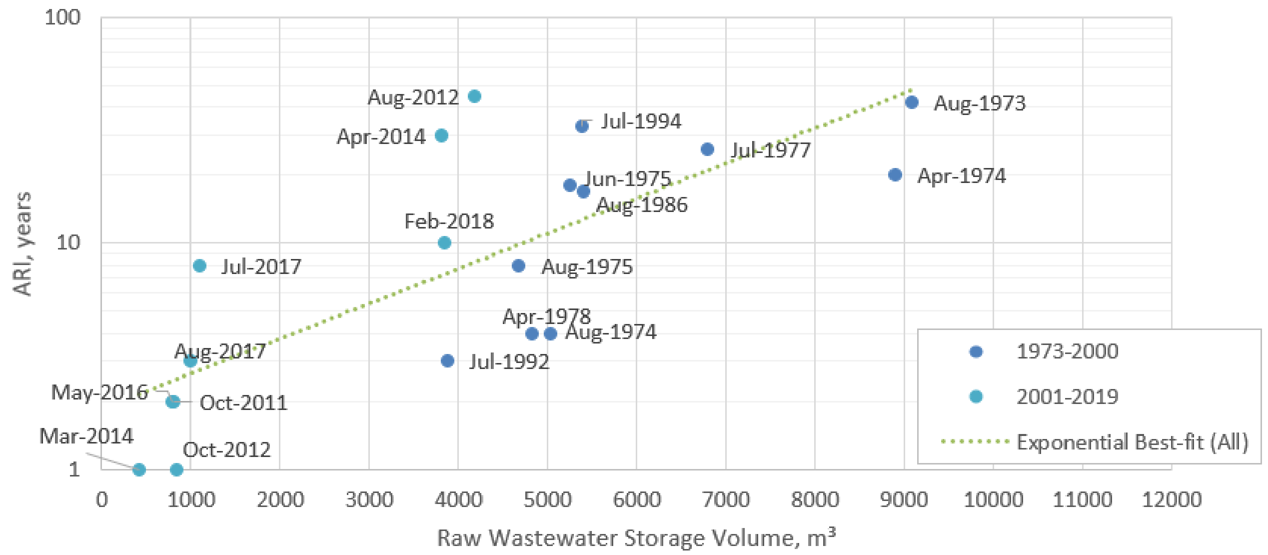


Figure 9-4 Storage Pond Volume Required to Store Historic Significant Wet Weather Events (1972 – 2019) With 20% Reduction in Rain-derived I&I

The current concept design for raw wastewater storage is for a capacity of approximately 6,000 m³. Based on the modelled flow (including the planned 20% reduction in I&I) this would result in three overflows for the period 1972 to 2019, i.e. an ARI of approximately 1 in 15 years. Alternative options were reviewed but not adopted at this stage. These alternatives include reducing overflows to 1 for the 47 year period (i.e. an ARI of 1 in 47 years), which could require a raw wastewater storage pond volume of 8,800 m³. To reduce overflows to 1 in 47 years would require an increase in capacity of the Terminal Pump Station from 65 L/s to 67 L/s.

9.2.13 Requirements for Treated Wastewater Storage

A treated wastewater storage pond may be included on the land opposite the treatment plant on Old Coach Road for the following reasons:

- Provides storage for a non-potable reuse scheme to maintain flows in high use periods (i.e. having a volume available for short duration high demand periods such as evening garden watering)
- Reduces the volume of treated wastewater storage required in a storage pond elsewhere
- For the Goughs Bay and Pompeys Pillar irrigation options, it could act as a buffer pond from which to pump. This avoids issues around the stoppages in pumping to the schemes disrupting the membrane filtration and biological treatment processes.

However, Council has advised that the treated wastewater storage pond should only be included for use with a non-potable reuse scheme and for the option of a harbour outfall from Glen Bay. This is on the basis that, in the absence of a reuse system, wastewater can be pumped directly from the treatment plant to the irrigation storage pond at the instantaneous flow rate hence no storage is required. The concept sizing for the treated wastewater storage pond for inclusion with a non-potable reuse scheme is 1,000 m³, which is greater than the average daily flow out of the WWTP, but less than the maximum daily flow of 1,200 m³. During later phases of design, the need for, and size of, a treated wastewater storage pond for other options will be confirmed.

9.3 Layout of Treatment Plant Storage Ponds and Wetland

Depending on which scheme option is progressed, the land opposite the treatment plant will need to accommodate some or all of the following:

- Covered raw wastewater storage pond (all options)
- Small pump station to transfer between raw wastewater storage pond and WWTP (all options)
- Treated wastewater storage (non-potable reuse and harbour outfall from Glen)
- Subsurface wetland (for Inner Bays irrigation option)
- Pump station (for pumping to Goughs Bay or Pompeys Pillar for those irrigation options)

Concept level geometric modelling of a possible layout has been completed based on the following, this is shown in Figure 9-5:

- Treated water storage pond of 1,000 m3
- Covered raw water storage pond of 6,000 m3
- Subsurface wetland of approximately 3,800 m2

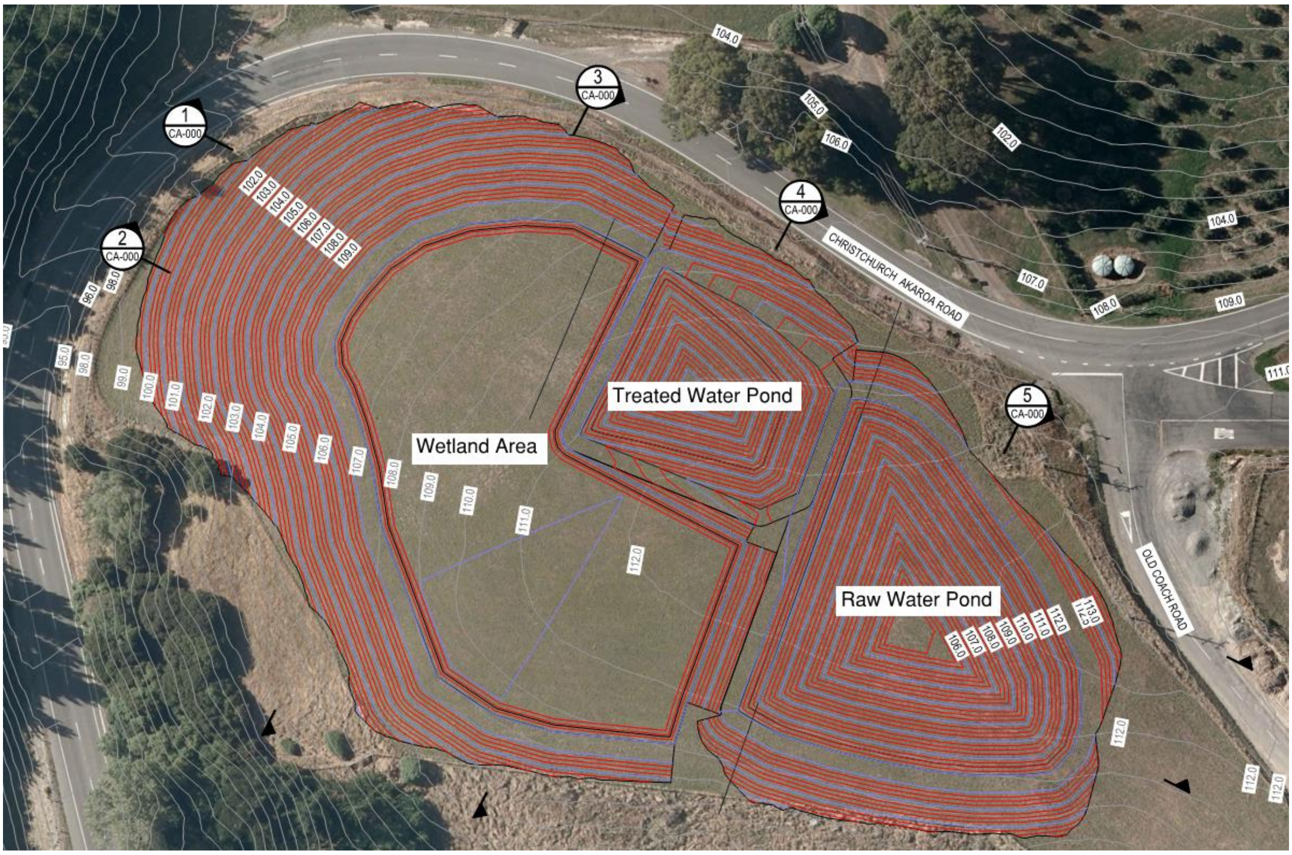


Figure 9-5 Geometric Design of Possible Storage Pond Configuration Opposite WWTP

The concept layout has sited the ponds with regard to view paths to vantage points, dwellings, public roads and other sensitive receptors. However, consideration of whether the ponds can be constructed into the ground to minimise the visual prominence will depend on site geotechnical conditions such as depth of rock. Estimates of the depth of rock have been made, based on previous geotechnical and borehole investigations nearby. However, physical investigation on site will be required to confirm assumptions.

Figure 9-7 shows an artist’s impression of how the site could look, with the original image shown in Figure 9-6.

Figure 9-6 Original image of treatment plant storage pond site viewed from Long Bay Road

Figure 9-7 Artist's impression of treatment plant storage pond site viewed from Long Bay Road

It is noted that trees are problematic when planted near to ponds, as their roots tend to seek out such water sources. This in time can be detrimental to the integrity of the pond embankment and can allow for an erosion path from the pond. Furthermore, falling branches may damage the pond cover or liner systems.

Planting the internal pond embankments with species such as flax that will grow to the water's edge is not possible in this case as it is intended that the pond be lined with a HDPE liner, or similar. Landscaping directly on the external embankment slope should also be minimised so that the integrity of the embankment system can be observed – pasture grasses could be used. The preference is for landscaping to be set back from the pond system. The presence of the sub-surface wetland will add to the overall landscaping of the site. The raw wastewater pond will be covered using a floating HDPE cover so that odorous air can be captured and treated. An image of a covered pond is shown in Figure 9-8.

Figure 9-8 Example of Covered Pond

9.4 Dam Break Assessment for Treatment Plant Storage Ponds

Unlike the Upper Robinsons Bay site, the treatment plant pond site with the Children's Bay stream below has a very short steep catchment. At this stage all modelling has been carried out as 'sunny day' case, i.e. with no elevated flows in the creeks in the area caused by wet weather as the volume of water from a dam break would be significantly in excess of any run-off volume from a wet weather event (i.e. flows from a rain event are unlikely to make a significant difference).

The dam breach parameters were assumed to be similar to those suggested at the Upper Robinsons Bay site, based on a high-level concept design. Breaches have been tested in a range of likely directions as the site is at the crest of a hill. A range of model runs have been tested, looking at volumes from 6,000 m^3 up to 17,500 m^3, at several possible failure locations. Refer to Appendix R for further details.

Initial modelling was further informed by a site visit on 31 July 2019. Notes from this visit are shown in Figure 9-9. The initial modelling and site visit have shown some risks based on an assumed pond layout. With the pond site being at the crest of a hill, multiple failure locations and consequent flow paths are possible depending on the pond layout which alters the location and nature of risks. The highway plays a major part in capturing and directing possible dam breach flows downhill toward the south.

As a result of findings the layout for the pond storage site opposite the WWTP (refer Figure 9-5) has been adjusted to position the raw wastewater pond, which has the largest storage volume, away from the state highway and in a position where water from a breach would tend to flow towards the major gullies shown in Figure 9-9. Furthermore the wetland and treated water pond have been positioned to be set back from the edge of the site, cut and fill adjusted to have the pond walls as close as possible to ground level, and configured to minimise the risk of a breach to the north (shown as the red line at the top of Figure 9-9).

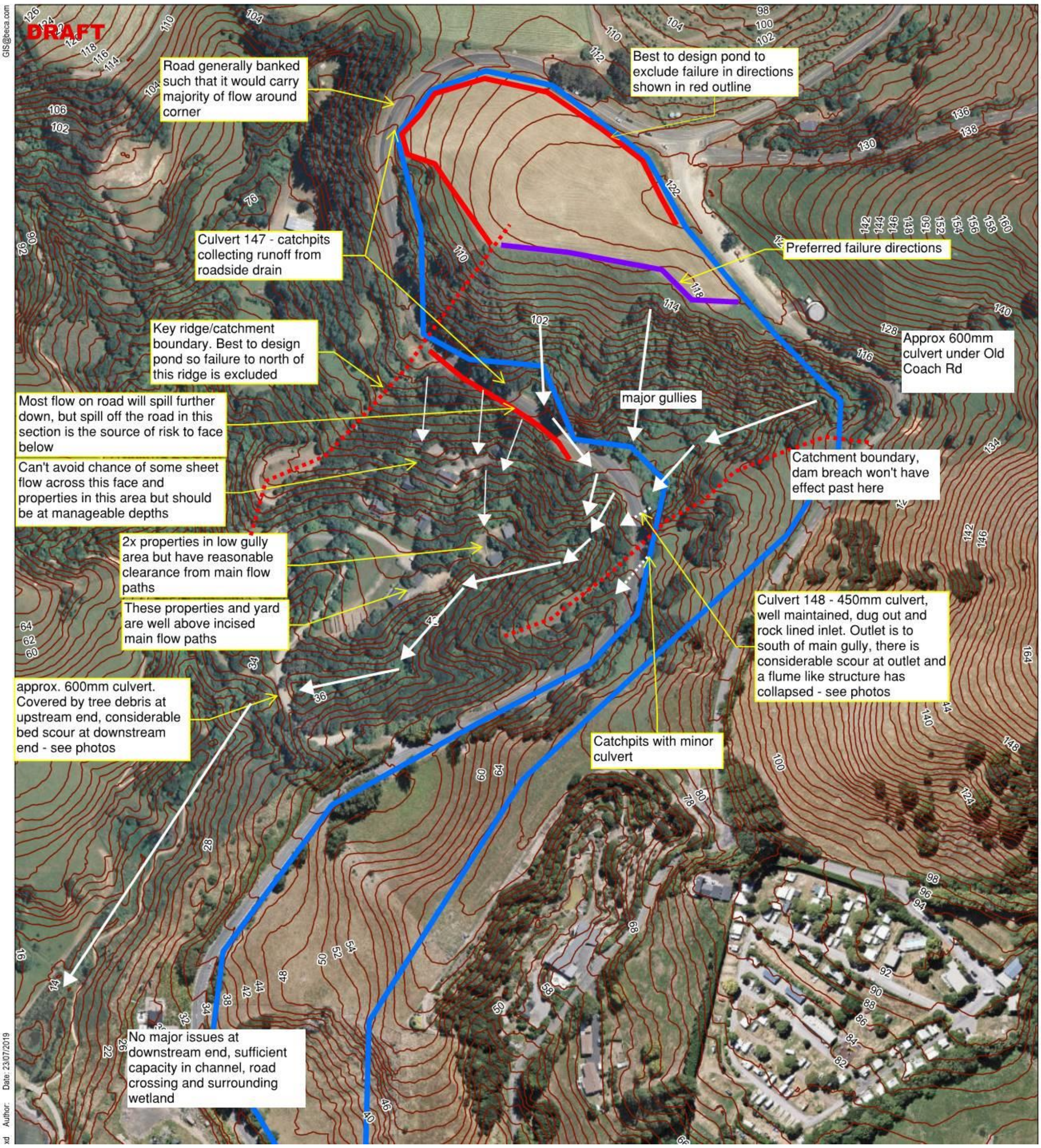


Figure 9-9 Notes from Site Visit and Initial Modelling at Pond Storage Site Opposite WWTP

When the layout for the site is confirmed (i.e. size of wetland, inclusion of treated wastewater pond) and a full geometric modelling completed for the water retaining structures further analysis can be completed. To better inform this analysis the following additional information should be obtained and reviewed:

- Better detail of the road and roadside drain, and detail of any culverts under the road
- Latest LIDAR for the area
- Floor levels for individual properties, to compare against predicted flood depths

9.5 Non-potable Reuse (Purple Pipe)

Treated wastewater can be beneficially reused within the Akaroa township for non-potable uses, such as flushing public toilets and irrigating public parks. As the treatment plant is located at the top of Old Coach Road, a reuse scheme could operate by gravity with no additional pumping. Non-potable reuse is often referred to as a "purple pipe" system as the treated wastewater is reticulated in purple coloured pipework to indicate the service. To minimise costs purple pipes could be laid alongside new raw wastewater pipelines when the Akaroa reticulation work associated with the overall wastewater scheme upgrade is constructed. Alternatively, trenchless pipe laying techniques could be used.

Two options were considered for the reuse of treated wastewater as a non-potable supply. Option 1 is to provide treated wastewater to the irrigable public parks and public toilets with branch tees provided for future extension throughout the town. Option 2 is to construct a purple pipe network throughout town, to the property boundary of every residence and business. For both options a pipe size and length, and the total annual amount of treated wastewater that could be reused were calculated. An indicative long section for the Option 1 purple pipe route through Akaroa is given in Appendix K.

As a final decision has not been made about incorporation of the purple pipe system and the initial feedback from the Canterbury District Health Board is that the use on non-potable reuse for private property use is not acceptable practice under the current NZ regulatory framework (refer Appendix G), the analysis of irrigation scheme land and storage requirements to date excludes any potential reduction from non-potable reuse.

9.5.1 Irrigation in Akaroa

There are several parks in Akaroa township that are potentially suitable for irrigation. However, some do not meet the slope criteria for irrigation. The sites deemed suitable were estimated to require 3 mm/day for 120 days a year i.e. irrigation during dry weather only. Table 9-7 summarises the locations that were assessed as being irrigable. Subsurface drip irrigation systems would be installed.

Table 9-7 Non-potable Reuse Park Irrigation Area within Akaroa

Location	Area For Irrigation (m^2)	Total Water (m^3/yr)	Suitability for Irrigation
Waeckerle Green	3,250	1,170	Suitable
Recreation Ground	20,000	7,200	Suitable
Woodills Rd Park (Jubilee Park on Figure 9-10)	1,000	360	Suitable
L'Aube Hill	0		Not suitable as slope greater than 15º
Stanley Park	0		Not suitable as downhill slope greater than 15º
War memorial	0		Excluded due to presence of gardens, monuments etc that would make installation very difficult
Britomart reserve	0		Excluded due to presence of mature trees and playground that would make installation very difficult
Total	**24,250**	**8,730**	

The three public parks within Akaroa assessed as suitable for irrigation with non-potable reuse water are shown in.

Figure 9-10 Akaroa Public Parks Suitable for Irrigation (image courtesy of Canterbury maps)

9.5.2 Option 1 – Supply to Public Parks and Public Toilets

The supply pipework begins at the WWTP with a DN110 PE pipe (nominal diameter of 110 mm) main pipe to part way down Old Coach Road. At this point the main would reduce to DN63 and continue at this size for the rest of the supply line. PN16 (nominal pressure of 16 bar, or 160 kPa) was selected to allow for de-rating the pipe should trenchless installation techniques be used. The main pipe diameter of DN63 is based on future expansion of the purple pipe network for peak flow conditions as follows:

- 100% guest occupancy in peak summer
- 55 litres/person/day for toilet flushing (Auckland Regional Council Technical Publication No. 58 (TP58) On-site Wastewater Systems: Design and Management Manual, Table 6.3)

- Peak flow diversity factor of 3
- A constant irrigation demand of 1 L/s (distributed evenly across Zones 2 and 3).
- Further non-potable reuse take-offs to individual house supply (as per Option 2) should Council want to pursue this in future.

The population of Akaroa fluctuates throughout the year according to season as described in Section 2.1. The estimated use of non-potable treated wastewater for Option 1 is shown in Table 9-8. To estimate the amount of non-potable water that could be used in public toilets a conservative assumption has been made that 50% of visitors use a public toilet once per day and each flush uses 5 litres of water. This estimated non-potable reuse for option 1 is approximately 4% of the total wastewater produced each year.

Table 9-8 Volume of Non-Potable Reuse Option 1

Non-potable Reuse Calculation	Visitors	Duration (days)	Flow (m^3/d)	Subtotal (m^3)
Peak summer public toilets	3,829	7	10	70
Non-peak summer public toilets	1,620	64	4	256
Winter public toilets	112	294	0.3	88
Parks irrigation (m^3/year)	-	120		8,730
Total Estimated Reuse (m^3/year)				**9,150**

9.5.3 Option 2 – Purple Pipe Throughout Akaroa

Option 2 is based on supplying treated wastewater for non-potable reuse to the boundary of every residence and business in Akaroa. Akaroa was divided into five zones according to population density based on the ‘Guest Number and Tourist Data’ supplied by the Council. Zone 1 contains 22 accommodation establishments, Zones 2 and 3 contain five each, and Zone 4 is the Akaroa Top Ten Holiday Park. Zone 5 is located to the south. The areas covered by each zone are shown in Figure 9-11.

The main pipe diameter (using PE 100 PN16 pipe to allow for de-rating the pipe should trenchless installation techniques be used) was sized based on the following peak flow assumptions:

- Total population of 4,557 at peak summer (in the year 2052)
- An average household size of 3.4 people (population divided by number of connections)
- 55 litres/person/day for toilet flushing (TP58 Table 6.3)
- A peak flow diversity factor of 3
- A constant irrigation demand of 1 L/s (distributed evenly across Zones 2 and 3)
- Garden watering not included at this stage – although this could use a significant amount of reuse water

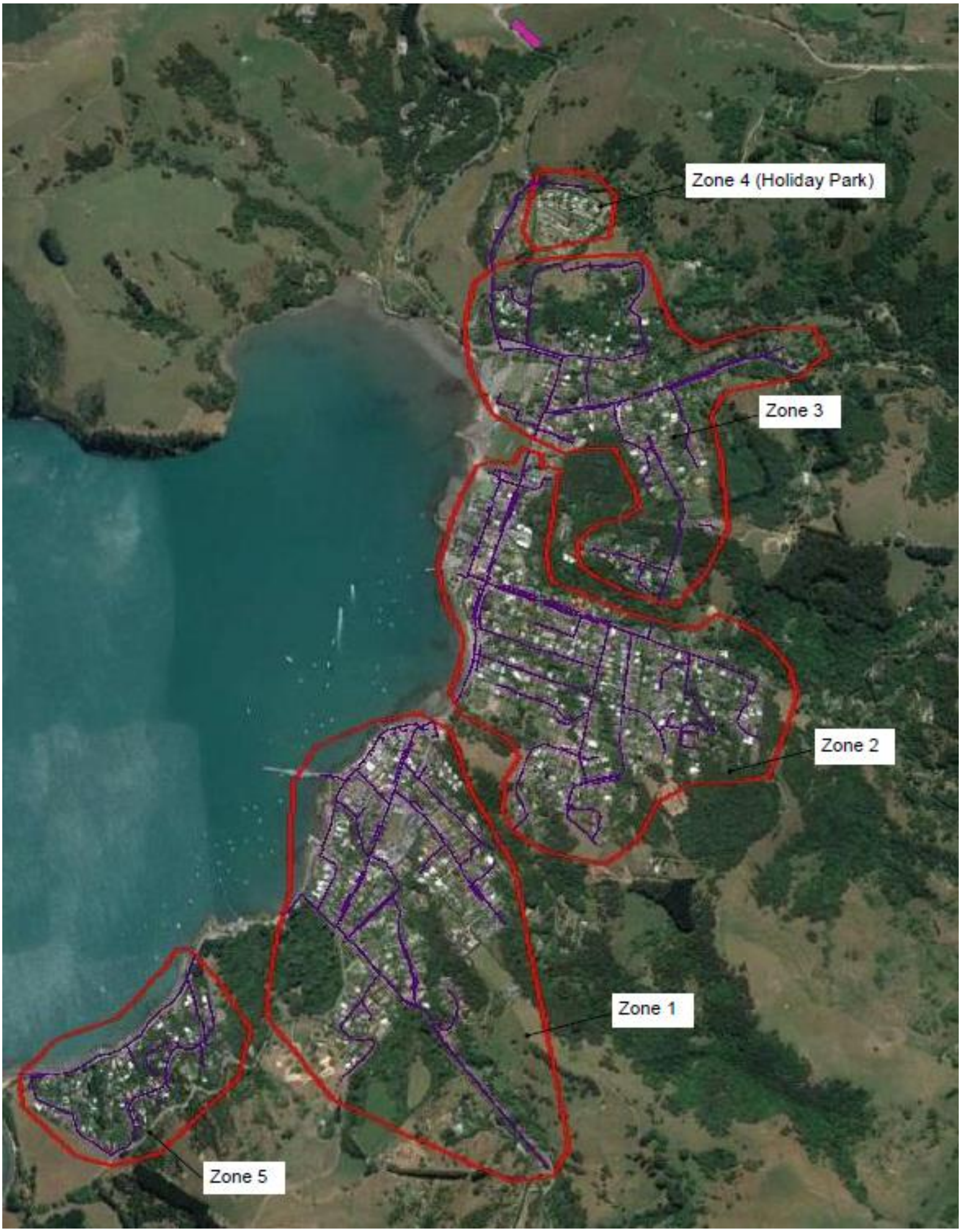


Figure 9-11 Option 2 and Populated Zones 1-5

The supply pipework to the zones was sized based on these parameters beginning at the WWTP with a DN110 PE pipe (nominal diameter of 110 mm) main pipe to Zone 4. It is assumed that DN63 will be suitable for mains pipe and DN32 for suitable for sub-mains pipe within residential zones. Residential connections assumed a 10 m DN25 lateral per connection (to the property boundary).

The seasonal population of Akaroa was taken from the 2052 estimated population described in section 2.1 and then an average household population of 3.4 was used to determine the toilet flushing requirements in each zone. The peak consumption of non-potable reuse water for all five zones for toilet flushing was estimated to be 251 m^3/day assuming:

- Peak summer population in 2052
- 55 Litres/person/day of water used for flushing toilets.

The irrigation requirements remained the same as for Option 1, with 1L/sec distributed evenly across Zones 2 and 3. The estimated total amount of non-potable reuse that can be used for Option 2 is shown in Table 9-9. These volumes currently exclude garden watering that could use a significant amount of reuse water.

Table 9-9 Volume of Non-Potable Reuse Option 2

Non-potable Reuse Calculation	Population	Duration (Days)	Flow (m^3/d)	Subtotal (m^3)
Peak Summer	4,557	7	251	1,754
Summer	2,348	64	129	8,256
Winter	840	294	46	13,524
Parks and sport field irrigation reuse (m^3/year)				8,730
Total reuse (m^3/year)				**32,264,**

9.5.4 Backflow Protection to Existing Potable Supply

Supplying non-potable reuse water to a property introduces a risk of contamination to the potable water supply if backflow occurs where there is cross-connection. Clause G12 Water Supplies of the Building Code outlines the requirements for backflow prevention. The type of backflow prevention device required depends on the cross-connection hazard rating. Where the hazard rating is medium, a testable double-check valve is required to be installed on the existing potable supply. Where the hazard rating is high, a testable reduced pressure zone device is required. Testable devices are required to be tested annually. All backflow prevention devices installed must be manufactured to AS/NZS 2845:2010 Water Supply – Backflow Prevention Devices.

A cross-connection hazard rating of medium was assumed, and therefore a double-check valve assembly was included for each connection in the cost estimate. It is noted that there is a non-testable single check valve in the water supply meter for each property. However, these do not meet the required standards.

There is also the risk of cross-connections within the property causing contamination of the private supply. This would need to be carefully managed to make sure this risk is at an acceptable level. A detailed risk analysis was not carried out, this should be undertaken at the next phase of design.

9.5.5 Opportunities to Increase Reuse Water Uptake

Some opportunities to increase the use of non-potable reuse water include:

- Treated wastewater use could be further increased if it was also used for irrigating private gardens and in laundries.

- Option 1 assumes that only the large accommodation providers would connect to the non-potable reuse supply. There is capacity in the proposed pipe size that allows other connections. This would increase the total volume used each year.
- Volumetric charging for potable water could be introduced, to encourage the use of non-potable reuse water.

9.5.6 Other Considerations for Non Potable Reuse

There is no regulatory framework surrounding recycled water in New Zealand. Previous Beca investigations into water reuse (such as in Picton) have recommended the Australian guidelines for wastewater recycling as an appropriate and robust framework for working through the technical, planning and risk management issues.

This is something that could take significant time (years) to be established. See Section 5.7.5 for commentary around the consenting of non-potable water reuse. From past experience that Beca has had with considering recycled water use, the following recommendations are made if non-potable reuse is pursued:

- Consult the Canterbury District Health Board and the Ministry of Health regarding the public health regulatory framework for urban wastewater reuse in New Zealand, and the acceptability of the Australian framework and guidelines
- Hold a discussion with the community on public perceptions and other challenges
- Complete a more detailed consideration of consenting and public health regulatory issues
- Complete a more detailed consideration of risks and mitigation (e.g. Recycled Water Management Plan)
- Confirm operational monitoring requirements (using the Victorian regulatory regime as a starting point) for the wastewater treatment plant.

10 Stakeholder Engagement

Through engagement with the Ngāi Tahu parties, the Akaroa Treated Wastewater Reuse Options Working Party and other members of the community, the direction of the Akaroa wastewater project has evolved. The Council has undertaken ongoing stakeholder engagement throughout the period of options development from July 2015 to April 2020. Key steps in this ongoing process are outlined below.

10.1 Consultation with Ngāi Tahu Parties

Engagement between the Council and the parties to the Council's appeal against the decline of resource consents associated with discharge to the harbour – the Ngāi Tahu parties and the Environment Canterbury and Christchurch City Council in their regulatory capacity – began in 2015. Hui were held on 21 September 2015, 2 December 2015 and 27 January 2016 to give regular updates on how the desktop study on alternatives to harbour disposal was progressing, and to obtain feedback on the options being considered.

A Concept Design Report on shortlisted options was agreed after a hui on 4 March 2016 to discuss and obtain feedback on the options in the draft report.

All parties wanted the collaborative process developed during the initial phases of the project continued. As such a hui was held on 2 August 2016 to discuss the preliminary findings from the ground investigations on the land identified as potentially suitable for irrigation in Takamātua, following public consultation earlier that year.

A second round of ground investigations was undertaken in the Robinsons Bay Valley, Takamātua Valley and Pompeys Pillar alternative sites in late September 2016. Again, the preliminary findings from these investigations were presented at a hui on 2 November 2016. At this hui discussions were also had around the next steps in the project and the forthcoming public meeting.

On 18 April 2017 another hui was held to give a summary of the work outlined in the options report. This also included an update on a presentation given to the working party in March 2017 which assessed the viability of land at Misty Peak, which had been considered at the request of the Akaroa Treated Wastewater Reuse Working Party. A summary of hui held after this date is shown in Table 10-1.

Table 10-1 Huis Held After April 2017

Date	Meeting Participants	Summary of Meeting Content
1 August 2017	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ Faulty flow meter and new flow metering ▪ Implications of new, higher flows for land irrigation ▪ Update on potential irrigation areas
6 November 2017	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ Update on wastewater flows and implications ▪ Akaroa Inflow and Infiltration issues ▪ Update on potential irrigation areas ▪ Deep bore injection concepts, costs, benefits and risks ▪ Non-potable reuse options
2 February 2018	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ New flow and rainfall data, impacts on land area ▪ Likely high-level scheme options ▪ Deep bore injection concepts and location options ▪ Akaroa Inflow and Infiltration improvement options

21 May 2018	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ Update on wastewater flows and network modelling, bore injection investigations, and Pond site 10 layout
20 September 2018	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ Irrigation to Eastern Bays ▪ Updates on borehole investigations ▪ Network modelling and overflows ▪ Consultation questions ▪ Existing WWTP ▪ Next steps for Akaroa ▪ Duvauchelle proposed wastewater scheme
11 February 2019	Ngāi Tahu Parties, Christchurch City Council and ECan	▪ Update on alternative options investigations including: – Deep bore injections – Irrigation to land – Non-potable re-use – Infiltration and ingress ▪ Presentation and discussion on an overarching inner bays basin concept and potential components of a workable re-use option ▪ Update on Council decision making processes and community engagement timeline

10.2 Akaroa Treated Wastewater Reuse Options Working Party

In response to community concerns, in January 2017 the Banks Peninsula Community Board decided to establish the Akaroa Treated Wastewater Reuse Options Working Party (the working party) to assist the Council in investigating and consulting on the options for the beneficial reuse of Akaroa's treated wastewater. The working party is made up of community members, Rūnanga appointees, the Councillor for the Banks Peninsula Ward and Banks Peninsula Community Board members.

The working party met seven times during February and March 2017 in the lead up to the public consultation in 2017. Copies of the working party's terms of reference, the meeting notes and the joint statement on the 2017 consultation options can be found on the Council's Akaroa wastewater scheme web page. The joint statement is also included in Appendix AB.

Working party meetings after April 2017 are shown in Table 10-2. A revised joint statement was agreed after the last meeting in June 2020. A copy of this joint statement is also included in Appendix AB.

Table 10-2 Working Party Meetings Held After April 2017

Date	Meeting Participants	Summary of Meeting Content
20 November 2017	Akaroa Treated Wastewater Reuse Options Working Party	▪ Update on wastewater flows and implications ▪ Akaroa inflow and infiltration issues and improvement options ▪ Treatment plant capacity increase ▪ Implications for existing plant discharge consent ▪ Update on potential irrigation areas ▪ Non-potable reuse options

22 February 2018	Akaroa Treated Wastewater Reuse Options Working Party	▪ New flow and rainfall data, impacts on land area ▪ Deep bore injection concepts, location options, costs, benefits and risks ▪ Likely high-level scheme options ▪ Next steps
16 March 2018	Akaroa Treated Wastewater Reuse Options Working Party	▪ Presentation by Keith Townshend on Ashburton wastewater irrigation scheme ▪ Beca presentation on deep bore injection including site selection, overall scheme costs, and non-potable reuse
27 April 2018	Akaroa Treated Wastewater Reuse Options Working Party	▪ Update on managed aquifer recharge option ▪ Deep bore injection site mapping ▪ Preferred bore sites
31 October 2018	Akaroa Treated Wastewater Reuse Options Working Party	▪ Updated cost estimates, update on deep bore drilling investigations, concept design for flow buffer pond at Pond Site 10, wastewater network modelling results ▪ Brainstorming of options without deep bore injection
12 December 2018	Akaroa Treated Wastewater Reuse Options Working Party	▪ Deep bore injection ▪ Soap box presentations of potential solutions for Akaroa's wastewater
8 March 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Inner bays reuse option ▪ Introduction of inner bays reuse option ▪ Wetland concept from Ōnuku Rununga
21 March 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Update on MAR ▪ Development of wetland concept ▪ Next steps
11 April 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Managed aquifer recharge presentation by Bob Bower ▪ Robinsons Bay irrigation and wetland concept design ▪ Purple pipe scheme potential
29 April 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Wetland at Takamātua ▪ Discussion on the benefits of managed aquifer recharge ▪ Land-based option within Akaroa Harbour
30 August 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Managed aquifer recharge ▪ Dam break analysis ▪ Options for consultation
30 October 2019	Akaroa Treated Wastewater Reuse Options Working Party	▪ Terms of reference ▪ Managed aquifer recharge ▪ Irrigation areas, storage pond volumes and overflow frequency ▪ Dam break analysis ▪ Wetland at Pond Site 10 ▪ Goughs Bay meeting with residents

12 December 2019	Akaroa Treated Wastewater Reuse Options Working Party	■ Received feedback from the working party on the draft public consultation document ■ Conducted a SWOT analysis of the four options ■ Confirmed a consensus view from the working party that the Pompeys Pillar option should be eliminated ■ Agreed a timeline for preparation of a joint statement from the working party to meet the terms of reference
23 January 2020	Akaroa Treated Wastewater Reuse Options Working Party	■ Site visit to potential irrigation areas ■ Meeting at CCC Akaroa service centre ■ Reviewed draft consultation document ■ Discussed landowner opposition to land being utilised for scheme and council response to this.
27 March 2020	Akaroa Treated Wastewater Reuse Options Working Party	■ Meeting held on Skype due to Covid 19 restrictions ■ Discussion on Hinewai option investigations ■ Presentation on options of irrigation to native trees at Goughs Bay and Pompeys Pillar ■ Discussion of updated cost estimates ■ Review of next steps, programme and possible consultation during lockdown restrictions
15 May 2020	Akaroa Treated Wastewater Reuse Options Working Party	■ Meeting held on Skype due to Covid-19 restrictions ■ Correspondence relating to consultation document ■ Discussion on format of consultation ■ Review of draft Joint Statement
5 June 2020	Akaroa Treated Wastewater Reuse Options Working Party	■ Correspondence and matters relating ■ Consultation document ■ Feedback from Te Rūnanga o Koukourārata ■ Review of draft Joint Statement
9 June 2020	Akaroa Treated Wastewater Reuse Options Working Party	■ Review of draft Joint Statement

10.3 The Akaroa Wastewater Technical Experts Group

The Akaroa Wastewater Technical Experts Group (the Technical Experts Group) was convened in early 2017 and consisted of experts working for the Council, the Friends of Banks Peninsula and the Ngāi Tahu parties. Representation on the Technical Experts Group was based on the parties nominated by each of the stakeholder groups – i.e. for the Council, the Friends of Banks Peninsula and the Ngāi Tahu parties. The Technical Experts Group was tasked with answering specific technical questions about irrigation schemes. It produced three joint statements dated 6 December 2016, 16 February 2017 and 26 April 2017. The joint statements were prepared independent of any stakeholder group and were issued to all stakeholder groups at the same time. Copies of these joint statements and the terms of reference are on the project website and are included in Appendix AC.

10.4 Public Consultation

10.4.1 Public Consultation Round in 2016

Public consultation was undertaken on six scheme options from 26 April to 12 June 2016. Owners of land that could be impacted by scheme options identified were also contacted and meetings were held with these parties on a one-to-one basis prior to wider public consultation. Three public drop-in sessions were held on Wednesday 27 April 2016 in Akaroa, Thursday 5 May 2016 in Christchurch and Saturday 7 May 2016 in Akaroa. These were attended by 80 people in total.

Questions raised at public meetings, and project team responses, were made available on the Council's project web page[4]. A further consultation meeting was hosted by Ōnuku Marae on Thursday 2 June 2016. This provided an opportunity for the community to hear about and consider the cultural significance of this project to the Ngāi Tahu parties. There were approximately 50 people in attendance. A summary of the hui was also made available on the project web site.

The public consultation brochure outlined six potential scheme options:

- Option 1 Year-round irrigation to trees
- Option 2 Year-round irrigation to pasture
- Option 3 Summer only irrigation, with wetland or infiltration basin and discharge via a coastal infiltration gallery at other times
- Option 4 Subsurface flow wetland and discharge via a coastal infiltration gallery
- Option 5 Infiltration basin and discharge via a coastal infiltration gallery
- Option 6 Mid-harbour outfall

Submitters were asked to rank the options. They were also asked to state their reasons for ranking the order and provided with space for further comments. At the close of consultation, 81 submissions were received with the most supported option being Option 6 – mid-harbour outfall (43%). No submissions were received in support of Options 3 or 5. Option 4 – Subsurface flow wetland and discharge via a coastal infiltration gallery also received limited support (1 submitter). A summary of the ranked scheme options is shown in Figure 10-1.

[4] https://ccc.govt.nz/services/water-and-drainage/wastewater/wastewater-projects/akaroa-wastewater-scheme

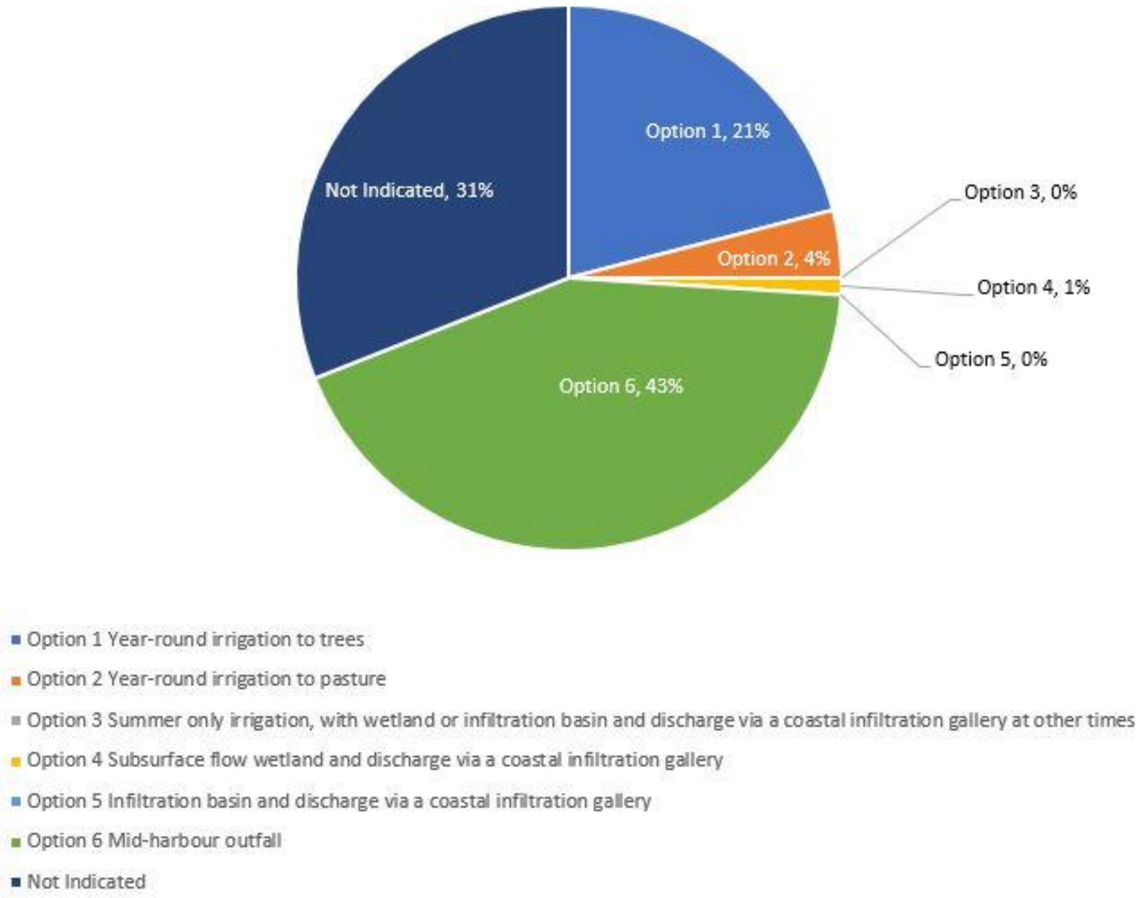


Figure 10-1 Ranked Scheme Options from 2016 Public Consultation

However, subsequent land investigations on the area identified as potentially suitable for irrigation on Takamātua Peninsula found that there was a risk of irrigation causing downslope instability. This area was therefore discounted as being suitable for irrigation and there was a risk that there was insufficient land for a land-based option. The Council therefore decided not to proceed with hearing the submissions and expanded the consideration of land for irrigation to a much wider area (see Section 4.5).

10.4.2 Public Meeting November and December 2016

Later in 2016, on Wednesday 9 November, a public meeting was held at the Gaiety Hall in Akaroa. The purpose of this meeting was to explain why the Council is exploring alternatives to a harbour outfall for treated wastewater disposal, how potentially suitable irrigation areas were selected, and to provide the results of land investigations for those areas. Takamātua Valley, Robinsons Bay and Pompeys Pillar. Representatives from the Ngāi Tahu parties also attended this public meeting.

A community consultation workshop was held at the Gaiety Hall on Saturday 3 December 2016. The community provided responses to four questions; see below for photos of these responses:

- What solutions do you want considered and what are your reasons for favouring these ideas?
- What are the pros and cons of 'useful to investigate further' of irrigation to land in your area?
- What concerns about any option to you have that needs to be addressed (e.g. through further information and/or taken into account in the design)?
- What would make you want, or find acceptable, an irrigation scheme in your area? What ideas to you have about making it a success/beneficial to the community?

- The community answers to these questions are on the project website.

Figure 10-2 Image from Akaroa Wastewater Public Meeting

10.4.3 Public Consultation Round in 2017

Consultation on the Akaroa reclaimed water beneficial reuse, treatment and disposal options took place from 3 April to 8 May 2017. The consultation booklet for this round of consultation included details of the five options being proposed:

- Option 1 Irrigation of trees or pasture in Robinsons Bay
- Option 2 Irrigation of trees or pasture at Pompeys Pillar
- Option 3 Irrigation of trees or pasture in Takamātua Valley, in combination with another area
- Option 4 Non-potable reuse in Akaroa, in combination with another option
- Option 5 Disposal via a new outfall pipeline to the mid-harbour

Submitters were asked to rank each option from 1 – 5, with 1 being their most preferred option and 5 being their least preferred option. They were also asked to state their reasons for ranking the order and provided with space for further comments. They were also provided with potential storage pond locations and asked whether they had a preference for the location of the pond. The results of the weighted scoring of preferences is shown in Figure 10-4.

10.4.4 Public Consultation Meetings

Figure 10-3: Attendees at the public consultation meeting at Ōnuku Marae (image courtesy of Akaroa Mail)

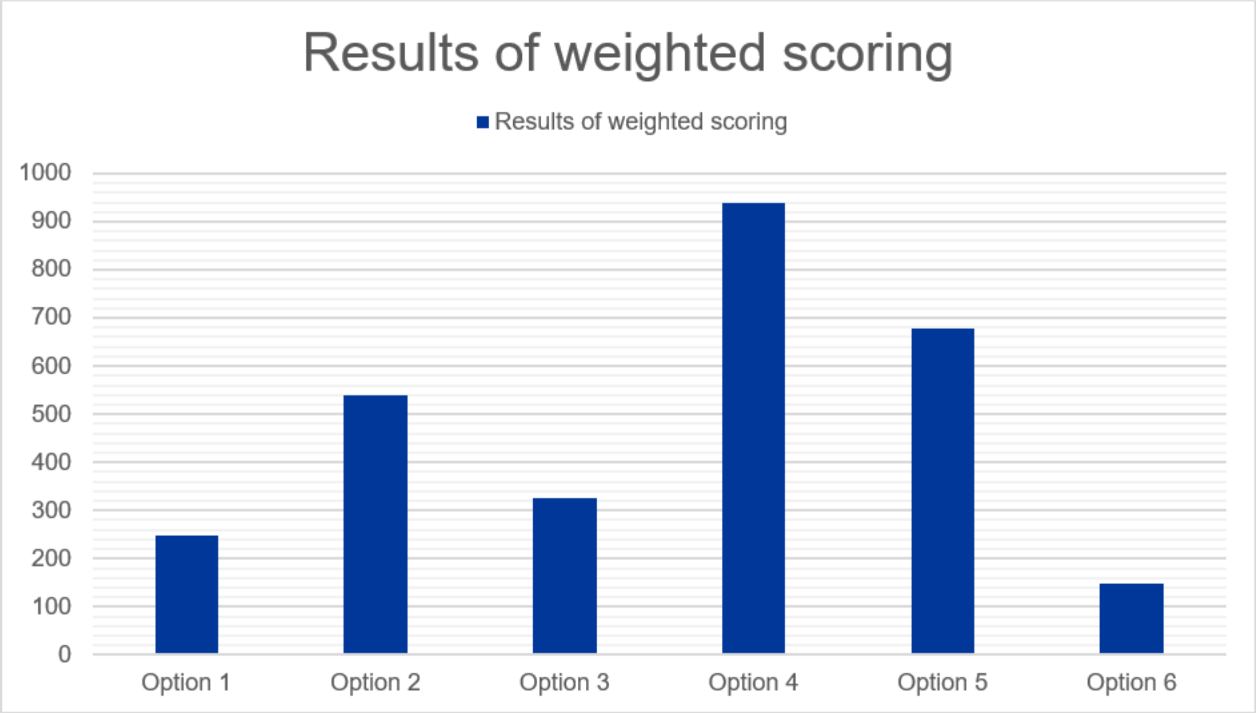


Figure 10-4 Scoring of Disposal Options from 2017 Consultation Round

In the 2017 consultation round there were 261 submitters who commented on possible location of storage ponds. Pond Site 10, an area of land opposite the proposed treatment plant site at the intersection of State Highway 75 and Old Coach Road, was the most preferred, receiving 24% support.

10.4.5 April 2018 Public Meeting

In April 2018 a further public meeting was held in Akaroa. This meeting covered:

- Update on faulty flow meter and new flow metering
- New flow and rainfall data
- Impact of higher flows
- Potential irrigation areas
- Inflow and infiltration
- Non-potable reuse
- Deep bore injection concepts, location options, and integration into overall scheme
- Deep bore field investigations
- Summary high level scheme options
- Next steps

11 Carbon Accounting

A high level assessment of the greenhouse gas (GHG) emissions has been completed to assist with decision making and selection of a preferred wastewater scheme. All figures are presented in tonnes of carbon dioxide equivalent (tCO_2-e), a standard metric to account for the relative warming impact of different GHG sources. The assessment considers the emissions generated in creating the asset (capital emissions) and in operating the asset (operational emissions). The conclusions in this section have been provided to illustrate relative differences between the options and should be relied upon for this reason only.

This information can be used to make more informed decisions in response to the climate crisis. The Council declared a climate change emergency in May 2019 and has since set a target of being carbon neutral by 2030.

11.1 Methodology

11.1.1 Boundary of Assessment

This assessment was performed to give an indication of the relative difference in carbon impact between the disposal scheme options. As such, the following common elements between the schemes were not included in the capital emissions estimate:

- Wastewater treatment plant
- Storage pond and wetland site opposite the treatment plant
- Redirecting wastewater flows from the southern end to the northern end of Akaroa
- Purple pipe reuse system

Therefore when considering the net impact of the scheme as a whole, all capital and operational emissions should be considered in addition to the results presented in this report.

11.1.2 Estimated Useful Life

The assumed design horizon for the scheme is 35 years from construction (noting that design life may be up to 100 years for some items). Estimates were made considering this 35 year design horizon.

11.1.3 Specific Exclusions

Specific categories of activities were excluded, based on whether they were considered immaterial in contribution to the overall footprint or would involve significant uncertainty and difficulty of calculation. These include:

- Site environmental management
- Geotextile liners
- Leak detection systems
- Mechanical works
- Landscaping and amenities
- Electrical, instrumentation and controls equipment
- Capital emissions of the pumps
- Testing and commissioning
- Geotechnical investigations

11.2 Capital Emissions Assumptions

11.2.1 Capital Emissions Assumptions – Materials and Transport

- Materials estimates for the emissions embodied in the materials used in construction, extracted from the cost estimate.
- Materials considered include concrete, steel, aggregates, PE pipe, Ductile Iron Cement Lined (DICL) pipe as used for the high pressure pipeline to Goughs Bay and Pompeys Pillar, PE liners, and pumps.
- The category 'concrete' listed include emissions related to steel reinforcement if it is required. The category 'steel' refers to the structural and roofing steel to construct the pump station in the Goughs Bay and Pompeys Pillar schemes.
- Transport estimates are for the emissions generated in transporting the materials to and from site.
- All materials were assumed to come from Christchurch.
- A provision has been made for the replacement of the top layer of HDPE lining on ponds every 10 years, adding to the capital emissions related to materials. This provision does not include emissions related to the installation as these were considered immaterial.
- Embodied emissions from materials and emissions from transport of materials relies on emissions factors obtained from the ISCA Materials Calculator Version 2.0 and the Ministry for Environment (2019).

11.2.2 Capital Emissions Assumptions – Construction

- An estimate of emissions related to construction fuel use was made. There is a high degree of uncertainty related to estimating construction emissions at the concept design stage due to the wide range of possible construction methodologies that could be applied by contractors.
- In addition, emissions factors for various construction activities are not widely published at this time. We have therefore relied upon a combination of published sources for certain activities (Transport - Greenhouse gas emissions mitigation in road construction and rehabilitation: A toolkit for developing countries (World Bank 2010)) and client and Beca internal information on emissions from other activities.
- Estimates of emissions related to construction fuel use should not be relied upon in place of detailed estimates from contractors.
- The estimate does not include activity related to possible deconstruction or decommissioning at end of life.

11.3 Operational Emissions Assumptions

11.3.1 Operational Energy

- The energy required to operate the proposed asset solution during operation has been estimated based on size and expected use of the pumps.
- This relies on the Ministry for Environment (2019) emissions factor for grid electricity over the design life.
- The estimate does not include fuel related to the maintenance and servicing of the plant.

11.3.2 Disposal and Treatment Emissions

- The release of Nitrous Oxide (N2O) during treatment and disposal has been estimated due to the difference between irrigation to trees and harbour outfall options. N2O emissions are presented in tCO2-e after applying a Global Warming Potential (GWP) factor of 298.
- This relies on the Intergovernmental Panel on Climate Change (IPCC) May 2019 Refinements emissions factors.

11.3.3 Carbon Sequestration

- For the Inner Bays Irrigation, Goughs Bay, and Pompeys Pillar options, an estimate of carbon sequestered by the native trees over 35 years was made based on default lookup tables provided by the Ministry for Primary Industries for forests under 100 hectares. MPI assumes carbon sequestration of native trees until 50 years of growth. With this in mind sequestration of these options will continue beyond the modelled 35 years.
- The above estimate assumes crown coverage of at least 30% per hectare at the tree's maturity.
- It does not include any changes to the carbon embodied in local soil as a result of discharge of wastewater to land.
- It is central to the carbon sequestration assumption that the trees remain in the ground indefinitely for the benefits to remain.

11.4 Results

11.4.1 Capital Emissions

The following tables describe what elements have been included in each scheme estimate, emissions related to each element and the section of the scheme to which the emissions relate.

Table 11-1 Capital Emissions Sources Inner Bays Irrigation Scheme

Section:	Includes:	Portion of footprint:
Pipeline to Robinsons Bay	Material, construction and transport emissions from excavation of trenches, export of spoil, PE pipes and import of fill.	~ 25%
Irrigation Storage	Material, construction and transport emissions from creation of access roads, pond excavation earthworks, HDPE liner, and concrete structures.	~ 65%
Irrigation	Material, construction and transport emissions from creation of access roads, and drip line irrigation pipe.	~ 10%

Table 11-2 Breakdown of Capital Emissions Inner Bays Irrigation Scheme

	Capital Emissions (tCO2-e)	Portion of Capital Emissions (%)
Pipe	370	31%
Concrete	42	3%
Steel	0	0%
Aggregates	13	1%
Liner	270	22%
Replacement liner	270	22%
Material	966	80%
Transport	46	4%
Construction	193	16%
Total Capital Emissions	**1204**	**100%**

Table 11-3 Capital Emissions Sources Goughs Bay Irrigation to Trees Scheme

Section:	Includes:	Portion of footprint:
Treated Wastewater Pump Station	Material, construction and transport emissions from creation of access roads, pump station concrete and steel.	~ 15%
Pipeline to Eastern Bays	Material, construction and transport emissions from excavation of trenches, export of spoil, DICL and PE pipes and import of fill.	~ 50%
Irrigation Storage	Material, construction and transport emissions from creation of access roads, pond excavation earthworks, HDPE liner, and concrete structures.	~ 25%
Irrigation	Material, construction and transport emissions from creation of access roads, delivery of trees, and piping for a drip irrigation structure. Excludes emissions related to installation of irrigation scheme.	~ 10%

Table 11-4 Breakdown of Capital Emissions Goughs Bay Irrigation to Trees Scheme

	Capital Emissions (tCO2-e)	Portion of Capital Emissions (%)
Pipe	501	35%
Concrete	217	15%
Steel	41	3%
Aggregates	54	4%
Liner	62	4%
Replacement liner	62	4%
Material	938	65%
Transport	154	11%
Construction	346	24%
Total Capital Emissions	1438	100%

Table 11-5 Capital Emissions Sources Pompeys Pillar Irrigation to Trees Scheme

Section:	Includes:	Portion of footprint:
Treated Wastewater Pump Station	Material, construction and transport emissions from creation of access roads, pump station concrete and steel.	~ 10%
Pipeline to Eastern Bays	Material, construction and transport emissions from excavation of trenches, export of spoil, DICL and PE pipes and import of fill.	~ 45%
Irrigation Storage	Material, construction and transport emissions from creation of access roads, pond excavation earthworks, HDPE liner, and concrete structures.	~ 35%
Irrigation	Material, construction and transport emissions from creation of access roads, delivery of trees, and piping for a drip irrigation structure. Excludes emissions related to installation of irrigation scheme.	~ 10%

Table 11-6 Breakdown of Capital Emissions Pompeys Pillar Irrigation to Trees Scheme

	Capital Emissions ($tCO2-e$)	Portion of Capital Emissions (%)
Pipe	607	31%
Concrete	427	22%
Steel	41	2%
Aggregates	92	5%
Liner	132	7%
Replacement liner	0	0%
Material	1299	66%
Transport	264	13%
Construction	398	20%
Total Capital Emissions	1961	100%

Table 11-7 Capital Emissions Sources Mid-Harbour Outfall

Section	Includes:	Portion of footprint:
Pipeline from WWTP to the Glen	Material, construction and transport emissions from excavation of trenches, export of spoil, PE pipes and import of fill.	~ 60%
Ocean Outfall	Material, construction and transport emissions from excavation of trench, chambers and backfilling of trench and PE pipe. Includes concrete diffusers and pipe weights. Assumption that trench backfilled using excavated material.	~ 40%

Table 11-8 Breakdown of Capital Emissions Mid-Harbour Outfall

	Capital Emissions (tCO2-e)	Portion of Capital Emissions (%)
Pipe	80	51%
Concrete	18	12%
Steel	0	0%
Aggregates	8	5%
Liner	0	0%
Replacement liner	0	0%
Material	106	67%
Transport	12	8%
Construction	39	25%
Total Capital Emissions	**157**	**100%**

Figure 11-1 summarises the sources of capital emissions for each scheme options and shows that the Pompeys Pillar scheme has the most emissions generated in constructing the asset.

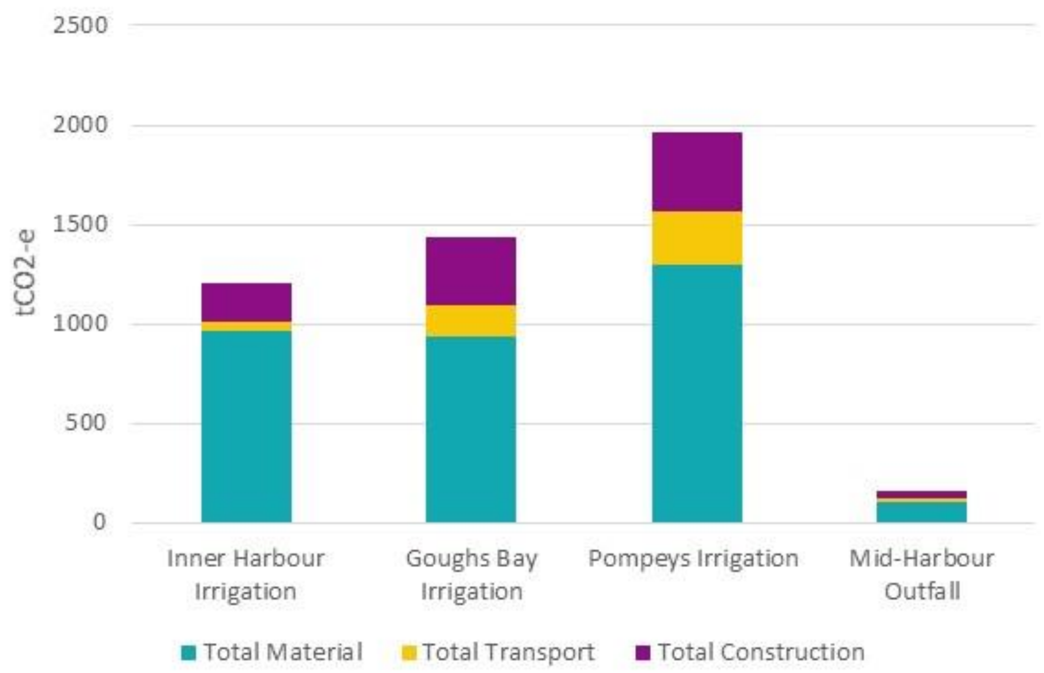


Figure 11-1 Summary of Capital Carbon Emissions by Scheme

11.5 Operational Emissions

The Goughs Bay and Pompeys Pillar schemes require significant amounts of operational energy per year to pump the wastewater over the hill, which will generate emissions over the lifetime of the assets. The Inner Bays Irrigation scheme, with far less pumping requirements has considerably less demand for energy and the mid-harbour outfall relies on gravity for its operation, meaning no emissions are generated in pumping. The operational energy of running the terminal pump station and WWTP for each option are also included in the table below.

Over the life of the asset, differences between options create a significant difference in operational emissions which should be considered.

Table 11-9 Sources of Operational Emissions per Scheme

	Operational Emissions (tCO2-e)			
	Inner Bays Irrigation	**Goughs Bay Irrigation**	**Pompeys Pillar Irrigation**	**Mid-Harbour Outfall**
Energy emissions/year	49	95	95	27
Treatment and disposal emissions/year	5	5	5	5
Total operational emissions/year	54	101	101	32
Total operational emissions (35 years)	1893	3518	3644	1111

11.6 Net Emissions

The Inner Bays, Goughs Bay and Pompeys schemes have the ability to be a net carbon sinks over their lifetimes. The Ministry for Primary Industries estimates that over 35 years native trees could sequester approximately 286 tCO2-e per hectare. This could increase to approximately 323 tCO2-e per hectare by time the trees have matured (50 years). The irrigation element of the schemes with trees could be carbon neutral after 10-15 years. There are limitations when describing this as carbon neutral due to the carbon assessment boundary, being the exclusion of common elements between the schemes including building and operations of the wastewater treatment plant. Despite this, the Inner Bays and Pompeys Pillar schemes would have the most positive impact towards reducing the impacts of global heating and contributing to New Zealand's Net Zero 2050 target. Pompeys Pillar has more of a positive impact as it has a larger area of trees.

Whilst having the smallest capital and operational carbon footprints of the options, the mid-harbour outfall has the greatest net emissions due to its inability to sequester carbon through trees. This could be offset through purchasing carbon credits. The price of carbon credits is currently capped at $25 per tCO2-e however this cap will be removed from the end of 2022 at the latest. There is uncertainty around what might happen to the value of carbon credits after this time, with predictions ranging from the price doubling over the following 5-years, to increasing 6-fold.

Table 11-10 Summary of Net Emissions per Scheme

	Net Emissions (tCO2-e)			
	Inner Bays Irrigation	**Goughs Bay Irrigation**	**Pompeys Irrigation**	**Mid-Harbour Outfall**
Capital Emissions	1204	1438	1961	157
Operational Emissions	1893	3518	3644	1111
Carbon Sequestration	-11976	-9455	-13895	0
Net emissions over useful life of asset (35 years)	-8879	-4499	-8290	1268

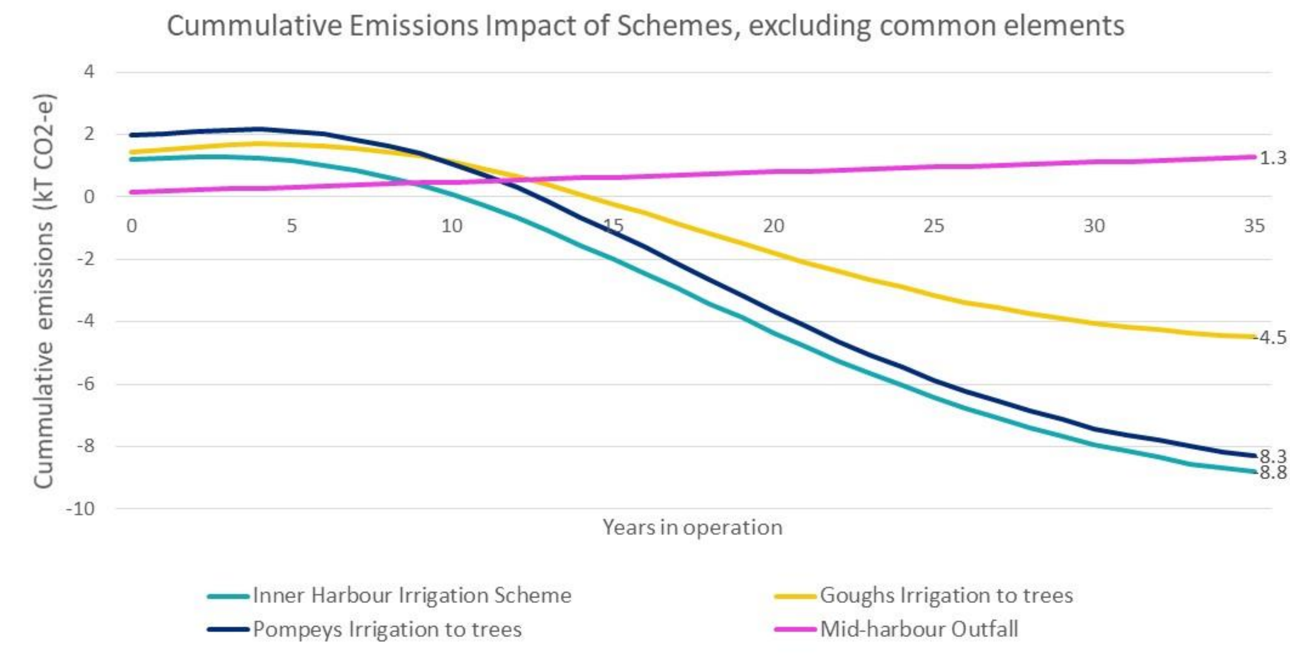


Figure 11-2 Summary of Cumulative Emissions by Scheme

12 Cost Estimates

A copy of the capital and operational cost estimates is provided in Appendix AD. These estimates have been produced by Council and have been reviewed by Beca.

Previous estimates by Beca had a contingency factor of 25%. This provision is required to address the level of accuracy of the estimate taking into account the current status of the design, which is concept level. Specific aspects of the design have been further developed since the previous (Beca) cost estimate. Based on this advancement, Council staff have adopted a lesser contingency for the current cost estimate. The level of contingency varies between the scheme options, due to the differences in level of advancement of components in the different scheme designs, as follows:

- Pompeys Pillar irrigation contingency = 19%
- Goughs Bay irrigation contingency = 19%
- Inner Bays irrigation contingency = 21%
- Harbour outfall = 22%

The following sections have been prepared by Council.

12.1 Cost Estimate Summary

The capital cost estimates for the proposed Akaroa wastewater disposal options range from $47.3 million to $69.3 million as summarised below in Table 12-1 Capital Cost Estimate Summary.

Table 12-1 Capital Cost Estimate Summary

	Inner Harbour Irrigation Scheme	Goughs Irrigation Scheme (Trees)	Pompeys Pillar Irrigation Scheme (Trees)	Mid-Harbour Outfall
Base Scheme Cost	$57,000,000	$64,300,000	$69,300,000	$47,300,000
Probable Cost Range (-5%)	$54,100,000	$61,100,000	$65,800,000	$44,900,000
Probable Cost Range (+10%)	$62,700,000	$70,800,000	$76,200,000	$52,000,000

It should be noted that all values within this report and included in the attached estimates are in New Zealand dollars (NZ$) and are GST exclusive. Refer to the Appendix AD for more detailed breakdowns.

12.2 Expected Accuracy Range

Estimate accuracy range is an indication of the degree to which the final cost outcome for a given project will vary from the estimated cost. Accuracy is typically expressed as a +/- percentage range around the point of estimate after the application of contingency, with a stated level of confidence. As the level of project definition and certainty increases, the expected accuracy of the estimate tends to improve, as indicated by a tighter +/- range.

This estimate is based on concept design information that is under development and the probable accuracy range of individual inputs has been assessed on a case by case basis, these values can be found in Appendix AD.

A project cost contingency of -5% to +10% has been applied to the total project estimate inclusive of individual item uncertainties. This accuracy range highlights unknown risks that can impact the project which are difficult to predict or value. As the design and tendering of works progresses this range will reduce to reflect the level of confidence in the design and information available and level of risk.

12.3 General Assumptions and Exclusions

- Elements of cost included within this estimate are based on costs from similar Council projects or other cost benchmarks, including quotes.
- It is assumed that a robust tendering process will be followed as part of the Council procurement process.
- It is assumed that all works are carried out during normal daytime working hours unless noted otherwise
- Professional fees and consent fees are yet to be confirmed. The estimate includes allowances for these anticipated costs.
- Traffic management costs from similar projects within Christchurch City Council.
- The estimates are based on rates and prices current as of February 2020 and no allowance has been included for increases in costs of currency fluctuations, labour, materials or plant beyond this date.
- Goods and Services Tax (GST) is excluded.
- Construction escalation beyond date of estimate is excluded.
- Foreign Exchange cost risks are excluded.
- Finance costs are excluded
- Incurred costs to date are excluded.
- Architectural treatment to exterior of buildings are excluded
- The estimates assume continuity of work and unobstructed access to the site.

Please refer to the Appendix AD for more detailed estimate assumptions, exclusions and clarifications.

12.4 Specific Assumptions

12.4.1 Project specific estimate inputs

The estimate is built up based on the following design inputs:

- Concept Design and Estimation on Terminal Pump Station, Beca 2012
- Concept Design and Estimation on Wastewater Treatment Plant, Beca 2012
- Concept Design of Disposal Options, Beca 2019
- Desk study on Inflow and Infiltration reduction by Wastewater network
- Desk study and GIS measurement on Wastewater Reticulation Network Upgrades and TPS Rising Main
- Desk study and GIS measurement on Wetland, Non-Portable Reuse Pipe and Overflow pipe
- Concept Design Estimation of PS and WWTP from the consultant was based on quotations received from suppliers in 2012. Currency inflation and cost escalation to the February 2020 are added in to reflect the current cost.
- Rates on forest plantation, irrigation, and establishment are based on consultancy with the specialist contractor in forest construction and Council TSD experts.
- Price of DICL pipes from Hynds in February 2020.
- Price of PE pipes from Hynds and Hume in 2019.
- Cost of logistics in Akaroa and extra cost for work in a remote area is considered within the construction rates

- Non-Potable Reuse Pipe and Cost Escalation are listed as Add on Item, which is not included within the Estimation Range.
- The quantity of rock excavation is based on preliminary site investigation and desk study. It must be refined with a more detailed investigation.
- Service clashing may occur during pipe laying crossing Akaroa Township. The impact on productivity has been considered within the construction rate. No allowance is made to shift or relocate any existing services.
- The archaeological survey has not been carried in the current stage of design work. No allowance is made on any delay or cost impact from archaeological investigation or management work.
- The allowance on Resource Consent is based on a high level estimate.

12.4.2 Storage Ponds, Dams and Wetlands

The basic concepts for the size and design of the storage ponds, dams and wetlands are described under each scheme option. It is assumed that the ponds, dams, and wetlands will be constructed of locally won soil materials and lined with HDPE, GCL, or a similar type liner system.

For the construction of the large dams at Goughs and Pompeys Pillar it has been assumed that the necessary volume of earth required to construct the dams (excluding imported drainage material) can be sourced locally from borrow pits on the larger site. This assumption can only be confirmed by physical testing on site. Should it be found that not all material can be borrowed on site, then the costs for the dams could increase significantly due to the need to import suitable material.

The estimates include allowances for making good irrigation areas at each site that may have been impacted by earthworks.

12.4.3 Irrigation to Trees

Irrigation to trees is assumed to be by drip line irrigation laid on the ground beneath the trees. Drip line irrigation has been allowed for and assumes small diameter polyethylene pipe laid on the ground at an average of 1m spacing.

Planting and establishing the trees allowances include:

- The sourcing of local seed stock
- Growing seedlings in a nursery environment to RT grade tree seedlings.
- Planting
- Replacement of seedlings during a 3 year establishment
- Weed and pest control for the establishment period.

No allowance has been made for potential offsets in planting costs from government funds or carbon credits as these are not bankable at this stage of the project and may not be in place when planting takes place.

12.4.4 Mid-Harbour Outfall Costs

It is noted that marine works are difficult to estimate as tendered prices are likely to vary depending on perception of risk, and access to appropriate floating plant. There are also a limited number of contractors in New Zealand market with experience in constructing ocean outfalls.

12.4.5 Purple Pipe Estimates

There are two estimates for the Non-potable Reuse Scheme or "Purple Pipe". For the irrigation to land options the purple pipe is a supplementary option and based on the irrigation options as described in 9.5 of this report.

For the mid-harbour outfall option, the estimate assumes that the outfall supply pipeline also serves as the purple pipe network main. The cost of this main pipeline is therefore included in the harbour outfall estimate and the remaining purple pipe network items (the branch lines, connection details, backflow devices, and subsoil irrigation items) are included in a separate Non-potable Reuse Scheme estimate.

12.4.6 Land Purchase Estimates

Land purchase allowances are based on rateable value cost information and takes into consideration the size of individual land parcels. The estimates do include offsets for sub-dividing and reselling sections of the surplus land.

12.5 On Costs

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

12.5.1 Preliminaries & General

Main Contractor's On-site Overheads, also called Preliminaries and General (P&G), covers the cost of fixed and time-related on-site overheads such as site set up, site offices, services, hoardings, amenities, plant, temporary works, supervision & management, insurances and bonds

The estimates include 12-15% of net construction estimate value for Preliminary and General. The estimates include an additional 6% – 12% of the estimated value of pipe laying activities for Traffic Management.

12.5.2 Margin

Margin or profit is assumed to be included in the Contractors overhead.

12.5.3 Contingency Allowances

Contingency or risk allowances cover the risk of cost increase due to:

- Design development and pricing risk covering the development of design elements from the current scope which are not yet documented.
- Construction contingency for unforeseen risks occurring post-contract such as geotechnical conditions and site constraints, temporary works requirements, delays, variations and changes etc.

The estimate includes Contingency allowances ranging between 20% - 30% as a percentage of the gross construction estimate value.

These contingency allowances reflect the current status of the design, the potential for design development changes, and the anticipated risks of construction (pipe laying, large scale earthworks, dam storage, etc).

There is an additional "Contractor's Risk" allowance included in the Outfall estimate which we assume will be procured as a Design & Build contract. This allowance reflects the additional risk associated with constructing an outfall pipe in a marine environment.

The above contingency allowances exclude the risk of scope change.

12.5.4 Professional Fees

Allowances for Professional fees provide for the cost of engineering and design, construction monitoring and management, project management and on-going technical support.

12.5.5 Client Costs

The estimates Council project-related costs, including staffing and management, consultation and community coordination/liaison fees.

12.5.6 Consenting

The estimates include lump sum allowances for costs associated with the resource consent process.

13 Risk Assessment

The key risks are summarised in Table 13-1. Note that the views of the Ngāi Tahu parties on specific scheme risks are yet to be advised.

Table 13-1 Key Project Risks

Key Risk Issues	Risk Mitigation
Potential for cultural impacts	The Ngāi Tahu parties are strongly opposed to wastewater disposal to the harbour, and the mid-harbour outfall option would have significant cultural impacts which could not be mitigated. Irrigation of wastewater to land is the first step to addressing cultural concerns. The design and layout of any land-based infrastructure should be cognisant of silent files and features that are culturally significant. Cultural impact assessments for specific scheme options may also assist in acknowledging and managing cultural concerns.
High wastewater inflow and infiltration difficult to cope with in scheme design	Inflow and infiltration management programme to be implemented within Akaroa wastewater network with the objective of optimising wastewater flows, reducing wet weather overflows to very infrequent events, and with the goal of optimising overall scheme costs.
Wastewater quality poses risks to receiving environment	Treatment of wastewater to a very high standard using ultrafiltration membranes for 100% of flow with no bypass during wet weather, for all options.
Wastewater discharge to harbour may not be consentable	Consent for a mid-harbour outfall was declined in 2015 due to cultural effects and an inadequate consideration of alternatives. Council may still apply for consent to discharge treated wastewater to harbour even if land-based alternatives are viable providing sound rationale established that is consistent with the principles and provisions of the Resource Management Act 1991.
Wastewater irrigation to land - slope stability risks	Adoption of suitable irrigation land slope criteria based on USEPA wastewater irrigation design manual. Preferred irrigation sites have been subject to a walkover by a geotechnical engineer to identify potential erosion features and physical testing of soil infiltration characteristics has been undertaken.
Wastewater irrigation to land – storage risks	Wastewater storage pond concepts to be developed taking into account dam break risk and consequences. Risks around building storage ponds in loess will require careful consideration and peer review in detailed design. At the concept stage a triple waterproof liner is proposed with dual leakage monitoring system reporting continuously at Council network control room.
Wastewater irrigation to land - impacts on surrounding area	Treatment of wastewater to very high standard. Beneficial reuse of wastewater in supporting native tree growth. Selection of dripper irrigation to avoid aerosol risks. Adoption of boundary setback criteria for storage and irrigation area to avoid impacts on surrounding properties, public roads, ephemeral and permanent wateways, the coastline, and other sensitive features.

Key Risk Issues	Risk Mitigation
Resilience to natural hazards	All scheme options are designed to accommodate sea level rise over life of scheme and to address tsunami risks. Resilience of land irrigation options is linked to site selection and design, management and maintenance of storage and irrigation infrastructure. Extended pipelines from treatment plant to irrigation sites requires consideration - reticulation along state highways and properly designed infrastructure corridors will be more resilient than via secondary and minors roads. Minimising overall length of land pipelines also improves resilience as longer pipelines are exposed to higher cumulative risks. Resilience of the harbour outfall is linked to design to resist tsunami surges and design of robust diffuser structures.
Long term sustainability	Develop greenhouse gas emissions inventory for all options and take into account in decision making. High level assessment of potential environmental effects to be conducted at concept development stage. This should be taken through into detailed assessment of effects, with avoidance and mitigation measures incorporated, for preferred wastewater scheme.
Social impacts	Strong community engagement via wastewater working party and other forums to raise awareness and provide for well informed position and feedback from community on respective options. Using feedback received from the community to modify and refine the scheme options to mitigate concerns and potential impacts.
Scheme affordability	Well developed capital and operational cost estimates to be prepared by qualified quantity surveyor, with staged development and accuracy defined based on the level of effort. Scheme costs should be communicated to Council and other stakeholders for consideration in decision making.
Consenting risks	Selection of preferred wastewater scheme through well structured and transparent process with strong community engagement. Incorporation of regonal and district planning requirements from early stages. Thorough investigation and assessment of potential environmental effects and documentation within Assessment of Environmental Effects to accompany application for consents for selected scheme.
Project governance risks	Long timeframe for scheme genesis poses risks around loss of important background and development context within governance group when final scheme selection decisions are made. Mitigation involves effective briefing by Council officers.

14 Evaluation of Short List Options and Conclusions

14.1 Overview

Concept level designs, cost and carbon footprint estimates have been produced for the shortlisted scheme options under consideration, and a high level planning and visual effects assessment has been completed for each option. The four schemes outlined below will be taken through by Council to the next round of community consultation. A summary of the key aspects of each option, followed by an evaluation of those options, is given in the following sections.

14.2 Summary of Scheme Features

14.2.1 Inner Bays Irrigation Scheme Features

The proposed configuration for the Inner Bays Irrigation Scheme is as follows:

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m^3, located on land opposite the new treatment plant on Old Coach Road (owned by the Council), to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Subsurface wetland of approximately 3,800 m^2 for evapotranspiration of wastewater and additional treatment of wastewater on the rare occasions that a discharge to the harbour is needed, located on land opposite the new treatment plant on Old Coach Road. Overflow to Childrens Bay from subsurface wetland.
- 4.8 km long gravity pipeline from the site opposite the WWTP to the irrigation areas, with the route along State highway 76 (Christchurch Akaroa Road) and paper roads.
- 40 ha of irrigated mixed native plantings on land made up of 34 ha at 11 and 88 Sawmill Road, 3.1 ha at Hammond Point (6528 Christchurch Akaroa Road) and 2.9 ha at Takamātua Valley (6683 Christchurch Akaroa Road)
- Two treated wastewater storage ponds with a volume of 9,500 m^3 each, located at 11 Sawmill Road
- Irrigation pump station, distribution pipelines and irrigation system at the three irrigation areas, all based on dripline irrigation to native trees
- Non-potable reuse network for irrigation of public parks and flushing of public toilets in Akaroa including UV treatment and possibly chlorination of non-potable reuse flow

14.2.2 Goughs Bay Irrigation Scheme Features

The proposed configuration for the Goughs Bay Irrigation Scheme is as follows:

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m^3 across the road from the treatment plant site on Old Coach Road, to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road

- Treated wastewater pump station on the site opposite the treatment plant
- 11 km long pipeline from the treatment plant to the Goughs Bay irrigation site, with the route along Long Bay Road and Hickory Bay Road and some paper roads
- Treated wastewater storage ponds (totalling approximately 30,000 m³) at 461 Goughs Road
- Dripper irrigation of 33 ha of mixed native plantings at 461 Goughs Road
- Non-potable reuse network for irrigation of public parks and flushing of public toilets in Akaroa including UV treatment and possibly chlorination of non-potable reuse flow.

14.2.3 Pompeys Pillar Irrigation Scheme Features

The current configuration for the Pompeys Pillar Irrigation Scheme is as follows:

- 20% reduction in inflow and infiltration in Akaroa wastewater network
- Redevelopment of the Akaroa wastewater network to pump wastewater to the north end of the township
- New terminal pump station located in the Childrens Bay boat park and rising main from pump station to the treatment plant site at the top of Old Coach Road
- Covered raw wastewater storage pond with a volume of 6,000 m³ across the road from the treatment plant site on Old Coach Road, to buffer peak flows to the treatment plant
- Full tertiary wastewater treatment plant with membrane filtration, located at 80 Old Coach Road
- Treated wastewater pump station on the site opposite the treatment plant
- 13 km long pipeline from the treatment plant to Pompeys Pillar, with the route along Long Bay Road and Fishermans Bay Road
- Treated wastewater storage pond with a volume of approximately 36,000 m³ at the irrigation site
- Irrigation pump station and distribution pipelines and irrigation system at Pompeys Pillar based
- Dripper irrigation of 48 ha of mixed native plantings.
- Non-potable reuse network for irrigation of public parks and flushing of public toilets in Akaroa including UV treatment and possibly chlorination of non-potable reuse flow

14.2.4 Mid-harbour Outfall Scheme Features

The current configuration for the harbour outfall option is as follows:

- Wastewater treatment plant (with biological denitrification)
- Treated wastewater storage pond of 1,000 m³ on the site opposite the WWTP
- Non-potable reuse network for irrigation of public parks and flushing of public toilets in Akaroa including UV treatment and possibly chlorination of non-potable reuse flow
- Capitalising on the proposed reuse pipe, the harbour outfall shoreline terminus has been shifted from Childrens Bay to Glen Bay. The outfall pipe would extend from Glen Bay to the same mid-harbour location as previously proposed. The net length of the harbour outfall is 1,170 m.

14.3 Summary Evaluation of Scheme Options

Scheme options identified in Section 10.2 have been evaluated against the sustainability Principles of the Local Government Act 2002. These principles are set out in Section 14(1) (h) of the Act as follow:

"In taking a sustainable development approach, a local authority should take into account -

(i) The social, economic and cultural well-being of people and communities; and

(ii) the need to maintain and enhance the quality of the environment; and

(iii) the reasonably foreseeable needs of future generations"

A summary evaluation of sustainability requirements is set out in Table 14-1. With regard to subsection (iii) of Section 14(1)(h), it is considered that all schemes have been developed with the reasonably foreseeable needs of future generations in mind. This includes a 30 year design horizon and broad consideration of community views, sustainability, resilience, scheme affordability and design and operational risks.

The views of the Ngāi Tahu parties and the Akaroa Treated Wastewater Reuse Options Working Party have been advised via separate statements – refer to Appendix AB for the latest joint statement from the working party. Further views from individuals and communities will be obtained via the consultation process. The comments in Table 14-1 are based on available information at the time of writing the report.

Table 14-1 Summary Evaluation of Options against Sustainability Requirements of the Local Government Act 2002

Scheme Option	Cultural well-being of people and communities	Social well-being of people and communities	Economic well-being of people and communities	Maintain and enhance the quality of the environment
Inner Bays Irrigation	The Ngāi Tahu Parties have stated their support for irrigation of 100% of wastewater to land. The Inner Bays irrigation option could meet this objective.	Irrigation to pasture in Robinsons Bay received a weighted score of 250 out of 1000 in the 2017 public consultation round. Recreational opportunities could be created on the site.	The Inner Bays Irrigation Scheme has the second lowest capital and annual opex cost.	Ecological restoration and enhanced biodiversity through establishment of a native forest. Carbon sequestration and ecological restoration through incorporation of 40 ha of native trees. Stores nearly 9,000 tCO_2-e over 35 years.
Goughs Bay Irrigation	The Ngāi Tahu Parties have stated their support for irrigation of 100% of wastewater to land. The Goughs Bay irrigation option has potential to meet this objective. Te Rūnanga o Koukourārata has identified cultural features that require protection in this area.	The views of the community on the Goughs Bay irrigation option have not been formally sought to date.	Goughs Bay is the second highest cost option (capital and operational costs).	Ecological restoration and enhanced biodiversity through establishment of a native forest. Carbon sequestration and ecological restoration through incorporation of 33 ha of native trees. Stores around 4,500 tCO_2-e over 35 years.
Pompeys Pillar Irrigation	The Ngāi Tahu Parties have stated their support for irrigation of 100% of wastewater to land. The Goughs Bay scheme option has potential to meet this objective. Te Rūnanga o Koukourārata has identified cultural features that require protection in this area.	The views of the community on the Pompeys Pillar irrigation option have not been formally sought to date.	Pompeys Pillar is the highest cost option (capital and operational costs).	Ecological restoration and enhanced biodiversity through establishment of a native forest. Carbon sequestration and ecological restoration through incorporation of 48 ha of native trees. Stores around 8,300 tCO_2-e over 35 years.
Mid-harbour Outfall	The Ngāi Tahu parties are strongly opposed to wastewater disposal to the harbour. Within this context it is considered that implementation of a harbour outfall would be culturally unacceptable.	Discharge to mid-harbour received a weighted score of 680 out of 1000 in the 2017 public consultation round.	The mid-harbour outfall has the lowest capital and annual opex cost.	Minor or negligible adverse effects on the environment were identified in the Assessment of Effects that accompanied the 2014 application for discharge of treated wastewater to harbour. Has the highest carbon emissions over a 35 year period, emitting over 1,200 tCO_2-e over 35 years.

15 References

- Slope Hazard Susceptibility – Akaroa Harbour Settlement Maps (Tonkin & Taylor, 2008)
- Wastewater Treatment in NZ: Evaluation of 1992/93 Performance Data (Hauber, 1995).
- Transport - Greenhouse gas emissions mitigation in road construction and rehabilitation: A toolkit for developing countries (World Bank 2010)
- Process Design Manual for Land Treatment of Municipal Wastewater (USEPA, 2011)
- Final Report (June 2017): A lysimeter experiment and field trail to determine options for the beneficial reuse of water from Duvauchelle and Akaroa, Banks Peninsula, (Brett Robinson, University of Canterbury, 2017)
- Akaroa Wastewater Preliminary Design Report (CH2M Beca, April 2014)
- Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation (CH2M Beca, March 2017)
- Australian Guidelines for Water Recycling (2006)
- Waterways, Wetlands and Drainage Guide (Christchurch City Council)
- Making Good Decisions Workbook ME679 Part D (Ministry for Environment (MfE) 2010)
- Decision of Hearings Commissioner in the matter of CRC150046, 150047, 150048, 150049, 150050 and 152814 (ECan 9th July 2015)
- Akaroa Wastewater Scheme Upgrading, Resource Consents Application and Assessment of Effects on the Environment (CH2M Beca, June 2014),

Appendix A

Model Build and Calibration

Appendix B

PDP Irrigation Modelling

Appendix C

Brett Robinson Reports

Appendix D

Assessment of Combined Akaroa Duvauchelle Scheme

Appendix E

Reports on Deep Bore Injection

Appendix F

Managed Aquifer Recharge

Appendix G

Correspondence on Non-potable Reuse from CDHB

Appendix H

Tonkin and Taylor Slope Hazard Maps

Appendix I

Hinewai Assessment

Appendix J

Irrigation Scheme Maps

Appendix K

Pipe Long Sections

Appendix :L

Inner Harbour Investigations

Appendix M

Hammond Point Geotechnical Assessment

Appendix N

Landscape Concept for Site Opposite WWTP

Appendix O

Subsurface Wetland Review

Appendix P

Updated GIS Mapping

Appendix Q

Robinsons Bay Dam Concept Design

Appendix R

Dam Break Assessment

Appendix S

Upper Robinsons Bay Landscape Concept

Appendix T

Hugh Wilson Plantings Letter

Appendix U

Planning Overlay Maps

Appendix V

Landscape and Visual Effects Review

Appendix W

Robinsons Bay Archaeological Assessment

Appendix X

Goughs Bay Site Visit Report

Appendix Y

Goughs Infiltration Testing and Irrigation Modelling

Appendix Z

Pompeys Pillar Investigations

Appendix AA

Concept Process Drawings

Appendix AB

Working Party Joint Statement

Appendix AC

Technical Experts Group Outputs

Appendix AD

Cost Estimates