Report

Akaroa Wastewater Updated Investigation into Alternative Land Disposal Options

Prepared for Christchurch City Council

Prepared by CH2M Beca Ltd

10 August 2018

Revision History

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Document Acceptance

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Executive Summary

CH2M Beca Ltd (Beca) is assisting Christchurch City Council (Council) in developing alternative disposal options for treated wastewater from Akaroa. This work has been underway since 2015 – starting initially with desk top studies and a long list of possible options, progressing through concept design, physical site testing and stakeholder engagement.

Council believes sustainability is a process of continual improvement – a society adapting and responding to change over time – not a destination. Council has applied this approach to the Akaroa Wastewater project by staging investigation work with stakeholder engagement in order to gain feedback and continuously develop the scheme.

This report covers scheme investigations in the period from April 2017 to August 2018. It assumes a level of background knowledge about the project. Information about the Akaroa wastewater scheme can be found at https://www.ccc.govt.nz/services/water-and-drainage/wastewater/wastewater-projects/akaroa-wastewater-scheme

Activity over this period that is described in the report includes:

- Stakeholder engagement
- Changes to the basis of design
- Development of design aspects including :
  - Wastewater network, treatment plant and raw wastewater storage
  - Non-potable reuse
  - Deep injection bores
  - Land irrigation including reticulation and storage
- Configuration of overall scheme options
- Review of consenting requirements
- Revised cost estimates
- Evaluation of options based on current situation

A drilling investigation is underway to confirm if deep bore injection of treated wastewater is a viable method for disposal of Akaroa wastewater. The outcome of this work, which will not be completed until the end of 2018, will strongly influence the scheme configuration and shortlisted options. This report represents the current, but evolving status.

Throughout the period of scheme development a number of features have been advanced while others have been excluded as a result of collaborative effort between council and community. The shortlist of overall scheme options that have been reached through this process and are reported on here are:

- Harbour outfall
- 100% bore injection
- Irrigation in Robinsons bay
- Irrigation at Goughs bay
- Irrigation at Pompeys Pillar

The concept designs for all options were refined for the new flows, and updated cost estimates were produced. Overall scheme costs, excluding purple pipe network ranged from $34.7M to $55.5M. Of these totals the disposal option costs ranged from $7.4M to $29.1M, with the baseline option of the harbour outfall being the least cost, and the option to pump treated wastewater to the Goughs site to irrigate being the most expensive, largely in part due to the need to construct a very large storage dam on the site. The installation of a non-potable reuse purple pipe network to irrigate parks, flush public toilets and supply high density accommodation users within Akaroa would cost an additional $2.4M.

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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. Council has been investigating long term options for management of Akaroa 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 sea (Akaroa Harbour) in 2013.

A consent application for a new treatment plant, changes to the reticulation, and wastewater discharge to the harbour was lodged in 2014. In June 2015 consents for the treatment plant and reticulation changes were granted. However the application for discharge of wastewater to the harbour was declined by ECan commissioners due to concerns regarding the potential for cultural effects and an assessment that the application did not satisfy Section 105 of the Resource Management Act (RMA). Specifically, the Commissioners considered that the Council had not undertaken sufficient investigation of 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.”

Subsequent to the June 2015 decision to decline, Beca was commissioned to investigate land-based alternatives. Work conducted between June 2015 and March 2017 is outlined in the following reports:

- Akaroa Wastewater Project – Review of Disposal Alternatives – First Stage (CH2M Beca, August 2015)
- Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall (CH2M Beca, May 2016)
- Akaroa Wastewater - Investigation of Alternative Sites for Land Irrigation (CH2M Beca, March 2017)

The Council will be making a Local Government Act (LGA) decision on which wastewater discharge option it will pursue. The Council's decision-making under the LGA includes a requirement to consider all reasonably practicable options to achieve the objectives of the decision, and the advantages and disadvantages of those options. The chosen option needs to meet the current and future needs of communities for good-quality (efficient, effective and appropriate to present and anticipated future circumstances) local infrastructure in a way that is most cost-effective for households and businesses. The option must also be consentable as sustainable management under the Resource Management Act (RMA). While Council has lodged an appeal against the declining of the consents, Council has not yet concluded a reassessment of options but considers that there are some discharge to land options that are more efficient, effective, feasible and appropriate than originally thought in 2009. Discharge via a harbour outfall may not be sustainable management under the RMA, or a reasonably practicable option under the LGA, if land disposal is efficient, effective, feasible and appropriate.

The Council has been working with Ōnuku Rūnanga, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Runanga o Ngāi Tahu (the Ngāi Tahu parties) to explore land-based alternatives to the harbour outfall as they have joined as parties to the Council’s appeal. The Council has been keeping the consent authorities – Environment Canterbury and the Christchurch City Council in its regulatory capacity –

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involved in that process as they are respondents to the Environment Court appeal. The investigations to date are assessing whether there are some land based discharge options that are efficient, effective, and feasible and may be more appropriate than the discharge to the harbour.

The report *Akaroa Wastewater Project Review of Disposal Alternatives – First Stage* (CH2M Beca August 2015) summarised the long list of possible alternative options to a harbour outfall that were identified. The findings of this report were discussed with the Ngāi Tahu parties and Council and from the long list an agreed short list of options was established for further investigation. This short list comprised:

- Year round irrigation to trees;
- Year round irrigation to pasture;
- Summer only irrigation with a subsurface flow wetland or infiltration basin and discharge via a coastal infiltration gallery at other times;
- Subsurface flow wetland and discharge via a coastal infiltration gallery;
- Infiltration basin and discharge via a coastal infiltration gallery; and
- Outfall pipeline to mid-harbour.

The Council sought public feedback on the range of options to help inform a decision on which option to progress through the resource consent process. Consultation on the short list of options was undertaken between 26 April and 12 June 2016. The consultation found that the preferred options at that time were a harbour outfall or irrigation to land, although a significant number of respondents did not have a preference. During this consultation phase concerns were raised by the public about irrigation causing land instability.

The report *Akaroa Wastewater – Concept Design Report for Alternatives to Harbour Outfall* (Concept Design Report, CH2M Beca, May 2016) summarised the concept investigations on the shortlisted options. This report also highlighted some risks around the effect of irrigation to land on slope stability noting that the effect of applying treated wastewater to land will increase the risk of instability occurring, particularly during heavy rainfall events. The report recommended that it would be advisable not to introduce treated wastewater to areas that are currently, or have been historically, unstable and suggested targeting areas where no instability had previously been identified and where the slope was not greater than 15 degrees. The 15-degree slope criteria was adopted based on guidelines in the *Process Design Manual for Irrigation of Municipal Wastewater to Land* (USEPA, 2006).

After considering this information and feedback from the April – June 2016 consultation on the short list options, Council staff decided that prior to making a recommendation to Council as to the preferred disposal option, preliminary geotechnical and infiltration testing should be undertaken to better understand the slope stability risk.

The results of these ground investigations indicated that the land previously considered possibly suitable on the Takamātua peninsula was less suitable than first thought, with slope stability risk in many areas. New criteria were established to exclude areas with slope stability risk, and the area of investigation was extended to a wider radius around the consented treatment plant site in an attempt to find sufficient potentially irrigable land. Community feedback during the 2016 consultation asked that Hinewai Reserve be considered as a possible area for irrigation. The far edge of the Hinewai area is approximately 10 km from the treatment plant site so the investigations were extended to a radius of approximately 10 km.

The report *Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation* (CH2M Beca, March 2017) summarises the assessment of 21 sites in a wider radius. By applying a revised set of criteria, a shortlist of four sites was identified – Robinsons Bay Valley, Takamatua Valley, Pompeys Pillar and Wainui. Very high level cost estimates eliminated the Wainui scheme due to comparatively higher costs. A second round of ground testing was completed and concept designs for storage and irrigation were developed for each of the remaining three sites. The designs were based on a requirement for 28 ha for irrigation to trees and a 17,500 m^3 storage pond, and 38 ha for year-round irrigation to pasture with a 35,000 m^3 storage pond.

1.2 Scope of this Report

This report outlines further investigation of options for wastewater reuse and/or disposal to land that followed the issue of the previous Beca report dated March 2017, including all work and stakeholder engagement between April 2017 and July 2018. This includes a summary of:

- A public consultation round that was concluded in May 2017
- The discovery of inaccurate wastewater flow measurements in June 2017 and subsequent actions taken
- Reassessment of wastewater flows and loads
- Review of the long list of options and introduction of bore injection and land irrigation at Goughs as additional options or sub-options
- Development of revised overall scheme options and costs
- Conclusions that have been drawn from investigations in the intervening period;

The purpose of this report is to clearly outline the staged process for development, refinement and exclusion of overall scheme options and their component parts based on new wastewater flow and load information; gathering and analysis of further site -specific information, and taking into account inputs from project stakeholders including Ngāi Tahu and the wider community through various forums.

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2 Stakeholder Engagement

Council believe sustainability is a process of continual improvement – a society adapting and responding to change over time. Through engagement with many different aspects of the community, the direction of the Akaroa wastewater project has changed and developed. The overarching principle in the Council's Strategic Framework is partnership. Council has engaged in ongoing stakeholder engagement throughout the period of scheme options development from April 2017 to July 2018. Key steps in this ongoing process are outlined below.

2.1 Stakeholder Engagement up to April 2017

2.1.1 Consultation with Ngāi Tahu Parties

Engagement between the Council and the parties to the Council's appeal against the decline of resource consent for the discharge to the harbour – the Ngāi Tahu parties and the two councils in their regulatory capacity – began in 2015.

The Concept Design Report on shortlisted options was finalised after a hui with the Ngāi Tahu parties and other parties to the appeal at Ōnuku marae on 4 March 2016 to discuss the draft report, and to accurately capture the feedback.

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 on the preliminary findings from the ground investigations on the land identified in the Concept Design Report as potentially suitable for irrigation. This hui was held at the Christchurch City Council Civic offices and was attended by representatives from the Ngāi Tahu parties, Environment Canterbury (ECan), Christchurch City Council (including councillors), Beca and their sub-consultants Pattle Delamore Partners Ltd (PDP).

A second round of ground investigations was undertaken on 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 with the Ngāi Tahu parties and Council, held at the Ngāi Tahu offices in Show Place, Christchurch on Wednesday 2 November 2016. At this hui discussions were also had around the next steps in the project and the forthcoming public meeting.

On Wednesday 9 November 2016 a public meeting was held at the Gaiety Hall in Akaroa. The purpose of this meeting was to advise the public of the process the Council was working through and work that had been undertaken since the last consultation round. Representatives from the Ngāi Tahu parties attended this public meeting.

On the 14th April 2017 another hui was held with the Ngāi Tahu Parties to give a summary of the work outlined in the March 2017 report and the findings from the consultation round held in April 2017. 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 Working Party.

2.1.2 The Akaroa Treated Wastewater Reuse Options Working Party

The Banks Peninsula Community Board established the Akaroa Treated Wastewater Reuse Options Working Party (the Working Party) in January 2017 to assist the Council in investigating and consulting on the options for the beneficial reuse of Akaroa's treated wastewater. The Working Party has been involved with the further review of options since consultation and awareness of the flow discrepancy.

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2.1.3 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. The Technical Experts Group was tasked with answering specific technical questions about irrigation schemes.

2.1.4 2016 Consultation Round

Scheme options outlined in the Beca Report were presented to the public via a consultation brochure and through public consultation sessions. Consultation on the Akaroa treated wastewater disposal options took place from 26 April to 12 June 2016. 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 project web page. A further meeting was hosted by Ōnuku Marae on Thursday 2 June 2016. This provided an opportunity for the community to 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 as follows:

- 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).

Table 2-1 Ranked Scheme Options

Scheme Option	Rated as most preferred (% of total submissions)
1 - Year round irrigation to trees	21
2 - Year round irrigation to trees	4
3 - Summer only irrigation, with wetland or infiltration basin and discharge via a coastal infiltration gallery at other times	0
4 - Subsurface flow wetland and discharge via a coastal infiltration gallery	1
5 - Infiltration basin and discharge via a coastal infiltration gallery	0
6 - Mid-harbour outfall	43

2.2 Stakeholder Engagement from April 2017 to July 2018

2.2.1 April 2017 Public Consultation Round

Consultation on the Akaroa reclaimed water beneficial reuse, treatment and disposal options took place from 3 April to 30 April 2017. The consultation booklet for this round of consultation included details of the six options being proposed which included:

- 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
- Other A new option could be discussed here

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.

2.2.2 Public Consultation Meetings

As part of this project drop in sessions were offered on Sunday 9 April 2017 from 1 pm to 4 pm in Akaroa and on Tuesday 11 April 2017 from 5.30 pm to 7.30 pm in Christchurch. There were approximately 40 people who attended these sessions in total.

A consultation meeting was also hosted by Ōnuku Marae on Tuesday 18 April 2017 from 6 pm to 8.30 pm in Akaroa. There were approximately 50 people who attended this meeting.

Attendees at the public consultation meeting at Ōnuku Marae (image courtesy of Akaroa Mail)

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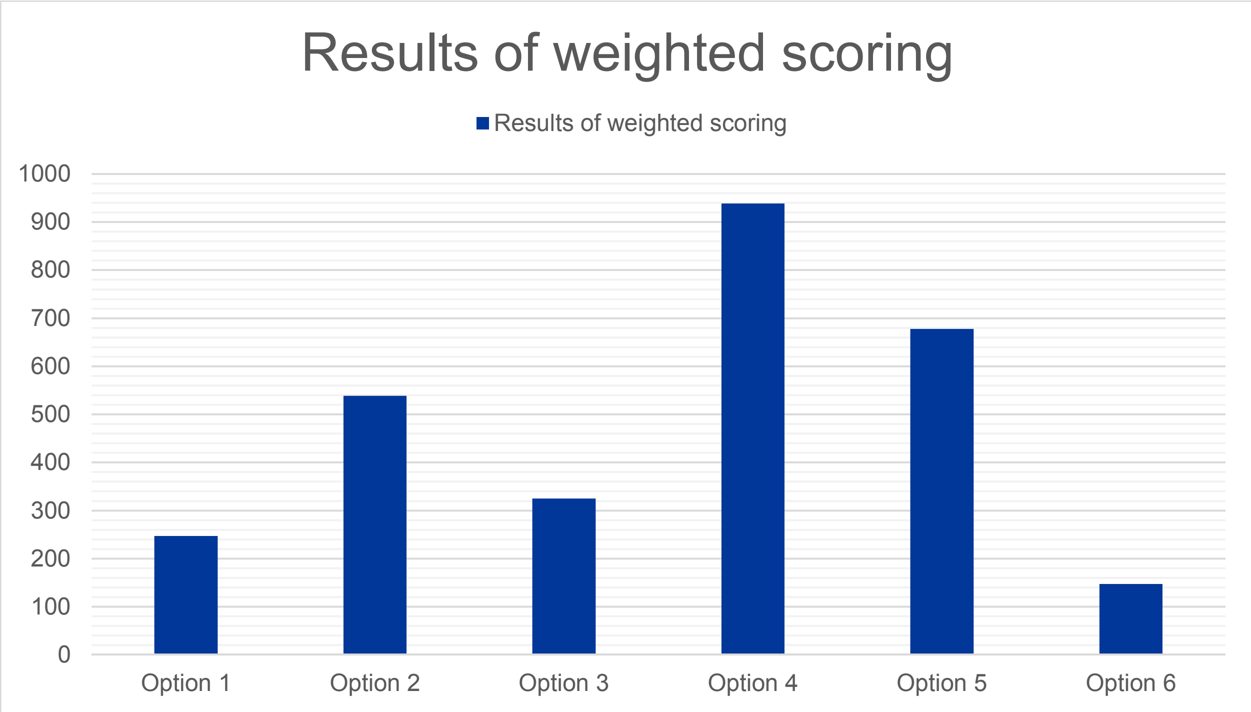

Figure 2-1 Scoring of Disposal Options from 2017 Consultation Round

There were 261 submitters who commented on possible location of storage ponds. Pond Site 10 was the most preferred, receiving 24% support.

2.2.3 Other Consultation

A number of stakeholder meetings and hui have been held since April 2017, as set out in Table 2-2:

Table 2-2 Stakeholder Meetings and Huis Held After April 2017

Date	Meeting Participants	Summary of Meeting Content
1 August 2017	Ngāi Tahu Parties	▪ Faulty flow meter and new flow metering ▪ Implications of new, higher flows for land irrigation ▪ Update on potential irrigation areas ▪ Next steps
6 November 2017	Ngāi Tahu Parties	▪ 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 ▪ Next steps

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Date	Meeting Participants	Summary of Meeting Content
20 November 2017	Akaroa Wastewater Reuse Options Working Party	▪ Minutes and matters arising ▪ 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 ▪ Next steps
2 February 2018	Ngāi Tahu Parties	▪ 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
22 February 2018	Akaroa Wastewater Reuse Options Working Party	▪ Minutes and matters arising ▪ 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 Wastewater Reuse Options Working Party	▪ Minutes and matters arising ▪ 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
4 April 2018	Public meeting in Akaroa	▪ 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
27 April 2018	Akaroa Wastewater Reuse Options Working Party	▪ Minutes and matters arising ▪ Update on managed aquifer recharge option ▪ Deep bore injection site mapping ▪ Preferred bore sites
21 May 2018	Ngāi Tahu Parties	▪ Update on wastewater flows and network modelling, bore injection investigations, and Pond site 10 layout

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2.2.4 The Technical Experts Group

The Technical Experts Group has not been utilised following the 2017 consultation round.

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3 Changes to Basis of Design

There have been a number of changes to the basis of design for the overall Akaroa wastewater scheme that have resulted from the new data collected. These changes are outlined in the following sections.

3.1 Water Balance and Identification of Flow Meter Error

During the April 2017 consultation round, questions were received from the community about the quantity of treated wastewater that could be reused. A water and wastewater balance for Akaroa township was undertaken in response to these questions, which highlighted a large discrepancy between the amount of water supplied to the township and the amount of wastewater being measured at the outlet of the existing Akaroa Wastewater Treatment Plant (WWTP). The original design basis for the Akaroa Wastewater Scheme was based on measurements taken from a flow meter located at the Akaroa Wastewater Treatment Plant. In May 2017, the design flow basis was crosschecked using previously collated and new data provided by CCC including:

- Number of residential and commercial water connections
- 2013 census data
- Water consumption data for 2016 – 2017
- SCADA information on wastewater network pump starts

Using these data sources and industry standard guidelines the wastewater flow was recalculated by two methods:

- Per-capita derived wastewater flow based on property number and occupancy
- Empirical comparison of water in vs wastewater out

These calculations came up with a new estimate of total annual wastewater flow of 235,000 m^3/year (for 2017), compared to a previous design total (year 2041) of 130,000 m^3/year. From this comparison it was concluded that the flowmeter at the treatment plant was reading inaccurately.

A letter summarising the revised flow estimate was issued to CCC on 19th of May 2017 (entitled Akaroa Wastewater – Estimation of Revised Flows and Loads May 2017, attached in Appendix A). This letter highlighted a high degree of uncertainty in the revised figures and recommended that new flow meters should be installed on the wastewater network to provide reliable flow data.

3.2 New Flow Monitoring

To improve the quality of data available to estimate actual flows and loads, Council installed new flowmeters at three locations on the Akaroa wastewater network, including a replacement for the faulty flowmeter at the existing Akaroa Wastewater Treatment Plant. Further data was also collected on BOD concentration in the wastewater, water consumption in the township, and estimates of peak tourist population. The location of the new flowmeters is shown in Figure 3-1.

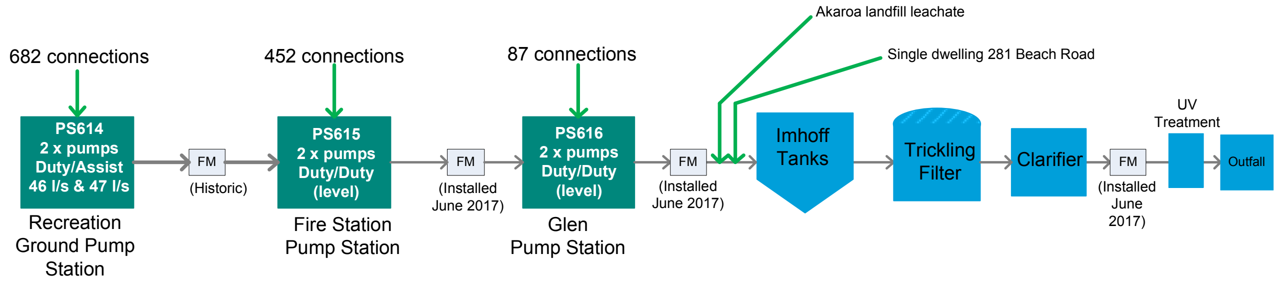

Figure 3-1 Location of Akaroa Wastewater Flowmeters

3.3 Update to Estimate of Flows and Loads (September 2017)

In September 2017, using the new flowmeter data and more detailed information on population numbers, another estimation of the revised flows and loads was made. Again a number of different methodologies were used for comparison, these included calculations based on:

- Population numbers – from census data and an accommodation survey
- Property numbers – from rating units
- Water supply measurements
- Estimation of likely inflow and infiltration

A summary letter describing the details of each calculation is given in Appendix A. Figures from the different methodologies used to estimate the revised flow basis are shown in Table 3-1. Theoretical calculations based on property and population number estimates produced lower estimates than those generated from measured data such as from water meters and pump station flow meters. Review of annual flow data indicated that the period of lower winter flows was approximately 5 ½ months. Therefore, estimated annual flows were calculated using a “winter” duration of 165 days and a “summer” duration of 200 days. An annual allowance of 78,000 m³/year was included for rain-derived inflow and infiltration (RDII) contributions based on night time flow measurements using the new flow meters. Night time flows readings are used to estimate infiltration as they show any incoming flow not related to normal day-time household use.

Table 3-1 Summary of Estimated Dry Weather Flows from Different Methods (September 2017)

Calculation Method	Estimated Average Summer Daily Flow (m³/d)	Estimated Average Winter Daily Flow (m³/d)	Groundwater Infiltration Allowance (m³/d)	Average Summer Daily Flow incl Infiltration (m³/d)	Average Winter Daily Flow incl Infiltration (m³/d)	Estimated Annual Flow Excluding RDII (m³/year)	Estimated Annual Flow Including RDII (m³/year)
Pump Station Flow Meters			included		619		277,000
Property numbers	540	239	216	756	455	226,000	304,000
Population based	652	273	216	868	489	254,000	332,000
WTP Water Meters	478	367	216	694	583	235,000	313,000
Average	588	302		773	537	229,000	307,000

The figures in Table 3-1 were used as an indication as to the overall likely magnitude of annual volume of wastewater. However these figures were not used to re-estimate land and storage required for different disposal options due to ongoing uncertainty around flows at that time (this is related to the short duration of new data measurements and the need for a longer time-based data set to provide higher confidence level).

3.4 Akaroa Wastewater Network Model

3.4.1 Background

In 2014 a calibrated network model for Akaroa was built by Aurecon on behalf of Council. The intention of this model was that it could be used "*for both planning and operation purposes allowing a better understanding of the system and assisting in development efficient and cost effective system improvement works*". As stated in the preliminary design report for the Akaroa scheme, the model was also expected to provide confirmation of the design flows for the pump stations, terminal pump station and to confirm the size of the treatment plant balance tank (Section 2.2 of *Akaroa Wastewater Preliminary Design Report*, CH2M Beca, April 2014).

However, Council suspected that the model was not giving accurate results and when the flowmeter error came to light they carried out an internal check of the model. This check found that many of the recommendations in the original model calibration report had not been carried out, and when Council ran long-time rain series data through the model, the outputs did not reflect actual performance of the network. In May 2017 they commissioned Beca to undertake a peer review of the model and its calibration.

The peer review found that:

- The use of LIDAR data for manhole cover level (rather than survey data) resulted in a low level of confidence
- Survey data was low quality and didn't consistently represent what was in the model
- Residential populations appeared to be incorrect and tourist populations were poorly represented
- There was only crude representation of commercial and impermeable flows
- The runoff model had been used incorrectly without evaporation and antecedent conditions

The recommendations from the peer review included:

- That rather than trying to fix the existing model, a new model be built utilising Council's latest asset database
- That current manhole survey data be used as an input
- That survey and modelling of ancillaries be undertaken to enable more accurate reflection of the network as part of the model build
- That residential and tourist population estimates be improved

The full peer review report is attached in Appendix B.

3.4.2 Development of New Network Model

On receipt of the model peer review report it was agreed that a new calibrated wastewater network model should be developed for Akaroa. To make sure that an accurate model was produced the following data was collected and provided to the modellers:

- Manhole level survey results
- Ancillary survey of:
  - Overflow – Including all pipe sizes and inverts, pass forward control details and spill levels. Details of outfalls including invert levels and the existence of flap valves.
  - Storage tanks – including filling mechanism, emptying mechanism and storage volume and any associated emergency overflow details
  - Pumping stations – wetwell dimensions, ground levels, numbers of pumps, pump arrangement (duty/assist), pump capacities, details of variable speed arrangement

- Network GIS data
- Full catchment LiDAR data
- Address point data that can be interrogated to pull out residential and commercial address points. Commercial address point spreadsheet attached, I will need to chase up residential
- Population data
  - Information regarding the permanent residential population (Census)
  - Information to help understand the tourist influence.

There was also a strong recommendation that there be a rain gauge in the each of the catchments upstream of the pump stations to make sure that accurate rainfall data was able to be captured and used in conjunction with the permanent flow monitor data to verify the model predictions. The use of three rain gauges over the three catchments (PS614, PS615 and PS616) would also give a good understanding of any spatial variation in the rainfall events across the township.

There was already an existing rain gauge at Stanley Park – Council organised for NIWA to install a further two rain gauges so each catchment was represented. They also proceeded to collate and capture the other data required for the model build. Full details of the model build are given in the report attached in Appendix C.

3.4.3 Calibration and Issues

While typically dedicated independent flow monitoring devices are installed for model calibration purposes, Council were interested in the possibility of using data from the newly installed flowmeters for calibration as a means of saving both time and expense. Sample flowmeter data was assessed and found to be suitable for use for calibration.

Council specified that the model build and calibration be undertaken in accordance with the Wellington Water standard (WWL Regional Wastewater Network Modelling Specification, September 2017) noting that there were portions of this specification that wouldn't apply to Akaroa. This specification required the use of three significant rain events to calibrate the model. The two additional rain gauges were installed in October 2017. The first significant rain events that occurred after the installation were in January 2018. Data from these events was used to calibrate the model.

During the calibration and interrogation of outputs a number of issues were identified. Firstly, it was found that the model was very sensitive to population, and the large degree of uncertainty around tourist numbers and the magnitude and duration of population increase during the summer months was leading to a lot of uncertainty in the model outputs.

Secondly, it was found that while the model was suitable for assessment of the network performance, the rain derived inflow and infiltration was under predicted by approximately 20% based on comparison with measured flows. The "tail" after a rain event was less in the model than what was observed in the network, and the model underestimated flow during significant events (i.e. the peak predicted by the model is less than the peak actually recorded). After reviewing the calibration methodology it was concluded that the calibration has been completed correctly. However, there were two reasons for the under prediction:

- The model was calibrated on the events recorded between the 5th January and 6th January 2018. During these "summer" events the network experienced very minor rain derived infiltration due to the dry ground conditions.
- An overestimation of the population numbers during summer meant that most of the wastewater flow generated in the model could be attributed to population and rain, leaving very little flow contribution needed from inflow and infiltration.

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A base infiltration flow of approximately 3 l/s was added to the model to better reflect network performance. The location and frequency of overflows predicted by the model were compared with the Council monitoring data for overflows. The model predicted events were similar to the recorded events. The findings from modelling of the existing network showed there are localised pipe capacity issues in several places in the network. PS615 is also restricted by pump capacity, resulting in overflows at or near this pump station.

The future network, where the flow is reversed, was also modelled. The model findings for the future network indicated that by reversing the network, the frequency of overflows would be reduced due to reduction in the size of catchments for the existing pump stations PS615 and PS616. The overflows remaining are caused by pipe bottlenecks that can be addressed as part of the reticulation network upgrade.

3.4.4 Calibration Using Winter Data

Due to the issues with the model under-predicting rain derived inflow and infiltration it was decided to update the model calibration using winter rain events. There were a number of events that occurred in July and August 2017 that met the requirements for a significant event. These were not used originally as only one rain gauge was in place at the time. However, after review of the data from all three rain gauges it was concluded that the differences between the rain gauge recordings were not significant and this data could be used.

The update of the calibration was undertaken in July and August 2018. Updated population figures were also used in the model to refine the impact of increased population over summer.

The calibration of the model with winter data proved effective, with the preliminary model outputs showing a much better fit with actual flowmeter data.

3.4.5 Findings and Overflow Predictions from Calibrated Model

TO BE COMPLETED ONCE MODEL OUTPUTS RECEIVED

3.4.6 Producing a Long Term Series

A long term series was needed to enable reforecasting of land irrigation areas and storage volumes for the increased flows. As there was a lot of uncertainty around exact population figures in Akaroa at any given time, the approach used was to remove population derived flow from the model and use the model to generate a drainage data series only. Population-generated wastewater flows predicted from using a separate spreadsheet incorporating measured BOD and flow figures were then added to the drainage data series.

Figure 3-2, courtesy of PDP, shows that the methodology applied gives results with the same observed differences to actual flow data as seen from the full model outputs; specifically the flow peak is underestimated, and the tail-off in flow after a rain event is also underestimated. PDP assessed the level of underestimation as being in the region of 25%. To reflect the actual volumetric flows, a factor was added to the data to address the peak and tail-off discrepancy. This is described in more detail in the attached PDP letter in Appendix D.

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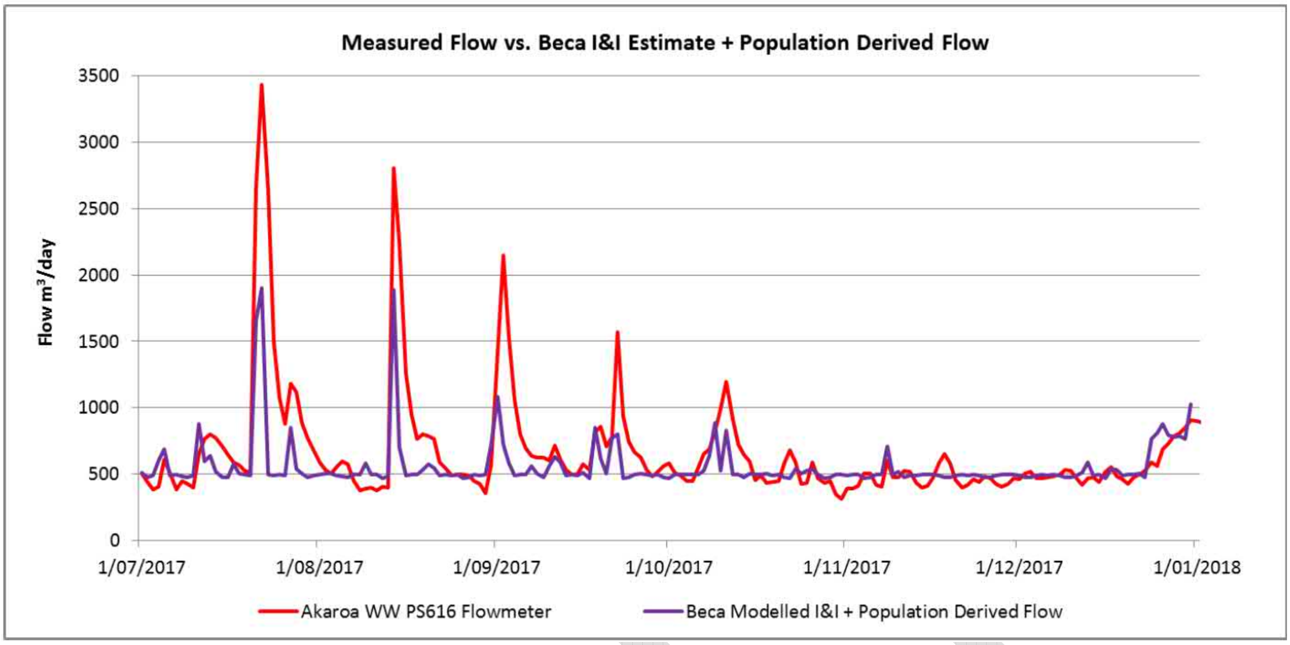

Figure 3-2 Comparison of Model Generated Long Term Series with Flowmeter Data

3.5 Updated Basis of Design

3.5.1 Design Horizon and Population

All scheme options are to be designed for year 2052 projected flows and loads, being approximately 30 years from when the new WWTP and disposal scheme could be built and commissioned, with 30 years the likely duration of any consent obtained.

Representative BOD sampling in June/July 2017 and January 2018 was carried out as a means to derive the design winter and summer populations using the standard per capita loads of 74g/p/d. The peak summer population is derived from the ratio of measured peak dry summer flow (936 m^3/d) to the average dry summer flow (594 m^3/d) for the 2017/18. Based on the council's population growth model, the 2017 domestic population is 668. The design populations are increased using the established growth rates of 0.246%/yr for the domestic population and 0.399%/yr for the visiting population (again from the council's population growth model). A summary of design populations is given in Table 3-2.

Table 3-2 Akaroa Design Populations

Season	Source	2017	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 2,605 3,273	728 2,995 3,723

3.5.2 WWTP Design Flows and Loads

Average Dry Weather Flows (ADWFs) are based on the populations given in Table 3-2 and a population derived flow of 220 L/p/d, as per council's Infrastructure Design Standard (IDS), plus a base line Inflow and Infiltration (I&I) flow of 328 m^3/d.

The design load basis is:

- The BOD load is based on the standard population load of 74 g/p/d
- The TSS load is based on the standard population load of 84 g/p/d
- The TKN load is based on a high strength population load of 20 g/p/d to match historical monitoring

Using this design basis the design flows and loads are given in Table 3-3.

Table 3-3 Akaroa WWTP Design Flows and loads

Season	Parameter	2017		2052	
Winter	ADWF	496m^3/d		513m^3/d	
	units	kg/d	g/m^3	kg/d	g/m^3
	BOD	57	114	62	121
	TSS	66	133	72	141
	TKN	15	31	17	33
Summer	ADWF	785m^3/d		845m^3/d	
	units	kg/d	g/m^3	kg/d	g/m^3
	BOD	154	196	174	206
	TSS	179	228	202	239
	TKN	42	53	47	56
Peak Summer	ADWF	1048m^3/d		1147m^3/d	
	units	kg/d	g/m^3	kg/d	g/m^3
	BOD	242	231	275	240
	TSS	281	269	320	279
	TKN	66	63	75	66

Based on historical influent monitoring (summer 2013/14), the wastewater alkalinity design basis is 225mg$CaCO_3$/L for winter and summer loads and 270mg$CaCO_3$/L for peak summer loads.

Other parameters including fractioning of the BOD, COD, solids and nitrogen will be refined prior to detailed design by a detailed wastewater characterisation to be carried out over the summer of 2018/19.

A typical diurnal flow pattern was established by averaging 2010 – 2012 hourly flow data (see Figure 3-3) Based on this a diurnal hourly peaking factor of 1.75 will be used.

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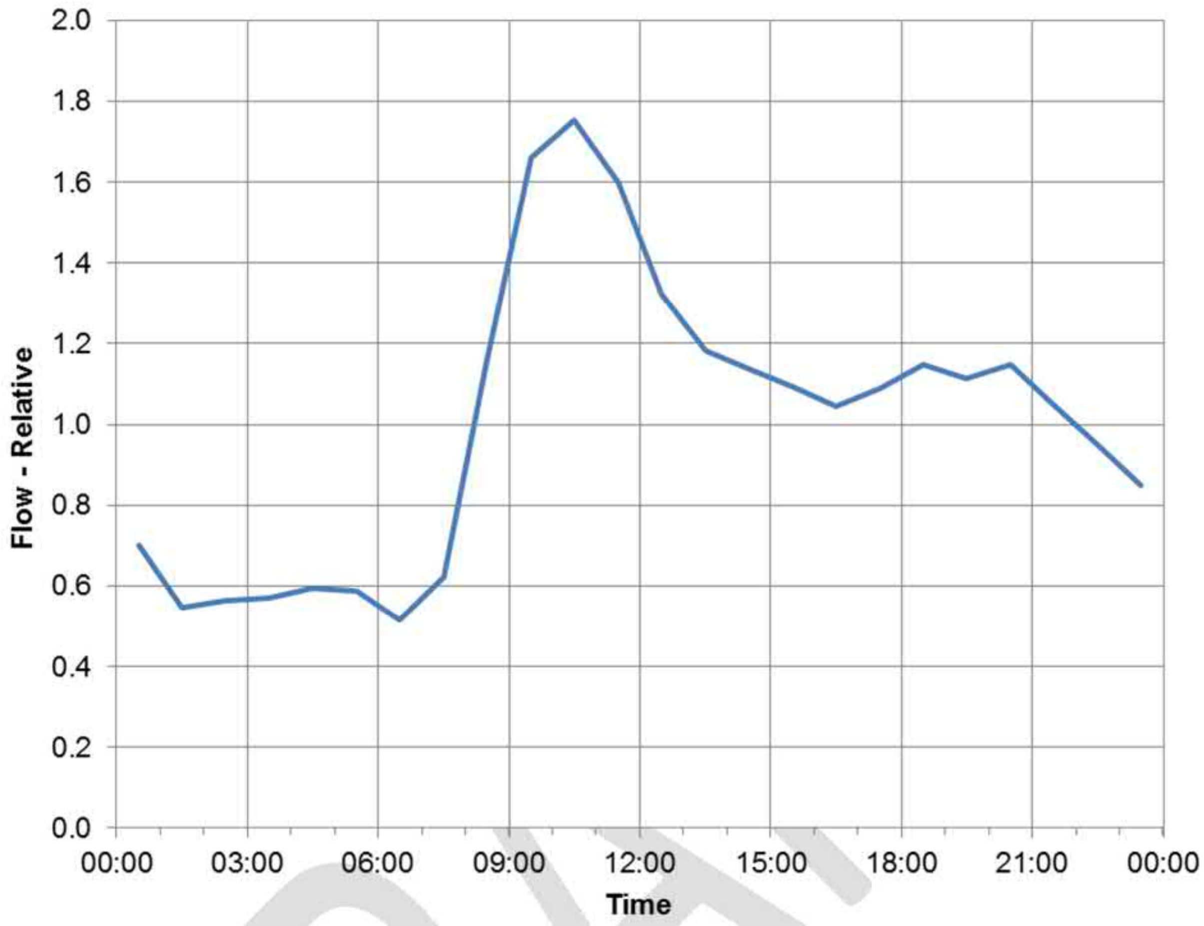

Figure 3-3 Diurnal Flow Pattern

3.5.3 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 wastewater receptor. The treatment plant performance was set taking into account a number of factors including the following:

- The Council's stated objective to produce the "best quality wastewater available"
- Specification of a membrane treatment, which removes suspended solids and BOD to 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 rejection of the harbour discharge consent application and pursuit of land disposal-based alternatives has spurred an assessment of the assimilative capacity of these alternative pathways. Working from the receiving environment conditions the wastewater quality requirements have been determined. The proposed wastewater quality for each disposal/reuse pathway is set out in Table 3-4.

Table 3-4 Proposed Wastewater Quality Standards

Wastewater Quality Parameter		Proposed Average Treated Wastewater Quality	
		Irrigation of Native Plantings Bore Injection Harbour Discharge	Irrigation of Pasture
TSS	mg/L	2	2
$CBOD_5$	mg/L	5	5
Amm-N	mg/L	1 (5[1])	46
TN	mg/L	10 (15[1])	51
TP	mg/L	7	8
E.coli	cfu/100mL	10	10
Enterococci	cfu/100mL	10	10

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

A commentary on the data presented in Table 3-4 is as follows:

- The standard proposed for the harbour outfall option is effectively unchanged from that specified in the 2014 consent application, except the biological quality parameter has been changed from faecal coliforms to E.coli
- The concept design for irrigation of native plants has been developed based on the same standard as set for the harbour outfall. In other words, the irrigation area has been set for the annual wastewater nitrogen mass load to achieve a suitable nitrogen application rate (70 kg/h/yr) and to minimise nitrogen leaching into groundwater
- For bore injection, the standard set for the harbour outfall has also been adopted. This is on the basis that wastewater injected into a deep bore may ultimately reach the harbour (although it would most likely be in a form diluted by groundwater)
- For irrigation of pasture, a higher nitrogen content in the wastewater is acceptable as the pasture assimilation rate is higher (estimated to be 100 – 150 kg N/h/yr) and to minimise nitrogen leaching into groundwater
- It is also assumed that no phosphorus removal is required. This is on the advice of Brent Robinson from University of Canterbury (refer Appendix E and Section 5.3.2). Dr Robinson found that irrigating at 500mm treated wastewater per year for 50 years would result in an increase in phosphorus levels in the soil, but that the concentrations would remain within the total range of phosphorus concentrations in soil found in NZ agricultural applications. The Akaroa Wastewater irrigation concept designs are based on application of up to 475 mm/annum for options with the least land area and largest storage, reducing to around 280 mm/annum for options with the most land area and least storage.

The proposed monitoring for these parameters is the same as the existing consent, i.e. weekly during December to February, and monthly from March to November.

For the options with wastewater discharge to native vegetation, bore injection, or harbour outfall the consent limits remain as per the same as per Table 3-4. For irrigation to native vegetation the TN annual median limit of 15 mg/l equates to a maximum irrigation rate of 470 mm/yr based on a nitrogen application rate of 70 kg/ha/yr previous adopted in the *Concept Design Report for Alternatives to Harbour Outfall* (CH2M Beca, 2016).

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3.6 Update of Irrigation Areas and Storage Volumes

The irrigable area and storage volume required for the different irrigation schemes presented in 2016 were based on incorrect annual flow estimates. Using the long term series described in Section 3.4.6, PDP updated the soil moisture water balance to reassess the area and volume that would be required for a 100% irrigation scheme capable of accommodating all the revised flows.

The methodology for this assessment is outlined in the letter in Appendix D. Two data sets were used – the first was a short term (8 year) data set of rain gauge readings from Stanley Park, the second a long term (45 year) NIWA VSCN data set. The long term series produced the most conservative estimates so the outputs from this series have been used for design purposes. The revised irrigable land areas and storage volumes are shown in Table 3-5, Table 3-6 and Table 3-7.

Table 3-5 Land Area and Storage Volume for 100% Irrigation to Pasture at Goughs

Irrigation Area (ha)	70	80	90	100	115
Peak Storage	98,000	91,000	85,000	78,000	69,000

Table 3-6 Land Area and Storage Volume fo 100% Irrigation to Pasture at Pompeys Pillar

Irrigation Area (ha)	60	80	100
Peak Storage	105,000	90,000	77,000

Table 3-7 Land Area and Storage Volume for 100% Irrigation to Trees at Robinsons Bay (Thacker Land)

Irrigation Area (ha)	50	60	70
Peak Storage	43,000	34,000	28,000

By comparison, in 2017 using the lower flows, the scheme concept designs were based on needing an area of approximately 28 ha of irrigable area for irrigation to trees combined with 17,500 m^3 of storage. For irrigation to pasture approximately 38ha and 35,000 m^3 of storage was required.

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4 Wastewater Scheme Features

There are a number of key design features for the Akaroa wastewater scheme. By combining these features overall wastewater scheme options can be 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
- Injection bores
- Pipeline to Eastern Bays
- Irrigation design

4.1 Network Upgrade and Terminal Pump Station

The Akaroa wastewater network will be modified as part of the scheme. The scope of work includes redirecting wastewater flows from the southern end to the northern end of Akaroa, construction of a new terminal pump station and rising main up Old Coach Road to the new treatment plant. 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 dated 14th April 2014.

The core concepts of the 2014 preliminary design are unchanged although minor revisions are required to address increased flows and proposed changes in the network overflow average return interval (ARI). This work is ongoing as stakeholders have not yet been fully consulted about network overflows and the costs and benefits of reduced overflow frequency are still in development.

Some details of the reticulation design have also been adjusted as a result of renewals work that is being 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 for the scheme appended to this report.

4.2 Wastewater Treatment Plant and Associated Storage

4.2.1 General

The following preliminary design has been developed to enable a consent envelope to be defined for a wastewater treatment plant at the top of Old Coach Road.

Council has committed to a "best wastewater quality available" approach for wastewater treatment. To achieve this Council has selected a year-round biological nitrogen removal (BNR) process with membrane filtration for solids separation and disinfection for the treatment plant. The nitrogen removal requirement does not apply for options where disposal is 100% to pasture, as the extra nitrogen can be beneficially reused. See Section 5.4.15 for further discussion.

Council has also committed to a 'no bypass' approach to wastewater treatment of peak flows. This implies that all wastewater captured for a design event will be fully treated, either as received at the WWTP, or stored for later treatment. This assessment is given in Section 4.2.13.

No phosphorus removal is proposed, based on advice received from Dr Brent Robinson from University of Canterbury about the assimilative capacity of irrigated land with pasture or tree coverage. However, space is reserved at the treatment plant site for liquid Alum storage should this be required for chemical removal of phosphorous.

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4.2.2 Overview

This section summarises the proposed treatment process. A concept design Process Flow Diagram (PFD) with treatment and hydraulic capacity is shown in Figure 4-1. Note for the WWTP without nitrogen removal there will be no anoxic zone (and hence no internal recirculation) and the aerobic zone is smaller at 250 m³.

Screening and grit removal will be provided at the Terminal Pump Station and no further primary treatment is proposed at the treatment plant.

All flow to the treatment plant will be received in a manhole. When flows are in excess of the hydraulic capacity of the membranes the manhole will overflow to a covered 5,000 m³ raw wastewater storage pond. The purpose of the raw wastewater storage pond is to:

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

Normal flows (up to 14 l/s) will flow from the manhole directly into the biological reactors in the treatment plant.

The treatment plant concept design process arrangement remains as Modified Ludzak-Ettinger (MLE) reactors. This is a conventional process for Biological Nutrient 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 provide sufficient nitrate and nitrite for nitrogen removal by denitrification. 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.

Wastewater from the MLE reactors will then be treated using membrane filtration, to remove suspended solids and pathogens. The membranes are most likely to be low pressure hollow fibre membranes located in a separate membrane building.

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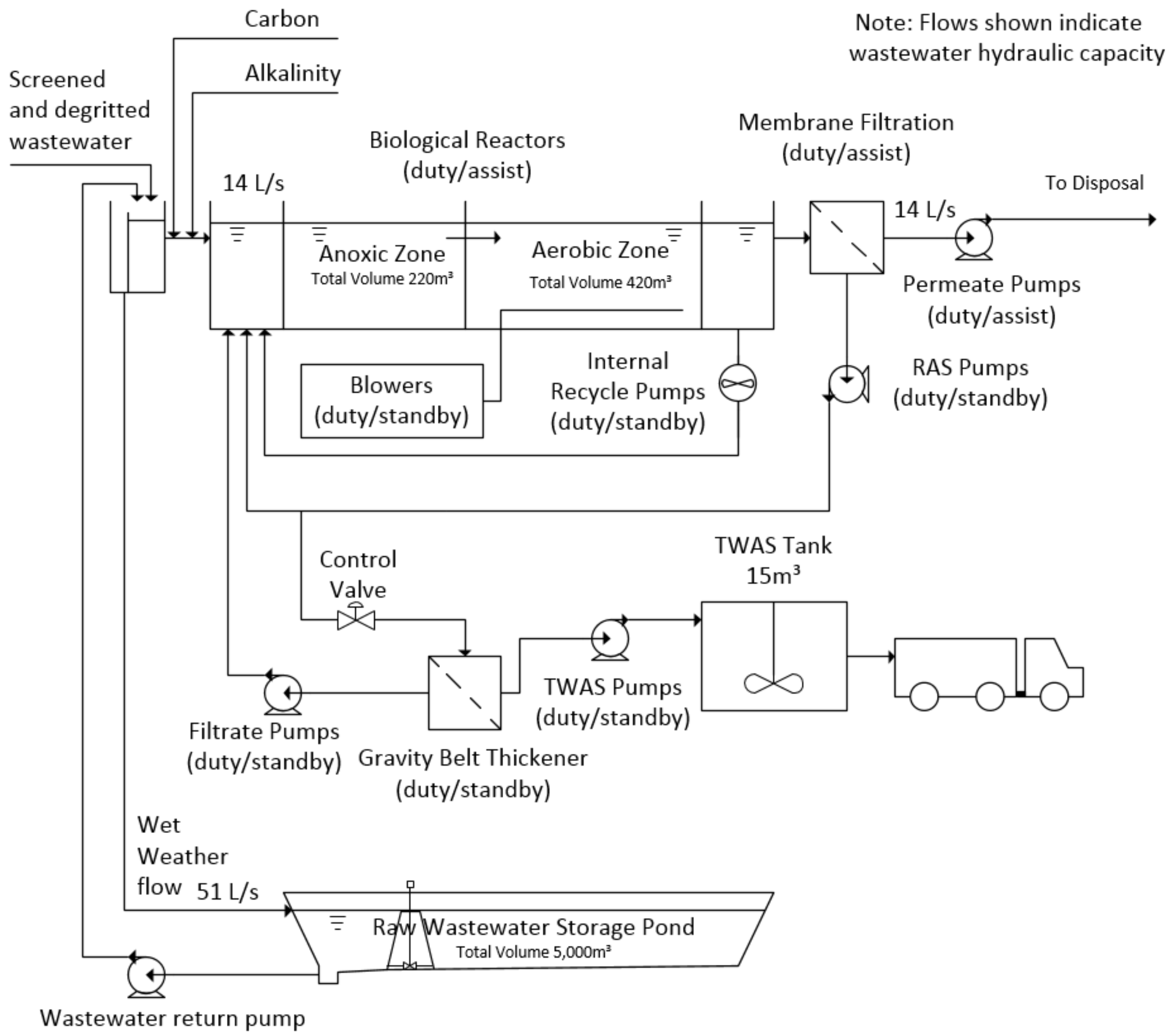

Figure 4-1 Process Flow Diagram for the Akaroa Wastewater Treatment Plant

Waste Activated Sludge (WAS) will be periodically removed from the membrane tanks and thickened using a gravity belt thickener, and stored in an enclosed tank. It is expected that sludge from the tank would be removed weekly and tankered to the Christchurch Wastewater Treatment Plant for processing into biosolids.

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

4.2.3 Primary Treatment

The de-nitrification process requires sufficient readily biodegradable COD (rbCOD) to proceed. Because the influent wastewater has a relatively high concentration of total nitrogen compared with BOD, all the influent BOD is required in the MLE reactor. Therefore, no primary treatment such as primary sedimentation tanks is proposed.

During the peak summer, the total nitrogen concentration increases. To allow de-nitrification to continue additional rbCOD 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% acetate would be required to reduce TN from 15 to 10 mg/L. A 1 m³ IBC is proposed to store this carbon source.

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/d of 10% sodium carbonate (soda ash solution) bicarbonate would be required. A 1 m³ IBC is proposed to store this alkalinity source.

4.2.4 Secondary Treatment

The concept design for secondary treatment is based on using MLE reactors. However, the consent remains open on other BNR processes. This will allow a design build contractor 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.

The MLE process has a pre-anoxic zone which means all the rbCOD 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 4-1.

Table 4-1 Preliminary Design Values for the MLE Reactors

Design Parameter		MLE	BOD rem
Design treatment flow	m³/d	1147	
Total anoxic reactor volume	m³	220	0
Number anoxic reactors	-	2 (1 duty + 1 assist)	0
Anoxic reactor dimensions	m (l × w × d)	9.0 × 2.7 × 4.5	n/a
Total aerobic reactor volume	m³	420	250
Number aerobic reactors	-	2 (1 duty + 1 assist)	2 (1 duty + 1 assist)
Aerobic reactor dimensions	m (l × w × d)	9.0 × 5.5 × 4.5	5.4 × 5.5 × 4.5
Design MLSS concentration	mg/L	5,000	
Peak Air flow	m³/s	0.2	
Number of Blowers	-	2 (1 duty + 1 standby)	
Blower size	kW	18.5	
Peak Internal Recycle flow	m³/h	326	0
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, 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 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 $AlPO_4$ 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 m³.

4.2.5 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 consent.

Concept design details for the membrane system are based on a duty/assist arrangement to provide more redundancy. Details are given in Table 4-2.

Table 4-2 Preliminary Design Values for the Membrane Filtration System

Design Parameter		Value
Membrane type	-	Hollow fibre, in tank, low pressure
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

4.2.6 Solids Handling and Removal

Waste Activated Sludge (WAS) will need to be thickened 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 so 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 4-1.

Preliminary design details for the solids handling and removal system are given in Table 4-3. 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 4-3 Preliminary Design Vales for the Solids Handling and Removal System

Design Parameter		Value
GBT capacity	m³/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 poly dosing dimensions	m (l × w × h)	2.1 × 0.85 × 1.6
Operation of GBT		1 to 2 hr/d

Design Parameter		Value
Peak TWAS flow	m^3/h	4
Number of TWAS pump	-	2 (1 duty + 1 stand-by)
TWAS pump size	kW	1
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.

4.2.7 Enhanced Disinfection for Non-potable Reuse

One of the options being considered for wastewater disposal is beneficial non-potable reuse within the Akaroa township for flushing of public toilets, irrigation of public parks, and potentially reticulated to higher density areas. See section 4.3 for an outline of the proposed non-potable reuse design.

There are no up-to-date 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.

For concept design the microbial criteria for Class A recycled water given by the EPA Victoria's *Guidelines for environmental management: Dual pipe water recycling schemes – health and environmental risk management* (2005) have been adopted as the most appropriate. Class A is required for water with unrestricted access as is being proposed for Akaroa. Microbial criteria in this guideline are:

- Bacteria: <10 E. coli /100mL (median)
- Viruses: 7-log reduction from raw wastewater
- Protozoa: 6-log reduction from raw wastewater

The concept design for the WWTP plant would achieve 4.5 log removal for viruses and protozoa (0.5 from activated sludge + 4 from membrane treatment). To get an additional 2.5 log removal for the most resistant virus, Rotavirus, a UV system with high dose rate ≥110mJ/cm² could be used. Concept design details for the UV system are given in Table 4-4.

Table 4-4 Concept Design Values for the Non-Potable Reuse UV Disinfection System

Design Parameter		Value
UV hydraulic capacity	l/s	14
Design UVT	%	60
Design TSS	mg/l	2
Design Rotavirus	log	2.5

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4.2.8 Odour Management

Major odour generating equipment (including the gravity belt thickeners, and sludge storage tank) will be enclosed and air extracted from these enclosures and the sludge and membrane building will be treated in a bark biofilter.

Ventilation of the blower, laboratory and control room will be discharged directly to the atmosphere.

4.2.9 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 an economy 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 access road, with the aeration reactor closest to the road.

4.2.10 Hydraulic Design

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

4.2.11 Civil and Site Layout

The treatment plant site concept site layout is shown in Figure 4-2 and Drawings 6517986-GE-040 and GE-041 in Appendix F. 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 a one way access lane
- 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
- The one way single lane access has been retained as per the Harrison Grierson concept design, as the width available is too narrow to allow vehicle turning. This means that large trucks and tankers leaving the site will need to travel down Old Coach Road to Akaroa.

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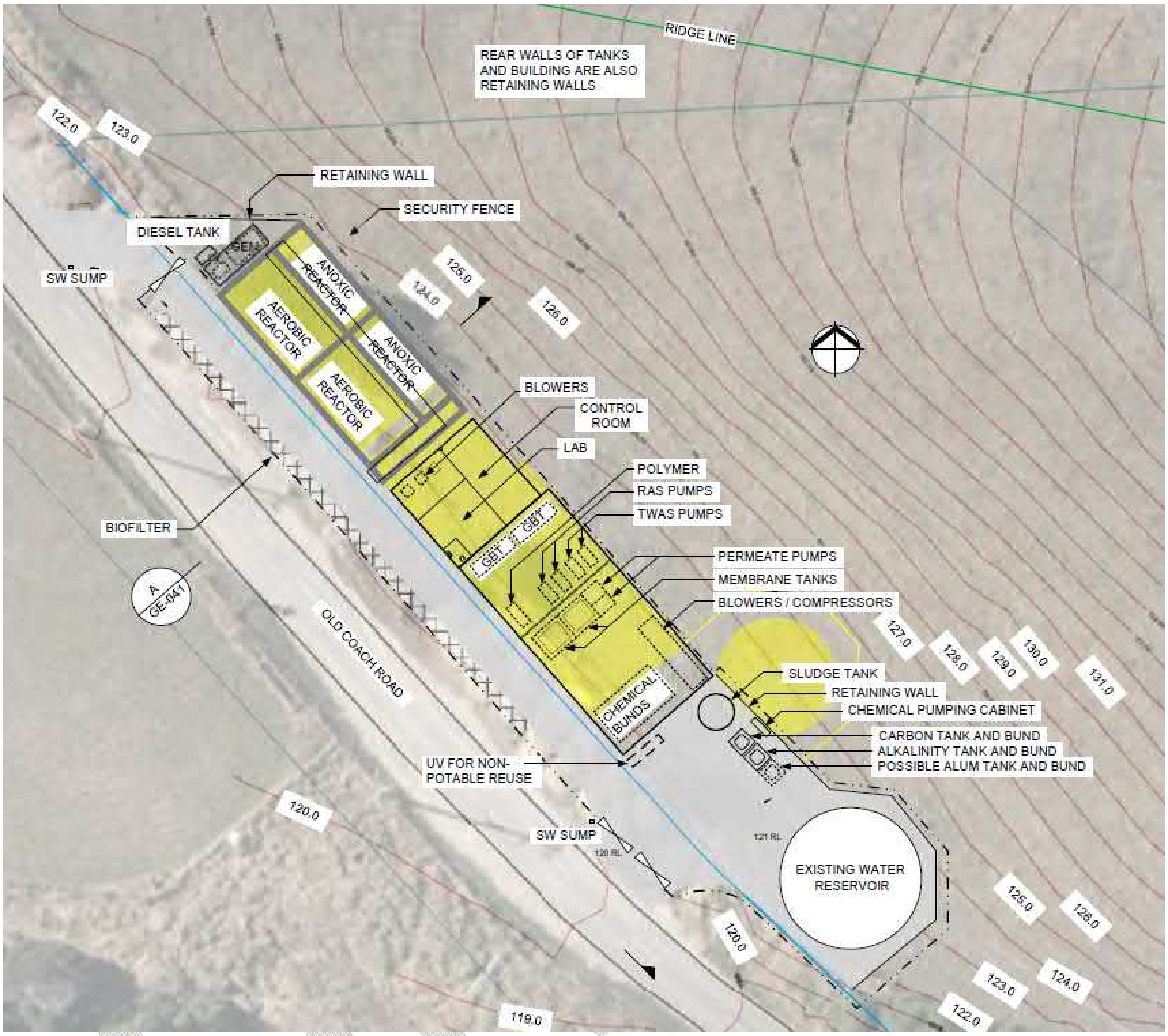

Figure 4-2 Concept treatment plant layout (previous concept in yellow, RWW storage pond not shown)

4.2.12 Wastewater Storage at the Treatment Plant

Based on feedback from the Working Party there is a preference to have any storage of treated wastewater at Site 10 across the road from the new WWTP. Reasons for this preference include that the site is near the treatment plant, has the lowest overall impact, is in the best position to provide reclaimed water for non-potable reuse in Akaroa and could provide storage of water for irrigation at any of the other locations being considered. The revised scheme concept requires less treated wastewater storage at Pond Site 10, and more raw wastewater storage to buffer peak flows and eliminate bypass of the WWTP.

4.2.13 Requirements for Raw Wastewater Storage

There is a trade-off between the hydraulic capacity of the WWTP (i.e. the UF membranes) and size of the raw wastewater storage pond. This trade-off is discussed in the letter *Akaroa WWTP update –January 2018* (CH2M Beca, 19 Jan 2018, Attached in Appendix G). It concluded that keeping the membrane capacity as small as possible was the most cost effective solution. Therefore, the membrane capacity is limited to 14 l/s to process the peak summer ADF. Any flows greater than this (including diurnal peaks during the peak summer) will be stored in the pond and returned when possible.

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 volume influences network overflow frequency. The pump at the terminal pump station will pump until the raw wastewater storage volume is at capacity. If the pond size is too small, wet weather flow events larger than a certain size will not be able to fully stored or treated, and an overflow from the network will result (this can occur at the terminal pump station after screening). The required raw wastewater storage pond volume to prevent an overflow has been assessed for various events based on a daily volume of wastewater from the PDP calibrated model. In Figure 4-3 these have been plotted against the Average Recurrence Interval (ARI) of the rain event based on Council's WWDG method.

The determination of the ARI for a given rain event is important in understanding overflow frequency – if the ARI of an event was 1 in 100 years, then it is not reasonable to design to try and capture all this rainfall, and any overflows that do occur will be very dilute. There are a number of ways of determining an event ARI. Initially analysis was based on depth-duration-frequency (DDF) tables from NIWA's HIRDSv3 website. However, this produced ARIs that seemed unusually high. The ARIs were recalculated with reference to Council's WWDG method, and these figures have been used for evaluation of the options. A more detailed description of the calculation of ARI for recorded rain events in Akaroa is given in Appendix G.

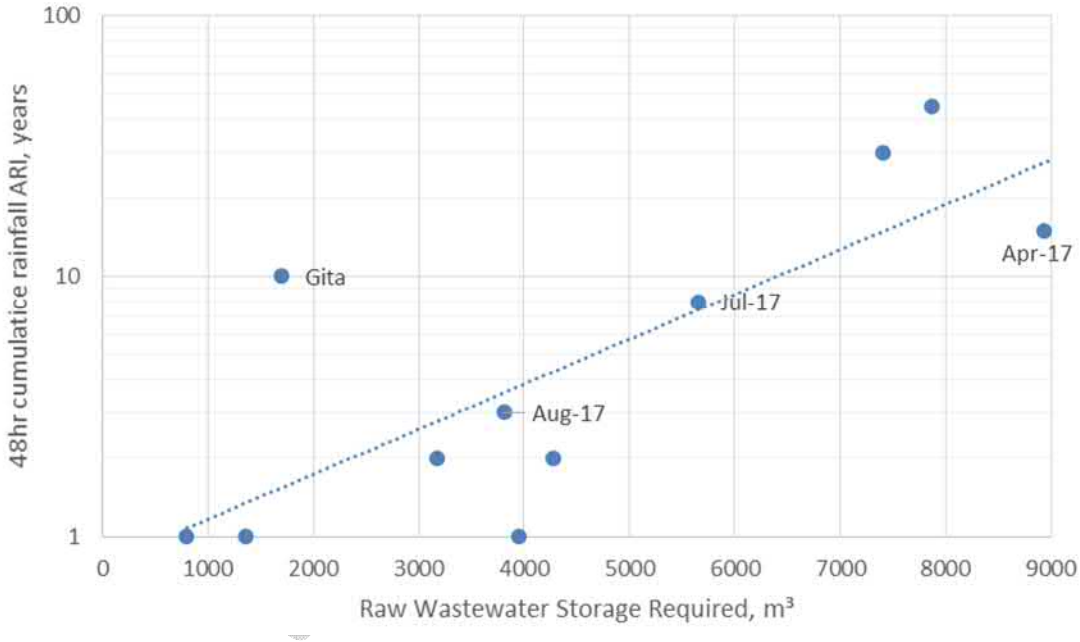

Figure 4-3 Recent wet weather events plotted as raw wastewater storage required versus Annual Return Interval

Figure 4-3 shows a reasonable fit with the 48hr cumulative rainfall ARI and the required raw wastewater storage volume to contain all flow. However, the network responds differently to each wet weather event, even with similar ARIs. For example, Hurricane Gita, had an assessed 48hr cumulative rainfall ARI of around 10 years, but requires relatively less storage than other 1:10 events. This is likely because the Gita event occurred after an extended period of dry weather and hence the associated I&I did not have a 'long tail-off'. Conversely, the April-17 event consists of two separate events with only a few days separation, and hence requires more storage than other events with a higher ARI.

The current concept design for the raw water storage is for a capacity of approximately 5,100 m³, which would capture most events with an ARI of 6 years of less. A PC sum has been included in the cost estimate to allow the increase the pond size to 10,000 m³ to capture large events should this be required.

This pond is split into two compartments. The first (~600 m³) is designed to capture the peak summer diurnal peaks, and the second to capture the wet weather flows. The first pond will have a steeper slope floor and PE liner as it will receive a higher strength wastewater and will benefit from better draining.

4.2.14 Requirements for Treated Wastewater Storage

A treated wastewater storage pond has been allowed for on Pond Site 10 for the following reasons:

- Ability to provide constant flow (and pressure) to the bore heads during operation
- Buffer volume when changing bores so the next bore can be brought on and run up before the operational bores are stopped
- Air removal and degassing prior to bore injection
- Ability to pump a constant and continuous flow to Eastern Bays (to prevent issues with stopping and starting pipeline in event of WWTP issues)
- Buffer storage for use with a non-potable reuse scheme (i.e. having a volume available for short duration high demand periods such as garden watering)

The concept sized for this is for one day of maximum flow out of the WWTP which is 1,200 m³. During later phases of design it is likely that this volume can be reduced, or there may be potential for the treated wastewater pond to be removed completely if the above reasons are able to be addressed in other ways.

4.2.15 Layout of Pond Site 10

Depending on which scheme option is progressed, Pond Site 10 will need to accommodate some or all of the following:

- Covered raw wastewater storage pond (all options, volume to be maximised)
- Covered treated wastewater storage
- Pump station for pumping to Eastern Bays
- Injection bores and monitoring bores
- Small pump station to transfer between raw wastewater storage pond and WWTP

Concept level geometric modelling of a possible layout has been completed based on the following, this is shown in Figure 4-4:

- Covered treated water storage pond of 1,200 m³ floor slope minimum of 1:100.
- Covered diurnal balancing raw water storage pond of 500 m³ floor slope minimum of 1:150.
- Covered peak flow raw water storage pond of 4,500 m³ floor slope minimum of 1:250.
- Four injection well heads with connecting track suitable for a large drilling truck. Drilling Pads are approximately 10 x 25 m in size.
- Pump station of approximate dimensions 7.6 m x 9.8 m by 3.4 m (internal height). To be cut into the slope with a cut height into the hillside of up to 4 m and a retaining wall to match, set back 1.5 m from the building.

Figure 4-4 Geometric Design of Possible Storage Pond Configuration Opposite WWTP (Pond Site 10)

One of the reasons Pond Site 10 is preferred is because of the limited view paths to the site. 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. Some estimates of the depth of rock have been made, based on previous geotechnical investigations nearby, to complete the modelling. However, physical investigation on site will be required to confirm assumptions.

Landscaping of the area surrounding the pond will be undertaken. 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 braches 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. It may be possible to plant some shallow rooting shrubs only. Landscaping directly on the external embankment slope should also be minimised so that the integrity of the embankment system can be directly observed. The preference is for landscaping to be set back from the pond system. At this stage it has been assumed that the injection bores will be sited within the planting setback for the ponds and that all three ponds be covered using a floating HDPE cover. An image of a covered pond is shown in Figure 4-5:

Figure 4-5 Example of Covered Pond

4.3 Non-potable Reuse (Purple Pipe)

Treated wastewater from the membrane treatment plant can be beneficially reused within the Akaroa township for flushing of toilets and for irrigation of public parks. As the treatment plant is located at the top of Old Coach Road, the reuse scheme can 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 pipework. To minimise costs purple pipes can be laid alongside new raw wastewater pipelines when the Akaroa reticulation work associated with the overall wastewater scheme upgrade is constructed costs. Alternatively, trenchless pipe laying techniques could be employed.

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, the public toilets and the four highly populated areas of Akaroa township. Option 2 is to provide treated wastewater to the property boundary of every residence. For both options a pipe size and length, and the total annual amount of treated wastewater that could be reused were calculated.

4.3.1 Option 1 – Supply to Public Parks, Toilets and High Density Users

Option 1 is to supply treated wastewater to the four populated zones in Akaroa shown in Figure 4-6 Akaroa was divided into four zones according to population density based on the 'Guest Number and Tourist Data' supplied by Council. Zone 1 contains 22 accommodation establishments, Zones 2 and 3 contain five each, and Zone 4 consists of the Akaroa Top Ten Holiday Park by itself. From this information the average daily flow requirements for the accommodation toilet use was calculated. The consumption of water for all four Zones, for toilet use was estimated to be 51 m^3/day assuming:

- 100% occupancy; and
- 55 Litres/person/day of water used for flushing toilets.

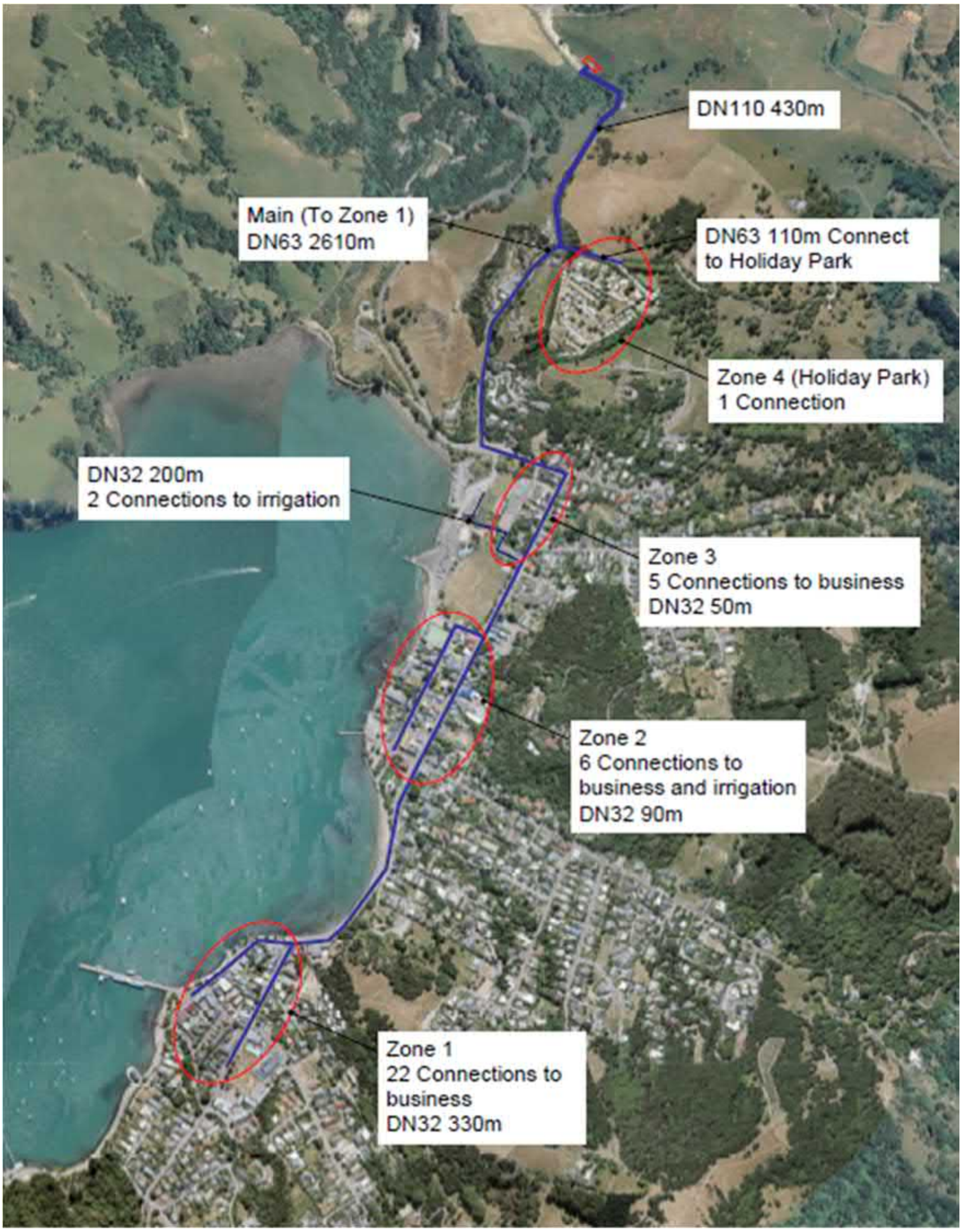

Figure 4-6: Option 1 and the populated zones 1-4

The supply pipework to the zones was sized based on these parameters beginning at the WWTP with a DN110 main pipe to Zone 4. At Zone 4 the main will reduce to DN63 and continue at this size for the rest of the zones. For each commercial connection an average length of 10 m of DN32 PE100 PN16 pipe was assumed to be suitable. PN16 was selected to allow for de-rating the pipe should trenchless installation techniques be utilised. The main pipe diameter of DN63 is based on Peak Flow Conditions as follows:

- 100% guest occupancy,
- 55 litres/person/day for toilet use (TP58 Table 6.3),
- A Peak Flow Diversity Factor of 3 (assumed); and
- A constant Irrigation demand of 1 L/sec (distributed evenly across Zones 2 and 3).

The DN63 pipe is of a sufficient size to still have capacity for further non-potable reuse take-offs in Zones 1, 2 and 3.

4.3.1.1 Irrigation of Reuse Water in Akaroa

A desktop study identified several locations of green space within Akaroa township as potentially suitable for irrigation. Further study found that some public parks were unable to be irrigated due to the risk of instability from steep gradients, or close proximity to playgrounds and mature trees. The sites deemed suitable were estimated to require 3 mm/m^2/day for 120 days a year (i.e. irrigation during dry weather only. Table 4-5 summarises the locations that are assumed to be irrigable with non-potable reuse.

Table 4-5 Non-potable Reuse Irrigation Area within Akaroa

Location	Area For Irrigation (estimated m^2)	Total Water (m^3/yr)	Suitability for Irrigation
Waeckerle Green	3,250		Suitable
Rec Ground	20,000		Suitable
Woodills Rd Park	1,000		Suitable
L'Aube Hill	0		Not suitable due to gradient
Stanley Park	0		Excluded due to drop off at bottom
War memorial	0		Excluded due to presence of gardens, monuments etc that would make installation very difficult
Britomart reserve	0		This area not usable due to playground and mature trees
Total	**24,250**	**8,730**	

4.3.1.2 Non Potable Reuse Calculation Option 1

The population of Akaroa township fluctuates throughout the year according to season as described in Section 3.5.3. The consumption of treated wastewater for Option 1 is shown in Table 4-6.

Table 4-6 Volume of Non-Potable Reuse Option 1

Non-potable Reuse Calculation	Occupancy	Duration (days)	Flow (m^3/d)	Subtotal (m^3)
Peak Summer	100%	7	51	360
Summer	66%	64	34	2,170
Winter	24%	294	12	3,625
Parks and Sport field irrigation reuse (m^3/yr)				8,730
Total Estimated Reuse (m^3/yr)				**14,885**

4.3.2 Option 2

Option 2 is based on supply treated wastewater for non-potable reuse to the boundary of every residence in Akaroa. The four zones for Option 1 were extended out to include the surrounding residences and an extra Zone (Zone 5) to the South was created. Zone 4 remained solely the Akaroa Top Ten Holiday Park.

The main pipe ID (using PE 100 PN16 pipe to allow for de-rating the pipe should trenchless installation techniques be utilised) is based on Peak Flow Conditions as follows:

- Total population of 3566 at Peak Summer (Year 2052),
- An average household size of 3.4 people (population/number of connections),
- 55 litres/person/day for toilet use (TP58 Table 6.3),
- A Peak Flow Diversity Factor of 3 (assumed); and
- A constant Irrigation demand of 1 L/sec (distributed evenly across Zones 2 and 3).

For each zone the length of pipe and number of connections was obtained by exporting data from Council GIS. The length of pipe from the existing potable water supply was used as the basis for the length of the purple pipe, and the number of existing water meters was used to estimate the number of connections required in each zone.

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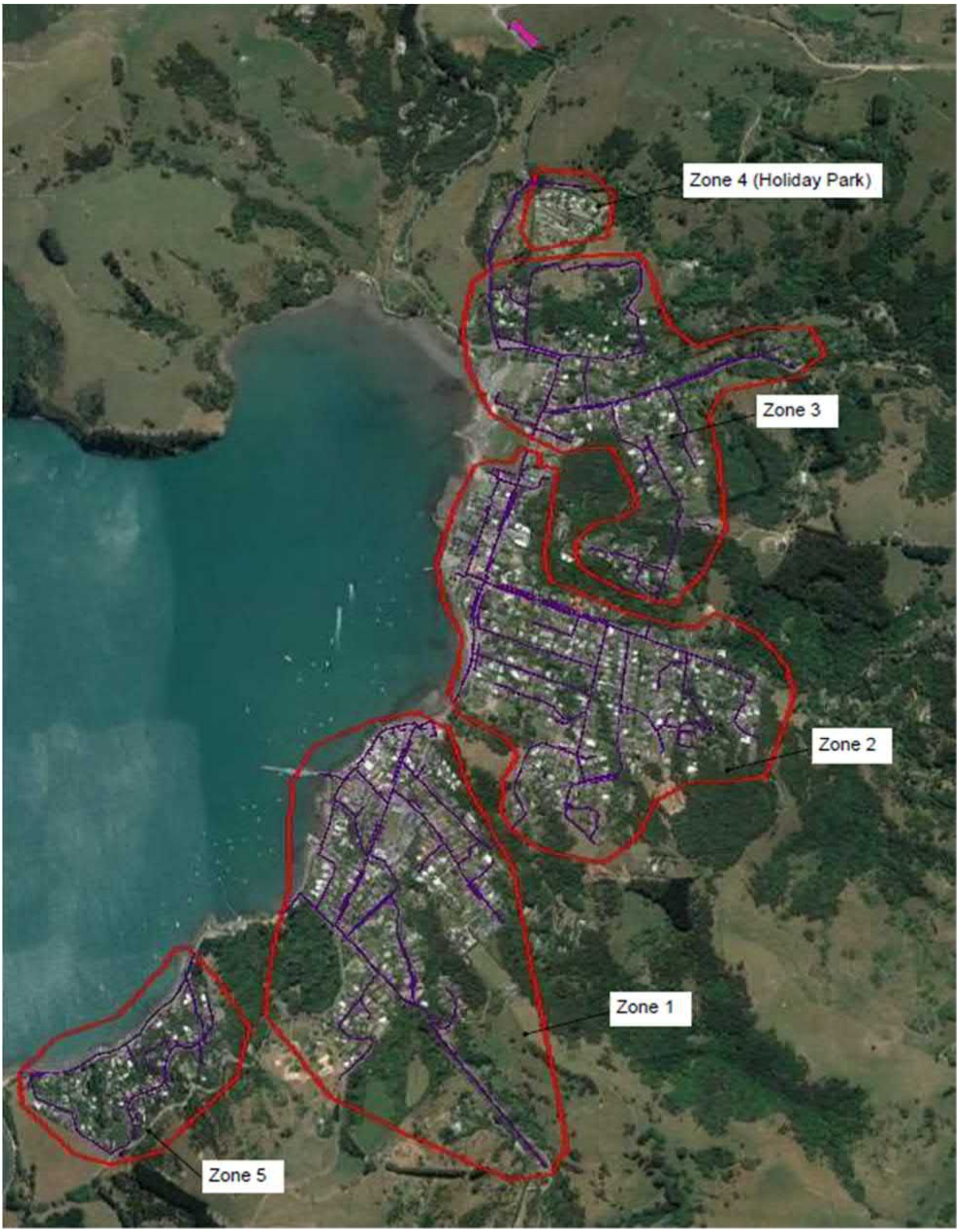

Figure 4-7 Option 2 and the populated zones 1-5

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 per connection.

4.3.3 Non-potable Reuse Calculation Option 2

The seasonal population of Akaroa was taken from the 2052 estimated population described in 3.5.3 and then an average household population of 3.4 was used to determine the toilet flushing requirements in each zone. The consumption of water for all five zones for toilet use was estimated to be 226 m^3/day assuming:

- Peak Summer 2052 population; and
- 55 Litres/person/day of water used for flushing toilets.

The irrigation requirements remained the same as for Option 1; 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 4-7.

Table 4-7 Volume of Non-Potable Reuse Option 2

Non-potable Reuse Calculation	Population	Duration (Days)	Flow (m^3/d)	Subtotal (m^3)
Peak Summer	3,566	7	226	1,582
Summer	2,348	64	135	8,649
Winter	840	294	49	14,448
Parks and sport field irrigation reuse (m^3/yr)				8,730
Total reuse (m^3/yr)				**33,409**

4.3.4 Backflow Protection to Existing Potable Supply

Supplying treated wastewater to a property introduces a risk of contamination to the potable water supply if backflow occurs where there is cross-connection. AS/NZS3500:2015 outlines the requirements for cross-connection control and 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. Non-testable devices are only permitted where the hazard rating is low. All backflow prevention devices installed must be manufactured to AS/NZS2845:2010.

A cross-connection hazard rating of medium was assumed for both Options 1 and 2, and therefore a Double-Check valve assembly was included for each connection for pricing. It is noted that there are existing check valves in the water supply meters to each property. However, these do not meet the required for a testable double check valve. A detailed risk analysis was not carried out to confirm the risk rating, this should be undertaken at the next phase of design.

4.3.5 Opportunities for Increase in Volume

Some opportunities to increase the utilisation of non-potable reuse or reduce the estimated cost exist:

- Consideration has not been given to the use of treated wastewater for private irrigation and/or boat washing etc. This could increase the total volume used each year.
- Utilisation of the treated wastewater could be further increased if consideration is given to the use in laundries – for clothing and linen washing. Further study into the associated risks would be required.
- 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.
- Less expensive backflow protection methods could potentially be utilised. A detailed risk analysis would be required during the detailed design of the Purple Pipe network to confirm this.

4.4 Deep Bore Injection

4.4.1 Deep Bore Injection Concept

Bore injection was on the original long list of options presented in the report *Akaroa Wastewater Review of Disposal Alternatives First Stage, CH2M Beca, August 2015*. At this time it was referred to as “Passage through land” and the option was to either feed treated wastewater into a natural feature such as rock fracture, or a constructed feature such as an infiltration basin. As part of options development the use of a constructed feature was progressed but the concept of injection into a rock fracture did not make the short list of options.

When the Akaroa wastewater flows were found to have approximately doubled in May 2017 and there was less likelihood of finding sufficient irrigable area, the original long list of options was reviewed and the possibility of using deep bore injection was revisited.

Deep bore injection takes the membrane filtration treated wastewater from the treatment plant and disperses it into the ground via a series of bores or chambers distributed over a suitable area and depth (see Figure 4-8). The flow of treated wastewater is rotated across the bore field such that “rest” periods follow application periods to allow the wastewater to disperse away from the bores, and to control groundwater mounding. The proposed MBR treated wastewater will contain very low solids loading and hence is well suited to ground injection.

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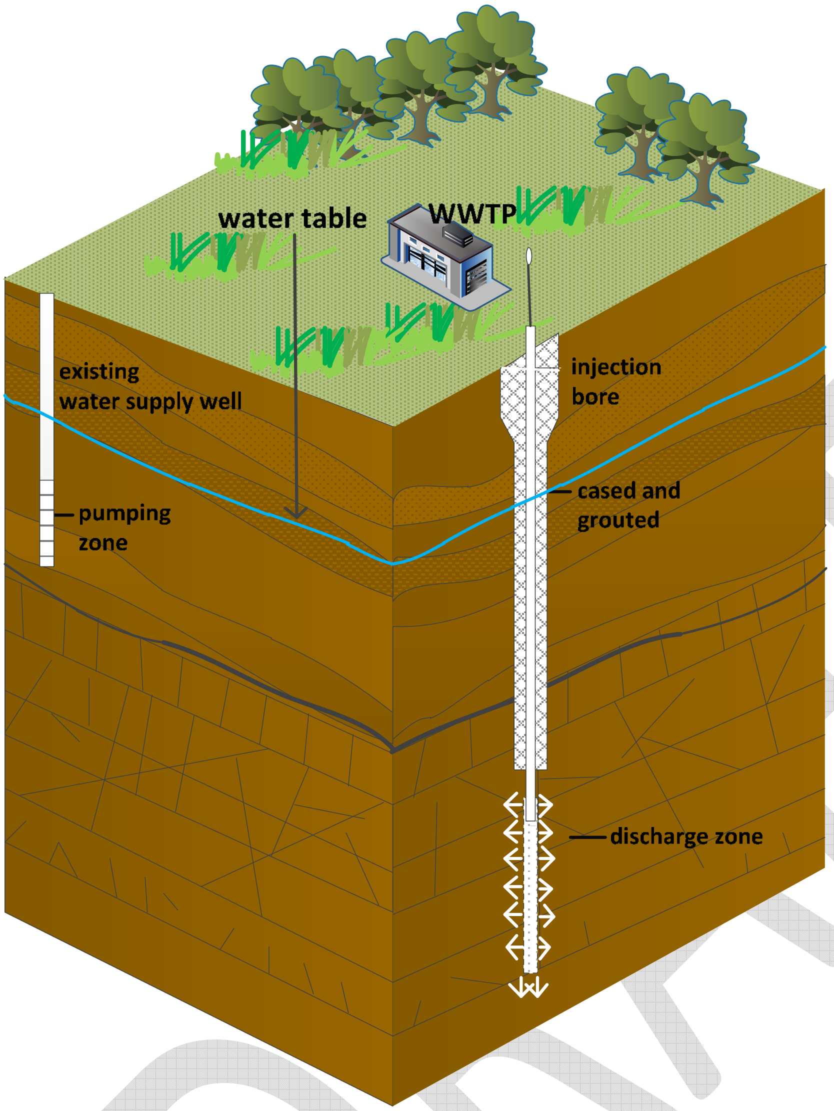

Figure 4-8 Bore Injection Conceptual Flow Diagram

Once the treated wastewater is injected into the underlying volcanic rock, the flow will then slowly migrate and disperse naturally through fractures and pore spaces and will mix within the groundwater (Figure 4-9). The bore sites can be situated to achieve a target minimum residence time (the time the treated wastewater is in the ground between injection and reaching a receiving environment) and/or dispersion, by placing the discharge point sufficiently deep or distant from important bodies of water such as the harbour or existing groundwater supply bores. Monitoring bore will be utilised to track the movement and dispersion of the treated wastewater from the discharge point.

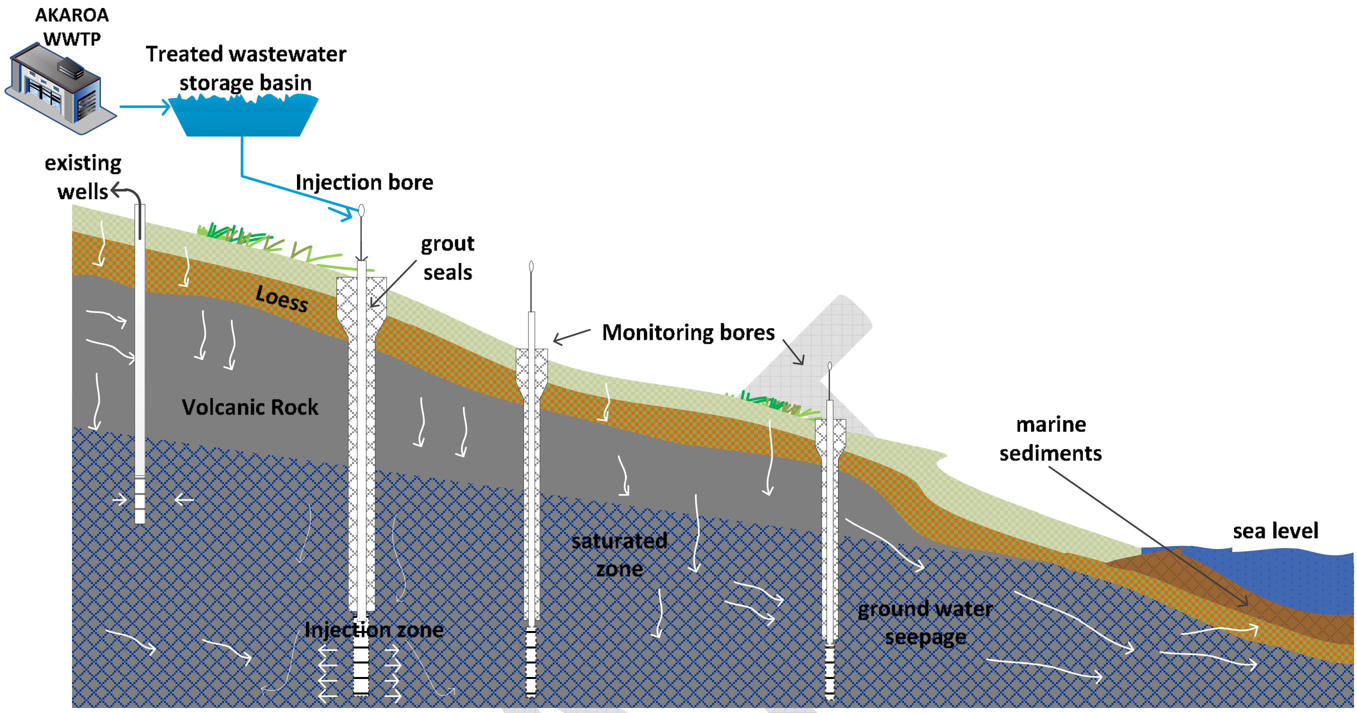

Figure 4-9 Conceptual diagram of the movement of treated wastewater in the ground following injection

Discharging the treated wastewater into the ground can further remove any pathogens should any remain after treatment. Time spent in the ground will allow the removal of viruses and any remaining bacteria by binding to the formation, predation by microbes already present underground and die-off due to age. For example, die-off rate constants for Poliovirus 1 can range from 0.01 to >1.42 day^{-1} and E. coli from 0.001 to 0.03 day^{-1}, depending on pH, temperature, microbial activity, salt content and a range of other factors[1].

Injection bore construction is typically made up of the following components (see Figure 4-10):

- Pipework and pumps to transport treated wastewater to the bore. Note that gravity flow might be feasible depending on the location of the injection bores relative to the Akaroa WWTP;
- A bore approximately 150 – 300 mm diameter and 50 – 250 m depth;
- Perforated well screen to allow water to pass to the surrounding rock;
- Air valves and backflow prevention valves;
- Motorised valve to control treated wastewater flow into the bore;
- Flow meter.

[1] Azadpour-Keely, A., Faulkner, B. R., & Chen, J. S. (n.d.). *Ground Water Issue - Movement and Longevity of Viruses in the Subsurface.* Cincinnati: U.S. Environmental Protection Agency.

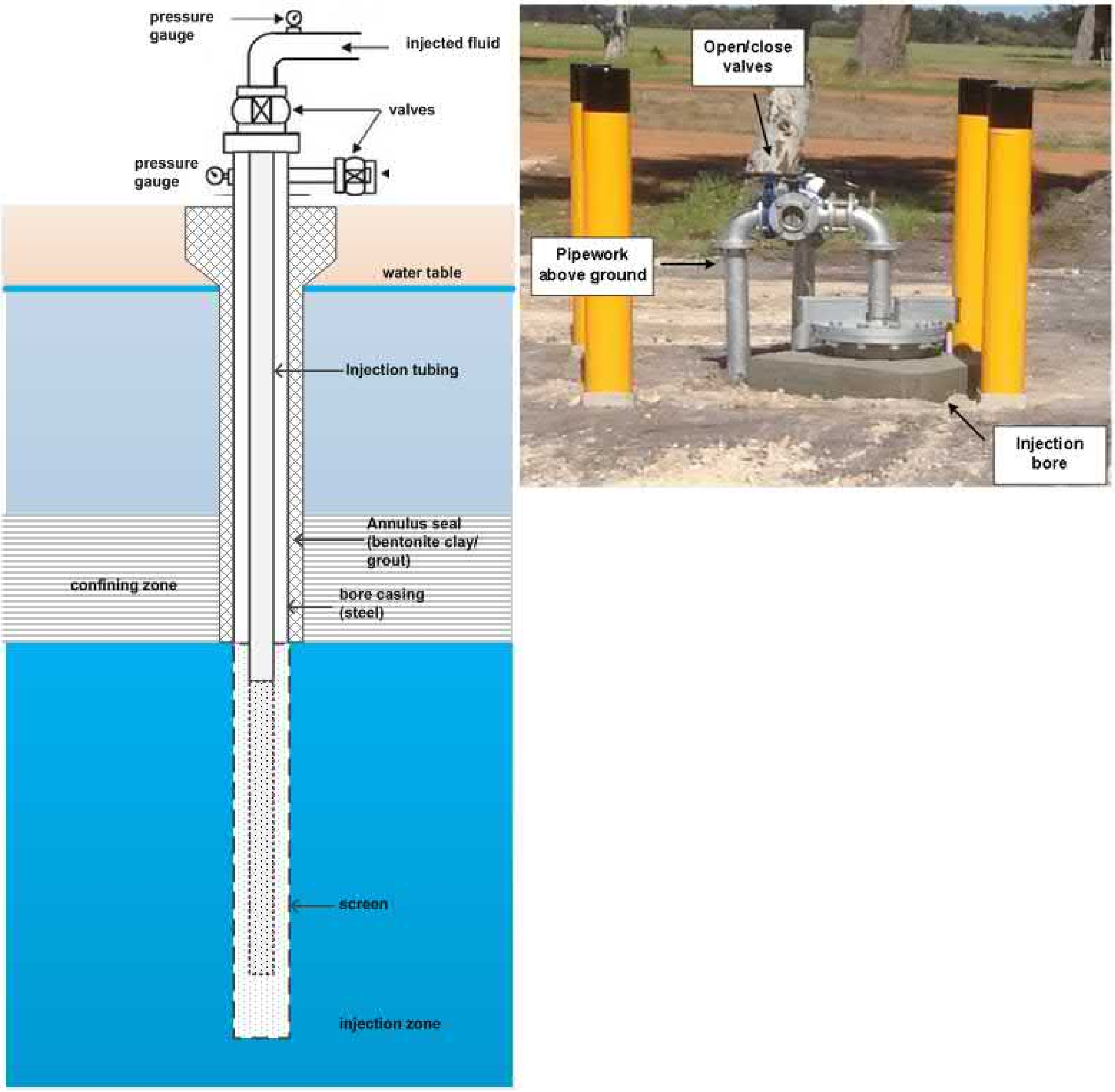

Figure 4-10 Example injection bore well design and a completed well head at surface

Irrigation of treated wastewater to land typically requires large land areas and low daily irrigation rates on relatively flat land. Generally, the loess soils and topography found in the Akaroa area pose challenges for the irrigation of treated wastewater including land-stability issues. Deep bore injection of treated wastewater has some key advantages in that it disperses the treated wastewater vertically within the ground and therefore requires a relatively small land area at the surface and once established requires less ongoing maintenance. If wastewater is injected at depth, exacerbation of slope instability can be avoided. It also allows for contact with Papatūānuku – the land, prior to discharging the wastewater to water.

One of the most significant concerns noted from feedback to the 2017 consultation round was the construction of large treated wastewater storage ponds. Deep bore injection offers the opportunity to avoid large storage requirements, and soil stability issues associated with irrigation.

Initial high level numerical groundwater modelling was undertaken to estimate the likely groundwater flow path time between an injection bore and the receiving environment. Groundwater flow paths were modelled for four possible deep well injection sites near the coast using a simplified and conservative model set up. The modelling indicated if the bore discharge was located 400 m from the coastal boundary, the modelled groundwater flow path travel time ranged from approximately 80 days to 11 years before reaching harbour, with an average of 2 years.

Whilst the modelling outputs are uncertain, the model was based on available hydraulic conductivity information and simplified assumptions of groundwater flow. It is acknowledged that the groundwater flow, and dispersion of injected treated wastewater will be highly variable and dependent on the site and local hydrogeological conditions. The model was produced for indicative purposes based on initial assumptions which will need to be updated with physical testing of the bore injection site.

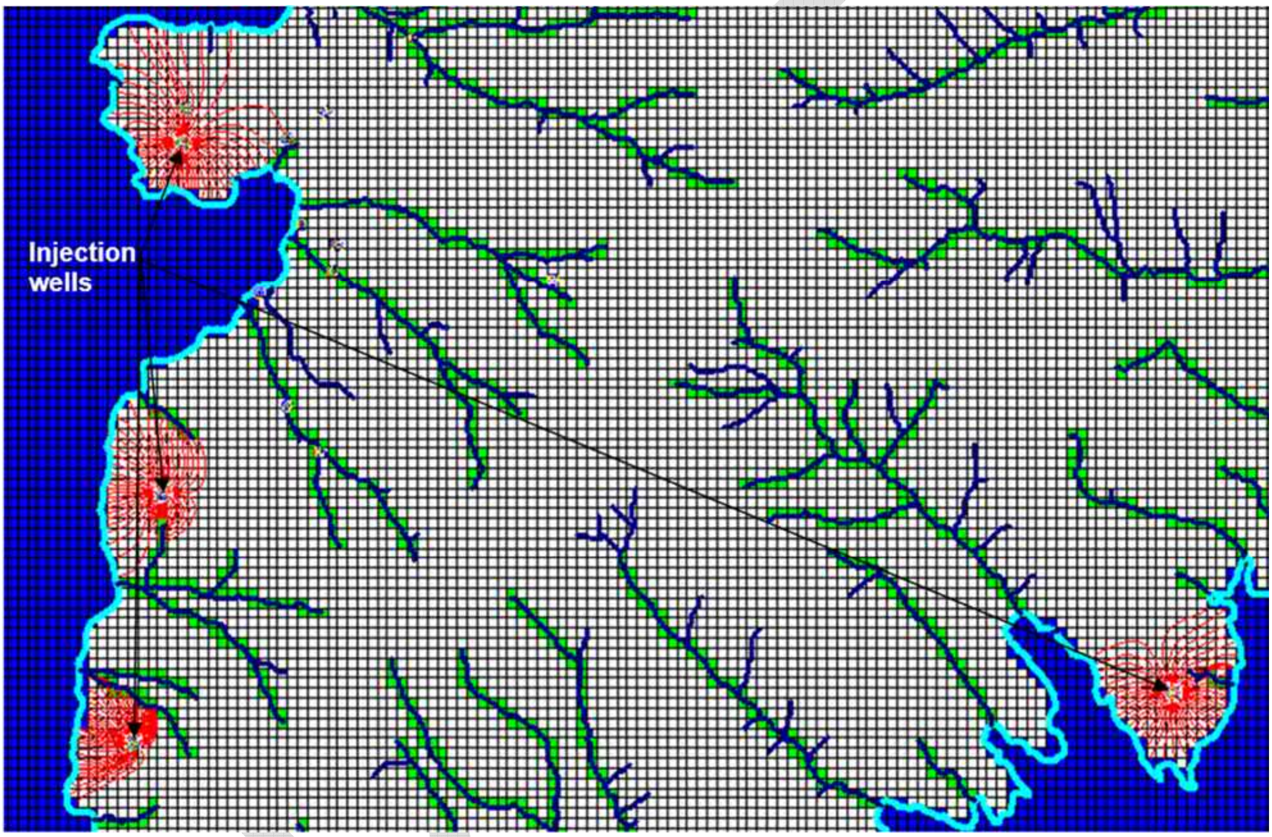

Figure 4-11 Estimated groundwater flow paths (red lines) from four possible injection well sites

4.4.2 Bore Injection Literature Review

A literature review was conducted to understand where else in the world deep bore injection was used for treated wastewater. The literature review found examples of injection schemes in Australia, Hawaii and Russell in New Zealand. The review also summarised findings from publications on geology and hydrogeology of the Akaroa area. A copy of the review is attached in Appendix H.

A review of possible applications of Managed Aquifer Recharge (MAR) for Akaroa with deep bore injection was also undertaken. MAR is unlikely to be an efficient method for reuse of treated wastewater in Akaroa if a purple pipe is to be pursued, and the position of the injection bores near the coast makes recovering the injected treated wastewater technically challenging. The appetite for potable reuse and recovery of injected treated wastewater in the community is likely to low. A copy of the review is also attached in Appendix I.

4.4.3 Criteria for Selecting Bore Injection Sites

Once it was agreed to progress investigations to determine the feasibility of deep bore injection for Akaroa, the next step was to determine possible locations for test bores. The investigation process for deep bore injection is outlined in Figure 4-12 and will involve several stages of exploration, analyses and community engagement.

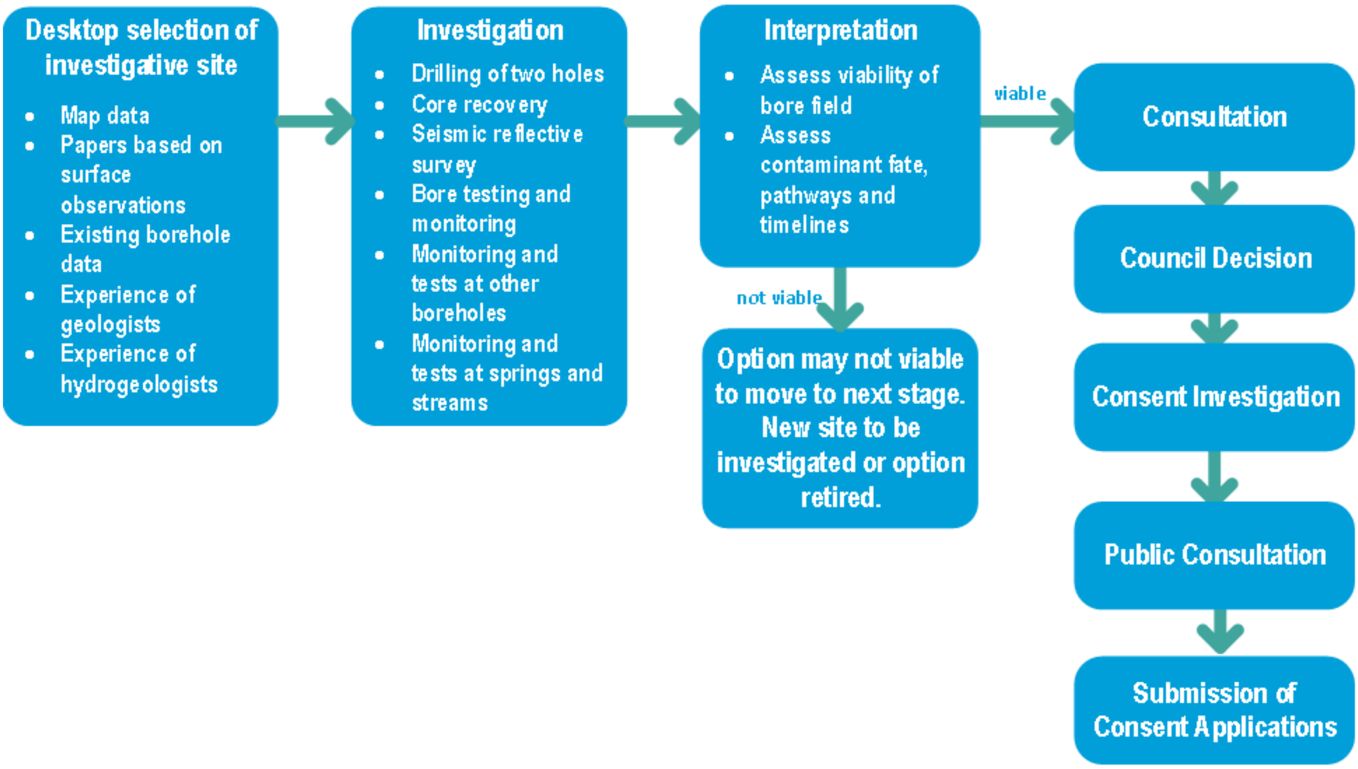

Figure 4-12 Diagram of the investigation process for establishing the feasibility of deep bore injection

A series of selection criteria were established, and GIS mapping was undertaken using these criteria to identify possible locations. The site selection criteria are shown in Table 4-8. The main criteria relate to the set back from the coast (400 m) and a site sufficiently low in elevation which that allows drilling to reach below sea level. Given the abundance of springs across the Akaroa area, there was a desire to avoid interference with springs by targeting disposal into strata at or below sea level. Therefore a 200 m elevation cut off was selected as drilling is considered feasible between 200-400 m, with technical difficulties and risk significantly increasing with depth. A 1,500 m setback from active Council potable water supply wells was selected to avoid the possibility of cross-connection with the public drinking water supply.

Table 4-8 Criteria for Deep Bore Injection Sites

Selection Criteria	Criteria	Basis for Criteria Selection
Minimum set back to coastline	400m	Set back to provide 1 – 3 months residence time (typical) before wastewater reaches harbour waters. To allow any remaining contaminants in the injected treated wastewater to be dispersed, diluted and attenuated.
Maximum height above sea level	200m	Greater depths are more difficult, higher risk and more costly to drill

Selection Criteria	Criteria	Basis for Criteria Selection
Public water supply exclusion zone	1500m	Separation of 1500m from public water supply wells is recommended to avoid any potential interaction with injected wastewater. Surface water catchment areas uphill of operational public water supply bores are also excluded.

The selection criteria were used to generate a GIS map showing potential investigation areas. Figure 4-13 shows the outputs from the GIS mapping, with green areas indicating potentially favourable locations to drill.

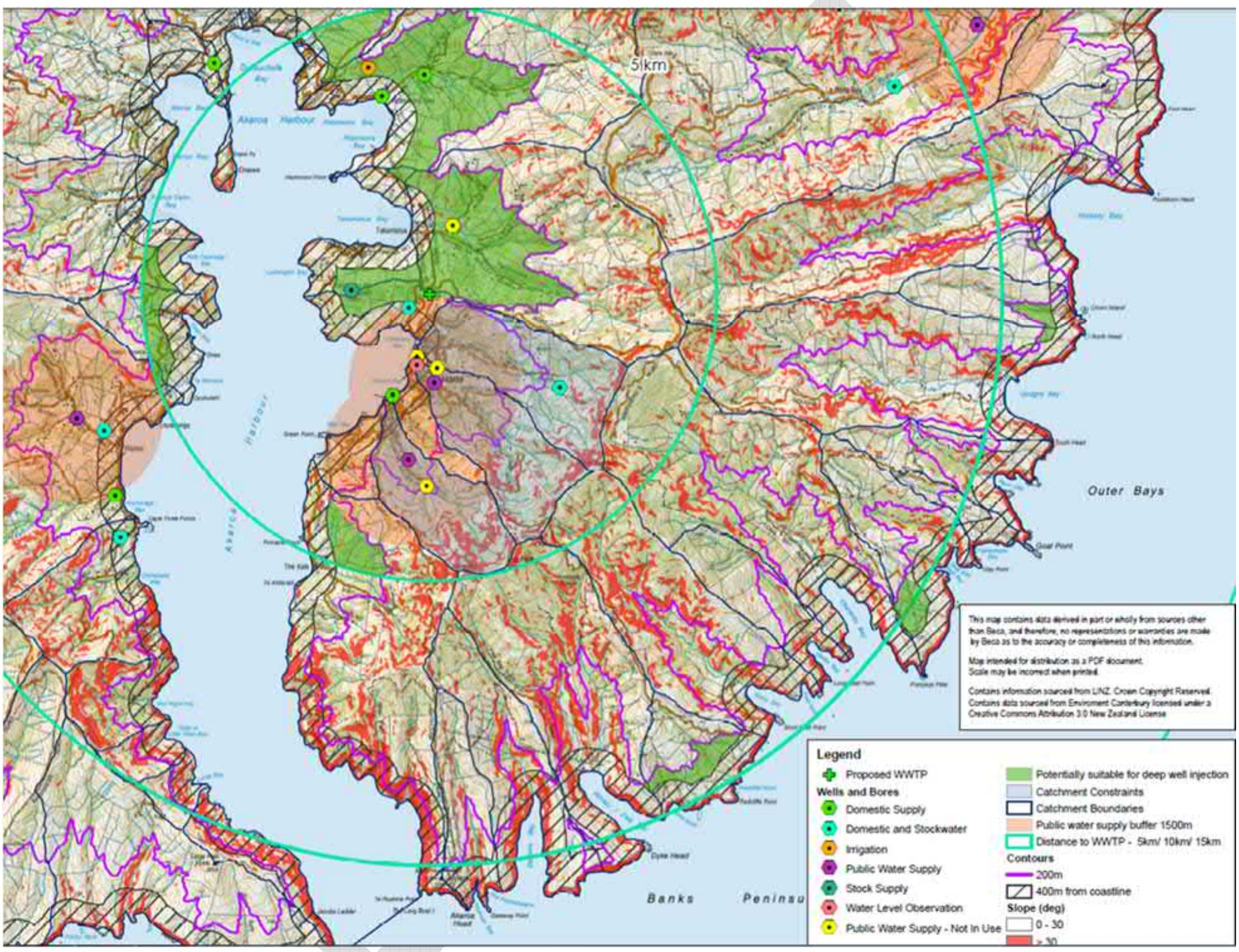

Figure 4-13 Potential Investigation Areas for Deep Bore Injection

To assist with identifying a preferred option, further criteria as shown in Table 4-9 were considered. These included access, facilitating the non-potable reuse pipeline, the ability to connect the bore field to an irrigation area and the site elevation, acceptability to the community and/or Ngāi Tahu Parties, and cost.

Table 4-9 Deep bore injection site screening assessment

	Borefield Site	Pipeline to borefield connects to possible irrigation area	Facilitates non-potable reuse	Starting site elevation (m above sea level)	Good access	Acceptability to Ngāi Tahu Parties and local community	Pipeline, pump and bore capital cost	Preferred / Not Preferred
1	Upper and western harbour areas	Some	Possible	60	Yes	TBC	$11.8M	Not Preferred
2	Pompeys Pillar	Yes	Possible	160	Yes	TBC	$11.9M	Not Preferred
3	Goughs	Yes	Possible	230	Yes	TBC	$13.9M	Not Preferred
4	Redcliffe Point	Yes	Possible	160	Yes	TBC	$13.2M	Not Preferred
5	Robinsons Bay	Yes	Possible	90	Yes	TBC	$6.8M	Preferred
6	Takamātua Valley	Some	Possible	60	Yes	TBC	$5M	Preferred
7	Takamātua Peninsula	No	Possible	120	Yes	TBC	$6.9M	Preferred
8	The Kaik	No	Yes	120	No	TBC	$6.8M	Not Preferred
9	Hamilton's Land	No	Yes	200	No	TBC	$9.5M	Not Preferred
10	Treatment Plant Site / Pond Site 10	No	Possible	120	Yes	TBC	$6.2M	Preferred

An assessment of likely geology in the Banks Peninsula area was undertaken to understand if there were any geological features that could potentially rule out a site. Given the lack of subsurface information about the geology in the area, a schematic interpretive cross-section from an earlier study was applied to the area around Takamatua Peninsula, refer Figure 4-14. The elevation and depth of existing wells and the possible depth of deep injection bores were plotted. This shows how the deep bores are likely to be screened in deeper and different strata than other wells in the area. It also shows how the deep bore could be drilled below sea level in an effort to avoid short circuiting via springs or fractures directly to surface.

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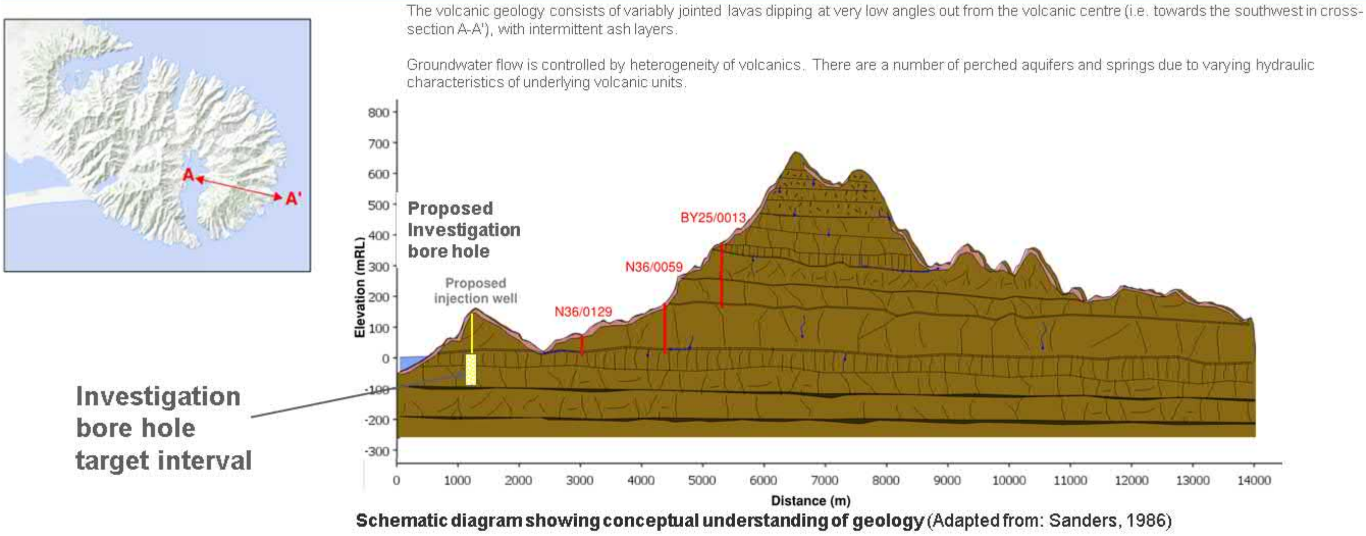

Figure 4-14 Schematic geological cross-section (adapted from Sanders, 1986[2])

Considering all the criteria, the following order of preference was proposed for borehole investigative drilling:

- Treatment Plant and Pond Site 10 (Old Coach Road)
- Takamātua Peninsula
- Takamātua Valley
- Robinsons Bay Valley

A "decision tree" was prepared to guide the drilling work progress and make clear go – no go decisions depending on the outcome of each step – the decision tree is given in Appendix J. Alternative bore sites may be considered if the initial drilling is unsuccessful

The treatment plant and Pond Site 10 was identified as preferred for the following reasons:

- The location is compatible with any land irrigation option and non-potable reuse
- The location is readily accessible for investigation
- Pond Site 10 simplifies scheme operation as the injection bores would be located at the same place as treatment plant and storage ponds

4.4.4 Investigative Bores

In early 2018 a tender was put out to the CCC Drillers Panel to construct two investigative bores around Pond Site 10 to inform the feasibility of the deep bore injection option. The location of the two bores is shown in Figure 4-15.

[2] Sanders, R., 1986. Hydrogeological Studies of Springs in Akaroa County, Banks Peninsula. A thesis submitted in partial fulfilment of Masters of Engineering Geology. University of Canterbury.

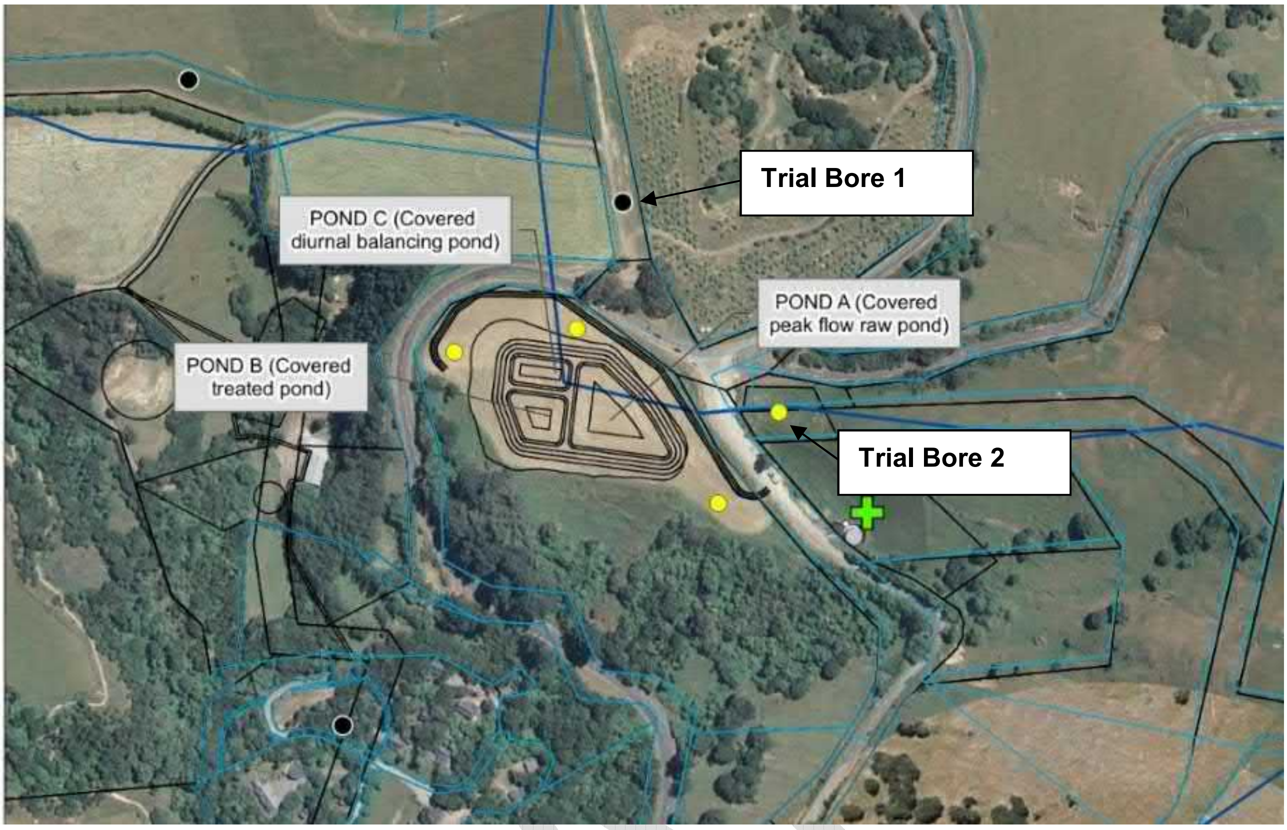

Figure 4-15 Map showing locations of proposed boreholes (monitoring = black dot; yellow = injection well) inlcuding the two trial boreholes presently underway

Beca also assisted CCC to commission initial surface geophysical studies. Southern Geophysical conducted shallow seismic and electrical resistivity studies to provide an early indication of likely geological structures beneath the Pond Site 10 drill site. The interim geophysical testing report is provided in Appendix K. This shows geological structures of interest with stronger seismic reflections occurring from approximately 70 m depth. The geophysical results will be updated and calibrated against the investigation borehole results.

4.4.5 Groundwater Survey

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4.4.6 Result of Investigative Bores

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4.4.7 Update of Hydraulic Model

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4.4.8 Conclusion

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4.5 Pipeline to Eastern Bays

4.5.1 Pump Station for Conveyance to Eastern Bays Irrigation Sites

A high pressure pump station is required to convey treated wastewater from Pond Site 10 to potential irrigation sites in the eastern bays (Goughs site or Pompeys Pillar). It is intended to pump in a single lift, with a pump station located at Pond Site 10 adjacent to the treatment plant. The pump station will be subject to ~580 m static and ~640 m operating heads. There are minor differences in head for the two different irrigation sites. Although operating at a much higher pressure than other council-owned pump stations, the design configuration and operation of the station will be similar to standard council stations.

The design duty for the pump station is 14l/s pumping to ~610 TDH. The specimen pumps chosen for this duty are KSB Multitec high pressure pumps, 185Kw each, operating on VSD control to mitigate potential surge pressures in the discharge pipeline. Two pumps will be setup in duty / standby configuration, with a heavy gauge mild steel manifold pipework and valves connecting. Significant thrust restraint will be required to protect the station from potential surge pressures from the uphill pipeline. It is intended that the restraint be buried external to the building structure.

The pump station will be a single building of concrete tilt slab construction with an integral MCC room. For serviceability the pumps will be removable using a standard monorail crane.

4.5.2 Reticulation from Treatment Plant to Eastern Bays Irrigation Sites

It is intended to pump in a single lift so the pipeline will be exposed to nominally 580 m of static head (610 m total dynamic head). A surge analysis has not been completed on the pipeline, but a transient pressure of 50% of working pressure is considered a representative estimate. On this basis the maximum design pressure requirement of the pipeline is 960 m (9,600 kPa) at the pump station, and a minimum pressure of approximately 2 m at the discharge point. This provides the opportunity to select different class pipe and/or materials along the pipeline.

The pipeline will be subject to transient pressures in response to flow changes at the pump station. Variable speed drives will be employed to provide a gradual ramp up and ramp down as pumps turn on and off to attenuate pressure transients. The aim of the design will be to reduce the transients as much as is practicable in order to reduce cyclical loads on the pipeline.

There is also a possibility that column separation may occur if a vacuum is created inside the pipe at any time. The pipeline will be designed to reduce transients, but under some conditions such as a power outage causing the pumps to stop quickly, column separation may occur. Transient analysis will be conducted in the next stage of design to confirm operating and shutdown scenarios and associated transient conditions.

Pipeline material options have been assessed based on the duty described above.

4.5.3 Pressure Pipeline Material Selection

A range of pipeline material alternatives have been reviewed as follows;

- HDPE
- Cement lined mild steel
- Ductile iron cement lined
- Stainless steel
- Mild Steel (unlined)
- Epoxy lined mild steel

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FRP and PE lined steel have been excluded from this study. FRP can only be sourced at PN32 with unrestrained joints and considered unsuitable. PE lined steel pipe has been excluded as a supplier could not be sourced in New Zealand or Australia.

The pipeline has been considered in two discrete sections and the high-level evaluation of options is outlined in the following sections of the report:

- Uphill pipeline from Old Coach Road to hilltop
- Downhill pipeline from hilltop to Townshend's property / Pompeys Pillar

4.5.3.1 HDPE

High density polyethylene is the preferred pipe for sections with a maximum operating pressure of <1,400 kPa. PE100 PN16 SDR 11 has been selected for concept design. Whilst there is the option to use PE100 PN25 SDR 7.4 this has not been included for the following reasons:

- It introduces an additional pipe material/class
- Difficult to source spare pipe and fittings
- Does not comply with the CSS
- Can be substituted for steel or ductile iron as discussed in the sections below

4.5.3.2 Cement-lined Mild Steel

Cement-lined mild steel (CLMS) is a well-established option for wastewater piping applications, combining the strength of steel and corrosion protection afforded by the cement lining.

Cement-lined mild steel will require the wielding of pipe sections. There are proprietary joints available that allow the wielding of the joint without damaging the internal lining. These joints can provide a deflection of approximately 3 degrees to reduce the number of fittings required. The welding of a DN150 CLMS pipe will impact pipe laying productivity, and welding in the trench would require stringent quality control.

There is some concern about the possibility of transients damaging the liner over time due to cyclical loading. This concern would need to be resolved through discussions with the pipe supplier during the design phase, and completion of a surge analysis.

4.5.3.3 Ductile Iron Cement Lined

Ductile iron cement lined (DICL) is a well-established option for wastewater piping applications, combining the strength of DI and corrosion protection afforded by the cement lining.

DICL has good mechanical properties and is installed without welding using gasketed socket type joints. The operating pressures for the uphill pipeline are well outside the pressure rating of standard ductile iron products. However, Saint-Gobain offer a concrete-lined ductile iron pipe with pressure rating of 100 Bar and surge rating of 120 Bar. This would potentially meet the operating pressure requirements, subject to further design assessment. The Saint-Gobain pipe has self-anchoring socket joints to provide a fully axially restrained pipe. This eliminates the need for thrust protection normally required for socket connections. While the supply cost for this pipe is likely to be higher than for welded steel pipe, the installation costs will be comparatively lower. This material provides a 100-year life.

There is some concern about the possibility of transients damaging the liner over time due to cyclical loading. This issue would need to be resolved through discussions with the pipe supplier during the design phase, and completion of a surge analysis.

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4.5.3.4 Stainless Steel

Stainless steel pipes are used for wastewater conveyance and in wastewater treatment plants in some circumstances. A stainless-steel pipeline can be fully welded, is moderate cost, and offers a degree of corrosion resistance. Commonly used and readily available options include SS304 and SS316. However, both materials are austenitic stainless steels which are known to suffer from stress corrosion cracking in the presence of chlorides. Akaroa wastewater contains elevated[3] levels of chlorides due to salt water incursion into sewer lines.

A welded pipeline may also be residually stressed, and the weld zone along with the rest of the pipeline will be subject to significant cyclical transients. These factors in combination with the presence of elevated chlorides may increase the risk of stress corrosion cracking on the pipeline. This risk will be difficult to assess and to manage. For these reasons stainless steel is not preferred.

4.5.3.5 Mild Steel (unlined)

Mild steel (unlined) pipe is not commonly used for wastewater applications due to the risk of internal corrosion. This issue can be addressed by provision of a corrosion allowance. The difficulty in this instance is assessing the corrosion rate and hence deriving the effective service life of the given pipeline. Further assessment would need to be undertaken to provide certainty of the service life of mild steel pipe.

The corrosion allowance has been assessed for a range of pipeline options using AS1579 Arc Welded Steel Pipes and Fittings Design Code. The analysis assumes an allowance for pressure transients of 50% above Total Dynamic Head i.e. 94 bar. The results of our initial analysis are shown in Table 4-10 below.

Table 4-10 Corrosion Allowance for Steel Pipe Options

Pipe Material	Wall Thickness (mm)	Corrosion Allowance (mm)
Schedule 40 mild steel Grade 250	7.11	2.05
Schedule 40 mild steel Grade 300	7.11	2.75
Schedule 80 mild steel Grade 250	10.97	5.45
Schedule 80 mild steel Grade 300	10.97	6.1

Schedule 40 Grade 250 steel offers a corrosion allowance of 2.0 mm while Schedule 80 Grade 250 steel provides 5.4 mm. Grade 300 steel provides slightly higher allowances.

The pipe would likely require pigging to remove tubercles that would increase pipe friction losses. Although not a frequent exercise it would be disruptive to the operation of the scheme.

4.5.3.6 Epoxy Lined Steel

Epoxy lined steel is not an approved Council material for pressure pipelines. It has been used for well casings in Christchurch without treatment on the welded joints. In terms of similar pipelines around New Zealand, epoxy lined steel was selected as the material for the WAS pipeline from Wellington (Moa) Wastewater Treatment Plant to the Careys Gully Dewatering Plant. This pipeline transfers waste activated sludge at 3% solids at pressures up to 600 m. The Moa WAS pipeline is fully welded and each internal weld joint was coated in situ after welding by inserting a painting spigot into the pipeline. The quality of the internal paint finish across the welded joint is difficult to ascertain and this represents a risk to the integrity of

[3] Akaroa wastewater chloride is elevated compared to normal municipal wastewater

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the pipeline system. Nevertheless, an epoxy lined pipe with internally epoxy coated joints is a more robust option than unlined mild steel pipe.

In addition to epoxy lining the pipe, a corrosion allowance must also be provided to provide an acceptable service life. Refer to Section 4.5.3.5 for discussion on corrosion allowance.

4.5.3.7 Uphill Pipeline Summary

For the sections of pipe with pressure less than 1400kPa pressure, HDPE is the preferred material choice.

For the higher-pressure section ductile iron cement lined pipe is the preferred option. For the following reasons:

- Ductile Iron cement lined pipe has a proven track record in water and waste water applications
- Provides a 100-year service life
- Complies with the CSS
- Installations requires less labour than welded pipe
- QA procedures are well established
- Any concerns of transient pressures can be addressed in preliminary design. Should Council wish to look at the alternative materials discussed this can be undertaken in the next phase of design.

4.5.3.8 Downhill Pipeline Option

The downhill pipeline(s) from top of hill to Townshend's property and/or Pompeys Pillar irrigation sites are gravity pipelines. The options looked at were a controlled pressurised system and a gravity system. Following discussions with Council the gravity concept design has been developed in preference to the pressure system option.

This approach for the gravity system is to avoid the need for any mechanical components such as control valves. The preferred approach to these pipelines is to employ a simple low-cost material of construction, preferably HDPE. Ideally the system should be "passive" in the sense that no pressure or flow control valves are required to maintain a prime in the pipelines and the system runs by gravity without any control.

The following are key design criteria to allow the passive system to perform:

- Maximum pipe velocity 8 m/s to avoid erosion
- Hydraulic jumps within the pipe to be avoided if possible
- Inverted siphons are preferred over deep excavation
- Stand pipes are to be used in preference air valves
- Minimum pipe grade of 1:100 (to increase this grade a DN200 pipe is required)
- The alignment sits within the current road reserve which has a variable grade. A maximum of 15% grade has been assumed. This would limit the pipe velocity to approximately 2.5 m/s.
- There are sections of road that travel down through small gullies. We have proposed to install inverted siphons in these locations to avoid installing deep sections of pipe. These sections of pipe that will remain full at all times. Typically, these will be small sections of pipe however on the Townsends option there is a 2000 m section that will operate as an inverted siphon. Consideration needs to be given to the requirement for a scour valve in these locations. Typically, the issue with siphons is the build-up of grit and stones. These will not be present in the effluent pumped from the WWTP. Scours valves have not been allowed for in the current design. The available data is to course to understand the exact quantity of inverted siphons, but it is assumed to be in the order of 15 (Pompeys worst case scenario).
- The downhill section of pipe will flow at <50% full depending on grade. Care will need to be taken where grade changes can cause hydraulic jumps that can create a hydraulic restriction. This can be dealt with

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through installation of a sealed chamber. The quality of existing level data does not allow an accurate understanding how many siphons will occur.

Stand-pipes will be installed to allow air to be drawn in and expelled. These have been selected in place of air valves as they are maintenance free. There is always a risk of a blockages, but the effluent has been fully treated. The risk of blockage would come from foreign objects being introduced post pump station. This could only occur at the discharge manhole or maintenance points (if installed). To manage this risk to avoid the hydraulic grade being lifted above the height of the stand pipes and pressuring the lower sections of the pipeline overflows should be installed. These would need to be located close to water ways to provide a flow path in the unlikely event of a blockage.

4.6 Irrigation Design

Irrigation design concepts are based on the designs developed in 2017 – with dripline irrigation to trees or spray irrigation to pasture. There are some particular considerations for each type of irrigation to promote the sustainability of the irrigation scheme.

4.6.1 Phosphorous Uptake by Trees

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

- Total average P concentrations in the top 0.3 m would remain within the range of total P concentrations found in NZ's agricultural soils
- Olsen-P (a measure of plant-available P) 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)
- P-leaching below the top 0.3m of topsoil would increase. However, most of this P would be retained in the subsoil before it reaches waterways. Given that NZ-native vegetation will decrease surface runoff and soil loss, the increase in P leaching will be more than offset by the reduction of P entering waterways through erosion and overland flow: There is likely to be less P lost by irrigation to NZ-native vegetation than an intensively grazed pasture.

This assessment is based on a range of phosphorus in the treated wastewater from 5 to 15 mg/l. Predicted phosphorus in the treated wastewater is 7 mg/l and on a typical average influent of 10.5 mg/l.

Based on this assessment and the likely effluent quality no phosphorous removal is anticipated at the WWTP for the irrigation to trees option.

4.6.2 Nitrogen Loading for Irrigation to Pasture

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 effluent is 46mg/l. At this effluent concentration the nitrogen loading rates for various irrigation areas are given in Figure 4-16. The standard nitrogen loading rate for pasture used for beef cattle is 150 kg/ha/yr. However, a loading rate as low as 100 kg/ha/yr may be required depending on a number of factors such as soil quality, stock levels.

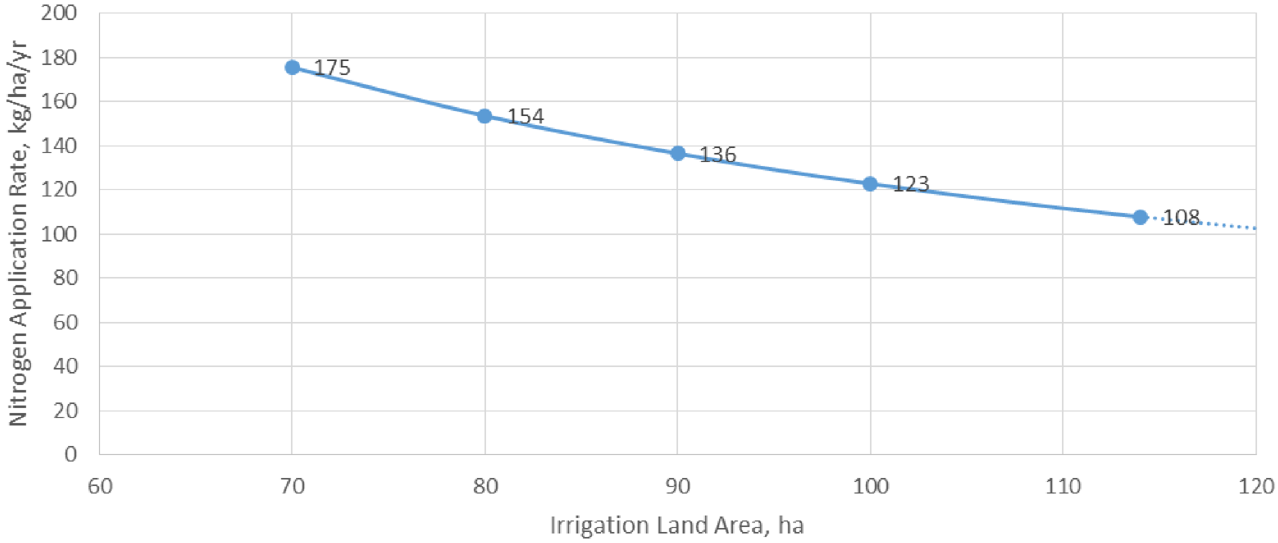

Figure 4-16 Nitrogen Loading Rate

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5 Overall Scheme Options

Based on work done to date the following scheme options are under consideration:

1. Harbour outfall (as the base case)
2. 100% bore injection
3. Irrigation to trees in Robinsons Bay with bore injection
4. 100% irrigation to pasture at Goughs with dam storage
5. 100% irrigation to pasture at Pompeys Pillar with dam storage

New concept designs have been developed for options involving bore injection. The concept designs for options with irrigation have been updated for the new irrigation areas and storage volumes required for the increased flows as outlined in Section 3.6. The following sections describe the design basis and assumptions for each scheme option.

5.1 Harbour Outfall

For the purpose of the preliminary design in 2014 a harbour outfall was specified as the disposal route for treated wastewater. The outfall was initially sized for 65 l/s of flow, with 14 l/s fully treated and flows in excess of 14 l/s bypassing the treatment plant and flowing directly, with UV disinfection, to the outfall. The resulting pipeline and outfall was sized at DN250 to accommodate this flow.

As part of the work done in 2017 on investigation of land irrigation alternatives, and in response to feedback from the Akaroa Wastewater Working Party, Council removed the bypass and committed to providing membrane treatment of 100% of the flow. Removing the bypass eliminates the disposal of partially treated wastewater to the environment during wet weather. To achieve zero bypass requires additional wet weather storage and extra membrane filtration area within the treatment plant. An effect of zero bypass is to throttle the wastewater flows to the harbour outfall to a maximum of 14 l/s.

Reducing the peak flow provides an opportunity to reduce the size of the harbour outfall pipeline. Beca has evaluated potential reductions in the pipeline sizing and has also referred to costs for the current Lyttelton harbour marine wastewater pipelines provided by CCC. Based on the likely smaller line sizing and per meter rates from Lyttelton, the derived costs were found to be similar to the initial estimate allowing for inflation from 2014 (12% total over 4 years). This escalated figure has been used for cost estimation purposes.

The concept design for a harbour outfall scheme option includes:

- Raw wastewater storage at Pond Site 10 to buffer wet weather flows
- Wastewater treatment plant (100% membrane treatment)
- Pipeline to harbour and harbour outfall
- Purple pipe network (Option 1)

5.2 100% Bore Injection

If bore injection is found to be a feasible concept it would be possible to build a scheme around bore injection where the total volume of treated wastewater can be injected. This avoids the need to construct large storage ponds and obtain large volumes of land for irrigation. As outlined in Section 4.4.3 the preferred site for injection was determined to be around Pond Site 10. The concept design for a 100% bore injection scheme is based around injecting at Pond Site 10 and is made up of the following components:

- Raw wastewater storage at Pond Site 10

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- Wastewater treatment plant (full treatment)
- Four injection bores of 150 mm diameter and up to 250 m deep
- Eight monitoring bores of 125 mm diameter and up to 250 m deep
- Purple pipe network (Option 1)

A layout map is given in Appendix L that shows indicative locations of the injection and monitoring bores.

5.3 Irrigation in Robinsons Bay (Thacker land)

5.3.1 Outline of Scheme Option

The owner of the Thacker Property at Sawmills Road in Robinsons Bay instigated discussions with the Council in 2017 regarding possible purchase of that land for use as a wastewater irrigation area. Beca therefore conducted an initial investigation into the feasibility of using this land for irrigation of trees using drip irrigation during 2017.

The initial walkover identified a preferred area for irrigation with slope less than 19 degrees. The use of 19 degrees is based on the USEPA Guideline recommendation that afforested slopes may be irrigated up to 19 degrees rather than the more conservative 15 degrees previously assumed. There is a total of 62 ha of land with slope less than 19 degrees. Of this the preferred area for irrigation amounts to 30.7 ha.

Based on the revised flows and loads there is insufficient irrigable area on the Thacker land for a 100% irrigation scheme. In the last round of investigations there were several pond sites identified, but these would not have the storage capacity required for a 100% irrigation scheme. Therefore to progress a scheme using irrigation to trees on the Thacker land, this disposal option would need to be combined with another option such as bore injection to enable the treated wastewater to be disposed of when irrigation is not possible.

The concept design for a scheme option with irrigation to trees on the Thacker property would include the following components:

- Raw wastewater storage at Pond Site 10
- Wastewater treatment plant (full treatment)
- Bore injection scheme around Pond Site 10 (4 injection bores and 8 monitoring bores)
- 5.6 km pipeline from Pond Site 10 to irrigation area
- Irrigation pump station and distribution pipelines and irrigation system at the Thacker farm based on dripline irrigation to native trees
- Non-potable reuse network (Option 1)

The pipeline design for this option has been updated since 2017. To make sure the treated wastewater can be transferred from Pond Site 10 by gravity, and to comply with Council standards, the pipeline is now specified as DN180 PE100 PN16 pipe.

The irrigation concept map for the Thacker land is attached in Appendix M.

5.4 Irrigation at Goughs

5.4.1 Overview of Scheme Option

In 2017 Mr Keith Townshend, the owner of a property between Goughs Bay and Hickory Bay, approached Council indicating that he would be interested in irrigating treated wastewater on his land. Mr Townshend

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has previous experience with irrigating treated wastewater on a farm he owns in Ashburton and viewed this as a favourable option to his farming practice.

The land around Goughs Bay and Hickory Bay (henceforth known as the Goughs site) had been identified as potentially irrigable in the high level screening carried out in 2017. However the site was not shortlisted due to the increased distance from the treatment plant and so was not investigated further at that time. When it was found that a large irrigation area was required, and with the positive input of Mr Townshend, the site was revisited as an option.

As with other irrigation options, a Goughs scheme would be made up of the following components:

- Raw wastewater storage at Pond Site 10
- Wastewater treatment plant (reduced denitrification)
- Treated wastewater pump station at Pond Site 10
- 11 km pipeline as described in section 6.4
- Treated wastewater storage dam for the storage of treated wastewater at the irrigation site when it can't be irrigated
- Irrigation pump station and distribution pipelines and irrigation system at Pompeys Pillar based on pole mounted fix grid irrigators.

An indicative layout of a Goughs irrigation scheme is given in Appendix M.

5.4.2 Assessment of Potentially Irrigable Area

Detailed survey information was not available for the Townshend site and assessment of irrigable area was initially based on 8 m DEM which had been found to be misleading in the past. Council organised to capture survey information via airborne LIDAR. The site was flown in May 2018. The data captured allowed the GIS mapping for the site to be refined.

A site walkover was also undertaken to assess slope stability and irrigation potential on 24th May 2018. A full outline of the findings is given in Appendix N, however the general findings were 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.

Because of the limited topsoil in some of the irrigable areas, a lower Profile Available Water (PAW) figure has been assumed and used for the irrigation modelling of the Townshend land. That is, because there is less depth of soil, there is less capacity for the land to absorb irrigated water. The PAW for the Townshend land needs to be confirmed by on site infiltration testing. This will be undertaken if the option is selected to proceed.

During this visit the possibility of irrigating on the property closer to the coast was introduced. This area had not been picked up by the 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 28th June 2018. Notes from this site visit are included in Appendix N. After this visit the potentially irrigable area map was updated based on the findings. A potentially irrigable area of approximately 112 ha was identified.

For irrigation to pasture at either Pompeys Pillar or Goughs (Townshend land), treated wastewater will need to be pumped from the new wastewater treatment plant, over a hill 620-680 m above sea level and a distance of 10 – 13 km to the irrigation area. A number of options were considered for the pipeline to both sites. These considerations are described in the following sections.

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5.4.2.1 Pipeline to Goughs

The pipeline to the Goughs irrigation site is 10.7 km in length. The difference in elevation between the pump station and highest point of the pipeline is 580 m. As described in Section 4.5 the uphill pipeline will be fabricated from cement lined ductile iron (DICL), the downhill section will be made of polyethylene. On overview of the pipeline is given in Figure 5-1.

Figure 5-1 Pipeline to Goughs Irrigation Site

5.4.2.2 Goughs Dam Storage Concept

The concept for storage at Goughs is based on forming a pond by damming an existing ephemeral waterway. There is approximately 112 ha of irrigable area on the Townshend land, the target storage volume of treated wastewater for this land area to allow 100% irrigation is approximately 65,000 m³. 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 will 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 to be 3 m wide, with concrete side walls of 1m height.
- Crest of the dam to have a concrete road on it, 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).
- 3 m wide, 250 mm thick, reinforced concrete ramp down into the pond base to allow for removal of solids that are deposited.
- 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 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.

Imported engineered fill, approximately 30,000m^3, will be required for the drainage core of the dam. It has been assumed that other material for building the dam can be obtained from borrow on site within a distance of 800 m from the dam site. The soil required to be harvested from borrow sites is approximately 102,500 m^3. This assumption needs to be confirmed by physical soil testing on site as costs for the dam could increase significantly if more imported fill is required.

In October 2017 Council installed a weather station on the eastern side of Banks Peninsula, above Pompeys Pillar. The rain data from this station has been used to estimate the amount of rainfall likely per year. Based on the data to date, an annual rainfall of 1,500 mm has been assumed. It is recommended that a weather station is installed at the location of the dam option is to be progressed. Rainfall throughout the entire year will need to be catered for from the dam system, i.e. discharged to irrigation system. It may be possible to directly discharge stormwater during the irrigation system to the valley below, but this may require cleaning of the dam for direct discharge of stormwater to the environment. The earthworks for the dam may only be constructible during summer months due to environmental conditions.

The HDPE liner will have a limited life, due to exposure to the elements (UV) and it is estimated it may need to be replaced every 10 years. Maintenance/repair inspection would be required to be undertaken frequently, and at the very least annually to monitor this.

As the pond will be uncovered, some form of filtration system would be required for the irrigation outlet to prevent blockages of the irrigators by things such as dead birds and debris that could fall into the dam. It is likely also that a pump station would be required downstream of the irrigation dam to provide the necessary head to the irrigation areas that lie above the floor of the dam.

No geotechnical analysis has been completed for the dam construction, it is unknown if the slopes formed are too steep and liable for failure during earthquakes. If this option is progressed further physical site testing of soil conditions should be undertaken to inform the design.

5.5 Irrigation at Pompeys Pillar

5.5.1 Overview of Scheme Option

Irrigation to pasture at Pompeys Pillar was assessed in 2017. The key components of this scheme include:

- Raw wastewater storage at Pond Site 10
- Wastewater treatment plant (reduced denitrification)
- Treated wastewater pump station at Pond Site 10
- 13 km pipeline as described in section 6.4
- Treated wastewater storage pond for the storage of treated wastewater at the irrigation site when it can't be irrigated
- Irrigation pump station and distribution pipelines and irrigation system at Pompeys Pillar based on pole mounted fix grid irrigators.

Initial indications are that this site is exposed to higher wind velocities than the other sites and this may influence the irrigation scheme.

An indicative layout of an irrigation scheme at Pompeys Pillar is given in Appendix M.

5.5.2 Reticulation to Pompeys Pillar

The pipeline to Pompeys Pillar irrigation site is 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 will be similar in design concept to the Goughs pipeline described in Section 5.4. A long section for the pipeline is given in Appendix O, with an overview of the pipeline shown in Figure 5-2.

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Figure 5-2 Pipeline to Pompeys Pillar

5.5.3 Pompeys Pillar Storage Dam Concept

The concept for storage at Pompeys Pillar is based on forming a pond by damming an existing ephemeral waterway in a valley on the site. This pond site is hidden from view from all terrestrial viewing points surrounding the farm. There is approximately 91 ha of irrigable area at Pompeys Pillar, the target storage volume of treated wastewater for this land area to allow 100% irrigation is approximately 85,000 m^3. The total dam volume that has been modelled includes allowance for rainfall (approximately 1,500 mm) and freeboard (approximately 1,500mm). The dam would be of similar construction to that proposed for the Townshend land being an earth bund dam with HDPE liner and concrete structures of dam crest, ramp into dam base and spillway.

Imported engineered fill of 20,000 m^3 would be needed for the drainage core of the dam. Soil required to be harvested from borrow sites is 45,000 m^3. It is assumed there is sufficient borrow on site within a distance of 600 m from dam site.

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6 Resource Consents/Authorisations

6.1 Overview

The resource consents and authorisations relevant to the disposal options under consideration were referred to in the Akaroa Wastewater Investigation of Alternative Sites for Land Irrigation (CH2M Beca, March 2017) report under Section 7. The considerations specifically addressed Takamatua Valley sites, Robinsons Bay Valley sites, and Pompeys Pillar headland site and a storage pond in terms of the Pond 10 site. The conclusions in that report still apply except for some minor changes to the Christchurch District Plan provisions following the plan being made operative in December 2017, which are detailed below.

This updated report considers the relevant planning considerations for the development on the "Pond Site 10", the Thacker site, Pompeys Pillar and the Townshend site 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 township. It is noted that this assessment is to identify the key planning considerations only and a more detailed panning assessment will be undertaken once the preferred site is selected.

6.2 Pond Site 10

Pond Site 10 is located adjacent to SH 75 and Old Coach Road, Akaroa. Figure 6-1 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 utility building housing a pump station (approximately 7.5 m x 10 m with an internal height of 3.5 m), reinjection bores and associated pipes and ancillary equipment as shown on Figure 6-1. The storage ponds will be covered and the utility building partly set into the slope of the site.

6.2.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone in the Christchurch District Plan (CDP) as shown on Figure 6-1.

The proposed activities associated with wastewater disposal area "utility" under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set pout 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 15m 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 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).

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.

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 site is located within this silent file area as shown on Figure 6-1. Earthworks relating to development of the site require resource consent as a restricted discretionary activity in terms of Earthworks Rule 8.9.2.3 RD5 as the earthworks are within a site 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 9.6.1. Such applications are not required to be publicly notified under Rules 8.9.1 and 11.3 (j). This is a new requirement following the CDP being made operative in December 2017.
- Rule 17.4.2.3Identified 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 1 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 17.4.1.3RD1 would be required. This is a new requirement following the CDP being made operative in December 2017.

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.

6.2.2 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.
- The discharge of contaminants to air from the disposal of human sewage effluent in terms of the storage pond/equipment is a discretionary activity under Rule 7.63 of the Canterbury Air Regional Plan (CARP) given that Rules 7.50-7.52 cannot be complied with.
- The discharge of treated wastewater into deep injection bores into groundwater is a discretionary activity under General Rule 5.6 of the LWRP.
- The storage ponds will have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds will not occur. If there was a discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.

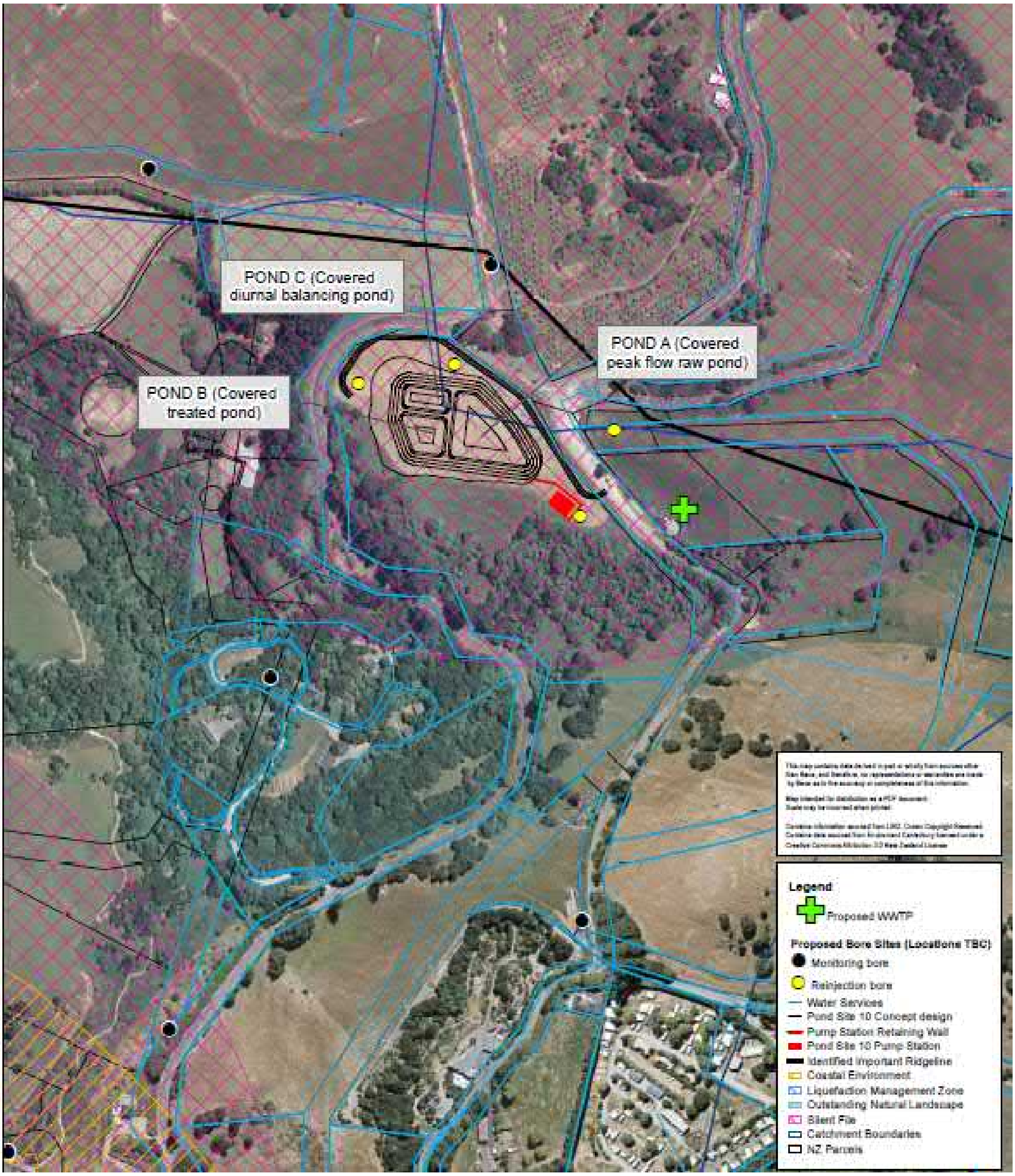

Figure 6-1 Pond 10 Site

6.2.3 Preliminary Assessment of Effects

An assessment of the site was undertaken for a pond only as part of the March 2017 report (Refer Section 7.7.1) and the relevant conclusions from that report can be largely adopted here (including the additional utility building) as follows:

In terms of effects the site is relatively well separated from sensitive uses with the nearest dwelling approximately 100m from the site. The Landscape and Visual Effects Review noted that the site is not visible from SH75 and views are limited from other vantage points and compared with other sites it is a preferred option. 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 treatment and operation regime and the distance to sensitive users.

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

In addition to the above, planting for naturalisation and screening purposes on the perimeter and between the ponds will assist to mitigate any adverse visual effects. Also, because users of SH 75 will see this vegetation, 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. The site is not located within any landscape overlays that trigger resource consents. While buildings may not achieve significant reduction below the Identified Major Ridgeline, the ridgeline in this location is broad and not sharply defined meaning any intrusion is less obvious, particularly as any buildings including the ponds are likely to have a low elevation. The utility building will also be located further down the site and set into the slope.

It is also noted that the ponds will be covered which will further reduce potential odour.

Noise effects from sources such as pump stations is anticipated to be minor and can be mitigated by measures such as insulation and maintenance of separation distances from sensitive uses.

In respect of the site being located in a Silent file area consultation should occur with Ngāi Tahu to determine the sensitivity of the site and agreement on conditions with regard to disturbance of the site. Ngāi Tahu are aware of potential development of the site and have not expressed any significant concerns.

In terms of the other activities on site testing is currently underway to determine the feasibility of deep bore injection. If the tests show that deep bore injection may be feasible on the site, then a number of injection bores will be located around the bores. However the quality of the wastewater to be discharged into the bores, effects on nearby drinking water bores, the dilution available in the groundwater, and the effect on coastal waters will be key matters.

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6.3 Thacker Site

The Thacker site is located at 11 Sawmill Road in the Robinsons Bay Valley as shown in Figure 6-2, which shows development areas and relevant CDP overlays. The development of the site includes irrigated areas, utility buildings, and associated pipes and ancillary equipment. The Thacker site is located in the Robinsons Bay Valley assessment area which was addressed in the March 2017 report (Section 7.2.1.2) and these findings can be applied to the site. In summary the following applies in terms of planning considerations for this site.

6.3.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone in the Christchurch District Plan (CDP).

The proposed activities associated with wastewater disposal area “utility” under the CDP. Rule 11.3a of Chapter 11 Utilities and Energy states that the rules that apply to utilities are set pout 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. 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).

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 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 pasture or 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 in terms of Rule 11.4.3 discretionary activity.

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.

6.3.2 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 .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 1m between any excavation and the aquifer and 50 m separation from a waterbody. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.
- The discharge of contaminants to air from the disposal of human sewage effluent in terms of the irrigated land is a discretionary activity under Rule 7.63 of the Canterbury Air Regional Plan (CARP) given that Rules 7.50-7.52 cannot be complied with.

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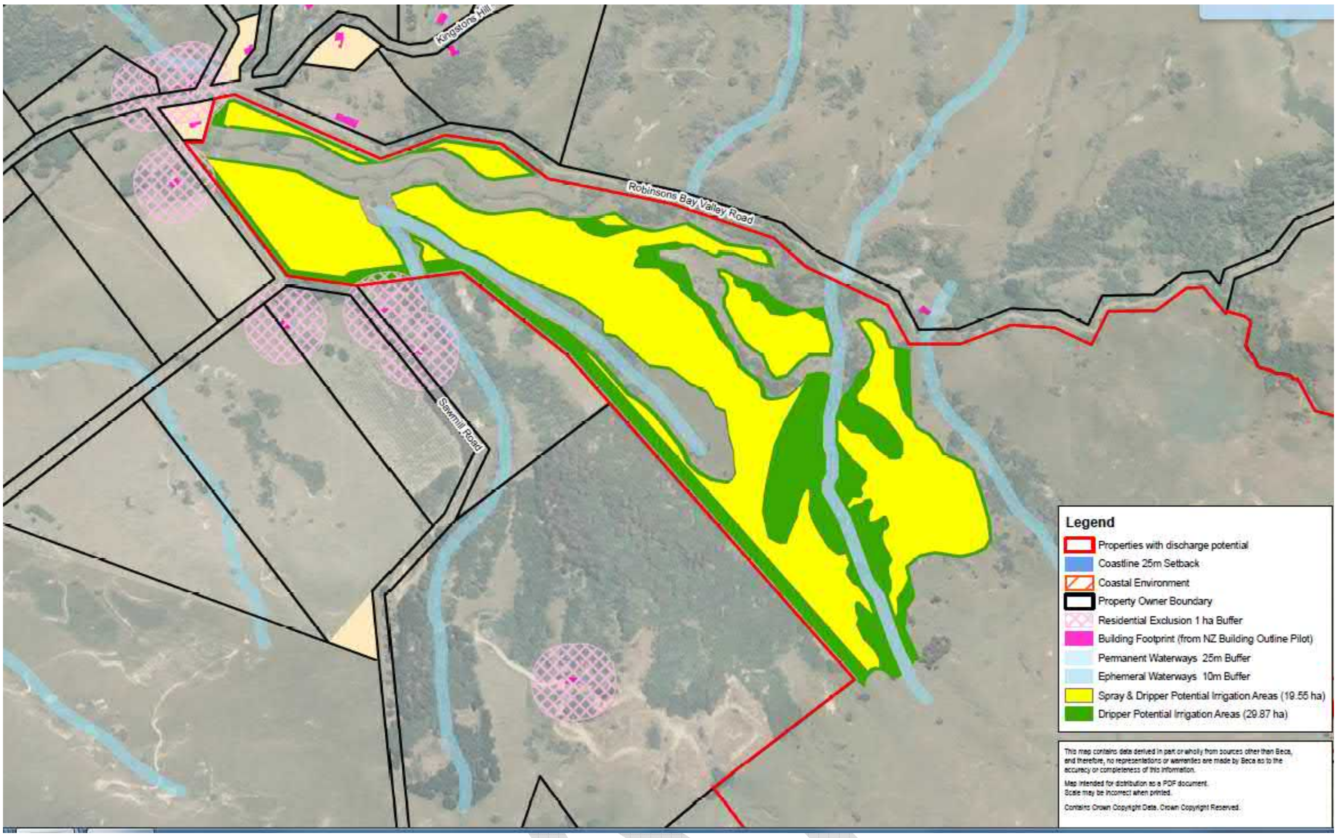

Figure 6-2 Thacker Site

6.3.3 Preliminary Assessment of Effects

The March 2017 report included a preliminary Assessment of Actual and Potential Effects on the Environment (Section 7.8) which can be applied to the Thacker site given that it is included in the Robinsons Bay Valley. In addition specific studies relating to the Thacker site in terms of geotechnical and infiltration matters are included in the March 2017 report. The conclusions from that report can be largely adopted here as follows:

- The report notes that in terms of visual effects. *The (landscape) review determined that all of the irrigated 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 the Thacker site.

- In terms of natural hazards the March 2017 report concluded that Beca's assessment *is that geotechnical risks are low for all shortlisted sites since geotechnically unstable land has been excluded from further consideration. Appropriate engineering design will minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity). The preference will be to locate storage facilities on, or within, relatively flat land so that these risks can be readily mitigated.*

The March 2017 report concluded that in terms of Effects on Soils, Groundwater and Surface water the following:

- 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 identified water bores and other ones should be confirmed and consideration of alternative waters supplies if required.
- The condition of existing waterways at the sites has not been assessed and any discharge into streams that then enter coastal areas would require assessment of the potential to cause adverse effects. However the possible locations for irrigation areas have been determined using setback distances selected to minimise the risk of discharge into waterways and low pressure type irrigators or drip lines that do not produce aerosols and/or planting of vegetation in the buffer areas will provide effective mitigation.
- In terms of heritage and cultural effects there are not any identified significant adverse effects. Ngāi Tahu 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.
- Modelling work carried out in 2017 concluded that the risk of irrigation odours is low 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 including from the effects of spray drift.

6.4 Townshend Site

The Townshend site is generally located on the eastern side of Banks Peninsula in an area between Goughs Bay and Hickory Bay. The Townshend site was not considered as part of the March 2017 report. Two sites comprising approximately 112 ha for irrigation are proposed – a site on a ridge area and a site lower down on the valley floor at Goughs Bay. Figure 6-3 shows the development areas and relevant CDP overlays. The general site is an isolated one with access from Goughs Road and Hickory Bay Road which are narrow and steep no exit gravel roads. There are a small number of farm dwellings on the Townshend site which are in relative proximity to the proposed irrigation areas.

The development of the site includes irrigated pasture areas, storage ponds including a dammed watercourse (Crown Island Stream), utility building to house a pump station in proximity to the dammed area, and associated pipes and ancillary equipment. Irrigation of trees is not proposed on this site. If Crown Island Stream is dammed this would result in a 45 m high dam containing approximately 100,000 m^3 of storage.

6.4.1 District Plan Provisions

The site is zoned Rural Banks Peninsula Zone in the 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.

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 11.8.1P2 for utilities, the standards in large part refer to bulk and location of buildings (which includes 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 17.2.3.9); 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. The Council's discretion is limited to the Built Form Standards that are not met. It is noted the utility building housing the pump station is likely to be of a modest scale which may not infringe any of the Built Form Standards. Similarly, depending on their location and scale, the storage ponds may also not infringe the Built Form Standards.

However, the use of the land for irrigation of wastewater to pasture 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 in proximity to the west of the ridge irrigated areas but does not apply to the site.

6.4.2 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 sewage effluent 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 .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 between any excavation and the aquifer and 50 m separation from a waterbody. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity
- If the storage pond is to be located in a waterway (such as Crown Island Stream), a resource consent is required under Rules 5.155 of the LWRP as a discretionary activity as it is unlikely that the volume limits and other matters (including the damming of a mainstem of a river) would be complied with. If the "mainstem" is dammed resource consent as a non-complying activity is required under Rule 5.156. Any associated diversion of a river requires resource consent under Rule 5.141B of the LWRP as a discretionary activity. It is also noted that dams that have a height of 4 or more metres and hold 20,000 or more cubic metres volume of water or other fluid, require building consent. (Dams that do not meet

these height and storage amounts do not require building consent, but must still comply with the Building Code).

- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond/irrigated areas is a discretionary activity under Rule 7.63 of the CARP given that Rules 7.50-7.52 cannot be complied with.

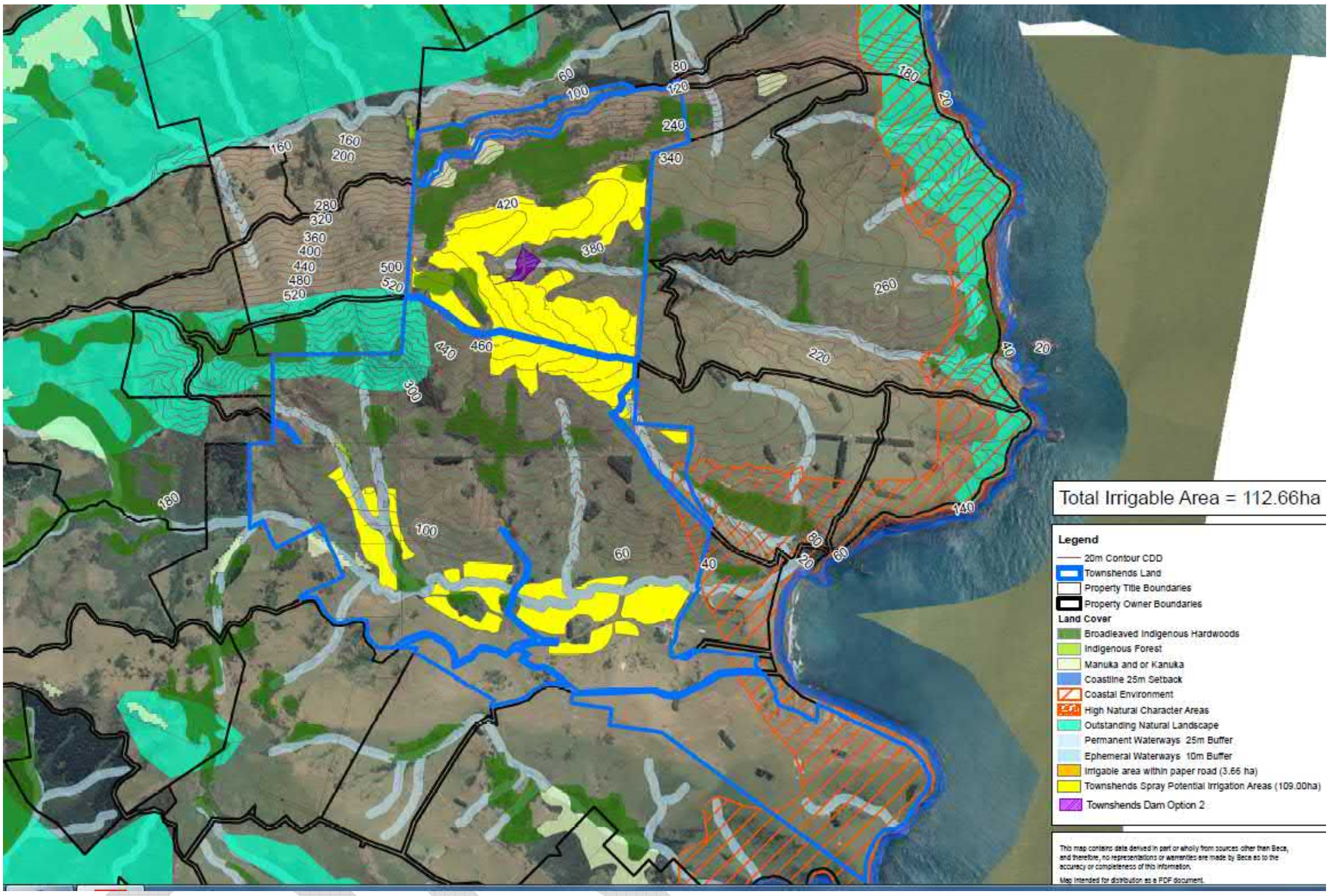

Figure 6-3 Townshend Site

6.4.3 Preliminary Assessment of Effects

Many of the matters addressed in the assessment of the Thacker site also apply to the Townshend Site. In particular the following is noted:

- The landscape, similar to Robinsons Bay, consists of a patchwork of various land cover and land uses including grazing and native vegetation and it is considered the introduction of a new land use in terms of irrigating existing pasture can be absorbed within this context. The sites are not in an ONL overlay and no tree planting is proposed. It is also noted that in terms of greening of the landscape, a permitted baseline exists in terms of “green” crops and irrigation of pasture with water is ancillary to farming, which is a permitted activity in the CDP.
- In terms of natural hazards geotechnical risks are low since geotechnically unstable land has been excluded from further consideration. Appropriate engineering design will minimise any risks of such matters as bund failure of storage facilities (e.g. from seismic activity). Larger dammed areas will require a building consent.
- In terms of Effects on Soils, Groundwater and Surface water:

  - 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.
  - There are no identified water takes within 2 km of the site and accordingly water supply should not be affected by irrigation to land. If there are other takes consideration of alternative water supplies can be undertaken.
  - The condition of existing waterways at the sites has not been assessed and any 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 have been determined using setback distances that have been selected to minimise the risk of discharge into waterways. In addition low pressure type irrigators that do not produce aerosols will provide effective mitigation. The location and impact of storage ponds on floodways will need to be specifically addressed in the design to avoid any changes to naturally occurring surface flooding events.
- The risk of pond/irrigation odours causing an adverse effect is considered low particularly with the absence of parties (other than Townshend) in the vicinity of the sites.
- In terms of heritage and cultural effects Ngāi Tahu have not identified any specific matters of concern or sites of significance to date. However a CIA has been commissioned which will provide further clarification.
- Land based recreation activities are unlikely to be adversely impacted given the absence of public recreation facilities and activities. 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 irrigated areas are located a substantial distance from the beaches.
- Akaroa treated wastewater will meet a very high standard and will present very low risks to public health including from the effects of spray drift, which is further mitigated by the absence of close neighbours.
- Noise effects from sources such 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.
- In terms of damming the Crown Island Stream for a storage pond, matters for consideration include integrity of the structure, effects on natural character, and provision of residual flow and fish passage. The design of the facilities should respond to the site and its surroundings by having regard to available contours, extent of earthworks and planting for naturalisation and screening purposes, particularly given the proposed height of the dam. It is noted however that the stream is ephemeral and is not located in any outstanding landscape, natural character or coastal overlays.
- In terms of access, significant upgrades to existing access ways will be required. Access ways are likely to have a gravel finish, therefore, they will be more noticeable when compared with the existing access ways on site. However when seen they will appear in keeping with the rural character of the site and its surrounds.

6.5 Pipeline to Townshend Site/Pompeys Pillar Site

It is proposed that the pipeline from the WWTP/Pond site 10 to the Townshend site and Pompeys Pillar site will be laid in legal road including Long Bay Road, Goughs Road and Hickory Bay Road. Roads in the CDP are zoned Transport and the installation of utilities is generally a permitted activity in this zone.

6.6 Pompeys Pillar Site Update

There is now a possibility that irrigation of the Pompeys Pillar site could occur within the Coastal Environment and Outstanding Natural Landscape overlays identified in the CDP. The most significant effect is likely to relate to visual impact. The March 2017 report assumed that the irrigation of this area would not

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occur although a subsequent Beca report "Pompeys Pillar Wastewater Land Irrigation – Landscape Character and Visual Effects - Strategic Consentability Summary Report (September 2017) did address this proposal.

The report in Section 8 noted that the *greatest potential for adverse effect on attributes is considered to be related to the potential 'year round' greening of the landscape which will change the existing character associated with the current farming practices. However, in this respect, it is noted that farming is included in the District Plan ONL attributes for natural processes and patterns and irrigation is an ancillary activity to farming activities. There is therefore the potential for an adverse effect on the existing farming character of the site, but within the planning context and when compared to the permitted baseline, it is not considered to be a significant consenting risk*.

Accordingly, based on this the consenting risk is not considered high.

In addition one of the options for a storage pond on the site includes the proposed damming of an ephemeral stream as shown in the diagram below.

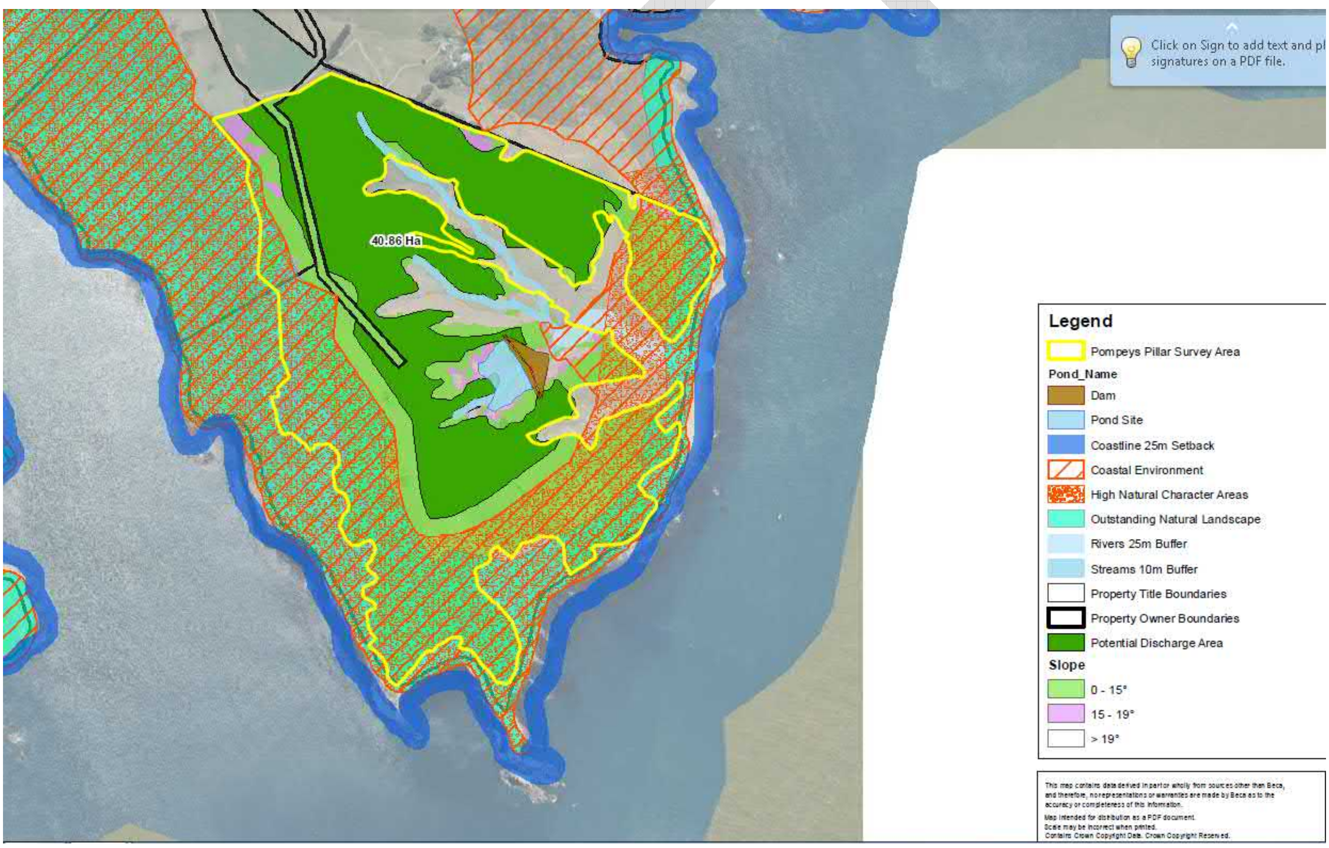

Figure 6-4 Storage Pond Site at Pompeys Pillar

The advice in the September 2017 report is still of relevance to this option and in particular the following in Section 6.4 "*the storage ponds will not change the nature of the landscape from a predominantly rural working landscape, the ponds will not impact on the wider volcanic landform or break the skyline or ridgelines, are not considered visually prominent in the context of the landscape, and will integrate with the existing landscape.*

Storage ponds within the site will be in keeping with a rural working landscape. However, excessive storage of water may alter the rural character of the site. It is recommended that not all four pond sites are used.

…

Additional adverse visual effects can result from cut faces associated with the construction of the ponds but these are limited in number and able to be integrated in a way that they are not 'visually prominent' in the context of the overall RAL (and therefore consistent with the policy direction). It is recommended that earthworks associated with earth bunds and cut faces have a slope of 0-15 degrees to appropriately blend into the immediately surrounding topography and be re-grassed to further mitigate the visual prominence".

Residual flows and fish passage may also be considerations although as indicated above the watercourse is ephemeral. Overall it is considered the consenting risk is low-moderate given the relative sensitive nature of the site.

6.7 Archaeological Sites

As indicated in Section 7.6 of the March 2017 report, Section 42 of the Heritage New Zealand Pouhere Taonga Act (2014) states that unless an Archaeological Authority is granted from Heritage New Zealand, no person may modify or destroy an archaeological site.

An "archaeological site" is defined as "a place that was associated with human activity that occurred before 1900". It is noted that Pond 10 site is located in a Silent File Area but potentially earthworks associated with any of the proposed study sites could result in a requirement to apply for an Archaeological Authority.

6.8 Reuse of Non-Potable Water

It is proposed to reuse treated wastewater for non-potable uses in Akaroa township for uses such as supply to:

- Irrigation of public parks and flushing of public toilets
- High density residential uses (such as accommodation providers) for toilet flushing.

In respect of parks the treated wastewater would be used for irrigation purposes. The use and discharge of treated sewage effluent from a community wastewater treatment system to land is a discretionary activity under Rule 5.84. Accordingly resource consent is required.

However the discharge onto land in 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 township which means that no parks in this area could be irrigated with the wastewater. It is understood the zones relate to groundwater bores that are no longer used and that Council will request that these bores and protection zones are removed so the "prohibited activity" discharge will no longer apply.

In assessing the discharge of wastewater for use on the parks it is critical any discharge is applied to land at rates that meet the assimilative capacity of the vegetation and soils. Odour is a consideration particularly given the likely proximity of residences, although the wastewater will be of high quality.

In respect of the use of the treated wastewater in public toilets and high density flushing it is considered that resource consent is not required because there is no discharge and the wastewater will be contained within a piped system.

As discussed in Section 4.3.4 of this report supplying treated wastewater to a property introduces a risk of contamination to the potable supply resulting from backflow events where cross-connection occurs. This can be addressed by installation of appropriate backflow prevention devices.

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6.9 Summary

This is a high level assessment of effects. As noted above, the assessment is preliminary only and has been undertaken without the benefit of detailed investigations.

Resource consents are likely to be of discretionary and restricted discretionary status although the damming of a mainstem of a river is a non-complying activity in terms of Rule 5.156 of the LWRP. The statutory threshold for a noncomplying activity is higher for a discretionary or restricted discretionary activity with the requirement to establish the adverse effects are not more than minor or the application is not contrary to the objectives and policies of the plan.

Similar to the March 2017 report (Section 7.9) the likely consenting risks for Pond Site 10, the Thacker site and the Townshend Site have been assessed below in Table 6-1 based on the following: high (red), medium (orange) or low (green).

Table 6-1 Likely Consenting Risks

Adverse Effect	Site	Risk	Comment
Landscape /Visual – storage pond/access/trees	All Sites	Low	The landscape and visual assessment identified a number of sites that have low to moderate risk. Effects can be mitigated by careful design in respect of such matters as contours and landscaping in terms of earthworks. In respect of the "greening" of land, a permitted baseline exists in terms of "green" crops and irrigation of pasture is ancillary to farming, which is a permitted activity in the CDP. Potential adverse effects relating to the irrigation of trees can be mitigated by the use of native trees.
Natural Hazards	All Sites	Low	Unstable soil areas avoided and facilities engineered to avoid bund failure.
Soils, Groundwater and Surface Waters	All Sites	Low	High quality wastewater, storage systems, setbacks from waterways, uptake by plants and lining of facilities reduces risk.
Noise	All Sites	Low	Little noise is anticipated to be generated.
Recreation	All Sites	Low	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. Potential public access to the sites results in a positive recreation effect.
Cultural/Historic Values	All Sites	Medium	Pond Site 10 in particular is located in a Silent File Area. The COUNCIL will continue to work closely with Ngāi Tahu to address concerns if they arise at this site and the others. A cultural impact assessment is underway at the Townshend site. Other sites are considered a low risk.
Terrestrial Ecology	All Sites	Low	No at-risk species identified at present.
Public Health – land and water	All Sites	Low	Discharges are likely to comply with relevant public health guidelines. The treated wastewater quality will be of a very high standard and suitable for use in public parks, so presents a very low public health risk. Implementation of setbacks from water bodies and minimising aerosol creation will also assist in mitigation.

Adverse Effect	Site	Risk	Comment
Odour and Spray Drift	All Sites	Low	Odour modelling has shown that the risk of odour is low. No aerosols would be generated by drip irrigation (for irrigation under trees), and the use of low pressure spray irrigation systems with buffer areas around the irrigation areas would mitigate any risk from aerosols from spray irrigation of pasture. Furthermore spray irrigation to pasture can be turned off if wind speeds are too high.
Amenity	All Sites	Low	While the actual or potential effects appear to be minor or minimal some people may perceive that amenity will be adversely affected particularly if the location of facilities is at the Thacker site, given its proximity to more populated areas. Conversely the public may perceive the establishment of additional native forest as a benefit to region. We do not consider 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 land-based 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 terms of the Pompey Pillar site, the visual effect is the main consequence of irrigating in the Coastal Environment Overlay and Outstanding Natural Character Overlay. Potentially this “greening” will increase the risk but its adverse effects are mitigated by a permitted baseline in which irrigation with water as part of a farming activity is permitted by the CDP. Similarly the damming of an ephemeral stream for a storage pond may be acceptable if appropriate landscaping provisions and other mitigation measures are put in place.

In respect of the reuse of non-potable water in Akaroa township the risk is anticipated to be low given the wide community support for this activity although in any irrigation 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.

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7 Cost Estimates

7.1 General Assumptions

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

The estimates assume the proposed work can be consented – allowances have been made for consenting costs.

The estimates are based on rates and prices current as of 3rd quarter 2018 and no allowance has been included for increases in costs of labour, materials or plant beyond this date.

7.2 On Costs

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

- On-site overheads or Preliminaries & General ("P&G")
- Off-site overheads and profit ("Margin")
- Contingency allowances
- Professional Fees
- Client costs
- Consenting
- Land purchase and access

7.2.1 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 allow 12% of net construction estimate value for Preliminary and General and Contractor's margin (on-site and off-site overheads).

The estimates allow approximately 6% – 12% of the estimated value of pipelaying for Traffic Management

7.2.2 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.

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These contingency allowances reflect the current status of the design, the potential for design development changes, and the anticipated risks of construction (pipelaying, deep well drilling, large dam storage etc). There is an additional 20% "Contractor's Risk" allowance included in the Outfall estimate which we assume will be procured and built 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 Client-driven scope change and we recommend that the Client hold a separate project contingency budget for this.

7.2.3 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.

The estimates allow 13% of Total Construction Budget value for Professional Fees for design and construction monitoring.

7.2.4 Client Costs

The estimates allow 4% of the total construction estimate value for CCC client-owned project-related costs, including staffing and management, consultation and community coordination/liaison fees.

7.2.5 Consenting

The estimates include lump sum allowances ranging from $200k - $500k for costs associated with the resource consent process.

7.3 Specific Assumptions

7.3.1 Provisional Sums

The estimates include provisional sum allowances for the following items:

- Power supply to irrigation sites
- Removing or including treated wastewater pond B as Pond Site 10
- Upsizing the raw wastewater pond at Pond Site 10 to 10,000 m^3 to capture 1 in 10 year events

7.3.2 Harbour Outfall Costs

It is noted that estimates for marine works are difficult as tendered prices are likely to range over 100% depending on perception of risk, and access to appropriate floating plant.

7.3.3 Land Purchase Costs

Land purchase costs are based on approximate areas required for irrigation and use weighted average rateable values applied to the land area required in each location. Actual areas purchase may be larger – the current cost estimates are based on only purchasing the amount of land required for irrigation and construction of ponds. Note that costs have not been allowed for purchasing larger blocks of land sub-dividing and reselling sections of the land, however a land acquisition factor of 25% has been included for each option where land purchase is required.

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Council are currently in negotiations with the landowner around Pond Site 10 and have commissioned valuations of the property as part of this process. An allowance of $800,000 has been included for purchase of this site.

For Goughs (Townshend land), the landowner is willing to lease the land to the Council for use as an irrigation site. Council are in the process of drawing up a lease agreement for discussion with the landowner. At this stage no land purchase costs have been included in the capital cost of the Goughs option. An allowance of $50,000 has been included to develop and implement a lease agreement.

7.3.4 Storage Ponds

The basic concepts for the size and design of the storage ponds and dams are described under each scheme option. It is assumed that both ponds and dams will be of earth construction and fully lined with HDPE liner.

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 on the 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.

Use of on-site borrow, while reducing the construction cost of the dam, is likely to be detrimental to irrigable areas. The estimates include allowances for making good irrigation area at each site based on the rough volume of material that is required.

7.3.5 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 at $5,000/ha and assumes small diameter polyethylene pipe or similar laid on the ground a 1 – 1.5m spacing.

A cost of $3,850/ha has been allowed for planting and establishing the trees. This has been based on $1,100/ha for the supply of tree seedlings (assuming a density of 1100 stems/ha), and $2,750/ha for planting and fertilising. The estimates do not include any allowance for replacing trees or post-planting maintenance.

7.3.6 100% Irrigation to Pasture

In accordance with landowner request, the estimate assumes that the irrigation system installed on the Townshend property will be in the form of pole-mounted, fixed-grid sprinkler type irrigators. We have assumed that this will also be suitable for Pompeys Pillar. The estimate includes $15,000/ha for pole mounted systems based on industry advice for typical installations. The estimate assumes pasture on site is suitable for use and excludes pasture renewal costs and fertilising.

No allowance has been made for shelter belt planting as both sites are relatively remote and not immediately adjacent to any residential properties that could experience spray drift.

7.4 Cost Estimate Summary

The capital cost estimates for the current short list of disposal options range from $7.4M to $29.1M as below shown in Table 7-1. These costs are for treated wastewater disposal only and exclude costs that are common to all options, such as construction of raw water ponds on Pond Site 10. Breakdowns are given in Appendix P.

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Table 7-1 Cost of Disposal Options

Option	1	2	3	4	5	6
Description	Ocean Outfall	100% Bore Injection	Robinson's Bay Irrigation	Goughs Bay Irrigation	Pompeys Bay Irrigation	Non-potable Reuse pipe
Total Estimate, rounded	$7,390,000	$7,910,000	$13,730,000	$29,090,000	$25,910,000	$2,170,000
Expected Range	$5.9m to $9.6m	$6.3m to $10.2m	$10.9m to $17.8m	$23.2m to $37.8m	$20.7m to $33.6m	$1.7m to $2.8m

It should be noted that the Non-potable Reuse Pipe, based on Option 1, is not a stand-alone option but a supplementary option only.

Whole scheme estimates have also been produced by taking the cost of the Reticulation and Terminal Pump station from the 2014 preliminary design estimates, and escalating these by 12% for inflation. The cost of the Wastewater Treatment Plant is also included and has been updated based on the current plant design, with allowances for increase in supplier and equipment pricing since 2014.

The Whole Scheme capital cost estimates for the current short list of disposal options range from $34.7M to $55.5M as below shown in Table 7-2.

Table 7-2 Whole Scheme Capital Cost Estimates

Option	1	2	3	4	5
Description	Ocean Outfall	100% Bore Injection	Robinson's Bay Irrigation	Goughs Bay Irrigation	Pompeys Bay Irrigation
Reticulation network, Terminal PS, WWTP, Ponds A-C	$27,320,000	$27,520,000	$27,320,000	$26,450,000	$26,450,000
Disposal Option	$7,390,000	$7,910,000	$13,730,000	$29,090,000	$25,910,000
Total Estimate, rounded	$34,710,000	$35,430,000	$41,050,000	$55,540,000	$52,360,000
Expected Range ($ million)	**$32m to $40m**	**$32m to $41m**	**$38m to $48m**	**$50m to $64m**	**$47m to $60m**

- The estimates above do not include the cost for the Non-potable Reuse Pipe option.
- The probable accuracy range of the estimates is -20% to +30%.
- Please refer to the Appendix P for more detailed breakdowns.

7.5 Cost Estimate Exclusions

The following items of work or likely project costs are excluded from our estimate but should be considered when establishing the likely project budget:

7.5.1 General Estimate Exclusions

- Goods and Services Tax (GST).
- Construction escalation beyond date of estimate.
- Foreign Exchange costs.
- Staged or phased handover or commissioning.
- Council reserves and Development Contributions.
- Legal / accounting fees.

7.5.2 Project Specific Exclusions

- Geotechnical ground improvement / treatment.
- Incurred costs to date.
- Fast track or accelerated programme.
- Work outside normal working hours.
- Treating & handling contaminated soil and materials.
- No allowance for working around or relocating existing services.
- Pond / dam excavation spoil assumed disposed of on-site (no cartage allowed for).
- Bores - drilling and development costs in addition to allowances included in the estimate.
- Temporary accommodation costs.
- Plantation management - pruning, thinning, etc.
- Pasture establishment/renewal.
- Architectural treatment to exterior of pumpstation.
- Archaeological costs.
- Land purchase for Townshend farm at Goughs - allowance for purchasing Site 10 and agreeing lease arrangement only at Goughs.
- Land access costs for monitoring bores.

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

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8 Risk Assessment

A full detailed risk spreadsheet has been developed for each option. However the five key risks to the project as a whole have been extracted and summarised in Table 8-1.

Table 8-1Key Project Risks

No	Risk	Description	Mitigation	Responsible
1	Wastewater bore injection option neither proven nor disproven	Risk that the investigation of wastewater bore injection will provide uncertain results in terms of the performance and ultimate fate of wastewater injected into the ground. This may pose concerns for the council, Iwi, and community during public consultation and present difficulties in scheme decision making.	Requires the coordinated efforts of Beca hydrogeology team, ESR and Jacobs peer reviewer working collaboratively to investigate, assess the results and provide required level of confidence in the bore injection recommendation	CCC / Beca / Jacobs / ESR
2	Wastewater flow uncertainties	The wastewater network model is intended to resolve previous flow uncertainties. However the model is not accurate at present and needs further development to incorporate wintertime I&I; this will have a major influence on storage requirements and storage is a major factor in overall scheme costs.	Further development of the model is required to incorporate winter I&I effects. This task is underway in August 2018.	Beca
3	Consentability risks	Risk that the selected scheme option is not consentable or intractable legal process ensues. This risk relates to the quality of early planning advice and complex and subjective nature of some consenting aspects such as landscape and visual impact.	Beca planning work to be reviewed by a suitably experienced technical director. Council project manager also to work proactively with CCC and ECan planners to understand and incorporate consenting risk issues and mitigations into scheme development.	Beca / CCC
4	Cost estimates	There is a risk around the accuracy of cost estimates due to limitations in the extent of concept engineering work done to date. Some features such as injection bores and storage ponds are also subject to comparatively high cost risks due to geotechnical uncertainties.	Contingency cost factors need to reflect level of design development and geotechnical uncertainties. Council to commission independent review of cost estimates.	Beca / CCC
5	Reputational risk	Possibility that the scheme as implemented does not meet scheme objectives and outcomes as agreed with the community in consultation. This poses reputational risk to Council, Beca and other parties as well as heightened consenting risks.	Scheme development work needs to be well scoped, sufficiently rigorous, and with careful consideration of risks and risk management such that council decision making is robust and implemented scheme works as intended	CCC/Beca

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9 Evaluation of Options and Conclusions

9.1 Overview

Concept level designs and cost estimates have been produced for the scheme options under consideration, and a high level planning and visual effects assessment has been completed for each option. Council need to determine which options they should take forward to the next round of community consultation as viable options that could proceed. A summary of the key aspects of each option is given in the following sections.

9.2 Harbour Outfall (as baseline)

9.2.1 Cultural Impacts

The Ngāi Tahu parties are strongly opposed to wastewater disposal to the harbour. Concerns around cultural impacts and inadequate assessment of land-based alternatives were key considerations in the decline of an application for disposal of wastewater to the harbour by ECan in June 2015. Council has been directed by the Environment Court to pursue land-based alternatives in order to address cultural concerns. Within this context it is considered that implementation of a harbour outfall would lead to significant cultural impacts.

9.2.2 Social and Nuisance Impacts

43% of respondents to the public consultation exercise in May and June 2016 support disposal of wastewater to the harbour. Disposal to the harbour was the second highest scoring option, behind non-potable reuse being used in combination with another option, in the 2017 consultation round. Furthermore, feedback from stakeholder groups identified opposition to infrastructural features of alternative, land-based schemes including storage dams and afforested land where they are located in proximity to rural residences. These features are absent from the harbour outfall scheme. Based on this assessment it is considered that the social impacts of the harbour outfall are potentially less than for land-based alternatives.

9.2.3 Environmental Impacts

The assessment of effects statement for the proposed discharge to harbour prepared in 2014 found that potential environmental effects were minor. This included water quality, ecological, and public health effects and effects on seafood including shellfish. With proposed improvements to the treatment process to eliminate bypassing during wet weather and to provide membrane treatment of all flows at all times, the potential effects of a harbour discharge will be further minimised. This will provide additional protection of shellfish and other seafood which are the most sensitive receptors in the environment. In this respect the harbour disposal of membrane treated wastewater represents an environmentally sustainable solution with minimal potential for environmental impacts.

9.2.4 Economic Costs

The cost for the harbour outfall option has increased due to the inclusion of raw wastewater ponds at Pond Site 10, which will eliminate any bypass flows such that all wastewater that would be discharged via the outfall would be fully treated. The current cost for the Akaroa Wastewater scheme using an outfall is $34.7M, with the outfall contributing $7.M to the overall cost as a disposal option. The harbour outfall is the lowest capital cost option.

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9.3 100% Bore Injection

9.3.1 Cultural Impacts

The Ngāi Tahu Parties have stated their support for a drilling investigation to assess the feasibility and performance of bore injection of wastewater. However, until specific information about the dispersion and ultimate fate of contaminants injected into bores is ascertained through this investigation the cultural acceptability of bore injection cannot be confirmed.

9.3.2 Social and Nuisance Impacts

Wastewater injection to ground has potential to avoid the need for infrastructural features associated with alternative, land-based schemes including storage dams and afforested land. To the extent these features can be avoided there is potential to minimise social and nuisance effects.

However this may be counterbalanced by community concerns about the impact of wastewater injection on groundwater. Basic information about the bore injection option has been disseminated to the Akaroa Wastewater Working party and at a public meeting on the 4th of April 2018. Feedback from the wider community about bore injection as a potential pathway for disposal of wastewater has not been sought. Hence the acceptability of this option to the wider community is presently unknown.

9.3.3 Environmental Impacts

Potential environmental impacts of bore injection will be characterised as part of the bore drilling investigation. Initial assessment of the potential for environmental effects resulting for deep bore injection suggests they are likely to be minor once the very high quality of wastewater and effective dilution, dispersion and contaminant destruction within the groundwater are taken into account. There are potential risks associated groundwater abstractions and this will require close and case-by-case scrutiny in order to avoid or manage any potential effects.

9.3.4 Economic Costs

The costs for the 100% bore injection of wastewater are comparatively lower than other options except for a harbour outfall, based on initial estimates of the number and depth of injection bores required. The cost for a scheme based on 100% bore injection is $35.4M, with the bore injection disposal option contributing $7.9M of the overall cost.

9.4 Irrigation in Robinsons Bay

9.4.1 Cultural Impacts

The Ngāi Tahu Parties have stated their support for irrigation of 100% of wastewater to land. The Robinsons Bay scheme option will not meet this objective as there is insufficient land available to irrigate all wastewater. If the Thacker land in Robinsons Bay only is irrigated this will beneficially utilise about 40% of total annual volume. Land application would occur during the summer when peak wastewater flows coincide with demand for water and nutrients for the irrigated vegetation. The remaining 60% of annual volume would be injected into deep bores at or near the treatment plant site. Injection would occur continuously during the winter and at other times during wet weather.

As described in Section 9.3.1, The Ngāi Tahu Parties along with other stakeholders are awaiting the outcome of the drilling investigation in order to understand the fate of wastewater injected to deep bores.

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Therefore the potential cultural impacts of the Robinsons Bay scheme option are intrinsically linked to the acceptability of bore injection. This issue will be resolved in due course.

9.4.2 Social and Nuisance Impacts

The current scheme for Robinsons Bay is based on irrigating native plantings on the Thacker Land in a mid-valley location. This location is partially obscured from the lower valley and from public viewpoints, including State Highway 75. Storage dams in Robinsons Bay, which were strongly opposed by local residents during stakeholder discussions in early 2017, have been deleted from the scheme.

Land irrigation in Robinsons Bay was also opposed by the Friends of Banks Peninsula based on their view that "it is a high risk solution because of unknowns in the ability of the peninsula soils and native trees to take up water and nutrients, the sloping terrain and proximity to waterways, and the number of residents in the vicinity"[4]. In summary there is limited community support for irrigation of land in Robinsons Bay.

9.4.3 Environmental Impacts

Irrigation of wastewater to land in New Zealand has a mixed track record. All land irrigation options proposed for Akaroa have been designed conservatively based on working experience from other operational land irrigation schemes. The approach at Akaroa is to learn from working examples and apply a conservative design approach. Particular features of the design of land irrigation for the Akaroa scheme that will contribute to long term environmental sustainability include:

- Wastewater is treated to a very high quality and will contain negligible suspended solids, BOD and microbiological contaminants and reduced levels of nitrogen
- Low and conservative daily wastewater application rates are proposed based on physical testing of soils at the site and modelling of soil moisture water balance using local, long time series meteorological data
- Very conservative nitrogen loading rates based on the most up to date and relevant scientific research into assimilative capacity for pasture or native plantings as applicable
- Integration of geotechnical land slip stability criteria into site assessments to manage land stability risks
- Selection of suitable application methods and conservative buffer distances for irrigation zones to protect surface water resources and minimise potential for public health risks
- Inclusion of contingency plans

Taking these factors into consideration it is considered that the proposal to irrigate land at Robinsons Bay will provide a sustainable long term solution to wastewater management at Akaroa.

9.4.4 Economic Costs

The costs for an Akaroa Wastewater scheme including irrigation to trees at Robinsons Bay plus bore injection for the treated wastewater that can't be irrigated, at $41.0M are third lowest etc. The cost of the irrigation and injection as a combined disposal method is $13.7M.

[4] FRIENDS of Banks Peninsula Submission Akaroa Wastewater V3-2 13 April 2017 page iv

9.5 Irrigation in Goughs

9.5.1 Cultural Impacts

The Goughs scheme option has potential to meet the objective of irrigating 100% of wastewater to land, as the total irrigable area of 113 ha available within the property is well in excess of the minimum land area required. However, this will only be realised if a large storage dam with base capacity of 75,000 m^3 is built at the site as only minimal quantities of wastewater can be applied to land over winter. If the costs and risks associated with provision of a large dam at this site can be managed, there is potential for this scheme to address the cultural concerns that lie at the core of the Ngāi Tahu Parties opposition to a harbour discharge.

9.5.2 Social and Nuisance Impacts

The Goughs site is divided into two zones, an upper zone located on a broad spur between Goughs Bay and Hickory Bay at 360 – 500 m above sea level, and a lower zone located in lower Goughs Bay Valley. The upper zone, which contains the proposed storage dam site, is unoccupied and the nearest residence is 700m away. The lower zone site features irrigation only with no storage, and the land area includes a derelict house and one occupied property (The site being defined as land owned by Keith Townshend and show on Beca map GIS-6517986-20-45c). There is one other residential property in Goughs Bay located 150 m distant from the edge of the irrigable area as currently defined.

Overall the risks of social impact and nuisance effects associated irrigation at Goughs is considered to be comparatively lower than for other irrigation sites due to sparse local population and large buffer distance to the few rural residences that exist in the area.

9.5.3 Environmental Impacts

As summarised in Section 4.6, land irrigation for the Akaroa wastewater scheme has been designed to provide a sustainable environmental solution. Particular features that will contribute to sustainability that would be applied at Goughs include:

- Wastewater is treated to a very high quality and will contain low levels of contaminants and reduced nitrogen
- Low and conservative daily wastewater application rates are proposed (physical testing at Goughs has not yet been conducted but is planned for September – October 2018)
- Very conservative nitrogen loading rates
- Integration of geotechnical land slip stability criteria into site assessments
- Selection of suitable application methods and conservative buffer distances for irrigation zones
- Inclusion of contingency plans

Taking these factors into consideration, and given the potential to beneficially reuse 100% of wastewater, it is considered that land irrigation at Goughs has potential to provide a sustainable long term solution to wastewater management at Akaroa.

9.5.4 Economic Costs

The capital cost for Goughs is the highest of all the scheme option costs. The overall scheme cost for 100% irrigation at Goughs is $55.5M, with the irrigation disposal method costing $29.0M. Key factors in this are significant costs associated with:

- Pumping to high heads and 11 km reticulation from the treatment plant to the Goughs site
- 85,000 m^3 storage dam in remote location with limited local construction material.

9.6 Irrigation at Pompeys Pillar

9.6.1 Cultural Impacts

The Pompeys Pillar scheme option may have potential to meet the cultural objective of irrigating 100% of wastewater to land. However there are complexities around consenting due to coastal landscape protection areas that cover a significant extent of irrigable land at this site. From a total irrigable area of approximately 91 ha only 41 ha lies outside the protected zones. This is insufficient to irrigate 100% of wastewater.

Irrigation within the protected areas may be possible subject to granting of consent that authorises the various activities involved including storage, irrigation to pasture, roading and ancillary activities. If consent to irrigate across a wider area cannot be obtained then the Pompeys site would not provide for full land application of wastewater. Any remaining wastewater would require land irrigation elsewhere or need to be disposed by alternative means. These eventualities may not satisfy cultural concerns.

9.6.2 Social and Nuisance Impacts

The Pompeys site is remote from the towns and settlements of Banks Peninsula and there is no downgradient infrastructure or other structures. The site itself is unoccupied and there is a single rural residence located 150 m north of the irrigation area boundary.

Overall the risks of social impact and nuisance effects associated irrigation at Pompeys Pillar are considered to be similar to Goughs and comparatively lower than for Robinsons Bay due to sparse local population and large buffer distance to the few rural residences that exist in the area.

9.6.3 Environmental Impacts

As summarised in Section 4.6, land irrigation for the Akaroa wastewater scheme has been designed to provide a sustainable environmental solution. Particular features that will contribute to sustainability that would be applied at Pompeys Pillar include:

- Wastewater is treated to a very high quality and will contain low levels of contaminants and reduced nitrogen
- Low and conservative daily wastewater application rates are proposed
- Integration of geotechnical land slip stability criteria into site assessments
- Selection of suitable application methods and conservative buffer distances for irrigation zones
- Inclusion of contingency plans

Taking these factors into consideration it is considered that land irrigation at Pompeys Pillar has potential to provide a sustainable long term solution to wastewater management at Akaroa. This is on the basis that consent can be obtained to irrigate within the coastal landscape protection areas.

9.6.4 Economic Costs

The capital cost for Pompeys Pillar is the second most expensive of the shortlisted scheme options. The overall scheme cost for 100% irrigation at Pompeys Pillar is $52.4M, disposal to irrigation costing $25.9M of this total. Key factors in this are significant costs associated with:

- Pumping to high heads and 13 km reticulation from the treatment plant to the Pompeys Pillar
- 85,000 m^3 base capacity storage dam in remote location

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Appendix A

Estimation of Revised Flows and Loads

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Appendix B

Peer Review of 2014 Network Model

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Appendix C

New Model Build and Calibration Report

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Appendix D

PDP Letter – Long Term Series and Irrigation Requirements

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Appendix E

Dr Brett Robinson Report on Phosphorus Uptake

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Appendix F

Concept Process Drawings

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Appendix G

Raw Wastewater Pond Sizing

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Appendix H

Bore Injection Literature Review

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Appendix I

Managed Aquifer Recharge Review

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Appendix J

Bore Drilling Decision Tree

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Appendix K

Geophysical Testing

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Appendix L

Indicative Injection Scheme Layout

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Appendix M

Irrigation Maps

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Appendix N

Townshend Land Site Visit Reports

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Appendix O

Pipeline Long Sections

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Appendix P

Concept Level Cost Estimates

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