Akaroa Treated Wastewater Irrigation Scheme –

Application for Resource Consents and Assessment of Environmental Effects

PREPARED FOR THE CHRISTCHURCH CITY COUNCIL May 2023

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Revision Schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)			
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Executive Summary

The Christchurch City Council (the applicant) is applying for resource consent from the Christchurch City Council (CCC as Consent Authority) and Environment Canterbury (ECan) to build and operate a scheme to treat and irrigate treated wastewater to land planted in indigenous trees, and to provide for reuse of a component of treated wastewater. The scheme is known as the Akaroa Treated Wastewater Irrigation Scheme (ATWIS). A suite of resource consents is needed to authorise the construction of the scheme, the structures, and the associated discharges. Treated wastewater will be irrigated to large areas of planted indigenous vegetation at Robinsons Bay Valley and Hammond Point using surface drip irrigation, and to Jubilee Park in Akaroa using a sub-surface drip irrigation system. Overall, the applicant requires resource consents for a discretionary activity, as defined by rules in the Christchurch District Plan, the Canterbury Air Regional Plan, and the Canterbury Land and Water Regional Plan. The assessment of effects set out in Section 10 of this document shows that the effects of the scheme on the receiving environment overall are minor at most and demonstrates that several aspects of the scheme will be positive in comparison to the current (baseline) situation.

The applicant currently holds resource consent from the CCC and ECan for various aspects of the scheme, including building a new wastewater treatment plant (WWTP) and storage facilities on land to the north of and above Akaroa. The applicant's concept for the scheme was developed based on the outcomes of an extensive public consultation process called the 'Inner Bays Irrigation Scheme'. It responds to concerns raised by the Ngāi Tahu parties (Ōnuku Rūnanga, Te Rūnanga o Koukourarata, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Rūnanga o Ngāi Tahu) and the community in respect of the current discharge of treated wastewater to Akaroa Harbour, adverse effects on amenity, the use of the treated wastewater as a resource, and providing opportunities for public recreation opportunities. The scheme also relies on reducing inflows and infiltration of storm water and groundwater into the wastewater network by approximately 20% of 2020 volumes.

The scheme will apply up to 220,800 m^3 / year of highly treated wastewater to approximately 35.7 ha of land at Robinsons Bay Valley and Hammond Point to the north of Akaroa. These areas will be extensively planted in indigenous vegetation grown from locally sourced seeds and planted across the sites in a way that will promote canopy closure. A further 23 ha of riparian and in-fill planting will be established on the Robinsons Bay Valley site, and heritage values on the site will be protected and enhanced. Both sites will be developed for public recreational walking access in due course, along with information and interpretation boards established at key locations to portray the heritage, landscape, natural environment, and cultural values. A portion of the treated wastewater will be used to irrigate Jubilee Park in Akaroa in place of potable water that is currently applied over the summer months. Capacity will be provided in the network to enable other non-potable uses in the future.

The concept design for the surface drip irrigation system involves planting indigenous vegetation in lines approximately 2.0 m apart and laying up to four drip lines between each row, with drippers spaced up to 0.5 m apart. The irrigation areas will be grouped into zones that can be independently controlled to enable multiple rotations to manage the anticipated flows of up to 22 l/s from the new treatment plant. The final scheme design will be confirmed following detailed design and configured to maximise the potential for the plants in the irrigation areas to take up a significant portion of the applied water and contaminants to minimise the potential effects on receiving water (groundwater, Robinsons Bay Stream, and Akaroa Harbour).

The applicant has committed to designing and constructing a treatment process that outputs an annual mean total nitrogen concentration of 10 g/m^3 at the end of the treatment process. The modelling conducted for this application contains several conservative elements and the actual nitrogen load from the scheme is expected to be less than predicted in the modelling due to destocking the irrigation sites, plant uptake and natural denitrification and volatisation. The modelling shows that the anticipated effect of nitrate-nitrogen (Nitrate-N) on Robinsons Bay Stream is minimal and within the interquartile range of the existing nitrate concentrations in the stream. The nitrogen applied to the land via irrigation and its effect on the receiving environment will be monitored in groundwater, surface water and Akaroa Harbour to inform future changes if any are needed to improve environmental outcomes.

In the unlikely event that the nitrogen concentrations are greater than predicted by the modelling, the applicant has a number of potential changes to implement to achieve the same or lower nitrogen concentrations, including but not limited to:

- Changing the scheme configuration, such as increasing the number of drippers, adjusting the flow rate, or changing the dosing regime;
- Reducing the nitrogen concentration in the treated wastewater delivered to the irrigation area by enhancing the treatment processes;
- Increasing the area of the destocked land;
- Increasing the area of irrigated land by adding additional areas.

The accumulation of other contaminants on irrigation site soils will also be monitored and addressed if necessary based on monitoring outcomes.

An Irrigation Management Plan (IMP) will be prepared which will describe how the scheme will be operated and actions to be taken to address any adverse environmental effects identified. An adaptive management regime will be an important facet of the IMP allowing the most appropriate and practicable mitigation measures to be implemented to achieve appropriate environmental outcomes. The IMP will be developed by the applicant and provided to the consent authorities, and periodically reviewed throughout the term of the consent so it remains appropriate and effective.

The proposed discharge of treated wastewater onto land is consistent with Part 2 of the Resource Management Act 1991 (RMA), Sections 105 and 107 of the RMA and the relevant provisions of the National Policy Statement for Freshwater Management 2020 (NPS-FM), the Christchurch City District Plan, the respective Canterbury regional plans, the Mahaanui Iwi Management Plan, and the Ngāi Tahu Freshwater Policy Statement.

Resource Management Act Forms

Resource Management Act 1991 – Form 9

Application for Resource Consent made under section 88 of
the Resource Management Act 1991

To: Christchurch City Council
P O Box 73013
CHRISTCHURCH 8154

From: Christchurch City Council (City Water and Waste Unit)
P O Box 73011
CHRISTCHURCH 8154

[Note the address for service at the end of this application form]

1. The Christchurch City Council (CCC) applies for the following types of resource consents:

   - Land use consent (s9 RMA) to construct and operate networks and structures for conveying, treating, storing, and retaining / detaining wastewater.
   - Land use consent (s9 RMA) to undertake earthworks within Sites of Ngāi Tahu Cultural significance (waahi tapu and silent file areas).
   - Land use consent (s9 RMA) to undertake the earthworks required in constructing the scheme and associated structures and buildings.

2. The activity to which the application relates (the **proposed activity**) is as follows:

   The irrigation of treated wastewater to land and to land where it may enter water, the discharge of contaminants (odour, dust) to air, and the storage of wastewater associated with the construction and operation of the Akaroa Treated Wastewater Irrigation Scheme.

   The use of land to construct and operate the Akaroa Treated Wastewater Irrigation Scheme, including:

   - pipelines from Akaroa within legal road to a new Wastewater Treatment Plant (WWTP) located on Council-owned land at 80 Old Coach Road
   - storage infrastructure on land opposite the WWTP site at Old Coach Road
   - a pipeline from the WWTP within legal road to treated wastewater irrigation areas at Council-owned sites at Hammond Point and Robinsons Bay Valley
   - a series of covered storage tanks at the Robinsons Bay Valley site; and
   - related earthworks, construction activities, structures, irrigation infrastructure, planting of indigenous vegetation, and development of public walking tracks, and related activities.

   The activity is fully described in the attached application document.

3. The site at which the proposed activity is to occur is as follows:

   The proposal involves multiple sites described in the following table:

Owner / occupier	Address	Legal description
CCC	80 Old Coach Road, Akaroa	Lot 3 DP 459704 and Sec 1 SO Plan 473916
	Old Coach Road Storage Site	Lot 7 – 10 DP 7273 (CT CB3C/568)
	6583 Christchurch Akaroa Road (State Highway 75), Hammond Point, Akaroa	Lot 1 DP 563448 (CT 1001524)
	11 Sawmill Road, Robinsons Bay,	Lot 2 DP 82749 (CT CB47D/512)

	Akaroa	
	Jubilee Park, Akaroa	Lot 2 DP 2868, Lot 1 DP 79110 and Sec 2 SO Plan 18642
	Old Coach Road (pipelines)	Legal Road
	Unformed legal road south of 6411 Christchurch Akaroa Road, 74 Robinsons Bay Road and 8 Sawmill Road (pipelines)	Legal Road
Crown C/- Waka Kotahi NZ Transport Agency	State Highway 75 (pipeline)	Legal Road

4. The full name and address of each owner or occupier (other than the applicant) of the site to which the application relates are as follows:

Owner / occupier	Address
Waka Kotahi NZ Transport Agency (SH75)	Level 1, BNZ Centre, 120 Hereford Street, Christchurch

5. The other activities that are part of the proposal to which this application relates are:

   The activity will involve earthworks in High Soil Erosion Risk Areas and the discharge of contaminants to receiving environments (land, air, water). Resource consents in respect of these matters are sought from Environment Canterbury as part of this application document.

6. The following additional resource consents are needed for the proposal to which this application relates and have been applied for in parallel to this application:

   - The use of land (s9 RMA) for community wastewater treatment and management, and associated structures and facilities
   - The discharge of treated wastewater to land, and to land where it may enter water (s15 RMA)
   - The discharge of construction-phase stormwater into surface water or onto or into land where a contaminant may enter ground or surface water (s15 RMA)
   - Earthworks and vegetation clearance in High Soil Erosion Risk areas (s9 RMA)

   Resource consents in respect of these matters are sought from Environment Canterbury as part of this application document.

7. Attached is an assessment of the proposed activity's effect on the environment that —

   a) includes the information required by clause 6 of Schedule 4 of the Resource Management Act 1991; and
   b) addresses the matters specified in clause 7 of Schedule 4 of the Resource Management Act 1991; and
   c) includes such detail as corresponds with the scale and significance of the effects that the activity may have on the environment.

8. Attached is an assessment of the proposed activity against:

   a) the matters set out in Part 2 of the Resource Management Act 1991; and
   b) any relevant provisions of a document referred to in section 104(1)(b) of the Resource Management Act 1991, including the information required by clause 2(2) of Schedule 4 of that Act.

9. No further information is required to be included in this application by the district plan, a regional plan, the Resource Management Act 1991, or any regulations made under that Act.

(K. Hills)
....
Signature of applicant or person authorised
to sign on behalf of the applicant

Date: 1/5/2023

Address for service:

Stantec New Zealand
P O Box 13052
Christchurch 8024

Attn: Janan Dunning
Email: janan.dunning@stantec.com
Phone: 03-341 4790 / 027 600 8432

Resource Management Act 1991 – Form 9

Application for Resource Consent made under section 88 of
the Resource Management Act 1991

To: Canterbury Regional Council
P O Box 345
CHRISTCHURCH 8140

From: Christchurch City Council (City Water and Waste Unit)
P O Box 73011
CHRISTCHURCH 8154

[Note the address for service at the end of this application form]

[Pre-application Reference: RMA214694]

1. The Christchurch City Council (CCC) applies for the following types of resource consents:

   - The use of land (s9 RMA) for community wastewater treatment and management, and associated structures and facilities
   - The discharge of treated wastewater onto and into land, and onto and into land where it may enter water (s15 RMA)
   - The discharge of construction-phase stormwater into surface water or onto or into land where it may enter ground or surface water (s15 RMA)
   - Earthworks and vegetation clearance in High Soil Erosion Risk areas (s9 RMA)

2. The activity to which the application relates (the **proposed activity**) is as follows:

   The irrigation of treated wastewater to land and to land where it may enter water, the discharge of contaminants (odour, dust) to air, and the storage of wastewater associated with the construction and operation of the Akaroa Treated Wastewater Irrigation Scheme.

   The use of land to construct and operate the Akaroa Treated Wastewater Irrigation Scheme, including:

   - pipelines from Akaroa within legal road to a new Wastewater Treatment Plant (WWTP) located on Council-owned land at 80 Old Coach Road
   - storage infrastructure on land opposite the WWTP site at Old Coach Road
   - a pipeline from the WWTP within legal road to treated wastewater irrigation areas at Council-owned sites at Hammond Point and Robinsons Bay Valley
   - a series of covered storage tanks at the Robinsons Bay Valley site; and
   - related earthworks, construction activities, structures, irrigation infrastructure, planting of indigenous vegetation, and development of public walking tracks, and related activities.

   The activity is fully described in the attached application document.

3. The site at which the proposed activity is to occur is as follows:

   The proposal involves multiple sites as described in the following table:

Owner / occupier	Address	Legal description
CCC	80 Old Coach Road, Akaroa	Lot 3 DP 459704 and Sec 1 SO Plan 473916
	Old Coach Road Storage Site	Lot 7 – 10 DP 7273 (CT CB3C/568)
	6583 Christchurch Akaroa Road (State Highway 75), Hammond Point, Akaroa	Lot 1 DP 563448 (CT 1001524)
	11 Sawmill Road, Robinsons Bay,	Lot 2 DP 82749 (CT CB47D/512)

	Jubilee Park, Akaroa	Lot 2 DP 2868, Lot 1 DP 79110 and Sec 2 SO Plan 18642
	Old Coach Road (pipelines)	Legal Road
	Unformed legal road south of 6411 Christchurch Akaroa Road, 74 Robinsons Bay Road and 8 Sawmill Road.	Legal Road
Crown C/- Waka Kotahi NZ Transport Agency	State Highway 75 (pipeline)	Legal Road

4. The full name and address of each owner or occupier (other than the applicant) of the site to which the application relates are as follows:

Owner / occupier	Address
Waka Kotahi NZ Transport Agency	State Highway 75

5. The other activities that are part of the proposal to which this application relates are:

   Other activities associated with the proposal relate to the development and use of land for structures and infrastructure related to the operation of a community wastewater management facility, including earthworks, built structures (tanks, a subsurface wetland) and related infrastructure.

6. The following additional resource consents are needed for the proposal to which this application relates and have been applied for in parallel to this application:

   - land use consent (s9 RMA) to construct and operate structures for conveying, treating, storing, retaining / detaining wastewater.
   - Land use consent (s9 RMA) to undertake earthworks within Sites of Ngāi Tahu Cultural significance (waahi tapu and silent file areas.
   - Land use consent (s9 RMA) to undertake the earthworks required in constructing the scheme and associated structures and buildings.

   Resource consents in respect of these matters are sought from the Christchurch City Council as part of this application document.

7. Attached is an assessment of the proposed activity's effect on the environment that —
   a) includes the information required by clause 6 of Schedule 4 of the Resource Management Act 1991; and
   b) addresses the matters specified in clause 7 of Schedule 4 of the Resource Management Act 1991; and
   c) includes such detail as corresponds with the scale and significance of the effects that the activity may have on the environment.

8. Attached is an assessment of the proposed activity against:
   a) the matters set out in Part 2 of the Resource Management Act 1991; and
   b) any relevant provisions of a document referred to in section 104(1)(b) of the Resource Management Act 1991, including the information required by clause 2(2) of Schedule 4 of that Act.

9. No further information is required to be included in this application by the district plan, a regional plan, the Resource Management Act 1991, or any regulations made under that Act.

(K. Hills)

....

Signature of applicant or person authorised
to sign on behalf of the applicant

Date: 1 April 2023

Address for service:

Stantec New Zealand
P O Box 13052
Christchurch 8024

Attn: Janan Dunning

Email: janan.dunning@stantec.com
Phone: 03-341 4790 / 027 600 8432

Resource Management Act 1991

Schedule Four Checklist

This application document has been prepared in accordance with s88 and the Fourth Schedule of the Resource Management Act 1991 and is therefore complete and able to be accepted.

Information Required	Document Location
Description of the activity.	**Section 3 - 5**
Description of the site at which the activity is to occur.	**Section 3 and 6**
Full name and address of each owner or occupier of the site.	**Refer to the RMA Form 9s attached**
Description of any other activities that are part of the proposal to which the application relates.	**Section 3 - 5**
Description of any resource consents required for the proposal to which the application relates.	**Section 7**
An assessment of the activity against the matters set out in Part 2.	**Section 12**
An assessment of the activity against any relevant provisions of a document referred to in section 104(1)(b), including: a) Any relevant objectives, policies or rules in a document; and b) Any relevant requirements, conditions or permissions in any rules in a document; and c) Any other relevant requirements in a document (for example, in a national environmental standard or other regulations).	**Section 12** addresses the activity against the provisions of the: • National Policy Statement for Freshwater Management 2020 (Dec 2022) • New Zealand Coastal Policy Statement 2010 • Regional Coastal Environment Plan for Canterbury 2005 • Canterbury Regional Policy Statement 2013 • Canterbury Air Regional Plan • Canterbury Land and Water Regional Plan • Christchurch District Plan • The Mahaanui Iwi Management Plan • Te Rūnanga o Ngāi Tahu Freshwater Policy Statement • Heritage New Zealand Pouhere Taonga Act 2014 • Reserves Act 1977
If any permitted activity is part of the proposal to which the application relates, a description of the permitted activity that demonstrates that it complies with the requirements, conditions, and permissions for the permitted activity.	**Section 7**
If the application is affected by section 124 or 165ZH(1)(c) (which relate to existing resource consents), an assessment of the value of the investment of the existing consent holder (for the purposes of section 104(2A).	**Not applicable**
If the activity is to occur in an area within the scope of a planning document prepared by a customary marine title group under section 85 of the Marine and Coastal Area (Takutai Moana) Act 2011, an assessment of the activity against any resource management matters set out in that planning document (for the purpose of section 104(2B)).	**Not applicable**
If it is likely that the activity will result in any significant adverse effects on the environment, a description of any possible alternative	**Not applicable – no significant adverse**

Information Required	Document Location
locations or methods for undertaking the activity.	**effects are anticipated.** However, while no significant adverse effects are anticipated, the proposal involves the discharge of contaminants and therefore alternatives must be considered as required under s105(1) RMA as provided for in **Section 8**.
An assessment of the actual or potential effect of the activity on the environment.	**Section 10**
If the activity includes the use of hazardous installations, an assessment of any risks to the environment that are likely to arise from such use.	**Not applicable**
If the activity includes the discharge of any contaminant, a description of: i. The nature of the discharge and the sensitivity of the receiving environment to adverse effects; and ii. Any possible alternative methods of discharge, including discharge into any other receiving environment.	**Sections 6 and 8**
A description of the mitigation measures (including safeguards and contingency plans where relevant) to be undertaken to help prevent or reduce the actual or potential effects.	**Section 11**
Identification of the persons affected by the activity, any consultation undertaken, and any response to the views of any person consulted.	**Section 9**
If the scale and significance of the activity's effects are such that monitoring is required, a description of how and by whom the effects will be monitored if the activity is approved.	**Section 11**
If the activity will, or is likely to, have adverse effects that are more than minor on the exercise of a protected customary right, a description of possible alternative locations or methods for the exercise of the activity (unless written approval for the activity is given by the protected customary rights group).	**Not applicable**
Any effect on those in the neighbourhood and, where relevant, the wider community, including any social, economic, or cultural effects.	**Section 10**
Any physical effect on the locality, including any landscape and visual effects.	**Section 10**
Any effect on ecosystems, including effects on plants or animals and any physical disturbance of habitats in the vicinity.	**Section 10**
Any effect on natural and physical resources having aesthetic, recreational, scientific, historical, spiritual, or cultural value, or other special value, for present or future generations.	**Section 10**
Any discharge of contaminants into the environment, including any unreasonable emission of noise, and options for the treatment and disposal of contaminants.	**Section 10 and 11**
Any risk to the neighbourhood, the wider community, or the environment through natural hazards or hazardous installations.	**Section 10**

Contents

List of Tables

List of Figures

List of Appendices

1 Introduction

The Christchurch City Council (the applicant) provides network infrastructure services across Christchurch District, including Akaroa and other Banks Peninsula settlements. The applicant has undertaken a number of significant water supply and wastewater upgrades across Banks Peninsula since the Christchurch City and Banks Peninsula districts amalgamated in 2006.

The applicant has progressed the planning and design of a substantial wastewater network upgrade and a new wastewater treatment plant (WWTP) to replace the existing Akaroa Wastewater Treatment Plant at Takapūneke which currently discharges treated wastewater to Akaroa Harbour.

This project is referred to as the Akaroa Treated Wastewater Irrigation Scheme (ATWIS) or 'the scheme' throughout this document, which constitutes an application for resource consents from the Christchurch City Council (CCC) and Environment Canterbury (ECan). This document includes an assessment of environmental effects (AEE) to the extent required by the Resource Management Act 1991 (RMA).

1.1 Project Objectives

The applicant's key objectives for the ATWIS are to:

- Build and operate a new treatment plant to treat community wastewater to a very high standard, irrigate the treated wastewater to land planted in indigenous vegetation, and provide for some non-potable use of treated wastewater. This will enable the existing treatment plant at Takapūneke to be decommissioned and the site rehabilitated.
- Design, consent, build and commission the scheme within the term of the resource consents for the existing treatment plant to comply with milestone conditions within those consents.
- Achieve a wastewater scheme that is technically feasible and is culturally acceptable.

1.2 Purpose of this Document

This document is an application prepared under the Resource Management Act 1991 (RMA) and associated assessment of environmental effects in respect of:

- The use of land to build and operate community wastewater infrastructure and to manage community wastewater
- The irrigation of treated wastewater to land and to land where it may enter water
- The effects on soil, freshwater, coastal water and air, and the associated ecosystems; and
- The construction effects from earthworks, including in high soil erosion risk areas, within areas of Ngāi Tahu cultural significance, the coastal environment area, and in proximity to surface watercourses.

This document has been prepared in accordance with the requirements of section 88 and the Fourth Schedule of the RMA. It includes a description of the location and receiving environment, a description of the activity, an assessment of the actual and potential effects of the activity on the receiving environment, the consideration of alternative methods and receiving environments, and methods to avoid, remedy or mitigate those effects as reflected in consent conditions proposed by the applicant.

2 Background

Discharges of treated wastewater to Akaroa Harbour via the Red House Bay outfall have occurred under various permits since the 1960s. ECan issued coastal permit CRC971242 in 1998 for a ten year term. In 2007 the applicant secured a discharge permit with a five year term to enable wastewater treatment and discharge to lawfully continue while investigations into long term wastewater management options for Akaroa were undertaken. That permit was replaced in 2013 with a new permit of seven years, along with a land use permit authorising wastewater storage at the WWTP, and which both expired in October 2020. They were replaced with a new suite of consents for an eight year term, expiring in May 2030.

Since 2013, the applicant has continued to investigate options for a replacement wastewater scheme for Akaroa, ultimately purchasing land near the intersection of Long Bay Road and Old Coach Road. Applications for the resource consents for the construction and operation of a new WWTP at that location were lodged in 2014, culminating in resource consents being issued in 2015 for changes to the wastewater network, the construction of a new pump station in Akaroa, and a new WWTP at the Old Coach Road site. The scheme concept relied on a proposed harbour outfall via Childrens Bay, however the applications associated with the outfall and discharge to the harbour were refused.

The applicant undertook public consultation in 2016 on six options for Akaroa's treated wastewater, including five land-based options within 2 km of the proposed WWTP at Old Coach Road. Geotechnical investigations at those sites found much of the land to be unsuitable for irrigation so investigations extended to the area within 10 km of the proposed treatment plant.

Public consultation was undertaken on five options in 2017, with the community indicating broad support for non-potable reuse of treated wastewater. However, a faulty flow meter meant that the flows relied on to develop the options were incorrect. The applicant developed the options further, in consultation with the community, Te Rūnanga o Ngāi Tahu, Ōnuku Rūnanga, Te Rūnanga o Koukourarata, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee (the Ngāi Tahu parties) and the Akaroa Treated Wastewater Reuse Options Working Party (the Working Party). The applicant undertook public consultation via its 'Have your say'[1] forum on four of the options in mid-2020; three schemes irrigating highly treated wastewater to native trees and one scheme involving a harbour outfall. The preferred scheme that emerged from this process was referred to as the 'Inner Bays Irrigation Scheme' and formed the foundation for developing the ATWIS for which resource consents are now sought.

2.1 The Inner Bays Irrigation Scheme

The Inner Bays Irrigation Scheme concept involved treating Akaroa's wastewater to a very high standard at a new WWTP and irrigating it to land over approximately 5.7 Ha. Three land irrigation sites were identified for the Inner Bays Irrigation Scheme, located at Robinsons Bay Valley, Hammond Point and Takamātua. Each site was to be converted from the current agricultural land use to indigenous vegetation and drip irrigated with the highly treated wastewater from the new WWTP. The Inner Bays Irrigation Scheme concept is shown in Figure 2-1, sourced from public consultation material provided by the applicant.

While the scheme now proposed is substantially similar to the Inner Bays scheme, it has some key differences. The Inner Bays concept included an irrigation site in the Takamātua Valley, however subsequent modelling and effects assessments indicated that irrigation sites at Robinsons Bay Valley and Hammond Point would be sufficient, and that the Takamātua site would not be required. The scheme now proposed is described in the following sections.

[1] [1] Have Your Say: Akaroa treated wastewater options consultation document 2020 https://ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/WEB-Akaroa-treated-wastewater-options.pdf

Figure 2-1: The Inner Bays Irrigation Scheme Concept

2.2 Current Wastewater Management

2.2.1 The Existing Akaroa Wastewater Network and Treatment

Akaroa's wastewater is predominantly domestic in origin with minor contributions from the town's commercial activities such as hotels, pubs, restaurants, and commercial laundries.

Akaroa's current wastewater network consists of three separate catchments. Each catchment drains the town's wastewater by gravity to three pump stations configured in series running under pressure from the Reserve Pump Station at the Recreation Ground (Jubilee Park) to the Fire Station Pump Station in mid-Akaroa to The Glen Pump Station at the southern-most point of the settlement. The pressure main then conveys the wastewater to the WWTP at Takapūneke for treatment and disposal to the harbour.

The existing WWTP is operated to meet the requirements of the existing resource consents (refer section 2.3), treating Akaroa's wastewater and discharging it to the harbour via an outfall extending approximately 100 m offshore into approximately six to eight metres of water (depending on the tides). The existing WWTP at Takapūneke (also known as Red House Bay) is at the end of Beach Road approximately 2.0 km south of Akaroa on the east side of Akaroa Harbour as shown in Figure 2-2. The WWTP operation generally complies with the treatment and receiving environment quality requirements set through consent conditions and is operated in accordance with an approved management plan.

Figure 2-2: Akaroa WWTP Location (Source: Google Earth)

Akaroa's current pump station and treatment plant arrangement is shown in Figure 2-3:

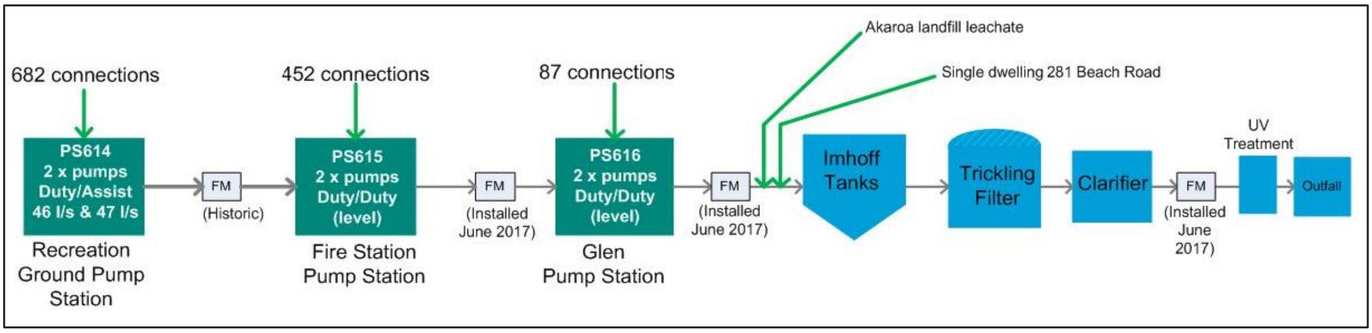

Figure 2-3: Akaroa's existing wastewater network and treatment process

2.2.2 Cultural and Heritage Value of Takapūneke

Takapūneke is a location of great significance to Ōnuku Rūnanga. In 1830 a kainga had been established where Te Maiharanui, an upoko ariki of Ngāi Tahu lived. Ngāti Toa chief Te Rauparaha took Te Maiharanui prisoner with help from the British, then destroyed the kainga and killed the inhabitants.

Takapūneke is tapu to the Ōnuku Rūnanga, recognised as wāhi tapu by Heritage New Zealand *Pouhere Taonga* and holds substantial cultural, spiritual, and historical significance. Takapūneke is a site of great importance in New Zealand's history.

With the site gazetted as a reserve in 2006 and the CCC recently purchasing the 'Red House' and property, it is increasingly timely for the existing WWTP to be decommissioned and removed in recognition of the site's significance. The cultural importance of the site is acknowledged by the applicant and has long been one of the key drivers for moving the existing WWTP and rehabilitating the site. The applicant is strongly supported by the Ōnuku Rūnanga in achieving this and adopting a wastewater scheme that does not rely on discharging treated wastewater directly to Akaroa Harbour, and this has been one of several key considerations in selecting the proposed replacement wastewater scheme.

2.3 Current WWTP Resource Consents

The applicant holds three resource consents for the existing Akaroa WWTP, providing for:

- The use of land for a community wastewater treatment system and to store wastewater at the WWTP (CRC204087). The total volume of wastewater 'stored' at the WWTP and the associated pipes during treatment is estimated to be approximately 1,000 m^3.
- The discharge of contaminants (odour) to air from the WWTP resulting from the treatment process (CRC210834); and
- The discharge of treated wastewater to the harbour (CRC204086).

All three resource consents expire on 24 May 2030.

CRC204086 includes a set of 'milestone' conditions that require the consent holder to achieve certain steps towards replacing the existing WWTP and ceasing the harbour discharge within the term of the consent so that the new wastewater treatment and irrigation scheme is operational before the existing consents expire. The conditions require that:

(a) Applications for all approvals needed to build and operate the scheme are submitted within eighteen months of CRC204086 commencing (i.e. by November 2023)
(b) Contracts for building the WWTP are awarded within eight months of the consents applied for commencing (i.e. being granted, and any appeals resolved)
(c) Contractors start construction within nine months of construction contracts being awarded (which will follow (b) above); and
(d) The new WWTP is fully operational within 60 months of awarding the contracts to build the new WWTP (item (c) above).

As CRC204086 expires 24 May 2030, the new WWTP must be commissioned and fully operational before that date for the consent holder to remain compliant with the conditions of this consent.

3 The Akaroa Treated Wastewater Irrigation Scheme

3.1 Concept

The ATWIS is conceptually based on the Council's 'Inner Bays' Irrigation Scheme, which involves treating wastewater to a high standard at a new WWTP and irrigating it to land planted in indigenous vegetation. The Inner Bays Irrigation Scheme proposed irrigation to land in Robinsons Bay Valley, Hamond Point and Takamātua, whereas the ATWIS does not include irrigation to land at Takamātua as subsequent irrigation modelling found that the area is not required.

Under the ATWIS, treated wastewater will be irrigated as follows:

- To land owned by the applicant at Robinsons Bay Valley using surface drip irrigation
- To land owned by the applicant at Hammond Point using surface drip irrigation
- To Jubilee Park in Akaroa by sub-surface drip irrigation

The ATWIS is designed to treat domestic and commercial wastewater for a projected population equivalent to 2052[2] (Table 3-1), which provides the basis for the peak population derived flow (
Table **3-2**) and which informs the scheme design.

Table 3-1: Forecast Design Population to 2052

Season	Origin	2052
Winter	Domestic	728
	Visitors	112
	Total	**840**
Summer	Domestic	728
	Visitors	1,620
	Total	**2,348**
Peak Summer	Domestic	728
	Visitors	3,829
	Total	**4,557**

(Source: Beca 2020[3])

Table 3-2: Modelled Flow Estimated for Forecast Population

Estimated Dry Weather Flow for 2052 Population[4]	
Parameter	Flow (m^3/day)
Baseflow	285
Peak Population (Jan)	894
Summer Population (Dec, Feb)	506
Population (Mar – Nov)	236

(Source: PDP 2022)

While the ATWIS is similar to the Inner Bays Irrigation Scheme concept, the key differences of the ATWIS are that:

- Treated wastewater will be irrigated to land at Robinsons Bay Valley, Hammond Point and Jubilee Park only. Under the Inner Bays Irrigation Scheme concept, land at Robinsons Bay Valley, Takamātua and Hammond Point was assessed, and potentially suitable irrigable land was mapped. Subsequent analysis confirmed that land at Takamātua was less suitable, and would not be needed for the projected volumes, so it was removed from the ATWIS concept.

[2] Outline of PDP Akaroa Wastewater Irrigation Model, Pattle Delamore Partners Ltd 2019
[3] *Akaroa Wastewater Summary of Disposal and Reuse Options'* (CH2M Beca Ltd, 2020)
[4] The values in this table account for planned reductions in infiltration and inflows to the network, and Water Treatment Plan retentate discharges as discussed in Section 4.3 of this document.

- The treatment process is not yet defined however it will be configured to deliver highly disinfected treated wastewater at the end of the treatment process with very low contaminant loads, including mean total nitrogen (TN) concentrations of 10 g/m^3.
- There are no direct discharges from the ATWIS to water (fresh or coastal) – all treated wastewater will be irrigated to land;

- All wastewater (untreated and treated) will be contained within the scheme's infrastructure (pipes, tanks, WWTP etc). Storage will be provided within roofed tanks (i.e. no ponds). The exception is the proposed subsurface wetland near the WWTP which will provide temporary emergency storage for treated wastewater. The base of the subsurface wetland will be sealed to prevent seepage, and any stored treated wastewater above baseload levels needed to maintain plant growth will be irrigated or returned to the WWTP as appropriate.

The ATWIS irrigation concept was developed by Aqualinc Research Limited (Aqualinc) and is described in the Aqualinc Report in Appendix A. A series of 'scenarios' were developed to support the assessment of the fate of nitrogen in the treated wastewater applied to the irrigation areas. These scenarios are described in the following sections.

The scheme concept and its key components are shown in Figure 3-1, and described in more detail in Sections 3.2 to 3.8.

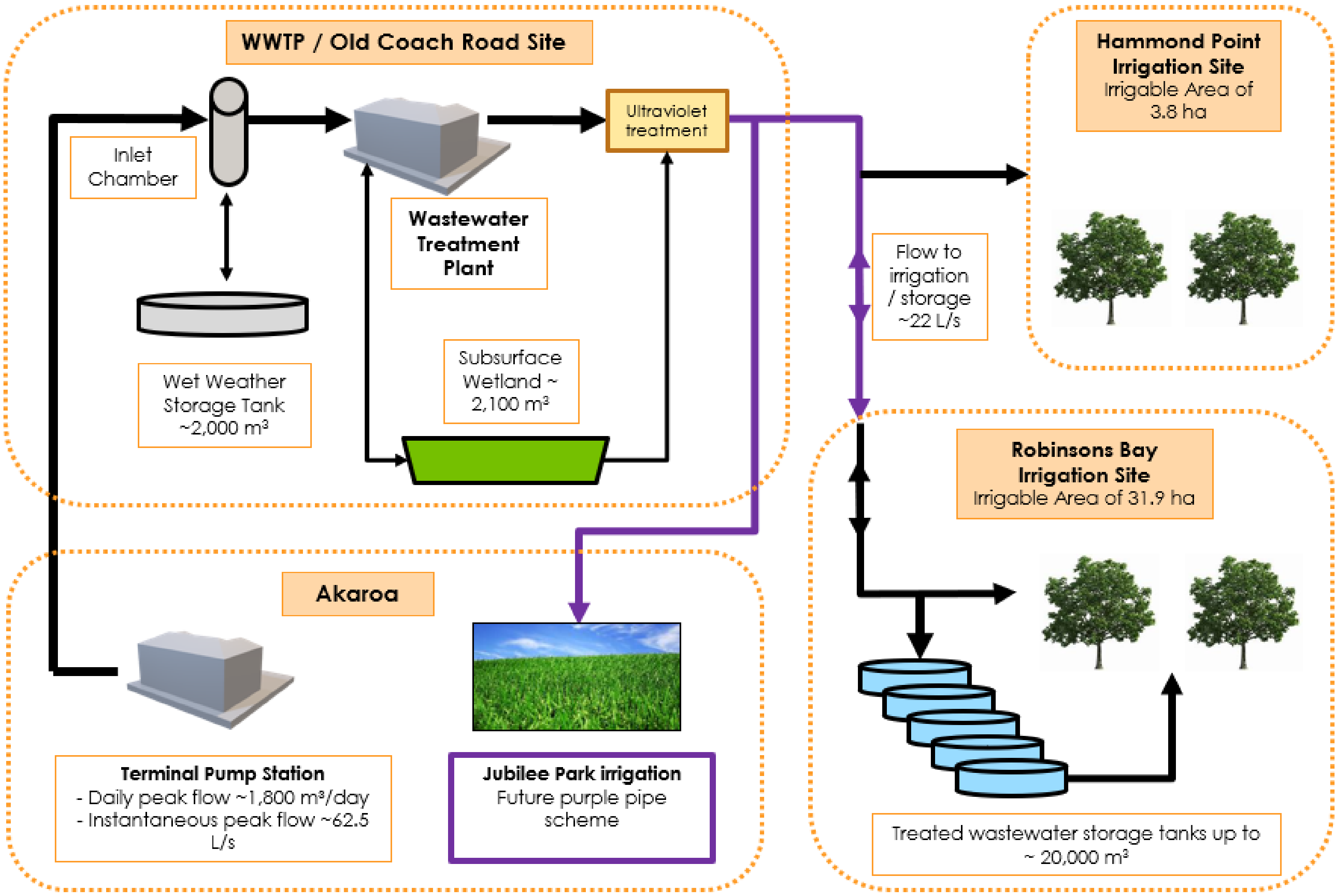

Figure 3-1: Schematic of the Akaroa Treated Wastewater Irrigation Scheme

3.2 Irrigation Scheme Description

The basis for the concept design and operation of the irrigation scheme including modelling outcomes, design parameters and anticipated effects on the receiving environment are detailed in the Aqualinc Report in Appendix A. Section 8.1 of the Aqualinc Report describes the concept layout of the scheme and shows it conceptually in Figure 12 of that report.

3.2.1 Irrigation Volume

The volume of treated wastewater to be irrigated across the scheme, and the resulting irrigation depth of irrigation is set out in Table 3-3:

Table 3-3: Irrigation Volumes

	Annual Volume applied (m^3/y)	Total wetted area (ha)	Depth applied (mm/y)
Mean	205,500	35.7	576
Maximum	220,800	35.7	618
Minimum	193,400	35.7	542

(Source: Aqualinc Report, Table 2)

The volume of treated wastewater irrigated to any one area will vary across the scheme subject to seasonal requirements, inflows, and soil conditions to maximise the efficiency of the scheme in distributing the wastewater in a way that minimises the effects of irrigation.

Aqualinc modelled the effects of irrigating treated wastewater with a mean Total Nitrogen (TN) value of 10 g/m^3. The TN value consists of a dissolved inorganic nitrogen concentration (DIN) of 8.6 g/m^3 (Nitrate-N equivalent) and was used to model the resulting nitrate concentrations in the receiving environment. The TN value of 10 g/m^3 was derived by determining the significance of the modelled effects of Nitrate-N discharges on the receiving environments of Robinsons Bay Stream and Robinsons Bay estuary and working back through the irrigation and treatment process to determine the appropriate output standards to minimise the environmental effects to the extent practicable. Aqualinc's findings are presented in Section 10.8 of the Aqualinc Report.

The irrigable land at the Robinsons Bay Valley and Hammond Point sites is shown in the concept irrigation maps in Figures 5 and 6 of the Aqualinc Report. The maps show areas identified as 'most suitable' for irrigation, and other areas that can also be irrigated but have less suitable characteristics. Approximately 35.7 ha of 'most suitable' land was identified across both sites combined. Approximately 5.0 ha of 'less suitable' land, bringing the total potential irrigable area across both sites to approximately 40.7 ha, however only the area of 'most suitable' land has been taken into account in the modelling.

Treated wastewater will also be irrigated to Jubilee Park in Akaroa using subsurface drip irrigation (Figure 4, Aqualinc Report). Irrigation of the park will be limited to that required to maintain healthy vegetation over the dry summer months and is the first step towards providing a 'purple pipe' system for Akaroa that may allow for broader non-potable use in the future. Treated wastewater for non-potable use can be drawn either directly from the WWTP or from storage as needed.

3.2.2 Robinsons Bay Valley and Hammond Point

The irrigation concept design is based on Hydrus and Irricalc modelling undertaken and reported by Aqualinc and applies across both irrigation sites. The irrigable areas within each site are shown in the irrigation maps in Section 3 of the Aqualinc Report. The irrigation concept is described in detail in the Aqualinc report and summarised as follows:

- Annual application of treated wastewater volumes will range up to 220,800 m^3/year with a mean of 205,500 m^3/year proportioned across both irrigation sites. Peak summer daily treated wastewater volume from the WWTP to irrigation will require application of up to 1,100 m^3/day of treated wastewater. A portion of the treated wastewater will be irrigated to Jubilee Park as needed. Seasonal application rates to each site will vary according to receiving environmental conditions. Modelling shows that the mean annual depth of irrigation water applied would be 576 mm across the 35.7 ha area.

- The recommended irrigation configuration would result in 8,400 m^3/ha of treated wastewater applied over 35.7 ha per year.

- The concept involves tree lines in the irrigable areas planted approximately ~2.0 m apart with trees at approximately 1.2 m centres. Up to four drip lines per row will be laid on the surface approximately 0.5 m apart. The final spacings and flows will be determined through the detailed design process. The irrigable land on each irrigation area will be divided up into zones, to be determined during the detailed design stage. With drippers at ~0.3 – 0.5 m apart along each dripline, there would be no dryland strips between irrigation lines. At this recommended spacing, the potential for drainage through the soil profile is minimised (3.1 mm/d) and the potential for uptake by tree roots is maximised, particularly as the plantings mature. Retaining the applied wastewater in the rootzone as long as possible is important to maximise potential plant uptake and minimise the potential for applied water and residual contaminants to leach beyond the root zone. Application rates will be monitored and managed relative to soil conditions to avoid or minimise the potential for ponding or overland flows.

- The Robinsons Bay Valley and Hammond Point irrigable areas will contain a series of equally sized zones, corresponding with the flow supplied by the WWTP under typical conditions. Treated wastewater inflows to these zones will be controlled as needed. Each zone will operate in a 'dose / rest' sequence, where treated wastewater is applied to a zone and that zone is then rested while the applied water soaks in, and the next zone in the sequence is dosed. This approach helps to avoid over-application in any one zone and minimises the potential drainage of applied water to groundwater. Dosing at an appropriate rate also helps to retain unsaturated horizons in overlying soils where irrigated wastewater is further treated by natural processes before moving into groundwater.

- Dosing allows single zones to be temporarily taken out of service if needed for repair or maintenance purposes without discernibly impacting the other zones or the receiving environment. The use of zones also enables future expansion of the scheme if needed, including adding additional land (e.g. within the 'less suitable' irrigable areas at the Robinsons Bay Valley Irrigation site, or a completely different site) should it be desirable for operational reasons. The zone concept provides scheme resilience and operational versatility.

- Irrigation is primarily focussed on slopes of less than 20 degrees with limited irrigation in steeper areas. Irrigation will avoid pre-existing slope instabilities and watercourses. Irrigation will be set back from property boundaries by 5 m, permanent watercourses by at least 20 m, and by at least 15 m from ephemeral watercourses. The irrigation maps in the Aqualinc Report have taken account of these constraints and excluded them from the irrigable areas.

- The treated wastewater will be irrigated directly from the WWTP where conditions are favourable. Where rainfall exceeds 50 mm / day and / or soil moisture conditions are unfavourable, treated wastewater will be stored at the Robinsons Bay Valley site until it can be progressively irrigated. The scheme will be designed with capacity in the system to enable stored and inflowing volumes to be irrigated together to draw down stored volumes and return storage capacity efficiently.

- The soil characteristics of the irrigation sites have been assessed and found to be able to accommodate the applied volumes proposed[5]. Any limitations on applied rates and volumes relate to:
  - the receiving capacity of the soil (soil moisture content) at the time of irrigation; and
  - the effects on the secondary receiving environments of Robinsons Bay Stream, and the harbour.

- The scheme involves approximately 55 ha of the Robinsons Bay Valley site being retired from grazing and planted in indigenous vegetation. This area includes the irrigated land, adjoining riparian margins and property boundary buffer zones. A further area above the irrigated area will also be retired and planted in indigenous species for land management purposes and to further enhance landscape and biodiversity values. The balance of the upper property will continue to be grazed for weed and land management purposes.

The scheme design, operation and characteristics of the discharges are described in the Aqualinc Report. The final design and operation of the irrigation system will be determined at the detailed design stage.

Detailed operation and maintenance plans for the WWTP and scheme operation will be developed prior to commissioning the scheme and will be maintained and updated as necessary over the scheme's operational life. The inspection and maintenance activities will be scheduled as part of the scheme's management. As the infrastructure is primarily above ground, any repair or maintenance requirements will be evident and easily addressed to keep the scheme's infrastructure in optimal condition.

3.2.3 Jubilee Park

The irrigation of Jubilee Park will adopt a deficit irrigation approach where irrigation is applied only when needed to maintain soil moisture for healthy grass cover. This will involve soil moisture monitoring to inform the frequency and extent of irrigation needed and will maximise plant uptake and minimise the potential for contaminants to leach beyond the root zone.

Under this proposal, treated wastewater will be irrigated to the Akaroa Recreation Ground / Jubilee Park (Figure 3-8) in summer using subsurface drip irrigation. This method will drip-irrigate treated wastewater beneath the land surface directly into the plant root zone, avoiding the potential for aerosols or mists to be generated and substantially limiting the potential for surface ponding and human contact. This method also minimises the potential for drainage of wastewater

[5] Aqualinc Report, Section 10.

and contaminants to groundwater through the underlying soils and maximises the potential plant uptake and evapotranspiration.

The scheme concept design assumes an irrigable area at Jubilee Park of approximately 1 ha, with irrigation using subsurface driplines at a depth of approximately 20 cm. Assuming a dripper flow rate of 2 L/hr with drippers at 30 cm spacings and driplines spaced 40 cm apart, ~83,333 drippers would be required to irrigate 100% of the irrigable area.

Adopting a deficit irrigation approach, a mean of 297 mm / year of treated wastewater (167 m^3 / hour with an application depth of 16.7 mm) could be applied to retain healthy grass cover. As an example, this could involve a mean of up to 18 hours of operation per year at a dripper flow rate of 2 L/hr, or 36 hours per year at a dripper flow rate of 1 L/hr as needed to optimise soil moisture conditions.

3.2.4 Irrigable Area Planting

A key part of the scheme is the extensive planting of indigenous species across the irrigation sites, and specifically the irrigable areas. The species are described in the Terrestrial Ecology Report in Appendix B and are shown in the Concept Landscape Plans in Appendix C.

The recommended species have been selected for their favourable characteristics, including unpalatability to sheep (which will initially lightly graze planted areas to control weed growth), rapid growth rates to achieve canopy closure for weed control and rainfall interception, biodiversity value, tolerance of the anticipated soil conditions (soil type and moisture content), applied water uptake, and 'crop' diversity and resilience. The longevity of some of the species was also considered, with a range of maturation helping to optimise nutrient uptake during plant growth phases, and some species maturing over several decades. Some of the species also hold mahinga kai values and may be available for cultural harvest in the future.

Planting across the irrigable areas will be supplemented by further planting in peripheral areas, and the riparian margins of permanent and ephemeral streams. This planting will consist of a wider range of species selected for their different characteristics such as being tolerant of wetter soils, broader biodiversity values, and landscape, visual amenity, and habitat values.

Planting in peripheral and riparian areas will have the added benefit of helping to intercept any surface flow originating from the irrigable areas, intercepting seepage in the root zone or in shallow flow paths that develop in the soil profile. Interception may be by physical obstruction (stems and trunks) and through plant uptake. The planting will also intercept rainfall at canopy level, particularly following canopy closure which will help to reduce the potential for soil erosion, and which will reduce soil saturation and suppress weed growth.

3.3 The Terminal Pump Station

Following changes to the Akaroa wastewater network all reticulated wastewater will be conveyed to the Terminal Pump Station and pumped to the new Wastewater Treatment Plant (WWTP) to be built at Old Coach Road. The Terminal Pump Station will be built on land owned by the applicant in Akaroa boat / trailer park near Jubilee Park, on land legally described as Lot 2 DP 2868, Lot 1 DP 79110 and Sec 2 SO 18642, held in Certificate of Title CB45A/1127 (Figure 3-2 – yellow square is the indicative location).

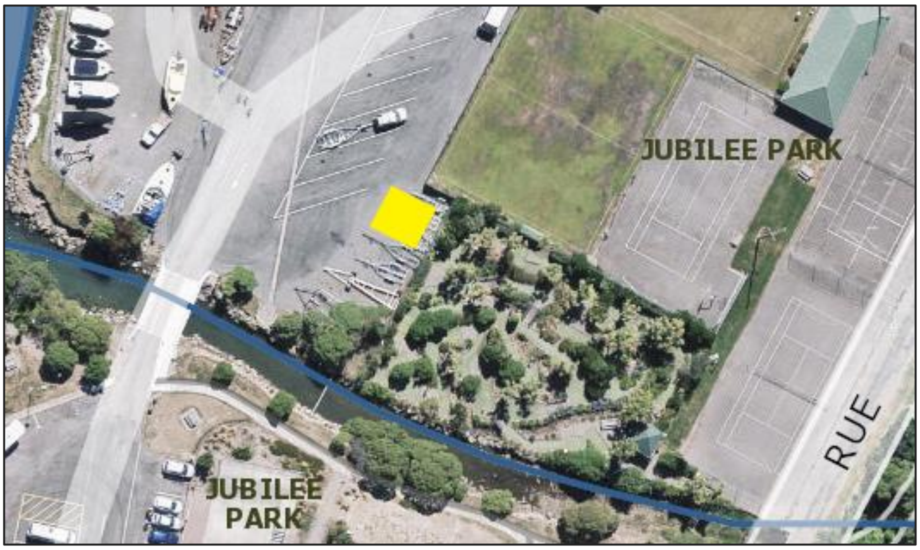

Figure 3-2: Indicative Terminal Pump Station Location

The Terminal Pump Station will be fully enclosed within utility building. The pump station will convey raw wastewater to the WWTP at an approximate daily peak rate of 1,800 m^3/day and an instantaneous peak rate of 62.5 L/s, via a pressure main to be built in Old Coach Road. A standby generator will be located adjacent to the north wall of the pump station building to provide emergency power and enable continued operation. Odour will be managed using a bark bed biofilter or similar, also located immediately next to the pump station building.

The applicant holds resource consents to build the Terminal Pump Station, including to discharge contaminants (construction phase stormwater) to water and disturb contaminated land[6] and to use the land for the pump station facility[7]. The construction of the Terminal Pump Station is subject to certification of a Construction Environmental Management Plan (CEMP) required by the conditions of that consent, with several sub-management plans including erosion and sediment control, contaminated soils management, and hazardous substances/spill contingency plans required. The CEMP will set out in appropriate detail how the construction of the Terminal Pump Station will be achieved, and the activity will be undertaken in compliance with the certified CEMP and consent conditions to appropriately manage adverse effects related to its construction.

3.4 The Old Coach Road Site

The new WWTP is proposed to be built at 80 Old Coach Road near the intersection of State highway 75 (SH 75), Old Coach Road and Long Bay Road on land owned by the applicant and legally described as Lot 3 DP 459704 and Sec 1 SO Plan 473916 (CT 659829). The WWTP site lies approximately 300 m north of the Akaroa urban boundary (refer Figure 3-3) at approximately 110 m above mean sea level. The applicant holds resource consent RMA92026256 from the CCC (consent authority) to use the land to build the WWTP at this location. The WWTP will occupy a small area immediately adjacent to the western boundary of Old Coach Road, to the immediate northwest of the existing water supply reservoir. The WWTP site is described and shown in the decision documents for RMA92026256 and is not changed or affected by this application.

Figure 3-3: The Wastewater Treatment Plant Site on Old Coach Road

Most operational parts of the treatment process will be contained within the building for noise, odour, and operational management purposes, and to help minimise the visual effect of the WWTP building in the rural setting.

The ATWIS includes two additional components of the WWTP to be constructed on land opposite to the WWTP site shown in Figure 3-4 (referred to as the Old Coach Road storage site hereafter). The additional components are shown in Drawing SK10 in Appendix D and consist of:

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[6] Issued through RMA92026256 under the Resource Management (*National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health*) Regulations 2011 (the NES-CS).
[7] RMA92026256, CRC152814 and CRC150049

- A covered raw wastewater tank to temporarily hold wet weather inflows to the WWTP that exceed its' instantaneous treatment capacity. The tank will have an approximate volume of 2,000 m^3; and
- A subsurface wetland with a volume of approximately 2,100 m^3.

Figure 3-4: The Old Coach Road Storage Site

(Source: Google Earth Pro)

These key components are described in the following sections.

3.4.1 Wet Weather Flow Storage Tank

The applicant has committed to a 'no bypass' approach to wastewater treatment, meaning that all wastewater conveyed to the WWTP will either be treated as it arrives, or if inflows exceed 14 L/s (equivalent to the peak summer mean daily flow) raw wastewater will be stored in the wet weather flow storage tank (~2,000 m^3) for future treatment.

As inflows reduce following rainfall, any wastewater stored in the tank will be progressively released and treated along with 'normal' inflows. Available storage in the tank will be restored to full capacity as efficiently as possible so it is generally maintained in an empty state, maximising potential storage capacity for future wet weather events.

The tank will be partially recessed into the landscape and will be a maximum of 30 m diameter. The apex of the tank roof will be approximately 3.7 m above ground level at most. The tank will be finished in a non-reflective recessive colour and screened from off-site view by landscape planting (see the proposed landscape planting concept plan in Appendix C). As the tank will be sealed, no odour discharges from the tank are anticipated, with odorous gases extracted and neutralised at the WWTP.

3.4.2 The Subsurface Wetland

A subsurface wetland will be formed immediately north of the wet weather flow storage tank, on the Old Coach Road storage site. The wetland will provide emergency storage for fully treated wastewater of approximately 2,100 m^3 in the unlikely event that irrigation is unavailable and storage at the Robinsons Bay Valley site is at capacity, or the pipeline to the irrigation sites is compromised (such as due to pipe break, earthquake or similar). Aside from situations where the pipeline is compromised, modelling shows that storage in the subsurface wetland may be needed to supplement that at Robinsons Bay approximately once every ten years if storage at Robinsons Bay Valley is at capacity.

The wetland will consist of a basin with a base area of approximately 3,200 m^2. The invert and batter slopes will be formed by redistributing site soils supplemented by imported materials as needed. The wetland will be lined with impervious material and the base covered with gravel to a depth of approximately 0.3 m to provide porous media.

Under normal operation a residual trickle flow of treated wastewater will be maintained from the WWTP into the gravel media to keep the wetland plants in good condition. The residual flow will be equivalent to the evaporation and evapotranspiration losses such that the wetland water levels consistently remain below the gravel surface (subsurface) and so no discharges from the wetland are required. This approach will optimise plant growth and health while maximising the available storage capacity in the wetland.

The gravel layer in the wetland's base will provide media for indigenous wetland plants to grow in, and porous material adequate to contain water below the gravel surface during normal operation. A species list of appropriate plants for each part of the proposed wetland is attached as Appendix E, which specifically includes mahinga kai species. The subsurface design will also reduce its appeal to birds and wetland fauna and the potential for contamination of the residual water by waterfowl. Maintaining water levels below the gravel surface will also minimise the potential for insects to proliferate.

If the wetland's storage capacity is required, only treated wastewater will be diverted into it. The water levels in the wetland may extend above the gravel surface depending on the volume of treated wastewater that needs to be stored. Any water stored in the wetland beyond levels needed to support healthy plants will be retained as briefly as possible. Once the storage is no longer needed the surplus volumes will be drained as a priority, either by diverting the stored wastewater back through the WWTP for re-treatment or conveying it directly to irrigation. The subsurface wetland will only be required for storage occasionally, however it is part of the conservative design of the scheme and provides contingency storage next to the WWTP in the event it is needed.

3.4.3 Future Land Use

The applicant owns the Old Coach Road storage site, which extends downslope to opposite the intersection of Childrens Bay Road and SH75. The upper part of the site will be extensively planted and developed with walking tracks and a boardwalk through the wetland as designed by Ōnuku Rūnanga along with interpretation panels and a small car park accessed from Old Coach Road. The public parking will provide access to a range of walking tracks and future community recreation areas (refer to the concept shown in the landscape plans in the drawing 'Old Coach Road Plan' Appendix C). Future development may include public walking access between Childrens Bay and Old Coach Road.

3.4.4 Site Development

Resource consent RMA92026256 was issued by the CCC in 2015 to authorise the building and operation of the new WWTP. Consents from ECan to discharge construction phase stormwater to water and odour to air were also issued[8]. While it was not required under the regional rules that applied at that time, the WWTP now also needs resource consent from ECan to use the land for community wastewater treatment.

The resource consent issued by the CCC requires a CEMP to be prepared prior to construction, with several sub-management plans including for traffic management, erosion and sediment control, and hazardous substances/spill contingency.

The CEMP requirement under RMA92026256 applies only to the WWTP and does not include the construction of the wet weather storage tank or the subsurface wetland on the Old Coach Road site. However, the scope of this application includes construction phase requirements for the Old Coach Road site and the overarching CEMP will be drafted to address construction management, and erosion, dust and sediment control for that site through an Erosion, Dust and Sediment Control Plan (EDSCP) as a subset of the CEMP.

The proposed wet weather flow storage tank and the subsurface wetland will involve approximately 9,000 m^3 of earthworks, with approximately 6,350 m^3 of cut to form a level platform for the structures. Approximately 2,250 m^3 of the cut material will be used to form the subsurface wetland basin by building a 3.0 m wide crest supported by internal and external batters at a 3:1 gradient. Excess material that cannot be redistributed and recontoured onsite will be removed from the site.

All earthworks will be preceded by erosion, stormwater, and sediment control measures consistent with Environment Canterbury's *Erosion and Sediment Control Toolbox* and appropriate for the scale of the works and the unique characteristics of Banks Peninsula's loess soils. The measures will be monitored and maintained for the duration of the works until unconsolidated surfaces have been stabilised, including by revegetating, mulching, surfacing, or compacting disturbed areas as soon as possible following the completion of works. Aspects of the construction phase that could generate unreasonable dust beyond the site will also be managed using appropriate methods such as water carts, sprinklers, compaction, mulching or revegetation.

Following the completion of works, screen and amenity planting will be undertaken as indicated in the concept Landscape Plan drawings in Appendix C and maintained until established.

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[8] RMA92026256, CRC152814 and CRC150049

3.5 The Pipelines

Resource consent CRC150046 authorises dewatering to enable the existing wastewater network to be extended to connect to the new Terminal Pump Station, however the scheme will require the installation of substantial pipelines across the remainder of the sites, as described below.

3.5.1 Terminal Pump Station to the WWTP

A new pressure main will be installed to convey raw wastewater from the Terminal Pump Station to the WWTP for treatment (Drawing C200, Appendix C, on the same alignment as the 'purple pipeline') from the Akaroa Boat Park up Old Coach Road to the WWTP. A separate pipe will be installed in the same trench to convey treated wastewater from the WWTP to Akaroa for non-potable use.

The pipelines will need to cross Ōinaka / Grehan Stream and will be installed beneath the bed of each branch using trenchless methods (e.g. directional drilling or thrusting). These methods will avoid disturbing the beds and banks of the stream and the associated adverse effects on water quality and stream ecology. The pipes will be placed deep enough to be protected from flooding, scour or other risks.

3.5.2 Treated Wastewater Pipeline

The largest pipeline will convey treated wastewater from the WWTP to the irrigation sites and will have an approximate internal diameter of 225 mm. This pipeline will terminate at the storage tanks in the Robinsons Bay Valley site. It will be installed in legal road for most of its length as shown on Drawing C200, tracking west from the WWTP to the intersection of Old Coach Road and SH75, then north along SH75 to an unformed legal road at approximate chainage 3800. The pipeline will follow the unformed legal road (currently comprising farmland) to the boundary of the Robinsons Bay Valley site at approximate chainage 4700. The remainder of the pipeline will be within the Robinsons Bay Valley site, connecting to the irrigation distribution network and to the storage tanks. An offtake to the Hammond Point site will be provided.

The pipe will typically be retained in a full (pressure) state. From time to time there will be the need to release accumulated gas to air via valves placed at high points along the pipeline as gasses will naturally accumulate and need to be released. Given the approximate 5.0 km length of the pipe between the WWTP and the storage at Robinsons Bay, it is estimated that approximately five valves may be needed subject to the pipeline profile. Given the highly treated nature of the wastewater and the operation of the pipeline under constant pressure, the volume and frequency of discharges from these valves will be minimal.

3.5.3 Pipeline Construction

The pipelines will be installed almost exclusively within legal road, much of which will be SH75 under the jurisdiction of Waka Kotahi NZ Transport Agency (Waka Kotahi). The applicant will work with the CCC and Waka Kotahi as the road control authorities regarding corridor access and construction traffic and effects management. Works will be undertaken to minimise disruption to traffic flow and safety. Works in the road corridors will be undertaken in line with the road controlling authority's traffic management requirements, and the scheme's EDSCP in respect of managing the effects of dust, sediment, stormwater, stockpiling and construction activities.

The pipeline will cross several watercourses including Ōinaka / Grehan Stream and Takamātua Stream (approximately chainage 1220), unnamed ephemeral streams at approximate chainage 1600 and 3550, and several tributaries of Robinsons Bay Stream at approximate chainages 4000 and 4440 as shown on Drawing C200. To minimise potential adverse effects on water quality and downstream aquatic ecology the pipeline will be thrust or drilled beneath streams with permanent flow, from thrust pits formed well landward of the stream banks. No works will occur in flowing water, or within 10 m of any existing lawful structures or utility poles.

The remainder of the pipeline construction including across ephemeral streams where no water is present will be by trenching. Construction will be timed over the summer when groundwater levels are low, and no surface water is present in the ephemeral streams. As the ephemeral streams are all small, the bed contours will be restored within 48 hours of completing construction, with only bed material deposited on stream beds. Stream bank marker posts will be erected at all stream crossing points.

The trenched sections from the Terminal Pump Station to the WWTP and on to the Robinsons Bay Valley site will be approximately 7,000 m long, 1.0 m wide and 2.0 m deep. Additional trenching will be required from the offtakes to each irrigation site, and within each site as part of the internal distribution network. Overall, it is estimated that the installation of the network will involve approximately 20,000 m^3 of earthworks between the Terminal Pump Station and the Robinsons Bay Valley site.

Dewatering may be required in some sections of the pipeline route given groundwater levels in some low lying sections, and the estimated 2.0 m depth of the pipeline trench. If dewatering is required, it will be undertaken only as needed to complete the pipeline installation and will avoid stream depletion or affecting any water supply takes in the vicinity, noting that none have been identified. Any dewatering and associated discharges required will be undertaken to comply with the permitted activity standards set out in Rule 5.119 of the Canterbury Land and Water Regional Plan.

3.6 Robinsons Bay Valley Irrigation Site

The proposed Robinsons Bay Valley Irrigation site is located at 11 Sawmill Road, to the southeast of Robinsons Bay Valley Road, east of Sawmill Road, Robinsons Bay Valley. The approximately 118 ha property is legally described as Lot 2 DP 82749 (CT CB47D/512) and is owned by the applicant. Following historic land clearance, the site has been used for pastoral farming and is currently leased for grazing.

Under the proposal, treated wastewater with a mean annual TN concentration of 10 g/m^3 will be irrigated to 31.9 ha of the land deemed 'most suitable' on the site (as indicated in Figure 3-5) which will be planted with indigenous vegetation.

A further 23 ha of riparian and 'in-fill' planting will be established, contiguous with the irrigated area but not irrigated (refer to the concept landscape plans in Appendix C). Consequently, the proposal will involve destocking approximately 55 ha of the Robinsons Bay Valley irrigation site and planting it with indigenous vegetation.

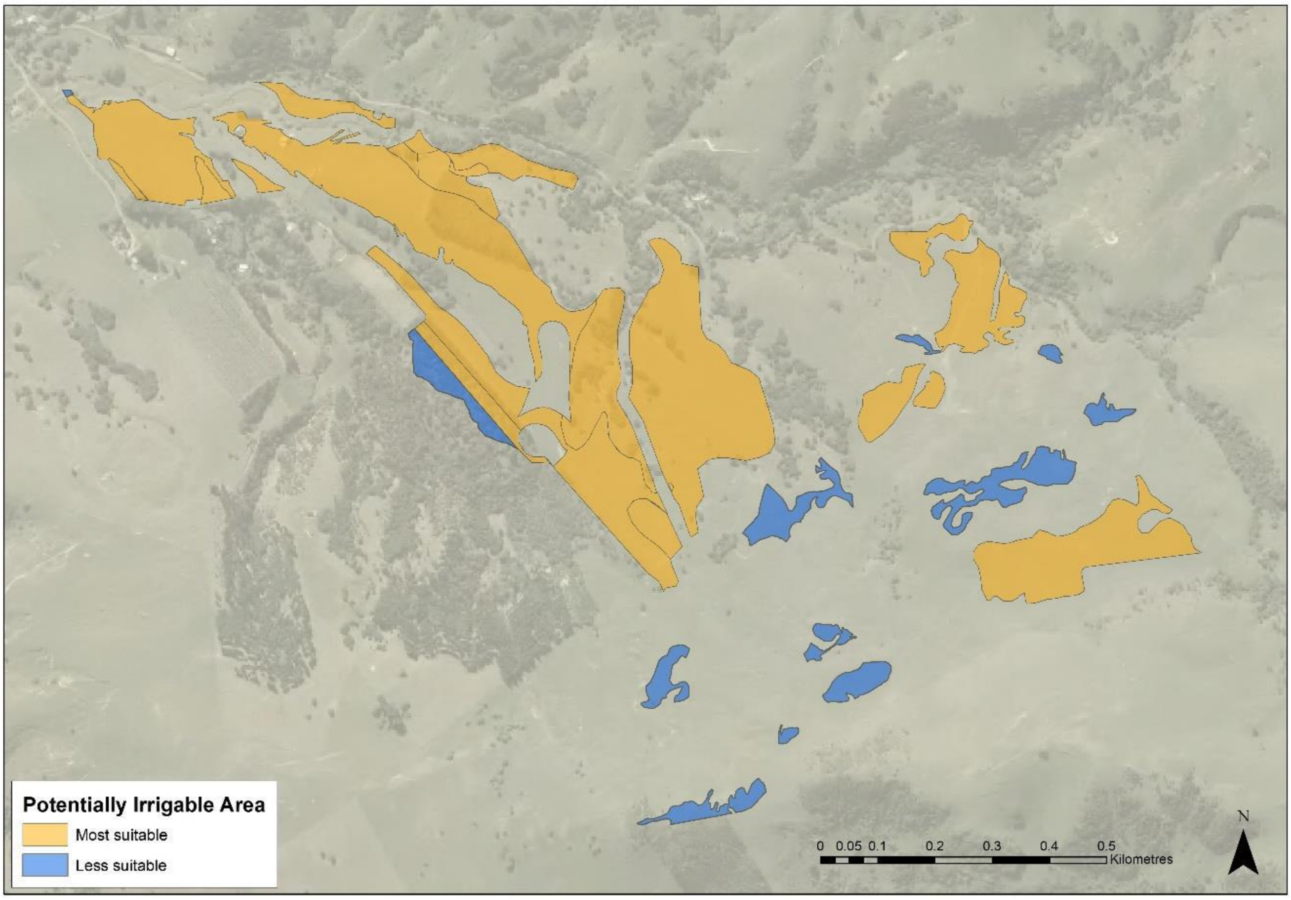

Figure 3-5: Irrigable land on the Robinsons Bay Valley Irrigation Area (Source: Aqualinc 2022)

Aqualinc's modelling allows for 13.5 kg/ha[9] of nitrate-N denitrification and uptake by the indigenous vegetation across both the 31.9 ha irrigated area and the 23 ha unirrigated area, as the latter will be contiguous with / downslope of the

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[9] Meister et al (2021): *A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula*; and
Meister, A, and Robinson, B. (2022) *An assessment of the likely fate of nitrate nitrogen irrigated onto NZ-native vegetation with Treated Municipal Wastewater in Robinsons Bay, Banks Peninsula*, Institute of Environmental Science and Research, University of Canterbury.

irrigated land. A further 2kg/ha[10] of nitrate-N offset from destocking the 31.9 ha irrigation area and the 23 ha unirrigated area was also allowed for. The effect of this change is assessed in Section 10.3.1.

Conceptually, up to four irrigation drip lines will be laid equally spaced between each 2.0 m wide tree row, with drippers set out in zones at approximately 30 – 50 cm centres, depending on the final design. Treated wastewater would be applied at a drip rate of up to 2 L/hr, delivering approximately 8,400 m^3/ha/yr. Rates may be adjusted to optimise soakage as groundcover changes from pasture to indigenous vegetation. The irrigation concept recommends pulsing irrigation, allowing short (e.g. 23 minute) run times per zone, followed by an equal rest period, then a repeat run time, followed by a longer rest period to maximise the time that applied water and nutrients are held in the root zone for uptake. Initially, clean water is likely to be irrigated, both to test the irrigation system and to help new plants establish, with planting occurring on the site up to four years in advance of treated wastewater irrigation.

The species to be planted and the concept planting regime are described in the Terrestrial Ecology Report[11] attached in Appendix B. The planting concept is shown in the Landscape Plans in Appendix C. The species have been selected specifically to thrive in the characteristics of the setting and the irrigation regime. The species have also been selected to extend and support naturally regenerating indigenous vegetation across the site and the wider area, and to support and increase biodiversity values. The plants will be propagated from seeds that have already been collected from across Banks Peninsula. The 23 ha of unirrigated land adjacent to and downslope of the irrigable areas, and between the irrigable areas and watercourses (permanent and ephemeral) will be planted in a complementary range of indigenous species. These plantings will provide visual and ecological continuity across the site and the wider valley. In addition, the planting will broaden biodiversity values and provide continuous vegetation cover across the site. These areas will intercept applied wastewater (within the root zone) from upslope irrigated areas to minimise seepage to watercourses and help to suppress weed growth for improved land management.

The future management of the upper part of the site is yet to be determined but will be compatible with the primary purpose of the property as the main irrigation area for the scheme.

3.6.1 Treated Wastewater Storage

A key part of the proposed scheme is a series of storage tanks proposed for the Robinsons Bay Valley irrigation site (Drawing C151 – Rev A, Appendix C). The capacity to store treated wastewater is fundamental to the scheme being fully land-based and avoiding any discharges to water (fresh or coastal water). An example of the proposed tanks is shown in Figure 3-6.

The tanks will store treated wastewater when soil capacity across the scheme is exceeded and irrigation needs to be temporarily suspended, such as may happen after extreme or prolonged wet weather. The PDP irrigation model[12] identified the required storage requirements for the scheme based on a comparison of daily wastewater flow records between 1972 and 2019, and the anticipated effects of climate change based on NIWA's RCP4.5[13] scenario. The modelling determined that storage capacity of approximately 11,250 m^3 would be needed so the scheme can irrigate and / or store all wastewater treated at the WWTP without requiring any bypass discharges of treated or untreated wastewater from the scheme to an alternative receiving environment. The modelling took account of the anticipated effects of climate change on rainfall frequency and intensity and forecast inflow and infiltration reductions.

To provide the necessary storage volume, the applicant proposes to provide up to ten covered tanks of approximately 22 m diameter and 6.0 m high (to the roof apex) depending on the final configuration as shown in Drawing C151 – Rev A. Initial storage capacity of at least 12,000 m^3 will be developed, but consent is sought in respect of all ten tanks, which would provide a cumulative total potential storage capacity of up to 20,000 m^3. The additional capacity would provide substantial storage above the modelled volume to account for unforeseen events.

As capacity returns to soils across the irrigation sites, stored treated wastewater will be irrigated along with incoming treated wastewater from the WWTP with the tanks emptied as soon as practicable and generally retained in an empty state to maximise available storage.

Treated wastewater will also be able to be returned to the WWTP by reversing flows along the WWTP – Robinsons Bay Valley pipeline. This will enable stored treated wastewater to be used for non-potable use in Akaroa (refer section 3.8).

[10] Messman, N (2022), Nutrient modelling Robinsons Bay Version 1. Lumen Environmental Ltd. 5th Sept 2022
[11] Meurk, C D: 2022; *'Baseline and Terrestrial Ecology Effects Assessment – Akaroa Treated Wastewater Irrigation Scheme (ATWIS)'*.
[12] PDP_C02239202L001_IrrigationModel_v2_pdf.pdf
[13] National Institute of Water & Atmospheric Research report 2020; *'Climate Change Projections for Canterbury Region'*; Representative Concentration Pathway (RCP) 4.5 scenario.

Figure 3-6: Example of the covered storage tanks proposed

(Image: From Kliptank)

The tanks will comply with the New Zealand Loadings Code NZS1170 to meet Importance Level 2 or 3 as is required for wastewater treatment facilities.

The tank area will be accessed by the vehicle track and will be the scheme's largest area of earthworks and structures.

3.6.2 Robinsons Bay Valley Site Development

The extent of the proposed construction works on the Robinsons Bay Valley site are shown on Drawing C151 (Appendix C) and will include:

- Formation of a new vehicle access track from Robinsons Bay Valley Road, and an internal access track (approximately 3.0 – 4.0 m wide and metalled) from the road to the proposed storage tank platform. Access to the site is currently gained from Sawmill Road. The vehicle access track will be formed from an existing access in upper Robinsons Bay Valley Road to provide construction and operational access. The track will follow the general alignment of an existing track and will appear similar to a standard farm track.
- Earthworks to form the storage tank platform of approximately 50,000 m^3 (cut and fill) involving cut slopes battered at 2:1 up to approximately 6.0 m high and fill at a 2:1 gradient and approximately 12 m deep. The platform will provide adequate flat area for vehicles to access, park, and manoeuvre on the site for tank construction, maintenance and operational reasons. Excess cut material will be distributed within the site, stabilised, and revegetated.
- Installing irrigation distribution infrastructure including the rising main from the WWTP, irrigation laterals across the site and surface drip lines in general accordance with the concept described in section 8 of the Aqualinc Report.
- Planting mixed species of indigenous vegetation as described in the Terrestrial Ecology report including *Leptospermum scoparium* (mānuka), *Olearia paniculata* (akiraho), *Coprosma robusta* (karamu), *Podocarpus cunninghamii* (Hall's totara), *Cordyline australis* (tī kōuka/cabbage tree) and *Phormium tenax* (harakeke/flax[14] across the irrigable areas within the site, and other indigenous vegetation including within the riparian margins of Robinsons Bay Stream in general accordance with the applicant's proposed species list (Appendix B) and concept landscape plan (Appendix C). The proposed planting will also include:
  - The restoration of riparian vegetation alongside Robinsons Bay Stream by destocking the area, fencing, and planting indigenous vegetation. The vegetation will contribute to improving the instream habitat by filtering overland storm flows and providing shade and habitat for aquatic species.
  - Ephemeral gully restoration, involving augmenting and facilitating regrowth of existing indigenous vegetation. This will have the added benefits of fostering biodiversity and habitat for indigenous fauna, stabilising soils in gully areas, and slowing stormwater runoff from the site.
- Establishing walking tracks and interpretation boards over time for future public recreational use of the site, in general accordance with concept landscape plan as shown in the drawings attached as Appendix C to this document.

[14] Trials on a range of indigenous vegetation identified species that responded strongly to irrigation with treated wastewater (*Final Report (June 2017): A lysimeter experiment and field trail to determine options for the beneficial reuse of water from Duvauchelle and Akaroa, Banks Peninsula,* Brett Robinson, University of Canterbury).

- Establishing fencing within the site to prevent public access to areas of contaminated soil and identified heritage value. The established oak plantation will be retained.
- Establishing, disestablishing, and rehabilitating contractor areas within the site (location and extent to be determined).

Erosion, stormwater, and sediment control measures will be developed specifically for the topography and characteristics of the site, and the extent of the earthworks required (refer Section 5). This will include measures to minimise tracking of soil and material onto Sawmill and Robinsons Bay Roads during construction.

3.6.3 Future Land Use

The site will transition from its current farmland state to (ultimately) indigenous bush with associated landscape, habitat and biodiversity values.

As the planting matures, indigenous vegetation will cover approximately half (55 ha) of the site. The applicant proposes to develop a series of public walking tracks and establish interpretation panels in key locations to highlight the heritage and biodiversity values present. Public access to the site would be via the walking tracks. The lower part of the site containing heritage values and items will be fenced off from the rest of the site and managed in respect of the heritage values present.

Areas of the site may also be made available for research to investigate and refine the use of indigenous vegetation in treated wastewater irrigation to improve understanding and inform future management and development options. These trials may enhance the effectiveness of the irrigation activity and enable the applicant to refine and optimise the scheme further. Future land use on the site will therefore be limited to the proposed irrigation activity, public walking access, and research.

3.7 Hammond Point Irrigation site

The Hammond Point Irrigation site lies immediately east of and adjacent to Hamond Point at 6538 Akaroa Christchurch Road (SH75). The site is approximately 11.9 ha, legally described as Lot 1 DP 563448 (CT 1001524) and is owned by the applicant. Access to the site is from SH75 via an existing unsealed vehicle track which is a shared access to a private property at the base of the site next to the coastline (Lot 2 DP 653448).

Currently, the site is dominated by exotic pasture. There is a small area of indigenous vegetation along the southeast boundary near a gully which will be retained. The approximately 3.8 ha of irrigable land on the site (Figure 3-7) will also be planted in indigenous species. Approximately 8.1 ha of contiguous boundary and ‘in-fill’ planting will increase the total planted area to approximately 11.9 ha. No new above-ground structures are proposed except for the irrigation off-take near the road boundary.

The applicant will plant a range of species appropriate for the location and which will complement restoration planting on Hammond Point undertaken by the Department of Conservation. The proposed species and planting methodology will be the same as for the Robinsons Bay Valley irrigation site.

Irrigation would be by surface drip irrigation under the extensive indigenous vegetation that would be planted on the site. The ‘preferred case’ for the Hammond Point Irrigation area as modelled by Aqualinc assumes that the treated applied wastewater will hold a mean TN concentration of 10 g/m^3. Aqualinc’s modelling allowed for denitrification in the site’s soils and uptake by the indigenous vegetation across the site, and destocking across the irrigation area. Under the irrigation proposal, the modelled concentration of nitrate-N from applied treated wastewater would increase at this site by approximately 129.7 kg N/ha//yr.

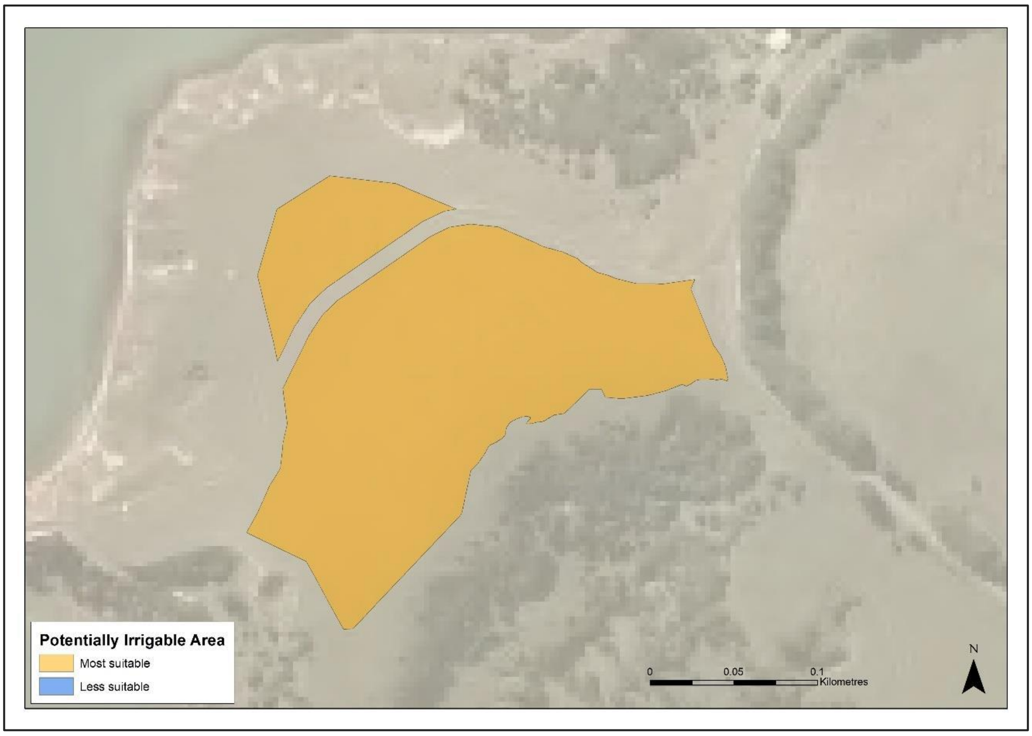

Figure 3-7: Irrigable land on the Hammond Point Irrigation site

(Source: Aqualinc 2022)

3.7.1 Hammond Point Site Development

The development concept for the Hammond Point site is shown in the drawing labelled 'Hammond Point' in Appendix C, and will involve:

- Upgrading the existing access to the site, retaining it as a metalled track from the existing access.
- Laying an irrigation lateral from the rising main in SH 75 to connect to a control system on the site. Installing irrigation infrastructure within the irrigable land including controls, laterals and surface drip lines.
- Planting the same indigenous vegetation as for the Robinsons Bay Valley Irrigation site across the irrigable area of the site, and other indigenous vegetation surrounding the irrigable area, in general accordance with the applicant's concept landscape plans
- Establishing walking tracks to connect to proposed public tracks from north and south of the site for future public recreational use as indicated in the concept landscape plans.
- Establishing, disestablishing and rehabilitating contractor areas within the site (location and extent to be determined).

Erosion, stormwater and sediment control measures will be developed specifically for the topography and characteristics of the site, and the extent of the earthworks required (refer Section 11). This will include measures to minimise tracking of soil and material onto SH75 during construction.

3.7.2 Future Land Use

The applicant's concept landscape plans show potential walking tracks and interpretation panels in key locations linking a coastal pathway from the southern end of Robinsons Bay towards Takamātua using an existing undeveloped legal road along the shoreline. Future public access to the site will be available along walking tracks that are designed to minimise the potential for contact with treated wastewater in the irrigation zone. Future land use of the site will therefore be limited to the proposed irrigation activity and limited public walking access.

3.8 Jubilee Park

A key theme in the community's feedback on the scheme was to enable treated wastewater to be used for non-potable purposes through a 'purple pipe' system. There are currently no New Zealand regulations which enable non-potable treated wastewater to be used by the public, however the applicant resolved to provide for limited non-potable use and proposes to install infrastructure that can be expanded in the future should the regulations change.

Irrigating Jubilee Park directly responds to community aspirations to reuse wastewater as expressed through the Council's extensive consultation and hearings process. It also implements the Council's resulting resolution to provide for non-potable use of as part of the scheme.

Figure 3-8: General areas of Jubilee Park to be irrigated

The non-potable water used to irrigate Jubilee Park will replace the current use of potable water via sprinklers, conserving potable water for community use. The irrigation concept anticipates applying treated wastewater only as needed to maintain vegetation in good condition. Using the sub-surface drip irrigation method limits the potential for public contact with irrigated water (in contrast to sprinklers for example). The low application rate proposed, and the subsurface method will mean that irrigated water will remain below the surface to be available for plant uptake and losses via evaporation and evapotranspiration. The application rate will be very low, limiting the potential for applied water and contaminants to leach to groundwater.

There are no Community Water Supply Protection Zones in the vicinity of Jubilee Park, with the nearest public water supply take approximately 300 m to the southeast near Settlers Hill.

3.8.1 Jubilee Park Site Development

Construction activities at Jubilee Park will be minimal, limited to the installation of the 'purple pipe' pipeline to the irrigation distribution system at the park, and the sub-surface drip irrigation system within the grounds. The pipeline is expected to be installed by open trenching where appropriate and by thrusting / drilling beneath Ōinaka / Grehan Stream, terminating near the park boundary. The sub-surface drip irrigation driplines can be installed by mole-plough or a similar comparatively unobtrusive method, and along with the flatness of the site, the need for substantial erosion, stormwater and sediment control measures will be limited.

4 Wastewater Treatment

The treatment and irrigation concepts are summarised in this section and described in more detail in the Aqualinc Report in Appendix A.

The concept treatment process is described in this section consistent with the process described in the resource consent application submitted in 2014[15] culminating in *inter alia* land use consent RMA92026256 for the development of the Terminal Pump Station and WWTP.

The ATWIS concept is based on modelling of several decades of wastewater flow data, as well as 42 years of climate data, and acquired soil moisture and receiving environment data, and takes account of:

- Forecast population growth in the Akaroa network catchment, including resident and visitor numbers to 2052
- Reduction of flows into the wastewater network from the Akaroa Water Supply Plant on L'aube Hill by up to 75% of current inflows
- Reduction of I&I into the wastewater network of up to 20% of current volumes
- Accounting for a 5% increase in rainfall and changes in rainfall intensity due to the forecast effects of climate change (NIWA RCP4.5 scenario), with a decrease in the number and frequency of rain events over time
- The known characteristics and contaminant load of wastewater from the Akaroa catchment.

The final treatment method is yet to be determined, however the required nitrogen concentration following treatment has been determined based on the assimilative capacity of the receiving environment as informed by modelling undertaken by Aqualinc. The final treatment process will be configured to achieve the minimum quality specified in Table 4-1 or better.

The ATWIS concept is based on raw wastewater being treated to a very high standard using a treatment process to be confirmed. Conceptually wastewater will be treated using biological nitrogen processes, membrane filtration[16] and Ultra Violet (UV) disinfection, or a process that achieves a similar quality. The final treatment process will be determined at the detailed design stage.

Under the current concept, raw wastewater will be pre-screened to remove course solids and grit, and then fine screened. Screenings will be diverted to fully enclosed / covered containers for offsite disposal. The concept then involves screened wastewater flowing to the treatment process. Sludge produced by the WWTP will be stored fully enclosed until it can be transported to the Christchurch WWTP at Bromley for processing into biosolids. Depending on the selected treatment process, this is expected to occur on a weekly basis.

If a membrane bioreactor process is selected, activated sludge solids will be separated from treated wastewater using aerated tanks containing ultrafiltration (UF) membranes. Filter backwash would be retained within the treatment process and recirculated. The resulting permeate (treated wastewater) would be of very high quality and clarity appropriate for further disinfection using UV light.

Regardless of the treatment process, the highly treated wastewater will be conveyed directly to irrigation or stored if irrigation is temporarily unavailable. All treated wastewater will be irrigated to land either directly from the WWTP, from storage, or both.

4.1 Filtration and Disinfection

As irrigation will use surface and subsurface drippers, filtration will be required to significantly reduce the potential for suspended solids to block dripper nozzles and affect the efficiency of the irrigation system. As with several treatment options, membrane filtration is extremely efficient at removing contaminants including particles and microbes however further disinfection using UV may also be included as a final step, particularly as a portion of the treated wastewater will be used for non-potable purposes.

Figure 4-1 shows the pathogens removed by filtration processes based on the size of the organisms relative to effective filter pore size of 1 µm or smaller. Most bacterial and protozoan pathogens and some viruses are removed by this level of filtration. The concept treatment, filtration and disinfection processes or its equivalent will result in a very high level of treatment, with treated wastewater further treated by natural processes in unsaturated soil layers following irrigation.

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[15] *Akaora Wastewater Scheme Upgrading – Resource Consent Application and Assessment of Effects on the Environment*, CH2M Beca Ltd

[16] The process is described in detail in *'Akaroa Wastewater Summary of Land Disposal and Reuse Investigations'* CH2M Beca Ltd, 2020

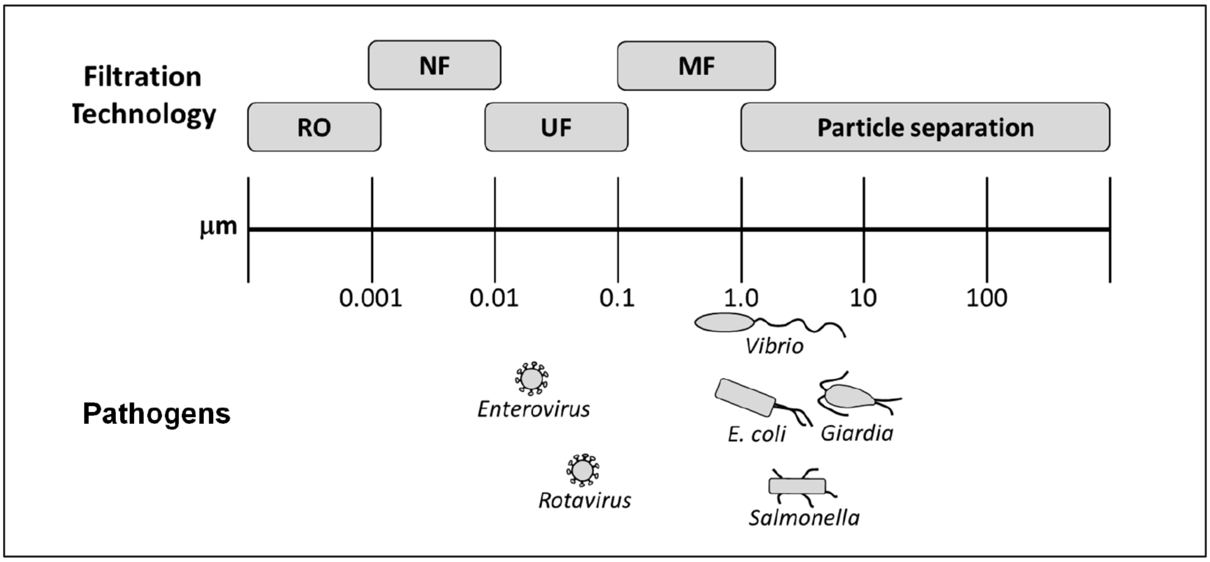

Figure 4-1: Membrane Filtration effectiveness for pathogen removal[17]

Key:
RO: Reverse Osmosis: NF: Nano filtration: UF: Ultra filtration: MF: Microfiltration.

4.2 Treated Wastewater Quality

The applicant determined the extent to which wastewater will need to be treated by determining the assimilative capacity of the receiving environment[18] as a starting point for determining the level of treatment needed at the WWTP, and the standard of the treated wastewater leaving the treatment process and conveyed to irrigation. While a final treatment process has not yet been determined, the process will, as a minimum meet the values described in Table 4-1[19] on a mean average basis:

Table 4-1: Proposed Treated Wastewater Quality Standards Prior to Irrigation

Parameter	Unit	Proposed Mean Annual Treated Wastewater Quality
Total suspended solids	mg/L	2
Carbonaceous BOD_5	mg/L	5
Total Nitrogen	mg/L	10
Total Phosphorus	mg/L	7
E.coli	cfu/100mL	10
Enterococci	cfu/100mL	10

The assessment of effects set out in section 10 of this document is based on achieving the values described in this table. In particular as the key contaminant of interest, the treatment process will be configured to produce mean total nitrogen (TN) concentrations in the treated wastewater of 10 g/m^3.

4.3 Network Inflow and Infiltration

The wastewater network in Akaroa includes five emergency overflow points which provide for untreated wastewater to overflow, safeguarding community health if network emergencies, natural hazard events or extreme weather overwhelms the network. The network is subject to stormwater and groundwater inflows and infiltration (I&I) entering the network during wet weather events, and the flow in the network can exceed network capacity as well as the capacity of the WWTP to receive and treat inflows.

[17] Source: *"Removal of Pathogens by Membrane Bioreactors: A Review of the Mechanisms, Influencing Factors and Reduction in Chemical Disinfectant Dosing"* by Hai et al, published in *Water* 2014, *6*, 3603-3630
[18] *Akaroa Treated Wastewater Irrigation Scheme;*, McIndoe, I. *et al*, 2022
[19] Adapted from *Akaroa Wastewater Summary of Disposal and Reuse Options*: CHRM Beca Ltd, 2020

Following extensive investigations, the applicant has identified that I&I is due to a range of factors including broken or cross-connected pipes on private property, tree root intrusion into pipes and an aging pipe network. Location-specific CCTV inspections of mains pipes and laterals were undertaken, along with visual inspections via manholes. The applicant also undertook a distributed temperature survey (DTS) of the network. Information from the DTS survey was aggregated with other condition and network information from the Council Asset Management datasets and GIS and areas with the highest identified I&I were prioritised for pipe repair or replacement.

The DTS work identified a significant contribution to the wastewater flows were from the Council's L'Aube Hill Water Treatment Plant, with wastewater from the treatment process (known as retentate) being discharged to the wastewater network. At the end of 2020 I&I along with retentate discharges from the water treatment plant were estimated to contribute up to 60% of wastewater flows. The applicant identified that modifying the L'Aube Hill Water Treatment Plant presents a significant opportunity to further reduce flows in the wastewater network, along with specific network improvements such as pipe repairs and replacement.

Reducing I&I directly influences the volume of raw wastewater storage and the treatment capacity, storage volume and irrigation area needed. I&I reduction will also help to reduce the risk and frequency of network overflows in Akaroa. The reduction of I&I and retentate as part of reducing inflows to the WWTP benefit the scheme is addressed in modelling by PDP[20] (Appendix F) which in turn informed the extent of treated wastewater storage needed for the scheme.

4.3.1 Reducing Inflows and Infiltration

In addition to identifying the L'Aube Hill Water Treatment Plant retentate, the applicant initiated a $3.2 million programme of works and improvements to substantially reduce I&I in the wastewater network from 2019, including:

- An upgrade of the wastewater main between Smith Street and Jubilee Park recreation ground. Repairs made to backflow preventers at the four network overflow points between Smith Street and Rue Brittan delivered a ~10% reduction of wastewater inflows to the current WWTP.
- Issuing of contracts to repair wastewater network issues in 16 areas over 2022.
- Identification of 133 laterals that needed further assessment, finding that 70% of them needed repairs at the time. Property owners are responsible for rectifying faults on private property.

Early indications show a reduction in the relationship between rainfall and WWTP inflows. In late July 2017 there was a mean of 27 mm of rain over seven days, with mean daily wastewater flow in the same period of 1,943 m³/day. In May - June 2021 rainfall of 35 mm /day was recorded but daily wastewater flows were 1,376 m³/day showing a reduced network response and confirming the effectiveness of I&I reduction work to date. The applicant's efforts to date have shown that the I&I component of wastewater flows has reduced from 44% in 2019 to 31% in 2021 with further work to complete. As of April 2022, the applicant has completed approximately half of the planned work and expects to complete the remainder by the end of 2022.

If monitoring shows it is needed, I&I may be reduced further by:

- Further reducing retentate flows from the water treatment plant by optimising plant processes, and / or through on-site reuse or recycling within the process
- Separately treating highly turbid source water to reduce or remove the need to discharge as much retentate to the wastewater network
- Undertaking further repairs to and replacements of pipes and infrastructure in the wastewater network

These options along with previous work and network improvements will enable I&I volumes to be reduced. This will reduce wastewater volumes needing treatment and reduce the storage and irrigation requirements of the scheme.

4.4 Residual Contaminants

While the treatment process will substantially remove or reduce contaminants from raw wastewater inflows to achieve the output quality parameters set out in Table 4-1, some residual contaminants will remain when irrigated to land. Applying the treated wastewater to land will enable further treatment of these contaminants in the receiving environment through natural processes including volatilisation, plant uptake, adsorption and absorption, denitrification, dilution and dispersion.

The primary residual contaminants of interest include, pathogens, metals, phosphorus, Persistent Organic Pollutants (POPs), pharmaceuticals, emerging contaminants and pesticides, and nitrogen (in various forms). Aside from nitrogen, these contaminants are generally expected to be removed or substantially reduced through the treatment process and further degrade in the environment following irrigation as they evaporate, are taken up and used by plants, pass through

[20] PDP, 27 January 2022, PDP_C02239202L001_IrrigationModel_v2_pdf.pdf

unsaturated soil, and eventually enter ground or surface water or the harbour in highly diminished states. The anticipated residual contaminants in the treated wastewater are described in the technical memo in Appendix G and summarised in the following sections.

4.4.1 Metals, Phosphorous and Persistent Organic Pollutants

Sampling of the treated wastewater at the existing WWTP shows that copper and zinc are the only metals that prevail in concentrations that exceed the standards in the Canterbury Regional Coastal Environment Plan (RCEP - as relevant to the current WWTP's coastal discharge). The RCEP limit for copper is 0.005 mg/L, and the limit for zinc is 0.05 mg/L. The applicant's sampling found copper concentrations between 0.015 and 0.030 mg/L, with 50% of the observations for zinc between 0.05 and 0.10 mg/L.

Phosphorous will be present in the irrigated wastewater. Soil storage and plant uptake are the major sinks for wastewater-applied phosphorous. The potential for significant concentrations of phosphorous to leach from the irrigable areas is considered minimal given the domestic origins of the wastewater, the low wastewater irrigation rates proposed, the propensity of phosphorous to bind to soil and its availability for plant uptake.

As for phosphorous, Persistent Organic Pollutants (POPs) are expected to be present in the irrigated wastewater. Soil organic carbon storage is a potential POP sink in surface soils, and it is expected that soils under forest canopy will act as efficient POP sinks.

4.4.2 Nitrogen

The primary residual contaminant of concern is nitrogen as the other key residual contaminants will either be removed or substantially reduced by the treatment process and following further treatment through the unsaturated zones in the irrigation sites. The concern with nitrogen is its solubility and mobility in the environment, and the corresponding potential to adversely affect receiving water quality. Consequently, the scheme was designed by determining the assimilative capacity of the receiving environment, determining the necessary treatment standard to minimise adverse effects from nitrogen to the extent practicable, and thereby identifying the quality of treated wastewater to be produced by the WWTP.

4.4.2.1 Modelling

Aqualinc used Hydrus and Irricalc models to inform the scheme concept design and configuration. The concept irrigation scheme is substantially based on the findings of those models and Aqualinc's recommendations. The assumptions and parameters used for the models are described in the Aqualinc report in Appendix A.

Hydrus was used to determine:

- The appropriate dripper spacing and establish the spread of irrigation between drip lines
- The hydraulic properties of the soil and its assimilative capacity
- The circumstances when ponding might occur (and therefore how to limit that happening)
- Irrigation drainage through the soil profile.

Irricalc was used to determine the overall catchment mass balance, and accounts for evapotranspiration, deep and lateral drainage through the soil, and runoff. The modelling results and their interpretation are set out in detail in the Aqualinc Report.

4.4.2.2 Annual Applied Nitrogen

Having modelled various applied nitrogen scenarios to inform the scheme concept design, the applicant proposes to manage applied nitrogen loads across the scheme by achieving a total nitrogen output from the WWTP averaging 10 g/m^3. On that basis, treated wastewater leaving the WWTP has been assumed to have a dissolved inorganic nitrogen (DIN) concentration of 8.6 g/m^3. The modelled nitrogen loading rates for the two irrigation sites are set out in Table 4-2:

Table 4-2: Modelled Nitrogen Loading Rates for the Irrigation Areas

	Total applied load (kg/ha/year)	DIN load over irrigable area (kg//ha/year)	DIN total load over wetted area[21] (kg/year)
Robinsons Bay Valley	57.5	49.5	1,580
Hammond Point	57.5	49.5	188

(Source: Table 3, Aqualinc Report)

[21] The wetted area refers to the area of land that is directly irrigated within the irrigable area.

The models run by Aqualinc indicate that the nitrogen load applied to the Robinsons Bay Valley site would increase nitrate-N in Robinsons Bay Stream from the existing measured mean concentration of 0.030 g/m^3 to 0.087 g/m^3, a change of 0.057 g/m^3 from the measured mean baseline.

Irrigation to the Hammond Point site under the 'Preferred Scenario' would result in a modelled nitrate-N load of 122.1 kg/year[22] across the 3.8 ha site, allowing for plant uptake, soil denitrification and destocking.

The annual applied nitrate-N load to Jubilee Park is modelled as 25.5 kg/yr[23].

4.4.3 Nitrogen Management Options

The scheme has been designed by considering the likely effects of the activity on the receiving environments, and then working back to the WWTP to determine the quality of treatment needed so treated wastewater leaving the plant minimises adverse effects on the receiving environments.

The modelling focussed on a range of TN values (as the key contaminant of concern) and considered the application methods, the area of 'most suitable' land identified for irrigation, and the characteristics and post-irrigation processes in the receiving environment. Consequently, a mean TN concentration of 10 g/m^3 in the treated wastewater was identified as being an achievable practicable treatment output that minimises adverse effects on the respective receiving environments.

Close monitoring of the effects of the scheme is proposed to enable the treatment process to be optimised to consistently achieve the minimal adverse effects anticipated (or better). In the event that adjustments to the scheme are needed to improve outcomes, the applicant will have several potential management options available. These could include but are not limited to:

- extending the irrigable land on the Robinsons Bay Valley irrigation site to include the 'less suitable' land and irrigating over a larger land area to reduce drainage
- purchasing additional land to further increase the irrigated area
- reducing inflows into the WWTP by further reducing I&I into the wastewater network to the extent practicable
- introducing additional treatment steps within the WWTP process to target specific contaminants if problematic.

5 Other Discharges

5.1 Construction-phase Discharges

Substantial earthworks will be required across the various scheme sites, but particularly at the Old Coach Road Storage site (including the already consented WWTP site) and at the Robinsons Bay Valley Irrigation site. The development of the pipelines will also result in cumulatively extensive works albeit in a linear, modular approach.

The works will largely involve the disturbance of loess soils including on slopes where there is a high risk of sediment migration and stormwater runoff with high suspended sediment content. The highest risk from construction-phase discharges will be during the construction of the wet weather storage tank and subsurface wetland at Old Coach Road, the pipelines to the irrigation areas including stream crossings, the formation of access tracks, and the construction of the tank platforms at the Robinsons Bay Valley site.

Uncontrolled discharges of sediment, sediment-laden stormwater, construction debris and materials and machinery-related contaminants (hydrocarbons, hydraulic fluids etc.) can present a substantial risk to people (e.g. from migrating onto roads) and receiving environments including aquatic habitat. Managing construction phase discharges will therefore be essential and will be achieved by adopting the appropriate measures set out in ECan's Erosion and Sediment Control Toolbox, as reflected in a site-specific Erosion, Dust and Sediment Control Plan (EDSCP) to be developed and submitted to ECan for confirmation prior to commencing construction. The underlying principles that will be adopted are to retain all sediment and stormwater within the boundary of each construction site to the extent reasonably practicable, and to discharge all construction-phase stormwater to land within the respective construction sites. By adopting this approach, the anticipated construction discharges will be contained and suitably managed to minimise the risk to the public and receiving environments.

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[22] Section 10.9.2, Table 20, page 50, Aqualinc Report, Appendix A.
[23] Section 10.9.3, Page 50, Aqualinc Report, Appendix A.

5.2 Operational Stormwater Discharges

Rainfall across the Scheme will generally soak to ground where it falls other than where it contacts built structures and hard surfaces. Only the Old Coach Road storage and Robinsons Bay Valley site will contain structures and hard surfaces that will shed stormwater. The remaining sites will largely contain substantial vegetation cover including existing pastoral areas and the proposed indigenous planting and will not require stormwater management measures.

5.2.1 Old Coach Road Storage Site Stormwater

Stormwater from all clean parts of the WWTP (roofs and hardstand areas) will be collected in sumps and swales and discharged to the roadside stormwater swale on Old Coach Road. The applicant holds resource consent CRC152814 which authorises the discharge of construction and operational phase stormwater from the WWTP site to water.

Stormwater will collect in the subsurface wetland and will generally evaporate or be evapo-transpired by the wetland plants until storage levels are restored. Where necessary, water levels in the facility will be managed by temporarily stopping treated wastewater trickle flows into the basin, and / or by drawing the stormwater level down by pumping to the WWTP for treatment.

Stormwater from the roof of the wet weather flow storage tank will soak to land on site. The soils on the site are not contaminated, have not been identified as previously used for a contaminating activity, and will not become contaminated as a result of using the land as proposed. Stormwater from the small car park proposed on the site will be discharged to the Old Coach Road swale.

5.2.2 Robinsons Bay Valley Stormwater

The Robinsons Bay Valley site storage tanks will be covered to prevent accumulated rainfall reducing the storage capacity of the tanks, and to maintain the quality of any stored treated wastewater. Rainfall will be shed by the roofs and will fall to ground, draining to land on the tank platform or directed toward stormwater management (e.g. swales). Toe drainage will be provided around the base of the tanks to direct captured stormwater either to a sump (draining to land) within the irrigation area or to a 'bubble-up' structure downslope from the tanks at the head of an ephemeral stream (Drawing C151, Appendix D).

Rainfall across the tank platform will either soak to ground or be directed by formed slope angle to the foot of the headwall batters where a formed swale or toe drainage will soak to land or direct flows to the ephemeral waterway. The discharge will not result in significant change to the receiving watercourse (ephemeral stream or ultimately Robinsons Bay Stream) given the scale of the tanks and platform in the context of the site, and the avoidance of hard surfacing such as concrete or asphalt in forming the platform. Much of the stormwater from the platform is expected to soak to land in the vicinity of the facility. Stormwater that is directed to the ephemeral stream is not expected to hold significant levels of suspended solids as the platform will be stabilised, metalled and revegetated to the extent practicable.
The soils on this part of the site are not currently contaminated, have not been identified as previously used for a contaminating activity (refer to the Preliminary Site Investigation report in Appendix J) and will not be contaminated by the proposed activity.

The access track and tank platform will be metalled and formed with a cross-fall toward the upslope (southern) side of the track. Stormwater from the track will generally soak to ground consistent with gravelled farm access tracks.

5.3 Construction-phase Discharges to Air

The most likely source of construction-phase discharges to air will originate from earthworks associated with establishing the subsurface wetland and wet weather storage tank on the Old Coach Road storage site, the storage tanks and irrigation infrastructure at the Robinsons Bay Valley irrigation site, irrigation infrastructure at the Hammond Point site, and the installation of the pipelines. Dust may also be generated at a minor scale by clearing and re-planting of vegetation in the respective irrigation sites, the formation of internal tracks and by construction traffic moving within and between each area.

Off-site dust will be most likely to be generated during windy conditions when actively undertaking earthworks such as when forming the tank platform on the Robinsons Bay Valley irrigation site. Other sources may include materials stockpiles at those sites, areas disturbed during pipeline construction and when placing the distribution network at each irrigation site, and when establishing tracks and site infrastructure.

In all cases, construction-phase discharges of contaminants to air are expected to be comparatively brief and limited to during and immediately following soil disturbance, movements of construction traffic and handling of construction materials within the project footprint. Disturbed land will be stabilised (such as by compaction, sealing or planting) and other dust control methods such as irrigation and water carts will be used as needed.

5.4 Operational Discharges to Air

5.4.1 Aerosols

Surface drip irrigation applies the treated wastewater directly to the land surface, with effectively no opportunity for wind to disperse wastewater, particularly as it will be applied within established vegetation.

Jubilee Park in Akaroa will be irrigated using subsurface drip irrigation, thereby avoiding any opportunity for aerosol generation.

5.4.2 Odour

A full description of the scheme components that could be potential sources of odour is set out in the Air Quality Assessment report attached in Appendix K of this document.

The report concludes that key potential odour sources are the terminal pump station and the WWTP including the raw wastewater buffer tank at the Old Coach Road storage site which will be vented through the WWTP biofilter. Discharges from these components are already authorised under CRC150050.

The subsurface wetland, air valves along the pipeline from the WWTP to the irrigation sites, the storage tanks on the Robinsons Bay Valley site and treated wastewater irrigation are also assessed in the Air Quality Assessment report and were identified as either having no or negligible potential to produce odour that is discernible beyond the site boundaries.

The Air Quality Assessment report concludes that the potential for odour discharges from the scheme is minimal, and centres primarily on components that will store and treat raw wastewater. The remainder of the scheme is considered unlikely to result in any discernible change to air quality. The effects of operational discharges to air are addressed in Section 10.8 of this document.

5.4.3 Sensitivity of the Receiving Environment to Discharges to Air

The location of the WWTP and the components on the Old Coach Road storage site are in relatively close proximity to other landowners and land use activities, including SH75 that would be sensitive to the effects of odour discharges. Similarly, the pipeline from the WWTP to the irrigation areas, and the irrigation areas themselves are in a rural area with typically high ambient air quality, noting the potential for odour generated by rural productive activities (e.g. faming, farm animals and effluent, silage etc). The mixed rural and residential context of the receiving environment is considered to be moderately sensitive to discharges of odour from wastewater storage, treatment and conveyance.

6 Description of the Environment

6.1 Soils

The soil characteristics are important as they determine how much treated wastewater can be irrigated to each site. They are also important in determining the fate of treated wastewater and residual contaminants applied to the sites i.e. the proportion that will evapotranspire, run off the land surface, or drain into the soil profile and below.

Aqualinc's site investigations identified the soils across both irrigation sites as Barry's Bay Loess (deep silt loam). The soils are described as approximately 9% sand, 71.5% silt and 19.5% clay, with variable depths and lower permeability horizons in some locations. The soil characteristics of Jubilee Park are unknown however part of the park consists of reclaimed land and soil characteristics are expected to be variable across the site.

Aqualinc adopted the following soil properties for modelling purposes, based on the properties of Barry's Bay deep silt loam:

- Profile available water (PAW): 157 mm down to 600 mm, 262 mm to 1 m
- Readily available water (RAW): 96 mm to 600 mm depth, 160 mm to 1 m depth
- Saturation: 45%
- Field capacity: 37%
- Stress point: 21%
- Permanent wilting point: 11%
- Surface infiltration rate: 6.6 cm/h
- Vertical hydraulic conductivity: 2 cm/h
- Bulk density: 1500 kg/m^3

- Tree and pasture rooting depths: 1 m and 600 mm respectively

A fuller description of these properties and their implications for the ATWIS is set out in the Aqualinc Report in Appendix A.

6.1.1 Sensitivity of Soils

The sensitivity of the soils across the ATWIS footprint to the application of treated wastewater is considered to be low to moderate. The residual contaminant loads in the applied treated wastewater will be comparatively low and are expected to be readily assimilated into or pass through the receiving soils. The presence of extensive planting and eventually, regenerating indigenous forest will assist with the uptake and treatment of irrigated contaminants insofar as they may affect soil quality and structure. The sodium adsorption ratio (SAR) of the applied treated wastewater is an important determinant of its suitability for irrigation to soil, and is calculated from the concentrations of sodium, calcium, and magnesium. High SAR has the potential to damage the physical structure of soil by reducing its porosity. The sodium concentration and the SAR value in the scheme's treated wastewater are both low, hence there is minimal 'sodium hazard' to the proposed irrigation site soils.

6.2 Groundwater

Groundwater is an important consideration because it is a receiving environment and acts as a medium for transferring applied treated wastewater to other environments (e.g. Robinsons Bay Stream or Akaroa Harbour). The potential effects of the proposal on groundwater include impacts on quantity (e.g. increased recharge resulting in potential mounding and discharge to connected surface water), and quality (e.g. increased concentrations of nutrients and other contaminants in groundwater and seepage into connected surface water).

Groundwater surveys and monitoring was undertaken at the irrigation areas to characterise the hydrological environment and provide baseline data for the project, including for ongoing environmental monitoring. The hydrogeological investigation included reviewing the geology of Banks Peninsula, identifying underlying aquifers, measuring groundwater levels, and identifying the groundwater chemical makeup.

6.2.1 General Hydrological Setting

Banks Peninsula is a relic of extinct volcanos extending from the Canterbury plains into the Pacific Ocean. Geological processes created steep landscapes, deep valleys, bays, coastal cliffs, and beaches. A layer of loess (wind deposited fine silt) covers the northern and western flanks of the peninsula, including the Robinsons Bay Valley and the Hammond Point sites.

There are over 100 streams in the Peninsula, all in catchments that are very steep, short (less than 10 km long), and have short lowland stream reaches commonly only a few kilometres long. Apart from the streams that flow into Te Roto o Wairewa (Lake Forsyth), streams in Banks Peninsula flow directly (and quickly) into the harbours and sea, naturally flushing in high rainfall events. Indigenous forest covers many of the stream headwaters, while most others are dominated by exotic pasture. The landscape is generally dominated by steep-sided valleys and flat land is very limited.

Groundwater in Banks Peninsula occurs in the alluvium filling the narrow valleys, the loess deposits, and the fractured basalt. It is generally limited to alluvium and loess in the flat and gently sloping areas near watercourses given the largely impervious nature of the underlying volcanic bedrock. In these areas, groundwater typically drains into surface watercourses via subsurface seepage, with some groundwater daylighting as springs which then flow to streams or the harbours. Overall, the groundwater resource potential of the alluvial deposits is limited due to their small sizes. The small grain size of the loess deposits and the prevalence on slopes means loess deposits have little potential as groundwater supply sources. The random, often disconnected nature of the underlying basalt means it is an inconsistent potential source for groundwater supply. There are no large-scale, reliable groundwater sources in Banks Peninsula, including in the vicinity of the scheme, and Aqualinc's investigations confirmed that there is no regional-scale aquifer beneath the irrigable land at the Robinsons Bay Valley or Hammond Point irrigation sites.

6.2.2 Groundwater Underlying the Irrigation Areas

Aqualinc's investigations found that the proposed irrigation sites hold variable depths of loess over basalt base rock. No deep groundwater aquifer was identified across the scheme area, however occasional deep groundwater does exist in fractured basalt throughout the Peninsula.

6.2.2.1 Robinsons Bay Valley

The LWRP identifies that an unconfined/semiconfined aquifer exists within the lower valley/valley floor, as shown in Figure 6-1. It is anticipated that this aquifer extends beyond the area shown in the figure and continues along the Robinsons Bay Stream alignment to underlie the irrigation area (not shown).

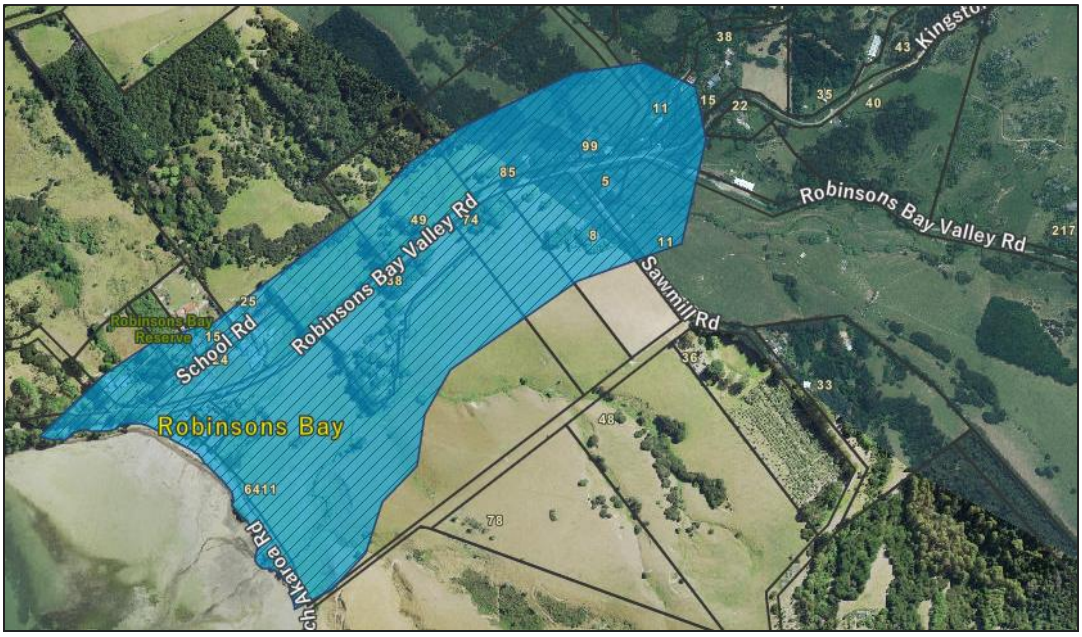

Figure 6-1: LWRP Unconfined / Semiconfined Aquifer at Robinsons Bay Valley

(Source: Canterbury Maps)

Aqualinc's study involved two piezometers in the Robinsons Bay Valley Irrigation site approximately 6 m deep and identifying shallow groundwater beneath the site. Groundwater was found at 2 – 3 m below ground level over the 2021 / 22 summer period that was monitored. The depth of the aquifer beyond 6 m below ground level is unknown. This shallow groundwater is anticipated to be the continuation of the aquifer shown in Figure 6-1.

The groundwater gradient is anticipated to be primarily towards the stream, with a slower gradient along the valley downstream. The anisotropy in the substrate underlying the site results in horizontal movement being faster than vertical movement.

Aqualinc concluded that the soil characteristics at the Robinsons Bay Valley irrigation site will not limit the amount of treated wastewater that can be applied to the land. The Aqualinc study indicates that most if not all the irrigation drainage water[24] at the Robinsons Bay Valley site would move through the soil profile and ultimately drain to Robinsons Bay Stream as per the concept shown in Figure 6-2.

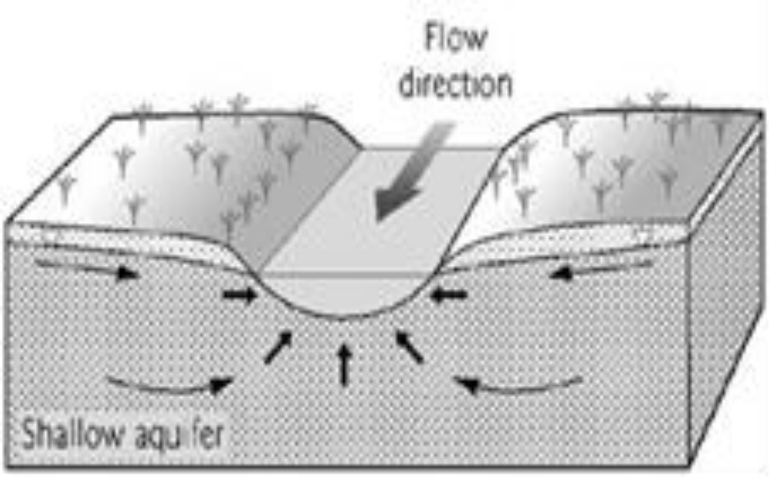

Figure 6-2: Groundwater recharge of Robinsons Bay Stream

[24] Irrigation drainage water is irrigation water that is not consumed by the plants and percolates through the soil profile.

Appendix D of the Aqualinc report presents the results of chemical analysis from water samples drawn from the piezometers at the Robinsons Bay Valley irrigation site including various species of nitrogen. Mean nitrate levels in Robinsons Bay Valley groundwater were found to vary between 0.08 mg/l upstream of the irrigation site to 3.27 mg/L downstream. Other chemical characteristics and contaminant levels including various species of nitrogen are set out in Appendix D of the Aqualinc report, however nitrate is the primary contaminant of concern and the focus of the modelling and effects assessment undertaken.

6.2.2.2 Hammond Point

The approximately 10 m deep piezometer Aqualinc installed at the Hammond Point site did not encounter any groundwater, hence it is assumed that any water applied to the site from rainfall or irrigation that is not taken up by plants or evaporated, is expected to pass through the soil profile and ultimately drain to Akaroa Harbour rather than becoming groundwater. No weathered areas are currently visible on the cliff faces, indicating that significant seeps above sea level are not currently present.

6.2.2.3 Jubilee Park

Jubilee Park is known to overlay shallow groundwater with a tidal influence, given its proximity to the harbour, and its location on reclaimed land.

6.2.3 Groundwater Users

While there are understood to be several groundwater users downgradient of the Robinsons Bay Valley irrigation site (bores and springs), two consented water supply bores[25] have been identified (Figure 6-3) supplying groundwater to individual properties for domestic use. Other groundwater users in the vicinity, including for stock supply and domestic drinking water are shown on Figure 6-4, all of which are identified as spring water sources. There are no known active bores on or near the Hammond Point site.

Figure 6-3: Active Consented Water Supply Bores in Robinsons Bay

(Source: Canterbury Maps)

[25] N36/0027, C. W. Crotty – active domestic bore; N36/0137, E. C. Ryder – active domestic bore.

Figure 6-4: Known ground and spring water users near Robinsons Bay Valley and Hammond Point (blue dots)

(Source: CCC)

6.2.4 Sensitivity of Groundwater

There is a shallow water table underneath the Robinsons Bay Valley irrigation site. However, the topography of the area and the low hydraulic conductivity of the loess soils across the Robinsons Bay Valley site indicate that water applied to the site through rainfall or the application of treated wastewater not taken up by the vegetation will become base flow in Robinsons Bay Stream. The drainage water is expected to largely travel directly to the stream within the property boundary. Because of this, the effects assessment focusses on the stream as the ultimate receiving environment rather than groundwater. The sensitivity of the groundwater beneath the Robinsons Bay Valley site is assessed as low to moderate.

As no groundwater has been identified beneath Hammond Point, there is no assessment of groundwater sensitivity. As the groundwater underlying Jubilee Park is tidally influenced and is within reclaimed land, it is considered to be relatively insensitive to the to the potential effects of applying treated wastewater to Jubilee Park.

6.3 Surface Water

EOS Ecology undertook water quality sampling and prepared a baseline assessment and environmental effects report[26] (the Freshwater Ecology Report) describing the surface waterbodies that may be affected by the construction and / or operation of the ATWIS, and their characteristics.

Twelve rounds of water quality sampling were undertaken approximately monthly between August 2021 and July 2022 across a range of environmental conditions. The median values of the parameters analysed for were recorded and assessed against the relevant default guidelines and LWRP Schedule 5 values as described in Section 3.4 of the Freshwater Ecology Report. Water quality across all surveyed streams is summarised in Table 5 of the Freshwater Ecology Report. The results show that water quality in Robinsons Bay Stream generally met Default Guideline Values (DGV) [27], LWRP Schedule 5 limits and NPS-FM 2020 national bottom lines over the sampling period other than for

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[26] Dewson, Z. 2022. *Akaroa Treated Wastewater Irrigation Scheme (ATWIS): Assessment of Environmental Effects on Freshwater Ecology*. EOS Ecology Report No. STA03-21004-01. 59 p.

[27] Australia and New Zealand Guidelines for Fresh and Marine Water Quality 2018

electrical conductivity, pH, dissolved reactive phosphorus and total phosphorus. The results also show that the measured median nitrate-N concentrations in Robinsons Bay Stream was 0.0295 g/m^3 in dry weather, rising during wet weather before dropping again. The quality of water in Ōinaka / Grehan Stream was not as high as that of Robinsons Bay Stream, but also generally met DGV and LWRP Schedule 5 limits other than for electrical conductivity, dissolved inorganic nitrogen, dissolved reactive phosphorus and total phosphorus (refer Table 5 of the Freshwater Ecology Report).

A range of ecological surveys were also undertaken to define baseline water quality and identify the ecological values present in each surveyed stream, including habitat assessments, macroinvertebrate and fish surveys and environmental DNA (eDNA) surveys. The data gathered in these surveys provide a comprehensive baseline to describe the current water quality and ecological health of the streams, enabling accurate evaluations of the construction and operational effects of the ATWIS to be made.

The following descriptions of ecological values in each stream are summarised from the Freshwater Ecology Report attached in Appendix H.

6.3.1 Robinsons Bay Stream

The Robinsons Bay Stream catchment drains approximately 1,383 ha of rural land near the head of Akaroa Harbour. The stream is fed by precipitation runoff and holds permanent flow in its mid to lower reaches, with a mean flow of 156 L/s as measured in the vicinity of the Robinsons Bay Valley irrigation site. At the time of the habitat survey undertaken by EOS Ecology, the stream in the vicinity of the irrigation site had a wet area of approximately 3.0 m wide with riffle / pool / run sequences evident, and the streambed dominated by boulders, with large cobbles also common. Periphyton were found to be abundant, with macrophytes limited to the stream margins. The stream characteristics identified in the surveys undertaken by EOS Ecology are summarised in Table 1 of the Freshwater Ecology Report.

EOS Ecology also undertook 12 months of water quality sampling in Robinsons Bay Stream, recording a range of parameters in both dry and wet weather conditions. The results are set out in section 3.4 of the Freshwater Ecology Report. The water quality in Robinsons Bay Stream was consistently the best of the surveyed streams across most parameters, however it did not meet the ANZG 2018 default guideline values for dissolved reactive phosphorous or total phosphorus, pH or electrical conductivity.

The macroinvertebrate surveys undertaken by EOS Ecology found taxa and EPT[28] taxa richness in the surveyed streams was highest in Robinsons Bay Stream (Tables 2 and 3, Freshwater Ecology Report). A mean of up to 27 species of invertebrates were identified in the stream using eDNA surveys. The surveys recorded MCI, QMCI and ASPM[29] values for Robinsons Bay Stream which were assessed as falling within Attribute Bands B and C[30] (Figures 6 – 8 Freshwater Ecology Report).

Twelve fish species, all native or endemic were identified across all streams surveyed, with eight species present in Robinsons Bay Stream. The lower reaches of the stream are known to provide inanga spawning habitat and are noted as inanga spawning habitat in the Canterbury Land and Water Regional Plan.

Robinsons Bay Stream was assigned an ecological value score by EOS Ecology that took into account the range of indicators surveyed. The stream score indicated a 'moderate to high' overall ecological value because of the moderate to high habitat and invertebrate value scores, and moderate fish value score. The scores for each criterion are set out in Table 7 of the Freshwater Ecology Report.

6.3.1.1 Sensitivity of Robinsons Bay Stream

Robinsons Bay Stream has been assessed as moderately sensitive to the potential effects of the ATWIS given the current water quality and aquatic habitat values present.

6.3.2 Ōinaka / Grehan Stream

Ōinaka / Grehan Stream drains a catchment of approximately 504 ha to the north and east of Akaroa. Land use in the upper catchment is dominated by productive farming activities with ground cover mainly in exotic pasture interspersed with exotic and indigenous vegetation. The lower catchment passes through the Akaroa urban area, primarily dominated by domestic dwellings, where it divides into the north and south branches and discharges to Childrens Bay.

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[28] Ephemeroptera, Plecoptera and Trichoptera taxa
[29] MCI: Macroinvertebrate Community Index; QMCI: Quantitative Macroinvertebrate Community Index; ASPM: Average Score Per Metric.
[30] As defined in the National Policy Statement for Freshwater Management 2020

The true left (south) branch passes close to the area of Jubilee Park that is proposed to be irrigated by sub-surface drip irrigation using treated wastewater from the ATWIS. The true left branch was measured with a mean flow of 37 L/s upstream of the mouth. The mean wetted bed widths of both branches were assessed as less than 2.0 m at the time of survey, with both branches showing riffle and run sequences. The beds of both branches were dominated by cobbles, with smaller sediment grades present. Periphyton was abundant in each branch, with macrophytes also present. The stream characteristics identified in the surveys undertaken by EOS Ecology are summarised in Table 1 of the Freshwater Ecology Report.

Water quality monitoring undertaken by EOS Ecology in Ōinaka / Grehan Stream showed that the stream meets or is better than most of the values for the parameters measured but does not meet the ANZG 2018 guideline values for lead, total and dissolved reactive phosphorus and dissolved inorganic nitrogen (Tables 5 and 6, Freshwater Ecology Report).

Taxa and EPT taxa richness in Ōinaka / Grehan Stream indicated dominance by taxa that prefer or tolerate degraded habitat or water quality. Ōinaka / Grehan Stream had the most macroinvertebrates of all streams sampled, with a mean of up to 37 species identified. Ōinaka / Grehan Stream's MCI, QMCI and ASPM scores were assessed as being within NPSFM 2020 Attribute Band C or D (Figures 6 – 8 Freshwater Ecology Report), with Band D being below National Bottom Lines and indicating severe loss of ecological integrity. Despite this, ten fish species were identified in the stream, and the lower reaches of the stream provide inanga spawning habitat, with a spawning habitat restoration project undertaken in the lower reaches in 2018.

Ōinaka / Grehan Stream was assessed against the criterion set out in Table 7 of the Freshwater Ecology Report to determine an overall ecological value score using the method described in that report by EOS Ecology. The stream was determined to hold 'moderate' overall ecological value for the reasons identified in the report.

6.3.2.1 Sensitivity of Ōinaka / Grehan Stream

Ōinaka / Grehan Stream is not considered to be sensitive to the potential effects of the ATWIS based on the existing water quality and habitat values present.

6.3.3 Robinsons Bay

Robinsons Bay Stream drains the valley catchment to Robinsons Bay, an inner shallow bay in the northeast part of Akaroa Harbour. Robinsons Bay is considered likely to be the primary coastal receiving environment for any residual effects from irrigating treated wastewater to the Robinsons Bay Valley Irrigation site via the stream. There is also potential for any resulting seepage from the Hammond Point Irrigation site to enter Robinsons Bay. Consequently, baseline surveys of the estuarine environment and its values were undertaken by EOS Ecology. Macroinvertebrate density and taxa richness was assessed, and infauna invertebrate distribution was recorded. The methods and outcomes are reported in the Estuary Ecology Report prepared by EOS Ecology[31] and attached to this document as Appendix I.

6.3.3.1 Ecology

The baseline assessment identified three flora taxa across the three intertidal sites surveyed across Childrens Bay, Takamātua Bay and Robinsons Bay. Of the three sites surveyed, Robinsons Bay had the highest mean cover of intertidal seagrass, some subtidal seagrass (observed but not surveyed) and the highest overall flora cover of the surveyed sites. The assessment noted that the presence of the seagrass *Zostera muelleri* in Robinsons Bay indicates that the system is not currently impacted by chronically high nutrient or sediment loads as the taxa is sensitive to poor water quality conditions. The low cover of *Ulva sp.* and *G. chilensis* are also indicative of low nutrient levels in the bay as they thrive in high nitrogen and phosphorus conditions.

EOS Ecology's surveys identified 11 macroinvertebrate taxa across the three sites surveyed, and these are described in detail in the Estuary Ecology Report. The survey did not identify any invertebrate taxa of conservation concern. The assessment concluded that the range and density of taxa identified in the intertidal surveys indicate that significant nutrients or fine sediment concentrations are not present in the harbour at the surveyed sites.

A total of 47 taxa were identified from the infaunal samples collected in the intertidal survey, the species are described in detail in the Estuary Ecology Report. No invertebrate taxa of conservation concern were identified in the surveys, and there was an absence of the type of taxa that indicate significant nutrient enrichment or the presence of excessive fine sediment.

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[31] Burns, J. & Hempston, N. 2022. Akaroa Treated Wastewater Irrigation Scheme (ATWIS): Assessment of Environmental Effects on Estuary Ecology. EOS Ecology Report No. STA03-21004-02. 51 p.

Robinsons Bay was found to be the most biologically rich inner harbour intertidal flat surveyed, with moderate ecological value based on the baseline habitat values surveyed and the presence of seagrass beds, and moderate macroinvertebrate species richness and abundance (Table 6-1).

Table 6-1: Estuary Aquatic Ecological Site Assessment Summary

Characteristics	Robinsons Bay		Takamātua Bay		Childrens Bay	
	Site Value	Reasoning	Site Value	Reasoning	Site Value	Reasoning
Flora	Moderate	Moderate cover (25%–75%) of habitat forming species. Presence of *Z. muelleri* ('At Risk' threat classification).	Low	Low species richness. Low cover (<25%) of habitat forming species. Species could be indicative of elevated nutrients.	Moderate	Presence of *Z. muelleri* ('At Risk' threat classification).
Macro-invertebrates	Moderate	Moderate species richness, diversity & abundance. Presence of taxa that are sensitive to enrichment & settled sediment as well as some that are more tolerant.	Low	Low species richness, diversity & abundance.	Low	Low species richness, diversity & abundance.
Habitat	High	Habitat generally heterogenous. Intertidal zone not limited through modified structures.	Moderate	Habitat generally homogenous. Sediments typically less than 50% silt & clay.	High	Habitat generally heterogenous. Sediments typically less than 35% silt & clay. Intertidal zone not limited through modified structures.
Overall Score	Moderate		Low		Moderate	

(Source: EOS Ecology: Estuary Ecology Report)

6.3.3.2 Sensitivity of Robinsons Bay

Robinsons Bay is considered to be sensitive to the potential adverse effects of the ATWIS in respect of the effects on the cultural values of the harbour, and moderately sensitive in respect of the resilience of fauna and flora present in the bay.

6.3.4 Childrens Bay

Childrens Bay is a shallow inner harbour embayment immediately west of and adjacent to the Akaroa settlement. Childrens Bay Stream and Ōinaka / Grehan Stream both discharge into the inner bay. Childrens Bay Stream drains the south-facing slopes above the bay, dominated by low density residential development and rural agricultural land use. The catchment for Ōinaka / Grehan Stream is substantially larger, covering the open slopes mostly in rural agricultural use to the east of, and above Akaroa, and passing through urban Akaroa in the lower reaches before entering the bay. The eastern shoreline of northern Childrens Bay has been heavily modified, formed by historic reclamation and is currently used for car and boat parking and storage, a boat ramp and the various facilities and spaces of Jubilee Park. Ōinaka / Grehan Stream has been partially channelised in its lower reaches with the north branch passing through a culvert beneath a boat storage area and the south branch forming the northern boundary to the primary open space of

Jubilee Park.

Components of the ATWIS in this area will include the construction of the Terminal Pump Station in the boat park, incidental changes to the wastewater network to connect to the pump station and from there to the new WWTP, and the installation of the 'purple pipe' scheme that will supply treated wastewater to the subsurface drip irrigation infrastructure in the park. However, the limited irrigation of Jubilee Park during summer is the only irrigation activity within the Childrens Bay catchment.

The limited irrigation proposed means that it is likely that any effects on the quantity and quality of Ōinaka / Grehan Stream and Childrens Bay will be indiscernible from baseline conditions. However, EOS Ecology undertook a baseline survey of estuarine values, recording macroinvertebrate density, taxa richness, and infauna invertebrate distribution. This baseline survey will provide a reference that may help to determine what, if any effect the irrigation of Jubilee Park may have on the values in Childrens Bay.

6.3.4.1 Ecology

The survey methods and findings are reported in the Estuary Ecology Report in Appendix I. In summary, the surveys found:

- The presence of *zostera muelleri*, indicating that water quality in the bay does not suffer from chronically high nutrient or sediment loads as the taxa is sensitive to poor water quality
- Some areas of subtidal seagrass present (not surveyed)
- Six epifaunal samples taken in Childrens Bay had no taxa, and a substantially lower macroinvertebrate density than the other surveyed bays. No invertebrate taxa of conservation concern were found in the infaunal samples, and the dominant taxa did not indicate a proliferation of nutrient or fine sediment tolerant species.
- The sandy sediment of the Childrens Bay seafloor supported the largest cockles surveyed across the three sites.

The baseline assessment concluded that Childrens Bay holds moderate ecological value overall, due mainly to the habitat values and seagrass beds present (refer Table 6-1).

6.3.4.2 Sensitivity of Childrens Bay

Childrens Bay is considered to be sensitive to the potential adverse effects of the ATWIS in respect of the effects on the cultural values of the harbour, and moderately sensitive in respect of the effects on water quality, and fauna and flora present in the bay.

6.4 Terrestrial Ecology Values

The existing terrestrial ecology values of the project area were investigated and are recorded in the Terrestrial Ecology Report[32] attached in Appendix B. The report focusses on the values present at the Old Coach Road storage site, the irrigation sites, and at the Inner Bays Scheme site at Takamātua, which was subsequently removed from the ATWIS. The terrestrial ecology values at Jubilee Park are not expected to change because of the scheme.

The assessment methodology is set out in the Terrestrial Ecology report, as are the findings of field work and desk top investigations. In summary, the assessment found that:

- The project area is generally dominated by pasture and exotic vegetation associated with livestock farming. In particular, no indigenous vegetation was identified within the areas to be irrigated with treated wastewater. The field evaluation consequently focussed on identifying areas of the project where indigenous vegetation and wetland habitats are currently present.
- The soils in the wider area consist of deep loess that receive approximately 700 mm of rainfall annually and are prone to summer drought. The soils generally provide a deep fine-textured substrate suitable for plant roots to effectively penetrate and to access the soil's water-holding capacity.
- A total of 139 plant species (84 exotic), 14 bird species (5 exotic), one indigenous skink and five mammals (all exotic) were identified across the project area. Of the 84 exotic species observed, 12 are regarded as serious invasive species requiring immediate eradication and 11 are less important weed species that will struggle to thrive in the forested setting proposed for the irrigation sites.
- Several small wetlands and seepages are present, primarily in the vicinity of the Robinsons Bay Valley irrigation site. None of the wetlands or seepages observed will be within irrigated land.

The specific values of each project site are considered in the following sections.

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[32] *'Base-line and Terrestrial Ecology Effects Assessment – Akaroa Treated Wastewater Irrigation Scheme'* – Meurk, C D: 2022

6.4.1 The Old Coach Road Storage Site

The Terrestrial Ecology values of the Old Coach Road storage site are limited, dominated by farming-related exotic species. The site is dominated by exotic pasture, particularly in the northern half. The southern part of the site includes a mix of large exotic and indigenous vegetation and mature trees. The land to be developed for wastewater management purposes at this site consists entirely of exotic species, with limited indigenous vegetation observed on the adjacent road verge.

6.4.2 The Robinsons Bay Valley Site

The Terrestrial Ecology report in Appendix B concludes that the Robinsons Bay Valley site is dominated by exotic pasture which is currently grazed. Indigenous ecology values are largely confined to peripheral areas where grazing stock has either been excluded or access is constrained. Parts of the landscape are dominated by exotic wattle, alder, pines, gums, grey willow, and associated ivy.

Small patches of kānuka were observed in clusters across the area with scattered kōwhai, hou-here and other woodland species identified within gullies, with 95% of these species outside areas identified for irrigation. The oak plantation within the property, and the eucalyptus trees on the western boundary that will be incorporated into the site, will shelter regenerating indigenous species.

The wetlands and seepages observed in the site assessment were noted to be of low quality, populated by common native rushes and some exotic wetland species. While they are outside the areas to be irrigated, there is potential for these areas to benefit from more consistent moisture levels due to upslope irrigation, resulting in a potential net gain of wetland values. The values of the small wetlands and seepages are considered likely to improve with the removal of grazing animals.

Overall, the following broad vegetation patterns and indigenous species were noted within the Robinsons Bay Valley site, outside the actively grazed land:

- Rocky bluffs with stonecrop, and lichens.
- Dry ridges with kōwhai, kānuka, narrow-leaved lacebark, manatu, ngaio, totara, broadleaf, five-finger, lancewood, and small leaved shrubs of coprosma and olearia.
- Sheltered, mesic gully forest supports the above plus kaikomako, tree fuchsia, titoki, rohutu, large-leaved coprosmas, vines and ferns.
- Floodplains have kahikatea, and nearby matai and pokaka, and potentially similar species to the gully forest including tarata and kohuhu
- Seepages have rushes and currently marsh foxtail, buttercups and lotus, and harakeke, toetoe, ti kouka and tussock sedges (pukio).

The indigenous vegetation noted above is currently limited to small pockets in sheltered or ungrazed land, with the site otherwise dominated by exotic vegetation related to the current land use.

6.4.3 The Hammond Point Site

The assessment of terrestrial ecology values undertaken for the Hammond Point site found it to be dominated by exotic pasture grasses. Rushes were identified near the small stockyards on the site, and indigenous vegetation is present in the gully along the southern boundary. Indigenous vegetation dominated by kānuka was also identified on the lower slopes of the site to the west and north, however it was assessed as being in a degraded state (Terrestrial Ecology Report, Appendix B). There is no indigenous vegetation or habitat of value within the irrigable land identified on the irrigation maps provided by Aqualinc.

6.4.4 Sensitivity of Terrestrial Ecology Values

The Terrestrial Ecology Assessment Report notes a general paucity of high value terrestrial ecology present across the scheme sites given the extensive modification that has taken place over an extended period since European settlement, and historic and current land uses. Accordingly, the remaining terrestrial ecology values are considered sensitive to effects which could further diminish their value and resilience.

6.5 Māori Cultural Values

The applicant acknowledges the importance of Whakaroa / Akaroa Harbour to Tangata Whenua and has a long history of engaging with Te Rūnanga o Ngāi Tahu, Ōnuku Rūnanga, Te Rūnanga o Koukourarata, Wairewa Rūnanga and the Akaroa Taiāpure Management Committee (the Ngāi Tahu parties) regarding long-term alternative options to treat and discharge Akaroa's wastewater. This is described in detail in the Cultural and Landscape Report prepared by Ōnuku Rūnanga[33], and attached as Appendix L to this application.

Fresh and coastal waters hold particular cultural and spiritual value to tangata whenua as sources of mahinga kai, for their mauri and in some instances as wāhi taonga. At a local level, Whakaroa / Akaroa Harbour is important both as a source of mahinga kai and for its significance in the history of Ngāi Tahu settlement in the area. The following is an extract from a statement made by a representative of the rūnanga[34] highlighting the cultural importance of the wider harbour area:

> *The Papatipu Runanga is Te Runanga o Ōnuku. Akaroa harbour is significant to the rūnanga in respect of the wāhi tapu and waahi taonga, and the collection of mahinga kai and kai moana.*
>
> *Akaroa harbour is of great significance as a mahinga kai - its waters traditionally provided the primary sustenance for the people of Ōnuku. The rim of hills and peaks that look down upon Akaroa's waters evoke many important histories. Directly across the harbour from Ōnuku Marae stands the distinctive Tuhiraki (Mt Bossu). This peak is said to have been formed when the Ngāi Tahu explorer Rākaihautū thrust his kō (digging stick) into Horomaka after using it to dig out all the principal lakes of Te Wai Pounamu including nearby Te Roto o Wairewa and Te Waihora.*

Schedule 101 of the Ngāi Tahu Settlement Act 1998 identifies the Statutory Acknowledgement for Te Tai O Mahaanui (Selwyn – Banks Peninsula Coastal Marine Area). It includes the coastline of Whakaroa / Akaroa Harbour. A Statutory Acknowledgement is an instrument created as part of the Deed of Settlement signed by the Crown and Ngāi Tahu on 21 November 1997 to achieve a final settlement of Ngāi Tahu's historical claims against the Crown. The Ngāi Tahu Claims Settlement Act 1998 gives effect to the Deed of Settlement. Statutory Acknowledgements give recognition by the Crown of Ngāi Tahu's particular cultural, spiritual, historical, and traditional association with specified statutory areas. Statutory Acknowledgments are only given over Crown-owned land.

The Mahaanui Iwi Management Plan (MIMP) published in 2013 covers Banks Peninsula and Akaroa Harbour, providing a values-based framework for protecting and enhancing Ngāi Tahu values.

The MIMP includes a chapter on Whakaroa / Akaroa Harbour, noting that Ngāi Tahu culture, history and identity is strongly embedded in the land and seascape of the catchment. The MIMP also notes that the harbour is part of Te Tai o Mahaanui, the Selwyn – Banks Peninsula Coastal Marine Area Statutory Acknowledgement, a Taiāpure reserve and that tāngata whenua have aspirations to establish a mātaitai as well.

The MIMP states that Ngāi Tahu values associated with Akaroa Harbour are strongly focused on mahinga kai and the discharge of wastewater to water (fresh and marine) is culturally offensive and incompatible with the use of the harbour for this purpose (Ngāi Tūāhuriri Rūnanga, Te Hapū o Ngāti Wheke (Rāpaki), Te Rūnanga o Koukourārata, Ōnuku Rūnanga, Wairewa Rūnanga, Te Taumutu Rūnanga, 2013).

Takapūneke has great significance to Ngāi Tahu, being the location of a previous settlement where Te Maiharanui, an upoko ariki (paramount chief) resided in 1830. Lead by Ngāti Toa chief Te Rauparaha, a Ngāti Toa war party attacked the settlement, taking Te Maiharanui prisoner and destroying the settlement along with a significant loss of life. Takapūneke is tapu as a consequence, and of great cultural and spiritual significance, as is the Ōnawe Pa site.

The cultural and historical context of Akaroa Harbour and settlements is set out in detail in Section Two of the Cultural and Landscape Report prepared by Ōnuku Rūnanga

6.5.1 Whakaroa / Akaroa Harbour

A taiāpure was established over Whakaroa / Akaroa Harbour in 2006 and applies to approximately 90% of the harbour excluding areas covered by existing marine farms and the Akaroa Marine Reserve. Taiāpure can cover areas that have customarily been of special significance to any iwi or hapū, either as a food source, or for spiritual or cultural reasons, and reflects the significance of the harbour to local Māori. Evidence presented in support of the taiāpure application in 1996 illustrated that the whole harbour is of special significance to Ngāi Tahu, both as mahinga kai and as the locus of the spiritual life of local hapū. There are particular sites of special significance around the harbour; however, it was the mana and mauri of the harbour as a single entity that the hapū primarily identified (Ministry of Fisheries, 2005).

The harbour has traditionally been a source of food for the people living in its vicinity, and for those who came from further afield. Although the harbour fishery has diminished it formerly produced a range of edible species upon which Ngāi Tahu people relied for sustenance (Ministry of Fisheries, 2005).

The cultural significance of the harbour is reflected in the extent to which it features in the stories of identity and occupation that define the local rūnanga. In addition, the Treaty of Waitangi was signed at Whakaroa / Akaroa (Ōnuku), and two significant kainga (settlement) are located on the shores of the harbour (Ōnuku and Opukutahi). Reserves were

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[33] *Akaroa Wastewater Wetland Reserve – Cultural Landscape Design Report*, Ōnuku Rūnanga / Christchurch City Council, January 2023
[34] From *Ōnuku Marae*, courtesy of Christchurch City Libraries.

established at these sites when the land was bought by the Crown in 1856 in recognition of the significance of these settlements. There are several urupā (burial grounds), pa kakari (battle grounds) and tūranga tipuna (ancestral areas) around the harbour (Ministry of Fisheries, 2005).

6.5.2 Sensitivity of Whakaroa / Akaroa Harbour

Whakaroa / Akaroa Harbour is a sensitive receiving environment. The harbour holds very high cultural importance to tangata whenua as described in the Cultural and Landscape Report prepared by Ōnuku Rūnanga.

The area is also valued by the wider community from an environmental perspective, reflected in the marine mammal sanctuary and taiāpure covering most of the harbour and two marine reserves incorporating an area around Akaroa Head and Pōhatu / Flea Bay. Many tourism and commercial activities in the harbour are also dependent on the quality of the harbour environment.

Several threatened species reside in or regularly visit the harbour including the nationally vulnerable Hector's dolphin, the nationally endangered hoiho / yellow-eyed penguin and the Kororā little blue penguins classified as at risk, declining.

6.6 Landscape and Visual Amenity Values

The landscape character and amenity values are described in detail in the Landscape and Visual Impact Assessment (LVIA) report prepared by DCM Urban Ltd. The assessment report is attached in Appendix M of this document and summarised below.

6.6.1 The Old Coach Road Site

The Old Coach Road site is located on a spur to the north of Akaroa within the Rural Banks Peninsula zone and a Rural Amenity Landscape overlay in the Christchurch District Plan. The top part of the site is covered primarily in exotic pasture grass with some indigenous bush around the periphery, and established vegetation in pockets downhill to the south towards Childrens Bay. SH75 partially encircles the upper part of the site and forms the west and south boundaries.

The lower slopes of the site are vegetated in pockets of indigenous vegetation with exotics becoming more prevalent on the lower slopes. There are several dwellings on the south-facing flanks descending to Childrens Bay, which become more common closer to Akaroa. Being on the periphery of Akaroa, the lower slopes of this site are the most developed of any sites included in the ATWIS. There are no identifiable watercourses within or in proximity to the site.

The landscape is rural in character and includes elements of farming, small scale residential activities, utility structures and infrastructure.

6.6.2 Robinsons Bay Valley

The 118 ha Council-owned site at 11 Sawmill Road extends from the valley floor up towards Summit Road. Robinsons Bay Stream traverses the northern boundary then follows the valley floor westward to Robinsons Bay. The site has previously been farmland and consequently is dominated by exotic pasture, shelter trees, fences and various farm infrastructure. The site includes a large plantation of oak trees and several heritage items including buildings and other indications of early European settlement (refer sections 6.7 and 10.13). There are no residential dwellings on the site.

The LVIA report notes that the Robinsons Bay Valley landscape is dominated by and typical of Banks Peninsula pastoral farming land use. The Robinsons Bay Valley site is identified in the Christchurch District Plan as being within a broad Rural Amenity Landscape (RAL) overlay.

The modified landscape is dominated by open pasture with pockets of exotic vegetation such as woodlots and shelter trees, interspersed with remnant and revegetating indigenous vegetation, the latter typically more prominent in gullies and streamside areas and dominated by kānuka. The landscape includes human use elements that are well integrated into the landscape, which retains the visual amenity characteristic of the wider Banks Peninsula. The human elements are dominated by farming and rural activities and provide an expectation of buildings and structures in the setting. The Robinsons Bay Valley site includes several small farm-related buildings and structures, but large structures and buildings are otherwise absent.

6.6.3 Hammond Point

The Hammond Point site is located at 6538 Christchurch-Akaroa Road (SH75) and is legally described as Lot 1 DP 563448. The 11.9 ha site consists of a broad spur separating Robinsons Bay and Takamātua Bay, with a westerly aspect and low gradient in the upper section. The land steepens towards the coastline and the lower northern and southern slopes. The site is dominated by exotic pasture, with indigenous vegetation confined to a wooded gully along the southern boundary with an ephemeral stream in the gully floor. The gravelled vehicle track from SH75 will be retained to provide access to a private property at the coastline.

The property has been used for some time for productive grazing. Development of the site is limited to the track, a small stockyard near the state highway, a small lean-to in the west and existing stock fencing and farming-related items.

The Hammond Point site lies primarily within the Rural Amenity Landscape as defined in the CDP. An 'identified important ridgeline' is indicated on the planning maps upslope of the site. Hammond Point is identified as an area of high natural character in the coastal environment and an area of at least high natural character in the coastal environment under the CDP. The site will, once planted, connect the vegetation in the wooded gully to substantial plantings at the tip of Hammond Point.

6.7 Heritage and Archaeological Values

A comprehensive Archaeological and Heritage Assessment report was prepared to identify and assess the heritage and archaeological values that may be affected by the scheme. The full report is attached in Appendix N. The assessment identifies key heritage features in the lower Robinsons Bay Valley site. These include:

- An historic sawmill area, including a mill dam and dam head race
- An ~1860s cottage
- The remains of a woolshed
- An oak plantation

The Robinsons Bay Valley site is the only part of the scheme holding significant heritage values, originating from 1842 when the site was first purchased by Charles Robinson who settled on, and then developed the land. The original forest cover was milled for timber and subsequently farmed, the latter activity continuing to the present day. The site holds several items and areas of heritage value and significance associated with those activities as set out in the Archaeological and Heritage Assessment report. The most notable heritage values are associated with the historic sawmill and are largely confined to the lower (northwest) portion of the site, particularly the northwest corner.

The site also adjoins a property next to the intersection of Robinsons Bay Valley Road and Sawmill Road which contains Pavitt Cottage (also known as Mill Cottage), Heritage Item 1171 in the Christchurch District Plan (CDP). A former School Master's House (Item 1173) is also nearby, on the northern side of Robinsons Bay Road, opposite Sawmill Road. While it is important to note these recognised heritage items, the assessment completed in the Archaeological Report notes that the ATWIS will not affect these heritage items as they lie outside the scheme's footprint.

6.8 Contaminated Land

A Preliminary Site Investigation (PSI) of the potential for contaminated land to be present was undertaken for the full scheme footprint. The PSI report is attached in Appendix J. The PSI report concludes that the scheme will not involve or disturb land identified as contaminated by the Ministry for the Environment's Hazardous Activities and Industries List (HAIL), other than potential disturbance of areas on the Robinsons Bay Valley site, the WWTP site, and the Terminal Pump Station site as discussed below.

6.8.1 Robinsons Bay Valley Site Investigation

Several locations within the Robinsons Bay Valley Site were identified as potentially containing contaminated soil and were investigated. There are three locations at the site that meet the definition of a "piece of land" under the NES-CS[35],. They are identified in the Detailed Site Investigation (DSI) Report in Appendix O as Farm Building A, Farm Building B and the sheep dip. The contamination was found to be associated with previous agricultural activities and historic building practices and includes lead paint and insecticide from the old sheep dip (Figure 6-5).

[35] Resource Management (*National Environmental Standards for Assessing and Managing Contaminants in Soil to Protect Human Health*) Regulations 2011

Figure 6-5: Robinsons Bay Valley Contaminated Sites

6.8.1.1 The Farm Buildings

Given their estimated age, it was assumed that the two farm buildings were painted with lead paint. Soil samples were taken immediately adjacent to each building and tested for lead contamination. The results confirmed elevated lead levels in the soil around both farm buildings that consistently exceed background levels (refer Section 10 of the DSI report) with the contamination confined to the immediate vicinity of each farm building. One of the samples from the soil around the lower of the two farm buildings (Building A) exceeded the recreational standard in the NES-CS, but none of the samples from either building exceeded the commercial / industrial standard. Building A has since been removed, and validation sampling confirmed there is no elevated risk from the residual soil contamination.

It was unknown at the time that the DSI report was prepared whether the buildings would be removed, and the soil disturbed or retained in-situ. The applicant has since determined that, in part to address the risk of disturbing contaminated soil and also given the heritage values, Building B will be retained undisturbed, and a stock fence erected to protect the building, avoid soil disturbance and to prevent people coming into contact with lead contamination. As there will be no change in land use or soil disturbance, the risk to human health is minimal and will be adequately managed by the above measures. Consequently, no resource consent will be required under the NES-CS for the proposed management approach.

6.8.1.2 The Sheep Dip

Twenty five soil samples were taken in the vicinity of the sheep dip. The results showed elevated concentrations of chemicals typically used in sheep dips (arsenic, lead, dieldrin and organochlorine pesticides (OCPs)). The highest level of arsenic contamination sampled exceeded both the recreational standard and the industrial / commercial standard in the NES-CS.

An additional 19 samples were then taken to define the spatial extent of contamination from sheep dip chemicals (Figure 18, DSI Report. The additional sampling confirmed that sheep dip chemicals were drained from the sheep dip facility to a shallow constructed channel, and likely to Robinsons Bay Stream. The sampling also confirmed that the contamination is confined to the vicinity of the sheep dip and channel.

6.8.2 The WWTP Site

The proposed WWTP site on the northern side of Old Coach Road has been used for storing roading materials which can include contaminants that can adversely affect human health. As the site no longer contains roading material stockpiles the likelihood of contaminants remaining in site soils is considered to be low to negligible. As determined in the PSI report, the site is consequently no longer considered ‘a piece of land’ under Regulation 7 of the NES-CS, does not require resource consent under the NES-CS and was given no further consideration.

6.8.3 The Terminal Pump Station

The Terminal Pump Station site has been identified on ECan’s Listed Land use Register (LLUR) as a contaminated site given its historic use as a landfill from 1900 to around 1978. A PSI and DSI were completed in 2019 for land in the general vicinity[36]. The DSI found evidence of domestic landfill content near to the proposed pump station site, however no DSI has yet been carried out at the pump station location specifically.

No additional assessment of the Terminal Pump Station site was undertaken as part of this application process as resource consents for the Terminal Pump Station have previously been issued[37] taking its HAIL status into account. If changes to those consents are needed (i.e. if a proposed methodology does not comply with the conditions) they will be separately sought.

6.8.4 Contaminated Land Conclusion

The areas of confirmed or potential contamination identified across the scheme are either not addressed by the NES-CS, already hold resource consent for their disturbance, or will be left undisturbed by the applicant during both the construction and operational phases of the ATWIS. In particular, the areas of contaminated land identified on the Robinsons Bay Valley irrigation site will be fenced off and remain undisturbed to avoid inadvertently mobilising any remaining contaminants that could adversely affect human health or environmental quality.

6.9 Recreational and Commercial Values

Akaroa Harbour and the harbour basin is a popular recreational area for a range of land and water-based activities, including walking, cycling, fishing, diving, swimming, recreational boating, water skiing, kayaking, and windsurfing. The scenic values of the harbour and its coastline, its numerous reserves, and areas of natural value for marine mammals, birds and other flora and fauna also provide considerable land-based attractions.

Akaroa’s proximity to Christchurch makes it a popular location for holiday homes, and its mixed history of Māori, English and French settlement, arts, crafts, and recreational opportunities make it an increasingly popular tourist destination. Tourism is an important industry within the harbour and tourism activities include harbour cruises, chartered fishing trips, sea kayaking, diving, and swimming. Harbour water quality is fundamental to these activities.

There are several marine farms on the western side of the harbour between Wainui and the Akaroa Harbour heads. These enterprises include salmon and paua farming, culture pearl production, and research sponge farming. Some limited commercial fishing of crayfish and flat fish also occurs in the harbour.

[36] ENGEO, August 2019

[37] CRC150046, CRC150049, CRC150050, CRC152814 and RMA92026256

7 Rules Assessment

Section 104(1)(b) of the Resource Management Act 1991 (RMA) requires consent authorities to have regard to a range of matters, including the provisions of applicable national planning standards, regulations, policy statements and plans.

This section identifies the resource consents currently held by the applicant for the existing (interim) wastewater scheme as they relate to the ATWIS.

The applicable rules from the Christchurch District Plan (CDP), the Canterbury Air Regional Plan (CARP), the Canterbury Land and Water Regional Plan (LWRP) and the Canterbury Regional Coastal Environment Plan (RCEP) are also set out.

7.1 Existing Resource Consents

7.1.1 Interim Discharge Permits

Resource consents CRC204086, CRC204087 and CRC210834[38] were issued to the CCC in May 2022 authorising the ongoing operation of the existing Akaroa WWTP and associated harbour discharge for an eight year term, expiring 24 May 2030. These consents enable the current WWTP and discharges to lawfully continue until the new WWTP and irrigation scheme can be commissioned. The existing WWTP will then be decommissioned and treated wastewater discharges to the harbour will permanently cease.

Conditions for these consents were agreed between the applicant and the Ngāi Tahu parties and included conditions that relate to achieving I&I reductions and a series of milestones for the project. Specifically, the following conditions state:

- Condition 6(a):

The volume of inflow and infiltration from the Akaroa wastewater network exiting the Akaroa Wastewater Treatment Plant shall reduce to:

i. *Below 50 percent inflow and/or infiltration by 31 October 2022; and*
ii. *Below 40 percent inflow and/or infiltration by 31 October 2025.*

Reducing I&I is critical to the proposed scheme in respect of managing inflows into the WWTP, the ability to provide sufficient storage for raw and treated wastewater and providing sufficient infrastructure and land area needed for irrigation.

- Condition 25:

The Consent Holder shall achieve the following milestones within the term of this resource consent:
a. Lodge all applications for the approvals under the Resource Management Act 1991 required to commission the new Akaroa Wastewater Treatment system within eighteen months of the commencement of this resource consent;
b. Award contracts for the construction of the new Wastewater Treatment Plant and disposal system within eight calendar months of the commencement of the resource consents sought under clause (a) of this condition;
c. Require contractors to commence construction on the site of the new Wastewater Treatment Plant within nine months of awarding the contracts under clause (b) of this condition;
d. To have a fully operational new Wastewater Treatment Plant and disposal system within 60 months of awarding the contracts under clause (b) of this condition.

This condition sets milestones that the consent holder must meet to comply with the consent. Achieving all necessary statutory approvals in a timely manner is critical to enabling the remainder of the design process, and the construction and commissioning of the scheme to occur in compliance with this condition, and importantly, before the current suite of consents expires.

7.1.2 ATWIS Consents Held

The applicant holds several resource consents relevant to the scheme that were issued in July 2019, as set out in Table 7-1. These consents are relevant as the consented activities have not substantially changed and still form a core part of

[38] CRC204086 – To discharge contaminants to coastal water; CRC204087: To use land to store wastewater; CRC210834: to discharge contaminants to air.

the approvals needed. The following consents hold common lapse dates of 30 September 2027 and expire on 9 July 2054.

Table 7-1: Existing Scheme Consents

Consent	Purpose	Comments
CRC150046-A	*A water permit to take groundwater for dewatering purposes during the construction of the Terminal Pump Station and during trenching works to install a new reticulated wastewater pipeline.*	This consent provides for dewatering during construction of the Terminal Pump Station, and the installation of a pipeline including along Old Coach Road between the Terminal Pump Station and the WWTP.
CRC150049	*A discharge permit to discharge contaminants (odour) to air from pump stations.*	This permit authorises the discharge of odour from a pump station at Beach Road, and the Terminal Pump Station.
CRC150050	*To discharge contaminants (odour) to air and a land use to use land to store effluent.*	This permit provides for discharges of odour to air from the WWTP site only. The consent also provides for the storage of wastewater and I&I water on the WWTP site (Lot 3 DP 459704) however the proposal now involves storing it and treated wastewater on land across the road (Lot 7 – 10 DP 7273) in the wet weather storage tank and the subsurface wetland respectively. No further permits for odour discharge will be required as there will be no other discharges.
CRC152814	*A discharge permit to discharge construction phase stormwater and developed phase stormwater to water.*	This permit authorises discharges of construction and operational (developed) phase stormwater to water from the development of the Terminal Pump Station and the WWTP.
RMA92026256	*Land use consent.*	This consent authorises the use of land at the Terminal Pump Station Site and the WWTP site for the development and operation of those facilities.

The applicant holds several global resource consents for activities related to infrastructure development and maintenance across Christchurch.

Table 7-2 identifies the global resource consents that may be relied on for aspects of this proposal:

Table 7-2: Relevant Global Resource Consents

Consent	Purpose	Comments
CRC146620	Global Resource consent for works in the bed and margins of waterways within Christchurch District (including Banks Peninsula as per Plan CRC146620A).	This global resource consent authorises minor works in the beds and margins of waterways across Christchurch District. Such works include but are not limited to: (a) Margin and berm planting, bank excavation and regrading, ground improvement for network utility structures or pipes, channel realignment These activities may occur in relation to (for example) planting proposed for the margins of streams on the Robinsons Bay irrigation site (margin and berm planting for amenity and biodiversity enhancement purposes), or bank excavation (trenching) across ephemeral streams to place the pipelines etc. (h) Trenching or subsurface tunnelling for placing network utility pipes The proposed pipeline will be placed beneath streambeds with permanent flows / water present using trenching or thrusting methods.

All works relying on CRC146620 will take place in accordance with the conditions of that consent.

7.2 Canterbury Regional Plans

The regional plans that contain rules relevant to the ATWIS are the Canterbury Air Regional Plan (CARP) and the Canterbury Land and Water Regional Plan (LWRP). These plans are considered in the following sections.

7.2.1 Canterbury Air Regional Plan

The Canterbury Air Regional Plan (CARP) sets out provisions to manage discharges to air to maintain air quality where it is appropriate, or to progressively improve air quality where it is degraded. The CARP includes rules relating to the use, development and protection of Canterbury's air resource, including rules allowing activities without resource consent, provided an activity complies with all specified rule conditions.

The key potential effects on air quality stemming from the proposed scheme will be dust during the construction phase, and discharge of accumulated gasses from pipelines during operation. Irrigation of the treated wastewater will be by surface and sub-surface drip irrigation and will not involve discharging contaminants to air in aerosol or vapour form. Given the quality of the treated wastewater, the potential for odour to be generated by the scheme is negligible. For odour to be generated, the treatment process would need to be operating poorly. Various factors would indicate issues with the treatment process and enable changes to be made, and that would happen well before odour is generated.

The assessment in Table 7-3 considers the scheme in the context of the CARP rules, with the proposal relying on the permitted activity rules identified:

Table 7-3: CARP - Permitted Activities

Rule	Activity
Rule 7.28	*Discharges from periodic use of standby generators at the Terminal Pump Station and the WWTP.* The standby generators will not exceed 300 kW output capacity and will meet all conditions of this rule. Discharges to air from periodically running the generators are therefore permitted.
Rule 7.32	*Discharge of dust to air from construction of buildings, land development activities, unsealed surfaces and unconsolidated land.* While the area of unsealed and unconsolidated surfaces during construction will exceed 1000 m^2 (e.g. for the Robinsons Bay storage tank platform) all works will be subject to a dust management plan. No buildings greater than three stories high will be built. The works will be carried out in compliance with the conditions of Rule 7.32 and any associated dust discharges will therefore be permitted.
Rule 7.50 / 7.63	*Discharges to air from the treatment and disposal of human sewage – less than 50 m^3/day.* Rule 7.50 provides for discharges to air from the treatment and disposal of up to 50 m^3 of human sewage per day. The ATWIS will exceed the 50 m^3 limit. No rule specifically addresses activities that exceed that limit so any discharge of contaminants to air would be discretionary activities under Rule 7.63 (i.e. activities that are not otherwise addressed). CRC150050 authorises discharges of contaminants (odour) to air from the Terminal Pump Station and the WWTP. No other discharges to air are proposed other than potential discharges from pipeline air valves as addressed by Rule 7.51 below.
Rule 7.51	*Discharges to air from pipeline air valves.* The proposal will comply with the conditions of Rule 7.51 as any discharges will be minimal, will not result in offensive or objectionable odour, and any pipeline valves will be located more than 100 m from a residential property (or be fitted with appropriate odour control). Any pipeline discharges will therefore be permitted.
Rule 7.63	As discharges of contaminants to air from the treatment and disposal of more than 50 m^3 of human sewage per day are not provided for by any other rule, any discharges that do occur will be captured by this rule as discretionary activities.

Odour discharges to air from the WWTP and the Terminal Pump Station are addressed under consent CRC150050, and assessment shows that discharges to air from parts of the scheme not addressed by CR150050 will be either absent or negligible.

7.2.2 Canterbury Land and Water Regional Plan

The LWRP sets resource management objectives, policies and rules for the integrated management of land and freshwater resources in Canterbury. The LWRP applies across Canterbury from the landward edge of the Coastal Marine Area (CMA). The LWRP has replaced the previous Canterbury Natural Resources Regional Plan (NRRP) under which the previous land use consents for this scheme were issued.

The LWRP sets out rules that guide the use and development of Canterbury's land and water resources. The rules identify activities that can be undertaken without requiring resource consent provided the activity complies with all of the conditions specified in the rules. The proposal relies on the permitted activity rules in Table 7-4:

Table 7-4: LWRP - Permitted Activities

Rule	Activity
Rule 5.95	*Discharge of stormwater to water, or to land where it may enter water.* Operational-phase stormwater discharges across the scheme will generally discharge to land within the sites. On the Robinsons Bay Valley Irrigation site, stormwater will discharge from the tank platform to the head of an ephemeral stream as indicated on Drawing C151. Condition 5(a) of Rule 5.95 will be met as no operational stormwater discharges will occur from unstabilised land, as all surfaces will be vegetated, compacted or metalled following construction. All other applicable conditions will also be met, and operational stormwater discharges will therefore be a permitted activity.
Rule 5.119	*Dewatering for the pipeline construction* Any dewatering required to install the pipeline from the WWTP to the irrigation sites will be undertaken in compliance with the conditions specified in Rule 5.119.
Rule 5.136	*Drilling, tunnelling or disturbance in, on or under the bed of a river for the installation of pipes.* All pipes that are to be installed beneath stream beds (including ephemeral streams) will comply with the conditions specified in Rule 5.136[39].
Rule 5.137	*Installation of bridges over the bed of a river* Two small bridges will be installed to carry the access track from Robinsons Bay Valley Road to the tank platform on the Robinsons Bay Valley Irrigation site. The bridges will be single span, will be installed in periods when there is no water present in the stream, and will comply with the conditions of this rule including in respect of maintaining flood capacity, avoiding impeding flow and maintaining fish passage during flows.
Rule 5.141	Temporary discharges to water or to land where contaminants may enter water, associated with the activities permitted under Rule 5.136 are permitted subject to compliance with the conditions of Rule 5.141. While no discharges are expected given the intention to avoid disturbances within or adjacent to flowing water, any such discharges associated with the activities described in Rule 5.136 would only involve sediment or other natural material originating from the streambed or banks and occur for less than ten hours per day or 40 hours per month. Any such discharges would be minimal and would comply with the conditions of Rule 5.141.
Rule 5.167	*Vegetation clearance within 10 m of the bed of a river or wetland in high soil erosion risk areas.* Clearance of vegetation within 10 m of the bed of a river or wetland in land shown as High Soil Erosion Risk on the planning maps is permitted subject to compliance with the conditions of Rule 5.167. The proposed works will comply with the conditions of Rule 5.167.
Rule 5.168	*Earthworks within 10 m of the bed of a river or wetland in high soil erosion risk areas.*

[39] Regardless, if circumstances mean that the conditions of Rule 5.136 could not be met, the CCC may be able to undertake the works under the authority of CRC146620 if the works comply with the relevant consent conditions.

	Condition 3 is the sole relevant condition to this proposal. The proposed works will comply with the condition and consequently earthworks within 10 m of rivers or wetlands within the high soil erosion risk areas of the scheme are permitted under Rule 5.168.
Rule 5.170	*Use of land in the High Soil Erosion Risk area for earthworks and vegetation clearance associated with the establishment, repair and maintenance of pipelines:* Part of the pipeline will be built within the High Soil Erosion Risk area defined on planning maps for the LWRP. Rule 5.170(j) provides for the establishment of pipelines within High Soil Erosion Risk areas as permitted activities subject to compliance with the specified conditions. These conditions, including the concentration of suspended solids (maximum of 50 g/m^3) will be met through requirements on contractors undertaking the construction. Consequently, earthworks to place pipelines within the High Soil Erosion Risk areas and the associated discharges of sediment and sediment-laden water will be carried out as permitted activities.
Rule 5.175	*The excavation of material over coastal confined, semi-confined or unconfined aquifers* is a permitted activity under Rule 5.175 subject to compliance with the conditions of that rule. The coastal confined aquifer does not extend beneath the project area. The lower Robinsons Bay Valley is underlain by a semi-confined / unconfined aquifer, including the lower (heritage) portion of the Robinsons Bay Irrigation site, however no excavations are proposed in that area that would result in less than 1.0 m of undisturbed material above the highest known groundwater level, and that are within 50 m of Robinsons Bay Stream. The proposed excavations will be permitted under Rule 5.175.

7.2.2.1 Resource Consents Required under the LWRP

The resource consents required under the LWRP are set out in Table 7-5 and have been applied for via this document:

Table 7-5: Resource Consents Required Under the LWRP

Rule	Activity
Rule 5.84	*Use of land for community wastewater treatment and the discharge of treated wastewater to land.* Resource consent is required as a **discretionary activity** for: • the use of all land required for the scheme, including pipelines, storage facilities, the irrigation areas and Jubilee Park, and all related infrastructure; and • the discharge of the treated wastewater to land on the Robinsons Bay Valley and Hammond Point Irrigation sites and to Jubilee Park. Note that the applicant holds resource consent CRC150050 providing for the use of land for the WWTP.
Rule 5.94B	*Discharge of construction phase stormwater into surface water or onto or into land where a contaminant may enter ground or surface water.* CRC152814 applies to construction phase and operational stormwater discharges from the Terminal Pump Station and WWTP sites only. Consent is required in respect of construction-phase stormwater discharges from the disturbance of land on the Old Coach Road and the Robinsons Bay Valley sites under Rule 5.94B as a **restricted discretionary activity** as the works in these sites will exceed the 1000 m^2 limit in permitted activity Rule 5.94A(1)(a). ECan's discretion over the following matters is retained: 1. *The actual and potential effects of the discharge on the quality of surface water, aquatic ecosystems, Ngāi Tahu cultural values; and* 2. *The actual and potential effects of the discharge on the quality and safety of human and animal drinking water; and* 3. *The actual and potential adverse environmental effects of the quantity of water to be discharged on the banks or bed of a waterbody or on its flood carrying capacity, and on*

	the capacity of the network to convey that discharge; and 4. *The potential benefits of the activity to the applicant, the community and the environment.* These matters are addressed in the assessment of environmental effects set out in 10.14.1 of this document.
Rule 5.171	*Earthworks and vegetation clearance in High Soil Erosion Risk areas shown on the LWRP planning maps* Earthworks that do not comply with one or more of the conditions of Rule 5.170 are **restricted discretionary activities** under Rule 5.171. The proposed earthworks for development of the Robinsons Bay Irrigation site storage tanks and the storage tank and subsurface wetland on the Old Coach Road storage site will exceed 10 m^3 per hectare and the maximum depth of cut / fill of 0.5 m. Consequently resource consent is required for the earthworks and the application is subject to the following relevant matters of discretion: 2. *The actual and potential adverse environmental effects on soil quality or slope stability; and* 3. *The actual and potential adverse environmental effects on the quality of water in rivers, lakes, artificial watercourses or wetlands; and* 4. *The actual and potential adverse environmental effects on areas of natural character, outstanding natural features or landscapes, areas of significant indigenous vegetation, indigenous biodiversity and significant habitats of indigenous fauna, mahinga kai areas or sites of importance to Tangata Whenua; and* 5. *The actual and potential adverse environmental effects on a wetland or the banks or bed of a waterbody or on its flood carrying capacity; and* 6. *The actual and potential adverse environmental effects on transport networks, neighbouring properties or structures; …* While the LWRP planning maps do not show the Hammond Point site being within the HSER area, earthworks on that site will be carried out in the same manner as the other sites with similar approach to stormwater, erosion, and sediment control. The matters of discretion are addressed in the assessment of environmental effects set out in Section 10 of this document.

7.2.2.2 Plan Change 7

Plan Change 7 to the LWRP was introduced to respond to emerging resource management issues, national direction, and water management. The Plan Change is currently progressing through appeals, so the changes are not yet fully operative however the provisions that are relevant to this application have not been appealed and therefore carry significant weight. The relevant matters include changes (reduction) to *E. coli* limits set through Table 1a – *Freshwater Outcomes for Canterbury Rivers*, and the introduction of water quality limits for Banks Peninsula rivers through Schedule 8 – *Region-wide Water Quality Limits*.

The assessment of the activity in the context of Plan Change 7 is set out in the assessment of effects of the ATWIS on surface freshwater quality in the Freshwater Ecology Report, and in Section 10.4 of this document.

7.2.3 Canterbury Regional Coastal Environment Plan

The Canterbury Regional Coastal Environment Plan (RCEP) sets a regulatory framework to guide the integrated sustainable management of natural and physical resources in Canterbury's coastal environment, including the coastal marine area (CMA). The CMA is defined in Section 2 of the RMA and generally considered to include the foreshore, seabed, coastal waters and the airspace above. The CMA extends from the line of Mean High Water Springs (MHWS) to New Zealand's maritime territorial boundary 12 nautical miles from the coast. Akaroa Harbour is classified as 'Class Coastal SG Water', with Robinsons Bay identified as 'Class Coastal CR Water'. There is potential for treated water irrigated to the Hammond Point site to seep from the coastal cliffs surrounding the site, although application rates will be carefully managed to minimise the risk of seepage occurring. The 'discharge' activity is considered under the rules of the LWRP as the point of discharge is landward of the CMA, and any seepage to the CMA would be to a secondary receiving environment. Consequently there are no RCEP rules that apply.

Parts of the ATWIS that are within the coastal environment include the Hammond Point irrigation site and a portion of the Old Coach Road storage site. Consequently, the policy provisions of the RCEP are relevant. The Coastal Environment is defined in the RCEP as *'an environment in which the coast usually is a significant part or element. The coastal environment will vary from place to place depending upon the extent to which it affects or is (directly) affected by coastal processes and the management issue concerned. It includes three distinct but interrelated parts: the Coastal*

Marine Area; the active coastal zone; and the land backdrop'.

7.2.4 Regional Rule Summary

The assessment above finds that resource consents are required under the LWRP in respect of:

- The use of land for the scheme, and the discharge of treated wastewater onto and into land, and on and into land where it may enter water;
- The discharge of construction phase stormwater;
- Earthworks and vegetation clearance in high soil erosion risk areas; and
- The discharge of contaminants (odour) to air.

It is appropriate to assess the required consents together as the proposal relies on all consents being granted to proceed. By 'bundling' the applications, the most restrictive activity status applies. The proposal is therefore a **discretionary activity.**

7.3 Christchurch District Plan

The following sections assess the aspects of the proposal that are not already addressed by resource consents currently held by the applicant. The relevant Christchurch District Plan (CDP) matters that influence the application of the CDP Rules are set out in Table 7-6 for each part of the Scheme:

Table 7-6: Overlays and CDP Criteria

Location	CDP Overlays and Characteristics
Old Coach Road storage site	• Rural Banks Peninsula Zone • Remainder of Port Hills and Banks Peninsula Slope Instability Management Area • Rural Amenity Landscape • Coastal Environment (partial) • 33kV Electricity Distribution Lines overhead • Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit (*14a, 15a*) • Wahi Tapu/Wahi Taonga (*14b, 15b*) • Ngā Tūranga Tūpuna (*Table 3: Ngā Tūranga Tūpuna - ID73 Akaroa Harbour - Areas of cultural landscapes with large concentrations of significant tribal history and archaeological sites, and prominent natural features that form landmarks*).
Jubilee Park	• Akaroa Recreation Ground / Akaroa Boat Park (Open Space Community Parks Zone) • Coastal Environment • Liquefaction Management Area • Environmental Asset Waterway, Hill Waterway and Water Body Setback (*Ōinaka / Grehan Stream – North and South branches*) • Ngā Wai Lakes Rivers and Streams: (*91 – Ōinaka / Grehan Stream North and South branches*)) • Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit (*15a*)
Hammond Point Irrigation site	• Rural Banks Peninsula Zone • Rural Amenity Landscape (partial) • Coastal Environment • Natural Character in the Coastal Environment (*NCCE1.0*) • Area of at least High Natural Character in the Coastal Environment (*NHC 19.0*) • Identified Important Ridgeline (partial – eastern part of site) • Ngā Tūranga Tūpuna
Robinsons Bay Valley Irrigation site	• Rural Banks Peninsula Zone • Remainder of Port Hills and Banks Peninsula Slope Instability Management Area • Rural Amenity Landscape • Environmental Asset Waterway, Hill Waterway and Water Body Setback (*Robinsons Bay Valley Stream and tributaries*)

	• 160 m Contour Line

The Scheme meets the definition of a utility in the CDP, with the utilities rules set out in Chapter 11 – *Utilities and Energy*.

The guide to interpreting the Chapter 11 rules (section 11.3) notes that the rules in Zone Chapters 13 – 18 do not apply to utilities and have not been considered however the rules in Chapters 4 – 8 and in some circumstances Chapter 9 might apply.

Chapter 4 addresses Hazardous Substances and Contaminated Land through objectives and policies but does not contain rules as the disturbance of contaminated land is addressed through National Environmental Standards. Chapter 7 sets out Transport rules and is also not relevant.

Chapter 9 sets out rules relating to natural and cultural heritage and include matters of discretion which are considered in the assessment of the effects set out in Section 10 of this document. The relevant provisions of the other chapters are set out in Table 7-7.

Table 7-7: Christchurch District Plan Rules

Rule	Activity	Assessment
5.6.1.1	Activities within Slope Instability Management Areas.	The Robinsons Bay Valley and Hammond Point Irrigation sites are located within the Slope Instability Management Area overlay identified in the CDP Planning Maps. Table 5.6.1.1a(h) refers to the development of new infrastructure within the Slope Instability Management Area overlay on Banks Peninsula, deferring to the zone and / or district-wide provisions. Table 5.6.1.1a(m) refers to earthworks associated with farm tracks, also deferring to zone or district wide provisions. No resource consents specific to works within the Slope Instability Management Area overlay under this rule are required.
5.5.1	Natural Hazards – Liquefaction Hazard	All aspects of the activity that take place within the Liquefaction Management Area overlay are **permitted activities** in respect of the Natural Hazards rules as they are not limited by Rules 5.5.2 or 5.5.3.
8.9.2.1	Earthworks	Earthworks associated with the development of a utility are typically exempt from application of the earthworks rules through Rule 8.9.3. However, the exemptions only apply to the earthworks for the proposed scheme if the scheme is a permitted activity under the rules in Chapter 11. Because the proposal does not meet all the zone built form standards as required under Rule 11.8.1.P2 the activity is not permitted under Rule 11.8.3.RD1, and therefore the exemption provided under 8.9.3(a)(vi)(A) does not apply. The permitted activity standards for earthworks under Rule 8.9.2.1 are assessed below: 8.9.2.1.P1(a) Volume: the volume of earthworks permitted in the Rural Banks Peninsula Zone over 12 months is 100 m^3. The proposed earthworks will exceed that volume, and the standard is therefore not met. 8.9.2.1.P1(b) Depth: earthworks are permitted if they do not exceed a depth (for fill and / or cut) of 0.6 m. The proposed works will exceed that depth of cut and fill, and the standard is therefore not met. 8.9.2.1.P1(c) Gradient: earthworks on land steeper than 1 in 6 are not permitted. Some of the proposed earthworks will take place on land that is 1 in 6 or marginally steeper, so will not meet this standard. 8.9.2.1.P1(i) Heritage: Earthworks within 5 m of any known heritage item are not permitted. In this case, no earthworks will be undertaken within 5 m of any known heritage item. Heritage Setting # 539 (Robinsons Bay Valley Road) lies immediately northwest of the lower Robinsons Bay Valley irrigation site, however there are no heritage settings listed in Appendix 9.3.7.2 within the project area, or

		that will be affected by the project. All other relevant earthworks rules will be met. **Resource consent is required under Rule 8.9.2.4.D1 as a <u>discretionary activity</u> in respect of earthwork volume, depth and gradient.**
8.9.2.3.RD5	Earthworks within Sites of Ngāi Tahu Cultural significance identified in Schedule 9.5.6.1.	Earthworks to install pipelines, form the subsurface wetland and build the wet weather flow storage tank on the Old Coach Road storage site will occur within Waahi Tapu area 14b on Planning Map 75C as set out in Schedule 9.5.6.1 Table 1. Earthworks to install pipelines and to build the subsurface wetland and wet weather flow storage tank on the Old Coach Road storage site will occur within Silent File area 14a on Planning Map 75C as set out in Schedule 9.5.6.2 Table 1. Earthworks to install a pipeline from the WWTP to Akaroa (Jubilee Park) will occur within Silent File area 15a on Planning Map 77C, H35C and H36C as set out in Schedule 9.5.6.2 Table 1. **The earthworks require resource consent as a <u>restricted discretionary activity</u> under Rule 8.9.2.3.RD5, with the matters of discretion set out in Rule 9.5.5.1.**
11.4.1.P6	Installation of underground utility networks	All pipes will be installed underground. This aspect of the proposal is a **<u>permitted activity</u>**.
11.8.1.P2	Constructing or operating structures for conveying, treating, storing, retaining / detaining wastewater by the Council.	Provided structures comply with the Built Form Standards for the Rural Banks Peninsula Zone (described in Chapter 17.4), they are permitted by this rule. The scheme includes the following structures: - the Terminal Pump Station and the WWTP (already consented) - the wet weather flow storage tank and subsurface wetland at the Old Coach Road site - the treated wastewater storage tanks at the Robinsons Bay Valley site. If the Built Form Standards are not complied with resource consent is required under Rule 11.8.3.RD1 as a restricted discretionary activity in respect of the non-compliance. The CDP does not separately define ‘structures’ however the definition of ‘building’ includes structures. Clause (l) of the CDP definition of ‘building’ excludes *‘any dam that retains not more than 3 metres depth, and no more than 20,000 m^3 volume of water, and any stopbank or culvert’*. Under this definition therefore, the subsurface wetland is <u>not</u> classified as a ‘building’ as it is no more than 1.0 m deep and will hold a maximum of 2,100 m^3 of treated wastewater. The storage tanks on Robinsons Bay and the Old Coach Road storage site are classified as buildings under the definition as they exceed the volume limits in clause (m) of the ‘Building’ definition, and are subject to assessment against the Built Form Standards in Chapter 17.4 as follows (items in bold do not meet the standards): 17.4.2.2 – *Building reflectivity*: all buildings will be finished to comply 17.4.2.3 – *Identified important ridgelines*: no buildings will be within 20 m of an adjoining Important Ridgeline 17.4.2.4 – *Building Height*: no buildings will exceed 7.5 m above ground level **17.4.2.5 – *Building setback from road boundaries*:** part of the wet weather storage tank on the Old Coach Road storage site will be within 15

		m of the road boundary. 17.4.2.6 – *Shading of State highway*: no shading of SH75 will result from the proposed structures. 17.4.2.7 – *Building setbacks from internal boundaries*: all buildings will meet the internal boundary setbacks specified. **17.4.2.9 – *Site coverage*:** the tanks on the Robinsons Bay Valley site will exceed the maximum site coverage limit for Banks Peninsula of 2,000 m^2. **17.4.2.10 – *Building Footprint*:** the maximum individual building footprint of 300 m^2 will be exceeded by the proposed tanks on the Robinsons Bay Valley site (up to ten 22 m diameter tanks = 380 m^2 per tank) and the wet weather storage tank (one tank up to 30 m diameter = 707 m^2) on the Old Coach Road storage site. **17.4.2.11 –** *Vehicle Trips:* the activity will generate very few vehicle trips once operational, with contractor visits to each site unlikely to exceed one per day. All other Built Form Standards for the Rural Banks Peninsula Zone will be met. The Farm Track development on Robinsons Bay Valley site will be less than 5.0 m wide and therefore meets Permitted Activity rule P15 for track development in the Rural Banks Peninsula Zone. **Resource consent is required under Rule 11.8.3.RD1 as a <u>restricted discretionary activity</u> in respect of road boundary setbacks (Old Coach Road storage site), site coverage (Robinsons Bay Valley site) and building footprint (Old Coach Road storage and Robinsons Bay Valley sites).**

The assessment in Table 7-7 finds that resource consent is required under the rules of the CDP in respect of structures not already consented, and earthworks as follows:

- **Rule 11.8.3.RD1** – land use consent to construct and operate structures at the Old Coach Road storage and Robinsons Bay Valley sites, and associated infrastructure for conveying, treating, storing, and retaining / detaining wastewater. The proposal is a **<u>Restricted Discretionary Activity</u>** with the Council's discretion limited to the matters of non-compliance.

- **Rule 8.9.2.4.RD5** – for earthworks within Sites of Ngāi Tahu Cultural significance (waahi tapu and silent file areas). The proposed earthworks are a **<u>Restricted Discretionary Activity</u>** with the Council's discretion limited to the matters set out in Rule 9.5.5.1.

- **Rule 8.9.2.4.D1** – to undertake the earthworks required in constructing the scheme and associated structures and buildings. The proposed earthworks are a **<u>Discretionary Activity</u>**.

It is appropriate to consider the required consents as a 'bundle' given their interrelationship (i.e. the consents for earthworks and for the use of land for the scheme cannot be decoupled). Consequently the proposal is a **Discretionary Activity** under the provisions of the CDP.

7.4 Consent Terms and Lapse Dates

The applicant applies for a lapse date of eight years from the date of issue for all consents, to align with the anticipated construction and commissioning timeframe while allowing for unforeseeable delays (such as may result from supply chain issues that are outside the applicant's control).

The applicant requests an eight year term for construction-related consents as a conservative timeframe that provides an envelope for constructing and commissioning the scheme within the term of the land use consent and discharge permits for the existing WWTP.

The applicant requests that the term for the operational discharge permit aligns with the term issued for the consents already held for the scheme's odour and developed phase stormwater discharges[40] such that the permits collectively expire in July 2054. Terms of this duration reflect the applicant's long term view and the economic commitment of the community to investing in this scheme. Table 7-8 sets out the terms requested for each type of resource consent applied for:

Table 7-8: Consent Terms Requested

Activity	Authority	Requested Term
Discharge of treated wastewater to land and to water where it may enter land	ECan	To July 2054
Use of land for community wastewater treatment and management (i.e. the WWTP and associated facilities, and the irrigation sites)	ECan	To July 2054
Discharge of construction phase stormwater to land and / or water	ECan	8 years from issue
Earthworks and vegetation clearance on High Soil Erosion Risk areas	ECan	8 years from issue
Earthworks including in waahi tapu and silent file areas	CCC	Not limited
Land use consent to construct and operate structures for conveying, treating, storing, retaining / detaining wastewater.	CCC	Not limited

7.5 National Environmental Standards

7.5.1 NES for Assessing and Managing Contaminated Land

The National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2011 (NES-CS) applies to the disturbance of land on HAIL sites that may impact human health and need to be managed accordingly.

The ATWIS was assessed in respect of the NES-CS given the identified land contamination at the Terminal Pump Station and Robinsons Bay Valley sites.

Having considered the regulations set out in the standard it has been determined that the NES-CS does not apply to the Robinsons Bay Valley Irrigation site for the reasons set out in the DSI report in Appendix O. The applicant already holds resource consent to disturb land at the Terminal Pump Station and no further consideration of the NES-CS is required.

7.5.2 NES for Sources of Human Drinking Water 2008

The National Environmental Standard for Sources of Human Drinking Water (NES-DW) is a regulation made under the Resource Management Act 1991 that sets requirements for protecting sources of human drinking water from contamination.

The NES-DW requires regional councils to ensure that effects on drinking water sources are considered in decisions on resource consent applications and when drafting or changing regional plans. Specifically, councils are required to:

- Decline discharge or water permits that are likely to result in community drinking water becoming unsafe for human consumption following treatment;
- Be satisfied that permitted activities in regional plans will not result in community drinking water supplies being unsafe for human consumption following existing treatment;
- Place conditions on relevant resource consents requiring notification of drinking water suppliers if significant unintended events occur (e.g. spills) that may adversely affect sources of human drinking water.

Sources of community drinking water include natural water bodies such as lakes, rivers, or groundwater. The NES-DW applies to community drinking water sources before treatment.

The NES-DW is not relevant to the ATWIS as there are no sources for community drinking water schemes that could be affected by the scheme.

[40] CRC150049, CRC150050, CRC152814

7.5.3 NES for Freshwater

The National Environmental Standards for Freshwater (NES-F) is a regulation under the Resource Management Act 1991 that addresses activities that may impact freshwater and related ecosystems. The relevant provisions of the NES-F relate to wetlands, several of which have been identified within the Robinsons Bay Irrigation site and on land under other ownership nearby. The wetlands were identified as small, low value seepages or similar, degraded following stock grazing and historic land clearance, and with few, if any indigenous wetland plants present. They were therefore assessed as retaining no or very limited natural wetland value in their current form.

The proposal will not involve any vegetation clearance or earthworks in, or within 10 m of any wetland on or near the Robinsons Bay Valley site other than disturbance related to the proposed planting of indigenous vegetation. No earthworks or land disturbance within 100 m of identified wetlands will result in complete or partial drainage of any wetland. The proposed public access tracks and associated signage will also avoid any of the wetland areas. In addition, no treated wastewater irrigation will occur in, over, or near any identified wetland (refer to the concept landscape plans in Appendix C).

The NES-F works together with the National Policy Statement for Freshwater Management 2020 (NPS-FW) which was updated in December 2022. The definition of 'natural inland wetland' in the NPS-FM excludes wet land that is within an area of pasture used for grazing and has vegetation cover that is more than 50% exotic pasture. Under this definition, none of the wetlands identified in the Robinsons Bay irrigation area are natural inland wetlands and consequently the wetland provisions of the NES do not apply. Regardless, the Terrestrial Ecology Assessment report notes that the wetland and seepage values present would be enhanced simply by destocking as proposed and could be further enhanced by planting appropriate indigenous wetland species in those areas and as a result of an overall increase in soil moisture across the site resulting from the proposed irrigation.

8 Description of Alternatives

Section 6(1)(d)(ii) of the Fourth Schedule RMA directs that all applications for resource consent to discharge contaminants must include *inter alia* a description of *"any possible alternative methods of discharge, including discharge into any other receiving environment"*. Decision makers are required by s105(1)(c) of the RMA to have regard to the same.

The commissioner's decision on applications CRC150047 / 48 for coastal permits to occupy the coastal marine area with an outfall and discharge treated wastewater to Akaroa Harbour made it clear that, in the absence of a comprehensive assessment of alternatives that indicated otherwise, discharging treated wastewater to the harbour was not culturally acceptable. The decision indicated that an application to discharge treated wastewater to the harbour would be unlikely to be approved in the absence of a comprehensive alternatives assessment that found a harbour discharge to be the only viable option.

This section provides an overview of the alternatives methods and receiving environments considered.

8.1.1 Alternatives Assessed

Since the existing resource consents for the scheme were issued in 2015, the applicant has undertaken a comprehensive assessment of realistic methods of discharging treated wastewater from the proposed WWTP, including to a range of receiving environments. These assessments have considered the feasibility of doing so given the volume of wastewater, the location of the WWTP and the characteristics of the physical environment.

The options investigated, including long and short-listed options and those which progressed to public consultation are discussed in detail in the report *'Akaroa Wastewater Summary of Disposal and Reuse Options'* (CH2M Beca Ltd, 2020) and included:

- **Deep bore injection** (*Akaroa Wastewater Upgrade: Factual Report on Site Investigation to Assess Feasibility of Deep Bore Injection;* CH2M Beca Ltd, December 2018). Investigations concluded that this option was not technically feasible given the nature of the underlying geology.
- **Potable water reuse** involving the treatment of wastewater to the point where it is suitable for human consumption. This option was not advanced as it was considered to be culturally and publicly unacceptable, operating costs would be extremely high, there was insufficient time to commission a scheme within the term of the existing WWTP permits, and given legislative barriers, Ministry of Health approval would be unlikely.
- **Overland flow or flow via a constructed wetland** prior to discharge to surface water or the harbour. This option was not favoured given cultural concerns raised by Ngāi Tahu.
- **Managed Aquifer Recharge** (*Akaroa Wastewater Scheme Assessment of Potential for Managed Aquifer Recharge*; CH2M Beca Ltd, April 2018). The assessment concluded that this option was not culturally appropriate and presented too great a potential risk to groundwater quality and consequently source water for public supply.
- **Tankering or pumping wastewater to the Bromley WWTP**. The costs of this option, the risks associated with the required infrastructure, the impact on the transport network, and resulting vehicle costs and emissions meant that tankering was not feasible. Pumping to Christchurch's Bromley WWTP was also not feasible due to the long

residency time of wastewater in a pipeline between Akaroa and Bromley, significant odour and maintenance issues, land availability issues for a pipeline and pump stations, and significant capital and operational costs.

- **Harbour discharges** – this included consideration of discharging via passage through land, wetlands, Rakahore chambers, or direct discharge. No harbour outfall options were supported as culturally appropriate and were therefore not pursued.
- **An ocean outfall** – as it would involve laying an 11 km long pipeline on the harbour floor, the costs and technical risks involved were considered prohibitive, and this option was not pursued.
- **Multiple land-based schemes** involving the irrigation of treated wastewater to land. These include the Inner Bays, Goughs Bay and Pompeys Pillar Irrigation schemes. These schemes advanced to public consultation in 2020 following detailed assessment by the applicant including involvement of key stakeholders including iwi and the Akaroa Treated Wastewater Reuse Options Working Party (the Working Party).
- **Irrigation of existing indigenous forest** areas (Native Forest Regeneration). This option differs from the three land-based schemes above which involve planting existing farmland extensively in indigenous vegetation, rather than irrigating to existing forest areas. This option was not favoured given the limited areas currently vegetated, their generally small size, and their devolved nature across Banks Peninsula.
- **Irrigation of Hinewai Reserve** as a stand-alone irrigation site. Investigations found that the land area was insufficient to receive all treated wastewater produced by the WWTP.
- **Irrigation to the Duvauchelle golf course**. Investigations showed that the land area of the CCC-owned golf course was insufficient to receive all treated wastewater produced by the WWTP.
- **Non-potable use of treated wastewater**. This option is limited by the current regulations which do not provide for treated wastewater to be made available to the public for non-potable use. That said, the proposed scheme does include a 'purple pipe' component enabling the irrigation of Jubilee Park with treated wastewater, and options for future use as changes in regulations allow.

The applicant worked closely with the community including through the Working Party to identify, select and assess options for managing treated wastewater. Each option was evaluated by considering the advantages and disadvantages, efficiency and effectiveness, social, cultural, environmental, and economic aspects of each.

8.1.2 Scheme Selection Process

The long list, short list and scheme selection process is discussed in detail in the report *'Akaroa Wastewater Summary of Disposal and Reuse Options'* (CH2M Beca Ltd, 2020). The Long List was determined and initial screening undertaken in July 2015. Following Council Infrastructure Transport and Environment (ITE) Committee review and Environment Court mediation between the applicant and the Ngāi Tahu parties, a hui was held late October 2015 at which the following Short List options were agreed:

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

These short-listed options were further developed in early 2016 with a focus on potential irrigable land, and were presented to the Ngāi Tahu parties, leading to a refinement of the Short List to:

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

Site selection and assessment for these options occurred between March 2016 and March 2017 and led to site-specific technical assessments to confirm the sites would be suitable. A list of suitable sites progressed to public consultation in March 2017.

A subsequent error in the measurement of wastewater flow data was identified in 2017 which revealed wastewater volumes were more than double the previously measured flows that had formed the basis of options assessments to date. With the significant increase in wastewater volumes now evident, new investigations were undertaken to identify more land to support the short-listed land disposal options. Deep Bore Injection and Managed Aquifer Recharge were also investigated at this point, although both were subsequently set aside given technical limitations.

Following the short listing of four wastewater schemes including three land-based schemes and a harbour discharge, extensive public consultation ensued in July 2020 and submissions were called for (refer section 9). Following the receipt of extensive submissions, hearings were held in Akaroa and Christchurch in October 2020, and the hearings panel prepared a report to the CCC recommending that the Inner Bays Irrigation scheme be supported and developed.

8.1.3 Reasons for Selecting the Proposed Scheme

The hearing panel's report was received by the Council which then passed a resolution on 10 December 2020 approving the panel's recommendation to adopt the Inner Bays Irrigation scheme. At that time the scheme consisted of a proposal to irrigate the highly treated wastewater to the Robinsons Bay Valley, Hammond Point and Takamātua irrigation sites, development of a wetland for additional post-treatment storage and natural treatment processes, and an outfall from the wetland to either Childrens Bay Stream or directly to the harbour via a pipeline into Childrens Bay.

The panel recommended the Inner Bays scheme because it would:

- meet the Council's legal obligations as well as their obligations to Ngāi Tahu as Treaty partner
- keep the treatment and potential reuse of treated wastewater close to the source community for potential future reuse
- result in approximately 40 ha of new and additional indigenous vegetation in the harbour area, increasing overall indigenous habitat and biodiversity values in the harbour
- be feasible and achievable, and was the lowest cost of the feasible land-based options considered
- be able to incorporate a purple pipe scheme for reuse, reflecting the community's value of fresh water and their aspirations for future beneficial reuse of treated wastewater.

9 Consultation and Engagement

In many respects, the consultation and engagement for the ATWIS has been ongoing for many years, with key parties engaging in each decision-making process for the applications for short-term replacement discharge permits for the existing WWTP at Takapūneke. Involvement in those processes formed the basis for early discussions between the Ngāi Tahu parties, key stakeholders and the applicant as to alternatives to replacing the existing discharge permit, and ultimately the WWTP itself. The Akaroa Treated Wastewater Reuse Options Working Party was formed in 2017 and provided substantial input from stakeholders and the community, assistance to the Council and guided initial concept development from that point onwards.

Consultation and engagement was undertaken from 2012 onwards in respect of the applicant's 2014 suite of applications which saw the existing resource consents for the new WWTP and Terminal Pump Station granted, and the discharge permits for the harbour outfall proposed at that time declined. The decision on those applications was a significant catalyst for extensive investigations into alternatives (refer Section 8) accompanied by various technical assessments and stakeholder involvement along the way.

Following a rigorous assessment process, six of the options investigated by the applicant advanced to broad community consultation and engagement, including direct engagement with the Ngāi Tahu parties and the Akaroa Treated Wastewater Reuse Options Working Group. Following community feedback the options were further refined, and public consultation on four options opened on 21 July 2020, closing at the end of August 2020. Three of the options presented involved irrigating treated wastewater to indigenous vegetation established in a range of locations on the Peninsula. The fourth option presented was to discharge treated wastewater to the harbour via a new 1.2 km long outfall to be built at Glen Bay.

The consultation process was supported by Council press releases, community information meetings and open days, and a 'Have Your Say' campaign which included a 24-page consultation booklet that described the four schemes[41], the decision making process, considerations, and other key information including how to make a submission. The public consultation phase led to a total of 342 submissions. Approximately 53% of submitters supported the harbour outfall option with 31% supporting the irrigation of native vegetation. The remainder did not indicate a preference.

Hearings to consider submissions on the various options were held in Akaroa on the 12th and 13th of October 2020 and Christchurch on the 16th of October 2020. The Council's decision on which option to pursue was released on the 10th of December 2020, revealing that the land-based option known as the Inner Bays Irrigation scheme to irrigate treated wastewater to land at Robinsons Bay Valley, Hammond Point and Takamātua was preferred and would be advanced.

Following the Council's decision, the applicant established a Community Reference Group (CRG) to provide a mechanism for community concerns with the proposed scheme to be raised, and solutions and ideas to be shared. The terms of reference were set out by the Te Pātaka o Rākaihautū Banks Peninsula Community Board, with the CRG comprised of a Community Board member, two representatives of Ōnuku Rūnanga, and five members of the public. The final report from the CRG is attached as Appendix P to this document. The scheme originally included storage ponds on the Robinsons Bay site and a treatment subsurface wetland on the Old Coach Road storage site. It also provided for the discharge of treated wastewater to Childrens Bay Stream or directly to the harbour at Childrens Bay. Following further development of the scheme concept, these elements, and all direct discharges to water (fresh or marine) were removed from the scheme. These changes were presented to the CRG and their views taken into account in finalising the scheme concept.

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[41] https://ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/WEB-Akaroa-treated-wastewater-options.pdf

The applicant developed and implemented a stakeholder engagement plan from late 2021 which focussed on updating and informing parties and the public of the scheme's evolution and indicative programme. In addition, the applicant has maintained an up to date web page to keep the community informed of progress and provide visibility.

Direct engagement with, and input from the Ngāi Tahu parties as a statutory partner has been ongoing from well before project inception, throughout the refinement of the scheme concept, and the preparation of the design and this application document (as also described in Section One of the Cultural and Landscape Design Report in Appendix L) . Key technical reports addressing the existing environmental values across the ATWIS footprint and the anticipated effects on those values were provided to the parties for their consideration in preparing this application, and are reflected in the Cultural Assessment Report attached in Appendix L.

10 Assessment of Environmental Effects

Applications for resource consent must include an assessment of the activity's effects on the environment to the extent that corresponds with the scale and significance of those effects. This section along with the appended effects assessment reports provide an assessment of the actual and potential effects of the activity proposed.

10.1 Positive Effects

10.1.1 Harbour Water Quality

Treated wastewater is currently discharged to Akaroa Harbour via the existing 100 m long outfall at Red House Bay / Takapūneke. Treated wastewater currently discharges continuously to the harbour with a peak dry weather flow rate of 945 m^3/day and a peak daily flow (wet weather) of 3,400 m^3/day.

Receiving environment sampling has been required for the Red House Bay / Takapūneke WWTP discharge since its commissioning, more latterly under the interim discharge permit CRC204086. The consent holder monitors microbiological contaminants, nutrients, temperature, oxygen, suspended sediments, total oils and grease, and heavy metals and regularly reports the results to ECan. The monitoring data for all but the microbiological contaminants was sampled at a 250 m radius from the outfall, and the monitoring for microbiological contaminants sampled at shoreline sites 400 m from the outfall.

The effect of the WWTP discharge has been assessed in detail in the application for CRC204086. The assessment concluded that the effect on receiving water quality and biophysical attributes is minor overall. Monitoring demonstrates that water quality in the vicinity of the outfall is consistently within the receiving water quality standards for all parameters except for faecal coliforms, in Class Coastal SG, AE and CR waters as defined in the Canterbury Regional Coastal Environment Plan.

The ATWIS will replace the harbour outfall with a 100% land-based scheme. The proposed treatment process at the new WWTP will produce significantly better quality treated wastewater which will then be applied to land over a diffuse area. The applied wastewater will then be further treated by natural processes in the receiving soils, taken up by plants, dispersed and diluted in groundwater and eventually enter surface freshwater and coastal water in a substantially modified (cleaner) state.

The ATWIS will enable the current harbour discharge to permanently cease and will result an improvement in harbour water quality proportionate to the effects of the current discharge. The effect of the proposed scheme on harbour water quality therefore will be positive in relation to the existing state.

10.1.2 Cultural and Spiritual Values

The proposal will result in significant positive effects on Māori cultural and spiritual values impacted by the current WWTP and treated wastewater discharge to Akaroa Harbour. As a 100% land-based operation, the proposed scheme will permanently end direct discharges of treated wastewater to Akaroa Harbour, a statutory acknowledgement area of great importance to mana whenua. There will correspondingly be a positive effect on the Māori spiritual and cultural values of the harbour as noted in the Cultural Assessment Report provided in Appendix L and the Cultural and Landscape Report prepared by Ōnuku Rūnanga also in Appendix L.

The scheme also has a positive effect on tangata whenua's cultural expression and presence in recognition of the importance of the harbour environment and their relationship with the land, water, cultural landscape and historic heritage of the area. Removing direct treated wastewater discharged from the harbour is a significant step in this regard, as well as enabling expression through, for example the design of the wetland reserve at the Old Coach Road storage site, and within the irrigation areas through interpretation panels in public areas.

Moving Akaroa's WWTP to the proposed Old Coach Road site will enable the existing WWTP to be decommissioned and removed, and the site rehabilitated, ending the significant adverse effect of the existing WWTP on the historic, spiritual, and cultural values of Takapūneke.

10.1.3 Marine Ecology

Discharge permit application CRC204086 for the existing harbour outfall included an assessment of the effects of the current discharge on marine ecosystems[42]. The assessment noted a 2006 assessment by Kingett Mitchell and a 2019 assessment by NIWA of benthic and epibenthic communities and shoreline environments. The studies identified minimal nutrient enrichment of benthic habitats in the immediate vicinity of the harbour outfall, but otherwise no discernible effect on the ecological communities that were surveyed.

The assessment also concluded that the risk from the harbour discharge to marine mammals and birds is likely to be low given the domestic characteristics of the wastewater, the quality of the treated wastewater discharged, the available dilution in the harbour, and the low contaminant concentrations and toxicant accumulation. Despite the low risk however, removing the discharge from the harbour altogether is considered likely to have a positive effect on marine ecology overall (it will, for example, remove the minor nutrient enrichment occurring in the vicinity of the current outfall). This overall positive outcome would occur even when taking into account the potential for contaminants to drain from irrigation to Robinsons Bay via Robinsons Bay Stream, and from Hammond Point to the harbour.

10.1.4 Terrestrial Ecology

The terrestrial ecology values across the scheme area are varied and closely related to land use. The terrestrial ecology values present are important in the context of the wider Banks Peninsula and are highly valued by visitors and the community. Given the dominance of agricultural land use across the sites proposed to be developed for the scheme, the remaining ecology values across the sites may be vulnerable to further development, and the potential adverse effects of constructing and operating irrigation infrastructure.

The Terrestrial Ecology report includes an assessment of the existing terrestrial ecology values across the Old Coach Road storage site and the irrigation sites. The report concluded that the sites currently contain very little indigenous vegetation or habitat. The vegetation that is present is of limited value due to its dominance by exotic species, its degraded state, current land use patterns including grazing, fragmentation and sparsity. The few small wetlands and seepages within and near the irrigation sites were also assessed as being of low quality and degraded, including by pugging from grazing cattle.

The Terrestrial Ecology assessment concluded that the planting proposed across the sites (both irrigated and non-irrigated vegetation) will result in a net gain of approximately 67 ha of indigenous vegetation and associated habitat. These areas will provide important seed and food sources for indigenous species and will contribute substantially to visual and ecological connectivity within the inner harbour. Over time, the diversity of species and the associated habitat value will increase as a broad range of plants naturally re-establish and the planted areas approach a more natural forest ecosystem.

The assessment determined that irrigating the sites will supporting a wider range of species than may otherwise be the case, with drought intolerant plants finding favourable habitat. Irrigation is expected to help maintain more consistent moisture levels across the sites, including in the wetlands and seepages within the irrigation sites. The biodiversity benefits gained from the scheme would be further enhanced by destocking the irrigation sites and planting the seepages and wetlands to support their recovery and enhance their currently marginal value.

Overall, the assessment of the effects of the scheme on terrestrial ecology values concluded that:

- The irrigation sites and Old Coach Road storage site currently contain negligible indigenous vegetation or habitat and there will be no detrimental ecological impact on existing natural ecosystems;
- The adverse effects of the scheme on terrestrial ecology values in general are assessed as minor to negligible
- The proposed planting and irrigation coupled with pest management will result in a substantial net gain in biodiversity, regeneration and conservation values for the Akaroa Basin when compared to the current land use and its associated ecological values.
- The biodiversity gains will be overwhelmingly positive in terms of indigenous forest, wetland, and wildlife habitat values.

10.1.5 Landscape Character and Visual Amenity

The extent of the positive effects of the proposal on visual amenity values of each site are set out in the Landscape and Visual Assessment Report in Appendix M and summarised in respect of each site below.

The species selected including the dominance of kānuka planting are considered to extend the naturally regenerating vegetation across the Robinsons Bay Valley and Old Coach Road storage sites. The planting will help to screen some

[42] Refer section 5.3: Application for CRC204086, April 2020

elements of the proposal and soften the larger structures such as the storage tanks at the Robinsons Bay Valley irrigation site and at Old Coach Road.

In summary, establishing substantial areas of indigenous vegetation across the irrigation sites and the Old Coach Road storage site with species endemic to Banks Peninsula will result in an overall positive effect on visual amenity and landscape character values.

10.1.6 Akaroa Water Supply

Jubilee Park is currently irrigated in the summer months using potable water from Akaroa's public water supply, which often has water restrictions, particularly in the peak summer period. Using treated wastewater as an alternative represents an opportunity to beneficially reuse wastewater in place of potable water, including at peak times. The positive effect therefore is two-fold; it provides access to a non-potable water supply for irrigation that is not subject to water restrictions, and it will replace potable water used for irrigation, easing pressure on potable water for community supply. The purple pipe scheme will be built in a way that will allow it to be extended in the future, providing an opportunity for further demand reduction on potable water supply such as for toilet flushing and garden irrigation.

10.1.7 Public Health

A well designed and operated wastewater treatment and management system is essential for protecting the health and wellbeing of the public. The proposed WWTP and irrigation scheme is a critical part of protecting community and environmental health, including in respect of residual contaminants that may be present in treated wastewater.

The current WWTP discharge to Akaroa Harbour includes potential to cause adverse public health effects from exposure to contaminants, including pathogens in the plume by either:

- Ignoring signage and swimming or boating near the outfall or within the plume (e.g. kayaking or water sports that involve substantial contact with affected water); or
- Consuming shellfish gathered near the outfall.

The substantial receiving environment monitoring undertaken for the duration of the existing discharge shows that it has generally minor adverse effects on water quality and marine habitat (including shellfish) health, and that monitoring results consistently comply with RCEP guidelines for shellfish and contact recreation standards[43]. The results of shellfish monitoring undertaken near the existing outfall since 2014 have consistently complied with guidelines for shellfish consumption, indicating a low public health risk if eaten. Similarly, monitoring shows that health risks for swimmers enjoying immersive contact recreation at Glen Bay, the closest monitored beach, are also consistently minimal.

As a fully land-based scheme that will replace the existing scheme, the ATWIS will remove the low risk contamination from the existing scheme from the harbour. The potential for adverse public health effects from the ATWIS is minimal within the irrigation sites, and therefore negligible beyond the irrigation site boundaries. Taking into account the highly effective treatment process proposed, UV disinfection as a final step, and the decay rates of any residual pathogens in soils, there is negligible risk to public health from the proposed scheme.

Enabling the existing discharge to be decommissioned and removed from the harbour by replacing it with the ATWIS will result in a positive effect on public health as relates to existing harbour water quality.

10.1.8 Recreational Values

The proposal includes the development of substantial access tracks and public recreation areas accompanied by opportunities through track and planting design and information boards to help build and maintain awareness and appreciation of landscape, cultural and heritage values throughout the Old Coach Road storage site and the irrigation sites.

The land in these areas has long been held in private ownership and inaccessible to the public. Following the development of the scheme, the public will have recreational access to each area through the extensive walking tracks proposed, including a coastal walkway across the Hammond Point irrigation site connecting Robinsons Bay to Takamātua. These tracks will pass through areas of indigenous vegetation, providing viewing points with interpretation panels explaining the area's history, heritage, and cultural values, and providing opportunities to experience the biodiversity supported by the scheme.

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[43] *Resource Consent Application and Assessment of Environmental Effects – Akaroa Wastewater Treatment Plant*; CCC, April 2020.

Public walking access from Childrens Bay to the WWTP via the Old Coach Road storage site will including substantial areas of indigenous vegetation, community open space reserves, and interpretation panels to connect users with the area's cultural, natural environment and historic heritage. The tracks, reserves and recreational facilities will support and enhance the community's social, cultural and recreational wellbeing.

10.1.9 Effects on Commercial Activities

A range of commercial activities are undertaken in the wider harbour area, all of which rely on adequate water quality to some degree. The activities include various aquaculture operations including salmon, mussel, crayfish and paua farming or gathering, as well as commercial recreation activities such as jet ski hire or swimming with dolphins. The harbour also supports other commercial activities that also rely on but are not directly affected by harbour water quality, such as tourist activities, and commercial fishing and aquaculture.

The viability of these commercial activities can be adversely impacted by poor water quality. While it is acknowledged that the existing WWTP and harbour discharge has no measurable effect on these operations, its replacement with the ATWIS scheme will remove the potential risk associated with the harbour outfall, presenting an overall positive effect on commercial harbour use.

10.2 Effects on Groundwater

As evapotranspiration rates will not match irrigation volumes, the resulting excess (drainage water) can affect groundwater quantity and quality. High application rates can, for example result in changes to groundwater levels caused by mounding, cause changes to the direction of groundwater flows, elevate soil and wetland moisture levels, and alter spring and stream flows. Connected environments can therefore be affected.

Irrigating treated wastewater to land presents a potential for contaminants in the applied treated wastewater to drain through the soil profile to groundwater. The resulting effects on groundwater quality depend on the residual contaminants in the applied treated wastewater, the volume, rate and method of irrigation, the land area irrigated, the characteristics of the receiving environment (soil type, topography, vegetation, other land uses etc.) and the capacity of the receiving environment to assimilate the contaminants and the volume applied. Adverse effects on groundwater quality can impact other values, including the ability of groundwater to be used for stock, domestic or community water supplies (with and without treatment after extraction), terrestrial and aquatic habitat quality, and social, cultural, and recreational values.

While the physical and chemical characteristics of the receiving environment cannot be controlled, it is possible to control the treatment process and the irrigation system to manage receiving environment effects from the activity. The approach taken for managing the potential effects of the ATWIS on the quantity and quality of groundwater and linked environments is based on an effective treatment process and irrigation system. Managing the quality of the treated wastewater, and the rate and method of irrigation is therefore essential to enable adverse effects on groundwater quality and quantity to be avoided, reduced or mitigated.

Given the different circumstances at each ATWIS site, the following sections describe the anticipated effects of the scheme at each location.

10.2.1 Old Coach Road Storage Site

The Old Coach Road storage site will contain a sealed wet weather storage tank, a lined subsurface wetland, extensive areas of planting, and a small car park for public use.

Rainfall will generally soak to land across the site as it falls. Stormwater from the roof of the wet weather storage tank, the only building on the site, will soak to ground. Much of the site will be planted out with a range of indigenous species that will intercept rainfall, particularly as the plants mature. Rain falling directly into the subsurface wetland will contribute to the residual flow used to maintain wetland plant health. If water levels are too high such as after heavy sustained rainfall, captured stormwater can be diverted to the irrigation sites or circulated to the WWTP for treatment if needed. Precipitation falling on the small car park will be directed to the roadside stormwater swale as part of the Council's stormwater network.

Construction-phase stormwater will be managed on site, including provision for onsite soakage to land of captured stormwater and mobilised sediment. The potential for stormwater to include additional contaminants from imported materials or mechanical plant is negligible and limited to the construction phase. Any changes to groundwater beneath the site resulting from the proposed development are therefore expected to be minimal. Any changes to groundwater beneath the site resulting from the proposed development of it, or the effect on precipitation soaking to ground are expected to result from the formation of the impervious surfaces and structures (the storage tank and the lined subsurface wetland).

There will be no discharges of treated or untreated wastewater from any operational part of the ATWIS on the Old Coach Road storage site. Also, there will be very little change to the vegetated area of the site (noting the nature of the vegetation will change from pasture-dominated to indigenous), albeit a slight increase in the area of impervious surfacing with the development of the car park. The impervious surfaces / structures will make up a small portion of the overall site which will transition from its existing state as a paddock with limited boundary vegetation, to a substantially landscaped and vegetated area.

All operational aspects of the scheme on the Old Coach Road site will be sealed / impervious, with the area of impervious surfacing proportionately minimal. Any adverse effects (construction-phase or operational) of the ATWIS on the quality or quantity of groundwater underlying the site will therefore be negligible to indiscernible from the current state.

10.2.2 Robinsons Bay Valley

The groundwater baseline assessment undertaken by Aqualinc at the Robinsons Bay Valley irrigation site investigated the presence of groundwater, identifying shallow groundwater beneath the site, an extension of the semi-confined / unconfined aquifer defined in ECan's LWRP Planning Maps. The presence of groundwater in the lower valley and the continuation of flow in the Robinsons Bay Stream at periods where there is no rain confirms there is connection between groundwater and the Robinsons Bay Stream, supporting the conservative assumption in Aqualinc's assessment that applied irrigation will most likely drain to the stream via groundwater. It is anticipated that the drainage water from the irrigation area will travel to the stream within the property boundary and hence any impacted groundwater will be within this area.

The modelling undertaken to estimate the movement of applied treated wastewater and associated contaminants through the soils at this site, and the parameters and assumptions applied are conservative and are described in detail in Sections 7 - 9 of the Aqualinc report.

10.2.2.1 Groundwater Quantity

The modelling indicates that the soils of both the Robinsons Bay Valley and Hammond Point irrigation sites are readily able to receive and assimilate the volume of irrigation proposed given the soil characteristics and the proposed application rate and method (Section 7.4 of the Aqualinc report). The additional groundwater recharge will result in a small increase in the Robinsons Bay Stream flow as described in Section 10.3 of this document.

Minor contributions to the existing small seepages and wet areas identified in or near the site are expected as a result of irrigation as reported in the Terrestrial Ecology Report in Appendix B. The effects on existing seepages and wetlands have been assessed as likely to be positive in respect of improving consistent moisture levels that better support the proliferation of wetland species.

10.2.2.2 Groundwater Quality

The irrigation site soils will be able to accept the volume of applied treated wastewater, the limiting factor was determined to be the ability to assimilate residual contaminants. Applied wastewater will contain residual contaminants following treatment as described in Table 4-1 of this document and in the Contaminant Fates Technical Memo attached in Appendix G, including various forms of nitrogen as modelled by Aqualinc.

The technical memo concluded that most residual contaminants would rapidly attenuate through a combination of natural processes in the unsaturated soil horizon and underlying groundwater, including by plant uptake, by binding to soils before naturally degrading, and dispersion and dilution in the groundwater as it travels to the stream. The technical memo concludes that the risk of the assessed residual contaminants entering groundwater is low as most contaminants will generally remain in the plants or site soils and will not significantly mobilise to groundwater and enter Robinsons Bay Stream.

The residual contaminants will include nitrogen in various forms as described, modelled and assessed in the Aqualinc report. The assessment notes that the oxidised forms of non-organic nitrogen (nitrate and nitrite) are the main potential contaminants, and the analysis focusses on nitrate as the primary contaminant of concern in the receiving environment. As the key conservative assumption in the modelling is that almost all wastewater irrigated to the Robinsons Bay Valley site will drain to Robinsons Bay Stream, the effect of nitrogen on the receiving environment is addressed in section 10.4.1 of this document.

With the adoption of good irrigation management practices and given the quality of the treated wastewater (with nitrate-N of 8.6 g/m^3 being less than the Drinking Water Standards[44] Maximum Acceptable Value MAV of 11.3 g/m^3) and

[44] Water Services (Drinking Water Standards for New Zealand) Regulations 2022
https://www.legislation.govt.nz/regulation/public/2022/0168/latest/whole.html

characteristics of the receiving environment, the potential for adverse effects on groundwater quality from irrigating to the Robinsons Bay irrigation site is assessed as low.

10.2.3 Hammond Point

Investigations at the Hammond Point Irrigation site did not find any shallow groundwater present beneath the site. The piezometer drilled to investigate groundwater was installed at the crest of the site, as the intention is to irrigate over the crest and the upper part of the site. As there is no groundwater identified beneath the site, it is assumed that there will be no effects on groundwater (quality or quantity).

The Geotechnical Investigation Report in Appendix Q notes that irrigation of the Hammond Point site will need to be managed and monitored to minimise potential for drainage to follow preferential flow paths and / or seepage. Managing the irrigation to the site may include:

- Irrigating primarily in summer when evaporation rates are higher, thereby limiting the volume of drainage passing through the root zone beneath the site
- Monitoring application rates and soil saturation and monitoring for seepage from the cliffs.

Given the absence of shallow groundwater, no further assessment of the effects of the ATWIS on groundwater quantity or quality at this site was undertaken. An assessment of the effects of the modelled seepage from Hammond Point to the harbour is set out in the Estuary Ecology Report.

10.2.4 Jubilee Park

The proposed deficit irrigation methodology will involve low application rates directly to plant root zones, limited to when irrigation is needed for plant welfare. According to the conservative modelling undertaken, drainage from the irrigation area would be only slightly greater than would occur naturally under un-irrigated circumstances (i.e. 590 mm/y compared to 560 mm/y with no irrigation). With the highly efficient irrigation method proposed, and most applied water being taken up by plants or lost through evaporation, it is anticipated that minimal (if any) drainage below the root zone to groundwater will actually occur.

As well as providing a water source to the plants, the treated wastewater will provide a source of nitrogen which will reduce/replace the current need to apply nitrogen fertiliser. Other residual contaminants are expected to be taken up by plants, naturally attenuate or bind to soils. Consequently there would be a negligible effect on groundwater quality or quantity from irrigating treated wastewater to Jubilee Park on a moisture deficit basis.

10.2.5 Effects on Groundwater Users

Several domestic groundwater and spring users were identified down gradient of the Robinsons Bay Valley irrigation site, with two groundwater users recorded on Environment Canterbury's bore / wells database (refer Section 6.2.3). Given the anticipated direction of travel of the drainage from the site towards the stream, these users are not considered to be down gradient.

Consideration of the groundwater environment in Robinsons Bay Valley indicates that it is unlikely that applied treated wastewater and residual contaminants would migrate towards groundwater drawn by the properties east of and adjacent to the Robinsons Bay Valley site. Most residual contaminants are expected to attenuate rapidly following irrigation, with Nitrate-N remaining the key contaminant of interest in respect of effects on downstream water quality.

The treated wastewater leaving the WWTP will have a mean Total Nitrogen concentration of 10 g/m^3, equating to a Dissolved Inorganic Nitrogen (nitrate-N equivalent concentration) of approximately 8.6 g/m^3. This is below the Drinking Water Standards Maximum Acceptable Value (MAV) concentration for human drinking water of 11.3 g/m^3 before the treated wastewater is irrigated. It is expected that nitrate concentrations will further reduce by natural processes after irrigation and will be generally equivalent to the existing concentrations in Robinsons Bay Stream by the time the applied treated wastewater drains via groundwater and mixes in the stream.

Regardless of the limited potential to affect the quality of groundwater near the Robinsons Bay Valley site, as an additional measure the applicant proposes to provide groundwater users with an alternative potable water supply by extending the Duvauchelle Community Water Supply scheme. This supply will be made available prior to the commissioning of the scheme, and any parties who wish to connect to the supply will be provided with reliable potable water regardless of any potential effect of the scheme on groundwater quality. While adverse effects on groundwater users are not expected, the connection offered will mean that all users will have access to a reliable potable water supply. In addition, the applicant proposes to undertake regular water quality monitoring and provide the results to interested groundwater users in the vicinity of Robinsons Bay for transparency.

Given the expectation that almost all applied treated wastewater will enter groundwater and then Robinsons Bay Stream, and with groundwater users being provided a community water supply, no further assessment of the effects of the ATWIS on groundwater users was undertaken.

10.3 Effects on Surface Water Quantity

Irrigating treated wastewater to land can result in changes to the hydrology of receiving surface water where applied water enters waterbodies via overland flow, preferential flow paths such as drainage depressions, ephemeral and permanent streams, or through the underlying unsaturated zone or groundwater. If the application of treated wastewater is not carefully managed adverse effects stemming from increases in stream volumes can result. The potential pathways for applied irrigation to enter surface water are set out in Table 10-1:

Table 10-1: Potential Irrigation and Contaminant Pathways to Surface Freshwater

Pathway	Potential risk	Likelihood of occurring
Overland flow Robinsons Bay Valley and Hammond Point	Over-application of treated wastewater / application to saturated soils results in ponding and overland flow.	**Very low** Application rates will be carefully set and monitored to minimise the potential for ponding and overland flow from irrigation. This is further helped by dosing then resting irrigation zones to promote soakage. When soil conditions are likely to inhibit soakage or rainfall exceeds 50 mm per day, treated wastewater will be diverted to storage until favourable irrigation conditions return. The planting on the irrigation sites will also substantially reduce the potential for overland flow by intercepting irrigation (both subsurface and surface flows if they occur) and taking up applied irrigation.
Robinsons Bay Stream and / or connected ephemeral streams	Irrigation enters Robinsons Bay Stream or connected ephemeral streams via drainage.	**Low** The Robinsons Bay Valley irrigation site is partially bounded by the Robinsons Bay Stream. The site also includes several ephemeral streams which can contain water during and following rainfall, and which are assumed to provide preferential flow paths for rainfall that drains from the site to the stream. The concept site development and landscape plans in show the irrigable land area (slopes of <19º) set back from the banks and margins of the stream and the ephemeral watercourses on the site. The land within those margins will be planted in indigenous vegetation (refer to the concept planting list) which will intercept flows to streams. The setbacks will not be irrigated.
Groundwater Robinsons Bay Stream	Treated wastewater irrigated to land may drain below the root zone and enter groundwater, eventually connecting to the stream via springs, seepage or subsurface connections.	**Moderate to high** The assessment undertaken by Aqualinc determined that, given the hydrogeological characteristics of Banks Peninsula, surface watercourses are typically connected to groundwater, and any contaminants entering groundwater will most likely enter surface water. Aqualinc modelled the effect of treated wastewater applied to the irrigation areas and accounted for losses to evaporation, drainage and plant uptake of water and contaminants. The effects assessment includes assessment of the discharge pathway as a diffuse discharge from the Robinsons Bay Valley irrigation site to Robinsons Bay Stream.
Coastal Seepage Hammond Point	Treated wastewater irrigated to land at Hammond Point may drain below the root zone and seep to, and from the coastal cliffs, including via preferential subsurface pathways.	**Low to moderate** The proposed management approach is to control the application of water to Hammond Point to maintain slope stability and enhance potential for evaporation / evapotranspiration. As for Robinsons

		Bay Valley irrigation site, any applied treated wastewater soaking below the root zone is expected to eventually enter the coastal environment, either by subsurface drainage or coastal seepage.

10.3.1 Robinsons Bay Stream Flow

Robinsons Bay Stream is the only surface freshwater body in the vicinity of either of the ATWIS irrigation sites. Baseline flow monitoring was undertaken over 12 months while preparing this application, and the results assessed in the Aqualinc report. Aqualinc concluded that direct runoff from rainfall and seepage from localised shallow groundwater recharge Robinson Bay Stream. The quantity of water flowing in the stream impacts the aquatic habitat, stream morphology and the characteristics of the estuarine environment.

Stream flow gauging's were used to inform the modelled stream response to show the likely contribution of irrigating the Robinsons Bay Valley site to flows in Robinsons Bay Stream. Aqualinc's assessment concluded that if 99% of irrigation applied to the Robinsons Bay Valley irrigation site drains through the soil profile and enters the stream, the mean flow in Robinsons Bay Stream would increase by approximately 2%, from a mean of 0.386 m^3/s to 0.39 m^3/s. As the model assumptions are very conservative, the effects of irrigating the Robinsons Bay Valley site on streamflow in Robinsons Bay Stream are expected to range from minimal to negligible.

10.3.2 Hammond Point Coastal Seepage

No groundwater flow was identified beneath Hammond Point, and it is considered extremely unlikely that applied water will drain to the ephemeral stream to the south of the site given the geological characteristics, the topography, the design of the irrigation area, and the interception role of the proposed plantings.

Aqualinc modelled the total catchment runoff for Hammond Point and identified the potential volume of applied water that could enter the harbour via shallow subsurface discharge (coastal seepage). The assessment modelled the mean existing catchment discharge to be 0.018 m^3/s, with the mean increase in coastal seepage from the catchment attributable to scheme irrigation of approximately 0.001 m^3/s (an increase in discharge from the catchment to the harbour by seepage). Given the scale of potential modelled seepage to the harbour, and the volume of coastal water contained in the harbour along with other naturally occurring subsurface seepage and surface water contributions, the potential effect of any seepage from the Hammond Point irrigation site on the quantity of water in the harbour would be undetectable.

10.3.3 Ōinaka / Grehan Stream

Irrigation of Jubilee Park will be undertaken using very small volumes of treated wastewater applied to the root zone of plants only as needed to maintain adequate moisture for growth. Consequently minimal if any seepage to groundwater and the connected Ōinaka / Grehan Stream is likely. Any drainage that does occur is not expected to have a discernible effect on the volume of the stream given the minimal volume of irrigation anticipated.

10.4 Effects on Surface Freshwater Quality and Ecology

Irrigating treated wastewater to land can result in residual contaminants entering surface water by various pathways. If the wastewater treatment and irrigation processes are not carefully managed and monitored, significant adverse effects on surface water quality and related aquatic ecology and habitat, community social, recreational and economic wellbeing, and on the cultural values associated with water can result.

Mellish (2002) concluded that most of the residual contaminants in the applied wastewater including phosphorous, suspended solids, heavy metals and pathogens will be removed or substantially attenuated by the treatment process, and further reduction would occur in the receiving environment by binding to or decaying in soils, volatising and through uptake by vegetation. This conclusion is consistent with field trials undertaken in 2014[45] (B Robertson – Field Trials Paper - Appendix R) using treated wastewater from the Duvauchelle WWTP. While Mellish concluded that the risk of residual contaminants draining to groundwater is low, any contaminants that do drain to groundwater will be diluted and dispersed before being further diluted in connected freshwater or harbour waters.

[45] Robertson, B. 2017: Final Report (2017): *A lysimeter experiment and field trial to determine options for the beneficial reuse of wastewater from Duvauchelle and Akaroa, Banks Peninsula*, School of Physical and Chemical Sciences, University of Canterbury (Appendix S)

The primary contaminant of concern being the one most likely to enter surface and harbour waters in concentrations that could result in adverse effects on water and habitat quality is nitrogen, specifically nitrate-N. EOS Ecology noted in the Freshwater Ecology Report that in high concentrations nitrate-N can result in toxic effects on aquatic life, although changes due to nutrient (nitrate) effects in the ecosystem will become evident well before toxic concentrations are reached. Such effects include eutrophication causing excessive aquatic plant or algal growth resulting in changes to the invertebrate community and ultimately the food available to fish. Further, excessive plant or algal growth can cause large fluctuations in diurnal dissolved oxygen concentrations with low concentrations affecting fish abundance, diversity and general wellbeing. High concentrations of nitrate in freshwater can also adversely affect human health if consumed.

Aqualinc modelled the movement of nitrate in the treated wastewater as applied to the Robinsons Bay Valley and Hammond Point irrigation sites. The modelling assumed a total nitrogen (TN) concentration of 10 g/m^3 in the treated wastewater leaving the WWTP and applied to land. Aqualinc also undertook modelling of TN concentrations of 5, 8, 12, 16, and 20 g/m^3 in the treated wastewater as part of sensitivity and uncertainty analysis. The modelling considered the following four scenarios.

1. **Base Case:** Including (a) 13.5 kg/ha uptake/denitrification from the trees on the 31.9 ha irrigated area, and (b) the 2 kg/ha offset from destocking the 31.9 ha area.

2. **Destock1:** As for the Base Case, but with (a) 23 ha additional infill/riparian planting that is assumed to have the 13.5 kg/ha uptake and denitrification as the irrigated area, and (b) the 2 kg/ha offset from destocking this additional 23 ha area. In this scenario we have assumed that the infill / riparian trees can access the leached N, so the 13.5 kg/ha uptake from Meister and Robinson (Appendix V) applies. This is the scenario that is preferred by CCC.

3. **Destock2:** As for Destock1, with the remaining area of the property (63.2 ha) destocked. We note that although the remaining area may end up being planted in trees, we haven't used the 13.5 kg/ha uptake on it, as this number was based on trees with wastewater applied.

4. **Conservative:** No uptake, offset or destocking on any part of the property.

The 'Destock1' scenario forms the basis for this application and associated effects assessments.

EOS Ecology undertook an assessment of the effects of the scheme on Robinsons Bay Stream's ecology. In particular, the effects of Nitrate-N on Robinsons Bay Stream based on Aqualinc's modelling and the baseline data collected from field surveys, were assessed. The conclusions from this assessment are summarised in the following sections, and in detail in the Freshwater Ecology Report in Appendix H.

10.4.1 Effects on Robinsons Bay Stream Quality

The operational effects of the ATWIS on the water quality in Robinsons Bay Stream were considered in detail in Section 4.3.2 of the Freshwater Ecology Report.

Mellish (2022) (Appendix G) concluded that given the high standard of treatment anticipated, the irrigation method, receiving environment characteristics, the limited leaching potential of the residual contaminants, and the opportunity for vegetation to take up applied water and contaminants, the potential for most contaminants to enter groundwater was low (refer Section 10.2 of this document).

Aqualinc modelled Nitrate-N movements at the irrigation sites. Wastewater irrigation field trials undertaken in 2014 concluded that potential nitrogen leaching in Banks Peninsula soils was likely to be negligible, however Aqualinc applied a highly conservative approach to modelling nitrate movements forming a key aspect of the effects assessment in this application. Aqualinc applied a range of scenarios, with the preferred scenario ('Destock 1', the basis of this application) involving application of treated wastewater to 31.9 ha of the 'most suitable' irrigable land at the Robinsons Bay Valley site.

The preferred scenario assumes the 31.9 ha irrigated area would be planted in indigenous vegetation with a further 23 ha of unirrigated indigenous vegetation planted in riparian areas and between irrigated areas across the site. It also assumes the total ~55 ha area would be destocked. The preferred scenario provides for denitrification and plant uptake of 13.5 kg/ha/y of applied nitrogen being removed across both irrigated and unirrigated areas and allows for a further 2 kg/ha/y nitrogen offset from destocking the land.

Aqualinc's assessment of the potential effects of the proposed irrigation with treated wastewater on the water quality in Robinsons Bay Stream can be summarised as follows:

- The existing mean nitrate-N concentration of Robinsons Bay Stream, based on available water quality measurements is 0.03 g/m^3.
- Nitrate-N uptake by trees and other factors such as denitrification is estimated to be 13.5 kg N/ha/y and the impact of destocking the land is estimated to be 2 kg N/ha/y.
- For the base case scenario, assuming an applied treated wastewater mean Total Nitrogen concentration of 10 g/m^3

(nitrate-N concentration of 8.6 g/m³) and allowing for nitrate-N uptake and destocking the irrigable area, the increase in nitrate-N concentrations in Robinsons Bay Stream is estimated to be 0.086 g/m³ resulting in a stream concentration of 0.116 g/m³.

- For the preferred scenario, which includes nitrate-N uptake from the additional surrounding 23 ha area in the calculations brings the expected change in nitrate-N in Robinsons Bay Stream to 0.057 g/m³ resulting in a stream concentration of 0.087 g/m³.
- Leached nitrate from the irrigated area is likely to enter Robinsons Bay Stream in pulses after rain events. Therefore, using mean annual values will overstate nitrate-N stream concentrations during base (low-flow) periods.

On the basis of these findings, EOS Ecology assessed the effects of changes in the Nitrate-N concentrations on Robinsons Bay Stream and its associated aquatic habitat and ecology. The assessment of the effects is set out in Table 10 of the Freshwater Ecology Report and is reproduced below as Table 10-2 below.

Table 10-2: Summary of Assessed Nitrate Nitrogen Effects on Robinsons Bay Stream

Scenario	Description	Increase in nitrate concentration in stream (g/m³)	Estimated post irrigation nitrate concentration in stream (g/m³)	Level of effects (see Table 9)
Existing land use	No wastewater irrigation, native tree planting, or destocking.	0.000	0.030	**Nil effects** (No change from current state).
Base case	Irrigation of wastewater to 31.9 ha of land in the catchment, with 13.5 kg/ha uptake from the planted trees and 2 kg/ha offset from the destocking of the irrigation area.	0.086	0.116	**Moderate–High (minor–more than minor)** (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).
Preferred scenario (Destocking 1)	As for the 'base case', but with the addition of 23 ha of infill or riparian planting and destocking to further reduce nutrient leaching.	0.057	0.087	**Low (less than minor)** (Post irrigation Nitrate-N values within existing interquartile range; moderate - high ecological value; low magnitude of effect).
Destocking 2	As for 'preferred scenario', but with the remaining 63.2 ha area of the property destocked.	0.047	0.077	**Low (less than minor)** (Post irrigation Nitrate-N values within existing interquartile range; moderate - high ecological value; low magnitude of effect).
Conservative	Irrigation of wastewater on the assumption that there will be no uptake/denitrification occurring and without offset or destocking on any part of the property.	0.126	0.156	**Moderate–High (minor–more than minor)** (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).

Source: EOS Ecology, Freshwater Ecology Report

EOS Ecology concluded that, although mean nitrate-N concentrations in Robinsons Bay Stream would increase as a result of the scheme, the modelled change under the preferred scenario proposal would fall within the baseline interquartile range of concentrations for the stream (i.e. within the range of nitrate concentrations currently experienced by the stream ecology). It was also noted that the stream's nitrate levels would remain below the ANZG (2018) default guideline value of 0.17 g/m^3 and would remain within the A-band nitrate toxicity attribute of the NPS-FM 2020. The assessment indicates that the predicted changes are unlikely to cause any toxic effects, including on sensitive species, and that the nutrient effect would be minimal, remaining within the streams existing interquartile range. EOS Ecology concluded that the effect of the expected nitrate-N increase to Robinsons Bay Stream on the stream's ecological communities would be low (less than minor).

EOS Ecology undertook baseline monitoring of a range of other parameters as set out in Tables 1 - 7 of the Freshwater Ecology report, finding that baseline conditions in Robinsons Bay Stream generally meet the freshwater outcomes for Banks Peninsula prescribed in Table 1a of the LWRP, and in Schedule 8 of Plan Change 7 (PC7). Water quality in Robinsons Bay Stream in respect of most parameters is expected to continue to meet those values after the ATWIS becomes operational. Consequently EOS Ecology concluded that the magnitude of the effect of the ATWIS on the ecology of Robinsons Bay Stream as affected by water quality would be 'low', defined in Table 8 of the Freshwater Ecology Report as:

- Consisting of a minor shift away from existing baseline conditions. Change arising from the loss/alteration may be discernible, but underlying character, composition and/or attributes of the existing baseline conditions will be similar to pre-development circumstances or patterns; and / or
- Having a minor effect on the known population of range of the element/feature.

In EOS Ecology's assessment, the ATWIS was found likely to result in a minimal adverse effect on the compliance of Robinsons Bay Stream water quality with the values in Table 1a and Schedule 8 (PC7) of the LWRP in respect of the effect of changes in water quality on instream ecological health. This was largely due to the high quality of the treated wastewater, applying it to land, and most residual contaminants attenuating within soil, groundwater and through uptake and natural processes. Importantly, the effect on water quality in the stream would be minimal and would not result in a significant shift in stream quality or related habitat values as affected by water quality.

10.4.2 Effects on Ōinaka / Grehan Stream Quality

With the sub-surface drip irrigation method proposed for Jubilee Park, most applied water is expected to be taken up by plants or lost to evaporation such that minimal (if any) drainage to groundwater is expected to occur.

Aqualinc's assessment indicated the potential for a slight increase in drainage below the root zone of the irrigated area of approximately 30 mm/yr more than under natural (un-irrigated) conditions. Any such drainage that occurs would then be diluted and dispersed within groundwater before entering the stream immediately upstream of the mouth or flowing directly to Childrens Bay by groundwater. Given the quality of the irrigated water, the characteristics of the receiving environment and the irrigation method, any drainage from Jubilee Park on Ōinaka / Grehan Stream (quality or quantity) is likely to be negligible.

EOS Ecology consequently concluded that as there would be no measurable effect on water quality in Ōinaka / Grehan Stream, there would be no adverse effect on freshwater biota attributable to irrigating Jubilee Park. Correspondingly, there would be no discernible change in the degree to which the requirements of Table 1a and Schedule 8 (PC7) of the LWRP would be achieved.

10.4.3 Hammond Point

There are no permanently flowing surface watercourses in the vicinity of the Hammond Point irrigation site. A short ephemeral stream flows in the gully to the southeast of the site following rainfall.

The irrigable land at the Hammond Point site lies approximately 100 m north of and above the ephemeral stream. Unirrigated planting is proposed between the southern boundary of the irrigable land and the site boundary as shown in the concept Landscape Plans. This planting will extend to the south facing slope south of the Hammond Point irrigation site which is covered with substantial mature indigenous vegetation extending to and across the gully floor to the opposite side of the gully. The planted and existing vegetation will provide a significant area where applied irrigation will be intercepted prior to reaching the ephemeral stream.

Given the separation distances between the irrigable land and the ephemeral stream, the low gradient of the irrigable land, the careful management of low application rates proposed, and the unirrigated vegetation bounding the irrigable land, irrigating Hammond Point is unlikely to result in a measurable effect on the volume or quality of flows in the ephemeral stream.

10.5 Effects on Marine Water Quality and Ecosystems

While the ATWIS involves irrigating to land, modelling shows that a proportion of the applied water will drain through the soil profile to Robinsons Bay Stream and enter Robinsons Bay, and from Hammond Point to the harbour. Diffuse contaminant discharges to the stream and directly to the coast could adversely affect estuarine, coastal water and habitat quality within the harbour.

The most likely origin of any adverse effects on the quality of the marine environment are likely to be fine sediment and construction-related contaminants (e.g. fuel from plant and machinery) released to surface water during construction, sediment released during waterway crossings by the pipelines, and leaching of contaminants from the irrigation areas once the scheme is operational. As addressed in previous sections of this document, construction effects will be carefully managed by applying measures reflected in a EDSCP to minimise potential for construction-phase discharges, pipelines will cross beneath waterways using trenchless techniques or when streams are dry, and the treatment and application of treated wastewater will be carefully managed to minimise contaminant migration. The conclusions from the effects assessments in respect of these matters are set out below.

10.5.1 Effects on the Robinsons Bay Estuary

EOS Ecology undertook an assessment of the effects of the ATWIS on the Robinsons Bay estuary (the Estuary Ecology Report). The assessment considered the potential risk of fine sediments and construction contaminants being transported from earthworks and vehicles on the Robinsons Bay Valley site to Robinsons Bay Stream and ultimately into the estuary environment. It also assessed the potential operational effects on Robinsons Bay estuarine health from contaminants applied to the irrigable area. These are considered in the following sections.

10.5.1.1 Construction Effects

The assessment noted that significant increases in fine sediments deposited in the harbour would likely result in adverse effects in the bay, including reduced food production, gill clogging of filter feeders, reduced water clarity, and reduced levels of dissolved oxygen in the water. High levels of sediment can also result in physical changes to the bay’s habitat, including adverse effects on benthic biota, and sub-optimal growing conditions for plants such as seagrasses which are sensitive to fine sediment deposition.

The assessment concluded that increases in sediment in the bay that may stem from construction of the ATWIS would likely be intermittent and comparatively short term, and consequently would be unlikely to result in significant adverse effects on the macrofauna or seagrass beds identified in the bay. Importantly, the magnitude of any effect can be mitigated by appropriate management of construction works, in particular the installation and maintenance of effective sediment and construction-phase stormwater controls to minimise sediment losses to waterways that flow to Robinsons Bay. Coupled with pipeline construction methods that will avoid disturbing stream beds other than for streams that are dry, the effects of the construction phase on marine and estuarine values in Robinsons Bay will be negligible.

10.5.1.2 Operational Effects

Operational effects on Robinsons Bay were assessed based on the results of Aqualinc’s modelling, and the conclusions of the Freshwater Effects Assessment report also prepared by EOS Ecology. The assessment indicates that any operational effects on Robinsons Bay’s marine ecology would stem from contaminants that leach from the Robinsons Bay Irrigation site following land application, primarily during rainfall when contaminants that have accumulated in the site’s soils are most likely to mobilise in groundwater and into Robinsons Bay Stream and be carried to the harbour.

The decommissioning of the current Akaroa WWTP and its replacement by the ATWIS will result in less wastewater-derived nitrogen entering the harbour. The main potential effect on the benthic ecology values in the harbour from the ATWIS stems from the potential for localised increases in nitrogen in Robinsons Bay from contaminants carried by Robinsons Bay Stream, and from seepage from Hammond Point (assessed below).

The nitrogen load currently discharged by the Akaroa WWTP has been measured at 24.95 g/m^3 which is more than twice the 10 g/m^3 output from the proposed new WWTP. Taking into account that the discharge to land will enable further reductions in nitrogen to be achieved by natural processes and plant uptake, the Estuary Ecology Report concluded that there would be changes to the nitrogen species, timing, location and volume of nitrogen entering the harbour but that overall nitrogen effects on the harbour’s aquatic ecology would likely be reduced. The assessment took into account the findings of Aqualinc’s modelling and the assessment in the Freshwater Ecology Report. The nitrate concentrations in Robinsons Bay Stream are expected to rise as a result of irrigating to the Robinsons Bay irrigation site, however, would remain within the interquartile range of the measured nitrate baseline concentrations in the stream. The operational nitrate effects of the scheme on the stream would be comparable to the existing baseline nitrate loads. The effect on the stream’s freshwater ecology was determined to be low and unlikely to result in a ‘notable’ change in the stream’s ecosystem function. On this basis, the assessment in the Estuary Ecology Report concluded that, following commencement of irrigation to the Robinsons Bay irrigation site, there would be little discernible change to the level of nutrients currently entering Robinsons Bay via Robinsons Bay Stream as a result of the scheme, and therefore minimal related change to the bay’s benthic ecology.

10.5.2 Drainage from Hammond Point

Aqualinc noted in their report the potential for nitrate in the treated wastewater applied to the Hammond Point Irrigation area to drain to the subtidal areas of Robinsons Bay given the soil characteristics and topography of the site. The Geotechnical Report in Appendix Q also noted potential for preferential drainage pathways through the soil profile, particularly towards the cliffs that bound the site to the north and west. Aqualinc's modelling indicates a potential for up to 122kg/y of nitrate draining to the harbour from Hammond Point, allowing for denitrification, destocking of the property, and uptake by the planted indigenous vegetation.

Potential construction effects on the harbour from establishing the Hammond Point Irrigation area would be negligible (almost non-existent) given the limited earthworks needed to establish the indigenous vegetation, fencing, recreational pathways and irrigation infrastructure. Consequently, the primary potential effects of establishing the Hammond Point site would stem from operating the scheme.

The assessment in the Estuary Ecology Report notes that the primary contaminant of interest would be nitrate-N. The assessment concludes that any nitrate entering the subtidal zone from the Hammond Point site would be rapidly diluted and dispersed across the harbour and would also be substantially less than the amount of nitrate currently entering the harbour from the existing WWTP. The commencement of the ATWIS would result in an overall decrease in WWTP-derived nitrogen to the harbour and would be a positive outcome of the ATWIS. The report notes that 'flushing' of nitrate stored in soil would likely occur during rainfall, and discharges may be concentrated over short periods. However, the effect of the modelled nitrate discharged from Hammond Point was assessed as negligible given the minimal volume of nitrate and the scale of the harbour.

The primary method of mitigating the risk to coastal water quality from irrigating Hammond Point is careful management of application rates and to plant a range of recommended indigenous vegetation across the site to maximise uptake and soil stability. Careful irrigation management will minimise the potential for ponding and overland flow, and accelerated drainage to the coastal environment. It will also help to prevent or minimise the development of new or exacerbate existing tunnel gullies and preferential pathways to minimise soil erosion and contaminant loss to coastal water.

The establishment of indigenous plant cover across the site before irrigation commences will help to bind the site soils, and intercept rainfall, helping to reduce the potential for contaminant loss due to rainfall. With carefully managed irrigation the actual and potential adverse effects on coastal water quality will be very small (negligible) as will any related adverse effects on the coastal ecosystems adjacent to Hammond Point.

10.6 Effects on Soil Quality

Contaminants typically remaining in treated wastewater can adversely affect soil structure and health, particularly where the contaminants accumulate, or are potentially ecotoxic above certain concentrations. There are no industrial activities in the Akaroa wastewater catchment that would contribute such contaminants to the waste stream, and wastewater from the commercial activities in the catchment are essentially domestic in nature.

None of the contaminants that will be irrigated to land are expected to result in significant adverse effects on soil fertility or structure, or life-supporting capacity including in the long term taking account of cumulative effects. Some of the contaminants in the treated wastewater will pass through the unsaturated zones unchanged and will eventually enter receiving environments of ground, surface and coastal water. The primary contaminant of concern is nitrate-N. As it does not adhere to soil, it has no discernible effect on soil structure or quality and is a greater potential issue in water. Other contaminants are addressed in the technical memo attached in Appendix G and are discussed in the following sections.

10.6.1 Phosphorus

Excessive accumulation of phosphorus in soils can result in soil infertility and leaching of excess phosphorous to ground and surface water, and eventually coastal waters.

Soil storage and plant uptake are the major sinks for applied phosphorus. The uptake of phosphorus by plants across the irrigation sites will depend on several factors, but particularly the application rate, the nature of the soils and plant growth requirements. Soil profiles can hold a finite amount of phosphorus, and when saturation is reached, soluble phosphorus will leach to groundwater. Where there is no unsaturated zone there will be minimal, or no removal of phosphorus but where there is an extensive unsaturated zone and appropriate soils, significant phosphorous removal will occur, minimising leaching potential.

Residual phosphorus in solution that does not adsorb to soil or get taken up by plants combines with other elements in the soil lowering the potential for leaching. Phosphorus readily adsorbs to fine soil particles such as clay and silt in the unsaturated soil layer. The soils in the irrigation sites consist of approximately 71.5% sit and 19.5% clay fractions, which will substantially limit the potential for leaching of residual phosphorus.

Research to determine the fate of phosphorous from treated wastewater irrigated to land under indigenous vegetation was undertaken at a test plot near Duvauchelle[46] (Appendix T). The treated wastewater from the WWTP is expected to contain a mean summer peak load of ~7 mg/L of total phosphorus, with concentrations typically less than 4 mg/L. The study found that at a mean phosphorus loading of 10 mg/L, the mean total phosphorus concentrations in the top 300 mm of soil would be within typical agricultural soil values. While minimal leaching is expected to occur, the study found that most of the applied phosphorus would be retained in the subsoils beneath. The study also found that plant-available phosphorus would also increase under irrigation but would remain within typical ranges for high-fertility soils. Many indigenous plants will thrive under increased phosphorus, and this has been taken into consideration in selecting the species to be planted in the irrigable areas.

The research found that applying 50 kg / ha / year of phosphorus over 50 years is unlikely to result in significant soil quality and fertility effects, or 'environmental issues'.

Monitoring of soil health and receiving water quality will inform whether additional treatment is needed to reduce the applied load, with alum dosing or similar a viable option if it is needed. The proposed scheme is considered unlikely to result in significant adverse effects on the life supporting capacity of the soils in the irrigable areas, the health and quality of the planted indigenous vegetation, or downstream waterbodies from applied phosphorus. On the basis of the assessment of the effects of applying phosphorus to the irrigation sites as part of irrigated treated wastewater, the potential adverse effects on soil quality are considered minimal.

10.6.2 Sodium

High concentrations of sodium (SAR Values) in wastewater applied to land can accumulate, resulting in instability and reduced porosity. High sodium content can also inhibit plant growth and affect plant and soil health, particularly in respect of plants that do not tolerate elevated sodium levels.

The field trials undertaken by Robinson (2017)[47] determined that sodium in treated wastewater irrigated to Banks Peninsula soils is unlikely to result in unacceptable adverse effects on soil structure or health for up to 10 years of irrigation. Application beyond 10 years may result in adverse effects on receiving soils, however these effects are able to be readily addressed by applying gypsum or dolomite if necessary. The expected ratio of sodium to calcium and magnesium in the treated wastewater will be too low to form a sodium hazard to the soil at the intended irrigation sites. Overall therefore, the effect of sodium on soil structure and health is expected to be minimal, and able to be addressed if monitoring shows that intervention is required.

10.6.3 Other Contaminants

Robinson (2017) (Appendix S) investigated the effect of potassium, sulphur, calcium and magnesium in field trials near Duvauchelle. His research concluded that potassium will typically accumulate in the soil, with only minor amounts retaining the potential to leach. Noting that potassium is relatively benign in the environment, he considered the accumulation of potassium in soil to be insignificant as the baseline soil concentrations were at least 100-fold greater than the applied load. He also found that there were no significant effects on sulphur, calcium or magnesium concentrations in the field trial soils. On the basis of the trials and the findings of Mellish (2022), the effect on soil health and structure of potassium, sulphur, calcium and magnesium applied in the treated wastewater will be negligible.

Persistent organic pollutants (POPs) are also expected to be present in the treated wastewater, however given the high-quality treatment process it is expected that the concentration of POPs will be substantially reduced compared to the current WWTP discharge to the harbour. Mellish (2022) indicates that these contaminants are expected to be taken up by plants and bind to site soils and while some may progress to groundwater, the concentrations would be low. Currently, the concentration of POPs in the treated wastewater discharged to the harbour meets the standards in the RCEP almost immediately, and it is reasonable to infer therefore that application of POPs to land as proposed will result in very low or potentially undetectable concentrations in the receiving water environments for the ATWIS.

10.7 Effects on Slope Stability

Significant earthworks are proposed for the Old Coach Road storage site to form the wet weather flow storage tank, and on the Robinsons Bay Valley irrigation site to form the platform for the treated wastewater storage tanks. The soils on Banks Peninsula are identified as erosion prone and particular care is required to minimise the potential for adverse effects on slope stability. The Geotechnical Report attached in Appendix Q assesses the proposal in detail and is summarised in the following sections.

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[46] Reported in Robinson, B; *Phosphorus in Treated Municipal Wastewater irrigated onto NZ-native vegetation*: June 2019 (Appendix T of this document)

[47] *Final report (June 2017): A lysimeter experiment and field trial to determine options for the beneficial reuse of wastewater from Duvauchelle and Akaroa, Banks Peninsula*; Robinson, B; 2017.

10.7.1.1 Old Coach Road Storage site

Given the scale of the wet weather storage tank and subsurface wetland, the associated earthworks to construct them, and the additional load on the slope when the facilities are at full capacity there is potential for the development of this site to impact site and slope stability, with significant adverse effects resulting from slope failure if the placement, design and operation of the facilities does not adequately address the potential slope stability risks.

The geotechnical characteristics of the site were assessed and are reported in the Geotechnical Report. The assessment concluded that the Old Coach Road storage site is stable and appropriate for the proposed structures in respect of slope stability. The report recommends that the subsurface wetland is lined and impervious to avoid seepage potentially destabilising the slope and this has been adopted in the wetland design concept.

The potential for the proposed development of the Old Coach Road storage site to adversely affect slope stability is therefore negligible.

10.7.1.2 Hammond Point

The Geotechnical Report in Appendix Q notes that given the soil and geological characteristics of Hammond Point, there is potential for soil erosion including of the coastal cliffs that form the north and west boundaries of the irrigation site. Soil erosion could be caused or exacerbated by excessive irrigation, leading to the development of preferential drainage pathways, tunnel gullying, breakout from the coastal cliffs, and soil and slope instability.

The key method of addressing these risks is to carefully manage the rate, method and volume of irrigation. The substantial planting proposed across the site will also be key in providing support for the soil structure as well as reducing drainage as the plants take up the applied irrigation and transpire it.

The applicant will manage application rates within the receiving capacity of Hammond Point's soils, minimising the potential for ponding and overland flow as well as the development or exacerbation of preferential drainage pathways or tunnel gullying that could destabilise the slope. By the time irrigation is applied to Hammond Point, the extensive planting proposed will have had approximately four years to establish, providing time for the plants to develop and provide support for the site soils. Dosing irrigation in zones avoids loading the entire area at once and enable irrigated zones to be rested periodically. The approach will help to minimise the potential for slope instability to develop, including erosion caused by excess irrigation.

With appropriate scheme design, planting and irrigation management the potential for adverse effects on slope stability at Hammond Point will be minimal.

10.7.1.3 Robinsons Bay Valley

The platform for the treated wastewater storage tanks at the Robinsons Bay Valley irrigation site will involve the most significant earthworks across the scheme. Given the soil and slope characteristics at this location, there is potential for slope stability issues to arise if the earthworks, tank platform and tanks are not appropriately designed and executed. Accordingly, these aspects of the proposal will be supervised by an appropriately qualified and experienced Chartered Professional Engineer or Engineering Geologist.

An assessment of the geotechnical characteristics of the Robinsons Bay Valley irrigation site was undertaken and is reported in the Geotechnical Report.

Site investigations identified several areas of potential slope instability across the site as well as where irrigation should be avoided, and areas that are suitable for irrigation. The location proposed for the tanks has been identified as appropriate subject to site-specific investigations confirming geotechnical conditions, the tanks avoiding the heads of identified areas of instability, and appropriate control measures being engineered into the tank platform. Such measures may include support and stabilisation, and adequate stormwater management.

Further recommendations include monitoring the irrigable land across the site for signs of erosion, the development of preferential drainage pathways, and slope instability on an ongoing basis once irrigation commences. Managing application rates will be important to minimise overloading the site soils and potentially destabilising them. As for the Hammond Point site, the proposed dosing approach will assist with this, and will help to avoid ponding, saturating the soil profile and the potential for related instability. This is important given the presence of erodible loess below the site's topsoils.

A further recommendation in the report is to plant vegetation that have deep root systems to help reduce irrigation runoff by uptake, and to use the stability provided by the roots. As for the Hammond Point site, the extensive planting proposed across the irrigable and unirrigated areas will have approximately four years to become established before irrigation commences and will have grown root systems to uptake irrigation and support site soils.

Provided the characteristics of the Robinsons Bay Valley irrigation site are taken into account in the design and construction of the scheme, and appropriate irrigation management is applied the potential for adverse effects on slope stability from either structures or irrigation will be minimal.

10.7.1.4 Jubilee Park

Jubilee Park is predominantly flat, however there are low gradient slopes on the northern irrigation area bounded by SH75. Regardless, given the low gradient, low application rates, established vegetation and (in respect of the cricket pitch area) existing retaining / sea walls, no slope stability issues are anticipated.

10.8 Effects on Air Quality

The collection, conveyance and storage of wastewater holds the potential to discharge contaminants (such as sprays, aerosols and odour) to air. The effects of such discharges can be minimal if they are contained or largely confined to the site of origin, however this is not always possible depending on the nature of the site and the characteristics of the discharge. Discharges, particularly odour can also have significant adverse effects on amenity and the health and wellbeing of communities if not adequately managed.

The potential for the proposed scheme to adversely affect air quality is minimal given the design of the scheme components, the characteristics of the treated wastewater and the drip irrigation methods to be used. In particular, there is no potential for mist or aerosols to be generated, especially as the proposed irrigation area plants mature. Consequently, the primary potential effect on air quality is odour.

The Air Quality Assessment attached in Appendix K identifies the various scheme components that could be origins of nuisance odour[48]. These are considered in the following sections.

10.8.1 Terminal Pump Station

Operational discharges of odour to air from the Terminal Pump Station are authorised until 9 July 2054 by resource consent CRC150049, and do not form part of this application.

10.8.2 Old Coach Road Storage Site

The management of odour from the WWTP and the Old Coach Road storage site is particularly important given that raw wastewater is to be stored and processed at the site, its proximity to adjacent land use activities and as the site is partially circled by SH75. Also, the nearest existing residential activity is more than 300 m to the north, but there is a visitor accommodation activity less than 200 m to the south of the Old Coach Road storage site. Effective odour control at the WWTP and Old Coach Road storage sites will be required to avoid or minimise adverse effects on amenity values including on transient receivers.

The applicant holds resource consent CRC150050 authorising the discharge of contaminants (odour) from the WWTP to air and the use of land at the WWTP site to store wastewater until July 2054. The permit does not provide for any discharge of contaminants to air from the wet weather flow storage tank or subsurface wetland on the Old Coach Road storage site, however.

Stored raw wastewater in the wet weather flow storage tank presents the most significant potential source of significant odour from the Old Coach Road storage site. The tank however will be fully enclosed, with captured air and gasses extracted to the WWTP biofilter for treatment. Biofiltration is an extremely effective method of treating odour such that a well-functioning biofilter will render any residual odour negligible at or beyond the WWTP site boundary. Any odours discharged from the biofilter are authorised by permit CRC150050. Consequently there will be no discharge of odours from the wet weather storage tank.

Treated wastewater may need to be discharged to the subsurface wetland for temporary storage (modelled at a one-in-ten-year frequency) if conveyance to irrigation is interrupted or storage at Robinsons Bay Valley is at capacity. The treated wastewater will be held in the subsurface wetland as briefly as possible, and progressively drained from the wetland as circumstances allow, either to irrigation or back through the WWTP for retreatment. Given that the wetland will store only treated wastewater and stormwater that falls directly into the basin, no odour is anticipated because of the very low levels of residual BOD following the treatment process.

As a result of the design of the WWTP and adjacent components, and the use of the biofilter to treat ‘foul’ air, the potential for adverse effects on air quality to occur is negligible provided the biofilter is operating effectively.

[48] Discharges from the Terminal Pump Station are addressed in the Odour Assessment Report. Note that as the applicant holds discharge permit CRC150049 authorising discharges of contaminants (odour) to air from the terminal pump station to July 2054, no further assessment of the effects of terminal pump station discharges is provided.

10.8.3 Pipeline Valve Discharges

While the pipeline will generally be maintained under pressure, there is potential for trapped air or generated gases to accumulate at high points along the route. To avoid adversely affecting the hydraulic functioning of the pipe, accumulated gasses need to be vented to the atmosphere.

The highly treated wastewater in the pipeline will be conveyed directly to irrigation and will not have a long residence time that could result in odour being produced in transit. The treated wastewater will also be under pressure in the pipe and have very low levels of residual BOD so will not generate significant odour. The potential for any air valves to be the source of nuisance odour when venting will therefore be negligible. Regardless, any such valves will be located at least 100 m from the nearest residential dwelling, and / or will be fitted with an odour management device (such as an activated carbon filter) if a 100 m separation distance cannot be achieved.

The potential for adverse odour effects resulting from discharges along the pipeline is therefore negligible and consistent with permitted activity Rule 7.51 in the CARP.

10.8.4 Robinsons Bay Valley Storage Tanks

As with the conveyance of treated wastewater in the pipeline, any wastewater stored in the tanks on the Robinsons Bay Valley site will contain very low concentrations of BOD. Given this and the expected levels of dissolved oxygen within the treated wastewater, anaerobic conditions are very unlikely to develop during storage. Furthermore, the storage tanks will be covered, further minimising the potential for any residual odour (if it was produced) to migrate beyond the boundary of the site.

Taking these factors into account, as well as the large size of the site and the distance between the tanks and the nearest site boundaries and potential receivers, the tanks will not be a source of odour.

10.8.5 Irrigation Sites

The application of wastewater to land can result in odour beyond the land application site depending on the characteristics of the wastewater, the nature and location (proximity to receivers) of the receiving environment, and the assimilative characteristics of the land. One key method of minimising the potential for adverse odour effects is to closely manage the treatment process to achieve high quality treatment and adopt an application rate appropriate for the receiving soil characteristics.

Irrigating Jubilee Park will not present a potential air quality risk provided wastewater quality and application rates are appropriately managed. The high quality of the treatment process (which may also include UV or chlorine disinfection as a final treatment measure), the very low BOD content of the wastewater, and the subsurface drip irrigation method and appropriate application rate will avoid aerosol and odour generation. Irrigating the park as proposed will therefore not result in any discernible effect on air quality.

For the proposed scheme, the treatment process will be closely managed to achieve a consistently high quality of treated wastewater including low levels of BOD. By using drip irrigation to land within established vegetation and considering the location of the irrigation sites relative to off-site receivers, there is no potential for spray drift, aerosol production or discernible odour beyond the boundaries of the irrigation sites.

10.9 Land Contamination Effects

Land contaminated by previous land use practices can have a significant adverse effect on human health, terrestrial and aquatic ecology through contact and ingestion of contaminants. Disturbing contaminated land through bulk earthworks, vehicle tracking, or mobilising sediment through slope erosion, dust generation or entrainment in stormwater can result in contaminants adversely affecting human and environmental health, water and air quality, and exacerbate the spatial extent of contamination. Irrigating over contaminated soil can also cause contaminants to mobilise and result in adverse effects on receiving environment quality, habitat and human health.

The existing contaminated sites on the Robinsons Bay Valley irrigation site have been identified and characterised in the DSI report attached as Appendix O. The DSI report recommends exclusion zones (Figure 10-1) around each site to enclose all soil known to be contaminated above the NES-CS industrial / commercial standard. This approach will prevent any disturbance of soil in those areas that could mobilise contaminants that could adversely affect human health and will also prevent public access to those areas. Amenity planting of indigenous species may be undertaken within the exclusion zones, noting that the scale of soil disturbance associated with such planting will be within the permitted activity limits set out in the NES-CS.

Preventing soil disturbance within the exclusion zones will also remove the potential to mobilise contaminants that could adversely affect habitat or soil quality beyond the existing contamination, or water quality where contaminants could enter Robinsons Bay Stream.

Figure 10-1: Exclusion Zones around Farm Building B and the Sheep Dip Facility

Section 16 of the DSI Report (Appendix O) notes that '*Irrigation of treated wastewater should be excluded from areas identified as a "piece of land" …*' given the potential for the identified contaminants to be mobilised by irrigation. The exclusion zones shown in Figure 10-1 lie outside the irrigable areas shown in the Aqualinc Report and the concept landscape plans.

Establishing exclusion zones around Farm Building B and the sheep dip facility will mean that the soil and associated contaminants within those zones are undisturbed by the development of the site for treated wastewater irrigation, and the effect of the exiting contamination will not change as a result of the proposed activity. Provided these exclusion zones are established at the outset of site works, the activity will essentially have no discernible adverse on human or ecological health or receiving environment quality.

10.10 Effects on Landscape and Amenity Values

The following assessment draws on the conclusions set out in the Landscape and Visual Impact Assessment (LVIA) report attached in Appendix M.

10.10.1 Old Coach Road Storage Site

The Old Coach Road storage site lies opposite the WWTP site on a prominent spur north of Akaroa, partially encircled by SH75 as it descends towards Akaroa. The site has been assessed as having a low ability to visually absorb unmitigated change given its prominent location, including visibility from SH75, nearby roads and being overlooked from Takamātua Hill with its public walking track.

10.10.1.1 Structures, site development and earthworks

Developing a large storage tank and wetland basin on the Old Coach Road storage site has the potential to be visually prominent in the otherwise rural setting, and out of step with the landscape character and amenity. Earthworks will be substantial and have the potential to be result in adverse visual effects if not undertaken considerately and remediated promptly.

The construction phase will require substantial earthworks to recess the tank into the spur and to form the wetland basin. The earthworks will be prominent during construction however they will appear as part of wider construction activity including the WWTP on the other side of Old Coach Road. The earthworks will not be out of context with the surrounding activities and the associated visual effects will be temporary. Effective sediment and stormwater control during the construction phase will also help to confine the extent of the visual effect of the construction phase to the site.

The low profile roof and recessive colour of the wet weather storage tank, and the substantial screen planting around it (refer to the concept landscape plans, Appendix C) will help to reduce the visual prominence of the location, once construction is complete. Following the planting around the subsurface wetland establishing, the site will be screened and the built elements will not be visually prominent from most off-site locations including SH75 despite the intrusion into the boundary setback. With the proposed mitigation, the site has been assessed as being able to accommodate the earthworks and the structures well, with the visual effects progressively reducing as the planting matures. The low profile of the structures and the proposed screen planting for the site will also minimise any adverse visual effects associated with the road boundary intrusion, and in time will not be visible from the road.

The tank, wetland, and associated earthworks have been assessed as resulting in a very low (minimal) adverse effect on landscape character given their scale and location within the site, and the location of the site relative to observers. Similarly, the effects on visual amenity values following mitigation are also assessed as very low, and potentially positive as the extensive indigenous vegetation plantings mature. The overall development of the site with the proposed car park, subsurface wetland basin, transition from open paddock to indigenous vegetation, development of walking tracks, and the cultural design and narrative of the wetland area have been assessed as resulting in a negligible adverse effect on amenity values overall and may have a positive effect.

10.10.2 Robinsons Bay

Robinsons Bay Valley and the irrigation site have been assessed as having a moderate to low ability to absorb the visual effects of the proposed development unmitigated.

The main aspects of the proposed scheme at the Robinsons Bay Valley irrigation site that will result in adverse effects on the landscape and visual amenity values of the site will be associated with the development of the vehicle access track off upper Robinsons Bay Valley Road, the proposed storage tanks (building footprint and site coverage), and the substantial planting of indigenous vegetation across the mid to lower parts of the site.

10.10.2.1 Access Track

Extending from an existing vehicle access from Robinsons Bay Valley Road, the approximately 3.0 – 4.0 m wide gravel track will provide construction and maintenance vehicle access to the storage tank platform and is a permitted activity as it is less than 5.0 m wide. The track will be most obvious immediately following formation when cut faces and disturbed soil are fresh and at their most visible. The visibility of the newly formed track will progressively diminish following construction, as vegetation (grass, indigenous species) establishes over recontoured material and the exposed faces weather.

The proposed access track and associated earthworks are assessed as having a low adverse effect on the landscape character of the site including in the wider setting. The significance of the adverse effect is considered to reduce to very low over time as the track becomes established and becomes visually consistent with farm access tracks in the vicinity. Similarly, the construction effects are considered temporary and will result in a low adverse effect on visual amenity values, dropping to very low once vegetation has established.

10.10.2.2 Tank platform and tanks

The proposal involves developing a low slope / flat area midway up the Robinsons Bay Valley irrigation site. Given the scale of the proposed earthworks to prepare the tank platforms, there is potential for substantial adverse visual effects during construction, noting the works will be visible from off-site locations, particularly from higher elevations and from within the valley.

Cut material will be redistributed to help form the tank platforms with excess material distributed across the site and revegetated as soon as possible to stabilise it. This will also help to substantially address the visual effects of the construction phase. Following the formation of the platforms, the tanks will be constructed, clustered in a group well within the site and finished in a recessive colour. As assessed in the LVIA report, the site will retain its fundamentally rural character and naturalness despite the scale and number of the proposed tanks, and the resulting area they will cover. Despite the area of the site that will be covered by the tanks, given the location of the tanks in the scale of the site, the effect on landscape and amenity values will be minimal.

Overall, the development of the tank platform (construction phase) was assessed in the LVIA report as resulting in low to moderate (minor) adverse effects on landscape character. Following the completion of construction and the establishment of vegetation including specific landscape mitigation planting (refer to the Concept Landscape Plans in Appendix C) the effect of the storage tanks on landscape character values will be low. The LVIA assessment concludes that the construction phase for the tank platform will result in moderate to low (minor) adverse effects on visual amenity, dropping to low once the associated vegetation has established.

10.10.2.3 Changes in land use

As with each irrigation site, the most substantial visual change will be the large area of revegetation proposed. This will contrast with the currently dominant openness of the areas under pasture with only small pockets of indigenous vegetation having been retained or naturally regenerating within the Robinsons Bay Valley irrigation site. Initial planting may appear linear however it will take on an increasingly natural appearance as it matures, with a corresponding reduction in the significance of any adverse effect on landscape character or visual amenity. The LVIA report concludes that the significance of the adverse effect of the change of land use and land cover on landscape character will be very low initially and will be positive overall for the site and wider environment over time. Similarly, the overall effect of the change on the amenity values of the site are assessed as positive.

10.10.3 Hammond Point

Hammond Point is a prominent landscape feature in the harbour landscape between Robinsons Bay and Takamātua Bay. The site is bounded by the coastline with SH75 forming its western boundary, and pockets of residential development to the north and south. Taking these features into account, the site has been assessed as having a very low ability to absorb change. Taking this into account, a change in land use at this site has significant potential to result in adverse effects on landscape and visual amenity values if effects are not mitigated.

The development of the Hammond Point site will not involve structures or built form. There is an existing vehicle track providing access across the site to a private dwelling near the coastline. The irrigation infrastructure on the site will be minimal, consisting of an offtake and irrigation control system for the surface dripline network. The most prominent change to the site will be the substantial planting of indigenous vegetation, noting that the species to be planted are endemic to Banks Peninsula, having been seed-sourced from the area.

As the plantings mature, Hammond Point will change from its currently open rural-productive character as it reverts to indigenous vegetation cover. The LVIA report assessed the change in land cover on landscape character and visual amenity values as initially very low, eventually becoming positive overall as the vegetation matures.

10.10.4 Jubilee Park

The proposal will result in temporary adverse effects on the amenity values of Jubilee Park, limited to the construction phase when the subsurface irrigation network is installed. As the installation of irrigation lines will be by mole plough or a similar unobtrusive technique, the effects will very quickly diminish as disturbed land reverts to previous form. The installation of irrigation infrastructure on the open space, character and amenity value of the park will not change.

10.11 Effects on Cultural and Spiritual Values

The discharge of treated wastewater to water is unambiguously offensive to mana whenua and it has long been an ambition of Te Rūnanga o Ngāi Tahu and Ōnuku Rūnanga to end discharges of treated wastewater to Akaroa Harbour. In addition, the cultural importance of Takapūneke is acknowledged and enabling the removal of the current WWTP and rehabilitation of the site is a key outcome of the ATWIS. Moving toward restoring the mana of Takapūneke will be a significant positive effect of the scheme.

The applicant has worked closely with Te Rūnanga o Ngāi Tahu and Ōnuku Rūnanga in developing what is now the ATWIS as key partners over many years, including in the consultation phase that culminated in the Inner Bays Irrigation scheme being approved by Council. Engagement continued throughout the preparation of this application and underlies the scheme now proposed, including specific input into aspects such as the design of the subsurface wetland, selection of species to be planted across the irrigation areas, earthworks in proximity to sites of cultural significance as indicated on the CDP Planning Maps, and other considerations.

The submission presented to the Council by the Ngāi Tahu parties in May 2020 made it clear that any form of treated wastewater discharge to the harbour would be opposed and expressed strong support for the irrigation of treated wastewater to land. The submission also strongly supported I&I reduction, irrigation to land in Upper Robinsons Bay, and for non-potable reuse of treated wastewater. The ATWIS incorporates all three matters into its concept.

The Aqualinc Report and the effects assessments on terrestrial ecology, landscape, freshwater and coastal water were provided to both parties for comment prior to lodging the application as they are essential to understanding the scheme, the actual and potential effects on the environment, and the effects on Māori cultural and spiritual values.

Ōnuku Rūnanga prepared the *Akaroa Wastewater Wetland Reserve Cultural and Landscape Design Report* in January 2023 attached in Appendix L. The report provides important background, and cultural and historical context to the scheme, the landscape setting and explanation of the rūnanga's design for the subsurface wetland and Old Coach Road storage site. Mahaanui Kurataiao Ltd. prepared a Cultural Assessment Report attached as Appendix L, on behalf of the parties. The conclusions in the report stated that *'The cultural effects of the scheme development and operation are assessed as overwhelmingly positive.'*[49]

10.12 Public Health and Recreation Effects

Treated wastewater has the potential to significantly affect public health where there is a risk of public exposure to and contact with the wastewater. Exposure to contaminants of concern to human health including pathogens can result in significant illness in the community, and in extreme cases public health emergencies. Wastewater networks, treatment and disposal is therefore critical to maintain public health and avoid the potential for serious adverse effects on the public from contacting wastewater, or from wastewater contaminants in the receiving environment.

To address this risk, all wastewater will be collected and conveyed via the existing wastewater network to the new WWTP at Old Coach Road for comprehensive tertiary level treatment. The treatment process will result in very high quality treated wastewater with very low levels of contaminants of concern to public health, which will then irrigate to land where it will be treated further by natural processes. The treatment process will significantly reduce the

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[49] Conclusion – Section 8, *Akaroa Wastewater Project: Cultural Assessment*; Mahaanui Kurataiao Ltd., Nov 2022

contaminants in the wastewater, and the risk from contaminants and pathogens to people will be minimal. As the highly treated wastewater will be irrigated to land within established vegetation, the potential risk to the public from treated wastewater will be extremely low.

Drip-irrigating the treated wastewater onto land within densely planted vegetation at a rate readily absorbed by underlying soils will minimise the potential for human contact either directly with irrigated wastewater or with runoff. It will also avoid producing aerosols that could be carried off-site to adjacent private or public areas where human contact could occur.

The irrigation of Jubilee Park will be achieved using subsurface drip irrigation. The quality of the wastewater, the low application rate and the subsurface method will avoid the potential for human contact with wastewater, while providing moisture and nutrients to maintain grass cover throughout dry summer weather.

10.12.1 Effects on Swimming and Shellfish Gathering

Replacing the current Akaroa WWTP discharge with the ATWIS will reduce the level of human-derived faecal contamination in Akaroa Harbour. Given other natural sources of faecal contamination such as animals and birds, and land and stormwater runoff however, it is unlikely that the level of faecal contamination overall will be significantly reduced. Faecal contamination can result in unsafe conditions for swimming and collecting seafood, impacting people's recreational and cultural opportunities.

The baseline monitoring carried out over 12 months as part of the Freshwater Ecology assessment identified elevated faecal contamination of the monitored streams during and following rainfall, concluding that contaminated soil and faecal matter was mobilised into streams during rain events, and transported to the harbour, affecting harbour water quality. The Estuary Ecology Report noted that the streams around the harbour have measurable levels of *E. coli* due to contamination by wild animals, birds and livestock and are the primary source of faecal contaminants.

The Estuary Ecology Report noted abundant cockles in Robinsons Bay as a potential recreational, cultural (mahinga kai) and food resource that would be affected by high levels of faecal contamination. The cockles in Robinsons Bay have previously been found to have elevated *E. coli* concentrations that made them unsafe to eat following wet weather, but that levels were safe during dry weather.

The effects assessment in the Estuary Ecology Report noted the potential for increases in *E. coli* in receiving soils, and following rain events, in Robinsons Bay Stream and Robinsons Bay from flushing of contaminants and soils if treatment does not effectively remove contaminants. However it also noted the potential benefit of destocking the Robinsons Bay and Hammond Point sites in reducing animal-derived contaminants. The report concluded that the scheme will likely reduce the potential for faecal contamination and may help to increase 'shellfish safety', noting that close monitoring would be needed to establish the effect on cockle populations. With substantial vegetation on the irrigation areas eventually providing a closed canopy over the irrigated land, the potential for rainfall to substantially mobilise faecal contaminated soil to waterways would be substantially reduced because of rainfall intercepted by the canopy and accumulated leaf litter and groundcover, and from roots binding soil particles.

The potential for the ATWIS to adversely affect public health or recreation such as swimming or gathering shellfish is negligible, and there may be some positive effects in respect of improvements to water quality, and the development of recreational walking tracks across the three planted sites. The scheme will remove direct discharges of treated wastewater to the harbour in favour of a land-based scheme and reduce the opportunity for residual faecal contaminants to mobilise to fresh or coastal water.

The effect on the scheme public health and contact recreation opportunities is minimal, and primarily limited to any effects on Robinsons Bay Stream and Robinsons Bay. No adverse effects on fresh or harbour water quality and associated recreational, social and cultural activities are anticipated as a result of irrigating Jubilee Park, and there are no discharges proposed to Childrens Bay as the primary recreational resource near the scheme.

10.13 Heritage and Archaeology Values

An archaeological assessment was prepared for the land that would be affected by the development and operation of the ATWIS and is attached in Appendix N.

No heritage or archaeological sites or values were identified at the Old Coach Road storage or Hammond Point sites. The known heritage and archaeological values at the Robinsons Bay Valley site were assessed in detail in the report, which also identified the potential for unknown values along the proposed pipelines between Akaroa and the WWTP, and the WWTP and the irrigation areas. The potential effects on these values and risks are discussed in the following sections.

10.13.1 Robinsons Bay Valley Irrigation Site

Heritage and archaeological values are vulnerable to damage or destruction from changes to land use, construction activities and the associated disturbance of land, and the subsequent irrigation and planting of vegetation proposed if it is not managed appropriately. Limiting access to the land where such values exist can serve to protect them but if access is prevented can also diminish their value to the community.

The identified heritage and archaeological values at and in the vicinity of the Robinsons Bay Valley site are described in the Archaeological Assessment report. The report notes two heritage sites[50] in the vicinity of the Robinsons Bay Valley Irrigation site identified in the CDP as protected heritage resources. While neither site is within the proposed irrigation area, a survey of the site identified several other items and features of heritage value. The Mill Cottage site is registered under the Heritage New Zealand Pouhere Taonga Act as N36/260, reflecting the sawmilling that occurred at Robinsons Bay in the late 19th century, and the subsequent transition to stock farming. A midden near the head of Robinsons Bay has also been recorded (N36/105) providing evidence of pre-European activity in the vicinity. The heritage values on and adjacent to the Robinsons Bay Valley site are well documented and detailed in the Archaeological Assessment report. No other sites or items of value are recorded.

The applicant is highly cognisant of the heritage values on and adjacent to the lower Robinsons Bay Valley site and acknowledges the potential for the development and operation of the ATWIS to adversely affect those values if the construction and operation of the ATWIS is not appropriately managed. Consequently the applicant proposes to separate the lower portion of the site from the remainder of the scheme as indicated in the concept landscape plans in Appendix C. This separation is generally consistent with the irrigation setback recommendation in Figure 58 of the Archaeological Assessment report. No construction activities, planting or irrigation will occur within that area or in an immediately upslope location that would result in adverse effects on archaeological or heritage values downslope. The proposal will also help to preserve the historic viewshaft across the site from Robinsons Bay Valley Road as identified in Figure 5 of the Archaeological Assessment report.

Other proposed measures include fencing off features elsewhere on the site such as the remaining building and woolshed remains and providing an irrigation setback of at least 5 m from these features, retaining the historic tracks and routes within the site to provide future public access, and including interpretation panels at key locations to convey the site's historic significance to users. The applicant's concept landscape plans show the potential public walking tracks in the site incorporating the remaining and remnant structures as recommended in the Archaeological Assessment Report.

An Archaeological Site Management Plan (ASMP) will be prepared prior to construction on the site and will be submitted to the consent authority as part of the scheme's EDSCP. An application for an Archaeological Authority from HNZPT will be prepared and submitted prior to commencing site development, and earthworks will be carried out subject to an Accidental Discovery protocol to be agreed with HNZPT and Ōnuku Rūnanga as part of the Archaeological Authority.

Adopting the recommendations described in the Archaeological Assessment report, the adverse effects on the heritage and archaeological values of the Robinsons Bay Valley Irrigation site will be minimal as summarised in Table 10-3:

Table 10-3: Summary of Potential Effects on Archaeological and Heritage Values

Site	Value	Assessed Value	Potential effect of the ATWIS with mitigation
Robinsons Bay coastal flat (N36/105)	Archaeological	Low to moderate	Negligible
	Heritage	Low	Negligible
Robinsons Bay Valley site (N36/260)	Archaeological	High	Minor
	Heritage	High	Minor

10.13.2 Pipeline Routes

The pipeline to Robinsons Bay Valley will be installed primarily within the shoulder of SH75, land which has already been disturbed in building the state highway and is well separated from the identified values. The potential for adverse effects on the values of the midden site is negligible. There is potential for trenching for the pipeline to disturb buried archaeological remains, however the works will be carried out according to an accidental discovery protocol which will enable any values to be recorded and potentially recovered if appropriate. The effects assessment in the Archaeology Assessment report assessed the adverse effects of such an event as minor.

[50] Mill Cottage – also known as Pavitt Cottage (No. 1171) and setting (No. 145); the former school master's house (No. 1173)

Excavation of the pipeline between the Terminal Pump Station and the new WWTP is also noted as containing some degree of archaeological risk, noting that although much of the pipeline route will be within formed road, there will be some areas that have not previously been disturbed, or disturbed to the depth needed for the trench. The risk to archaeological values will be managed using the proposed accidental discovery protocol, to be developed as part of the Archaeological Authority application for the scheme. Consequently, the actual and potential risk to heritage or archaeological values along the pipeline routes is considered to be minimal.

10.14 Construction Effects

Construction activities generate a range of adverse effects such as noise, traffic and dust. Construction activities are temporary, will primarily be confined to land owned by the applicant and legal roads, and the associated effects will be carefully managed through appropriate methods to mitigate their significance and extent during the construction period. All construction activities will be subject to management through methods set out in Erosion, Dust and Sediment Control Plan (EDSCP) to be required by resource consent conditions proposed by the applicant. The EDSCP will include a range of sub-management plans specific to the effects that will need to be managed. The following sections address specific construction-related effects.

10.14.1 Construction-phase Stormwater

The development of the scheme will require earthworks across multiple sites, most substantially at the Old Coach Road storage and Robinsons Bay Valley sites. Earthworks will be required to install the pipelines and place irrigation infrastructure at the Hammond Point site however those works will involve minimal disturbance. While all earthworks will require careful management during the construction-phase, the works at the Old Coach Road storage and Robinsons Bay Valley sites have the highest potential to result in adverse effects from construction-phase stormwater, primarily from:

- Mobilising soil, sediment, and construction-phase stormwater from the large-scale earthworks at these sites onto roads, across property boundaries and into surface or coastal water
- Impacting groundwater quality from exposing shallow groundwater in excavations to contaminants
- Discharging construction-related contaminants such as imported materials (e.g. gravels), machinery-related fluids (fuels, lubricants) across property boundaries or into water.

As noted in the Freshwater Ecology Report, aquatic fauna in Robinsons Bay Stream is ‘not especially tolerant’ to high levels of suspended or settled sediment, and it will therefore be necessary to effectively control and minimise discharges of construction-phase stormwater to any watercourse (permanent or ephemeral). A construction-phase Stormwater Management Plan (SMP) will be developed specific to the construction methodology and submitted to ECan prior to construction commencing. The SMP will adopt the appropriate best-practices measures set out in ECan’s Erosion and Sediment Control Toolbox, and describe how construction-phase stormwater will be managed in accordance with (but not limited to) the following principles:

- Separating clean and sediment-laden stormwater at source. This will include measures such as cut-off drains and temporary bunding to direct stormwater as needed.
- Retaining sediment-ladened stormwater on site to the extent practicable, to drain (discharge) to land as a first preference. Any discharges to streams will be limited to exceedances of land-based options and preceded by settlement measures to reduce suspended sediment levels to the extent practicable prior to discharge.
- Undertaking earthworks during dry conditions to the extent practicable and minimising the area of exposed soils at any time.
- Stabilising disturbed areas as soon as practicable, including compacting, mulching, replanting, or covering as appropriate. This includes management of stockpiled materials which should be located appropriately, covered, compacted, or otherwise managed to minimise potential mobilisation, and drainage provided for.
- Ensuring all plant and machinery used for construction is well maintained and operated to minimise hydrocarbon losses (leaks, drips), and that all refuelling is undertaken in a way that minimised the potential for hydrocarbons or mechanical fluids to enter water. Any fuel or fluids are stored appropriately, and spill kits are maintained on site at all times with appropriately trained personnel.

With the adoption of appropriate measures, the effects of construction-phase discharges on Robinsons Bay Stream are expected to be negligible to low as assessed in the Freshwater Ecology Report. There are no recorded human drinking water or stock water takes from lower Robinsons Bay Stream that could be affected by any increase in suspended sediments in the stream, and the minimal sediment expected would be readily flushed by the stream and not impact flood capacity or stream morphology. The minimal and temporary construction-phase effects would be outweighed by the substantial and long term benefits to the community of the proposed ATWIS, and the substantial positive effects associated with the scheme in respect of landscape, biodiversity and recreational benefits.

10.14.2 Stream Crossings

Placing pipelines across surface watercourses can adversely affect water quality and freshwater habitat from bank and bed disturbance, mobilisation of sediments, temporary obstruction of fish passage, and disturbance of riparian vegetation and instream habitat. Bed and bank disturbance can also cause or exacerbate erosion, particularly if not reinstated properly at the completion of works.

The pipelines from the Terminal Pump Station to the WWTP, the WWTP to Jubilee Park, and from the WWTP to the Robinsons Bay Valley irrigation site will be buried along their lengths and will cross several permanent and ephemeral streams. There is therefore potential for the construction process to result in adverse effects on those watercourses, including water quality, and riparian and aquatic habitat. None of the streams to be crossed are identified as salmon or inanga spawning sites.

Pipelines across Ōinaka / Grehan Stream and Takamātua Stream will be installed beneath the beds using trenchless methods (directional drilling or thrusting) to avoid disturbing the beds and banks, and any effects on water quality. Trenchless methods also maintain fish passage including throughout construction. The crossings will therefore have no adverse effects on either stream.

The pipeline will also cross several ephemeral streams, particularly as it nears the Robinsons Bay Valley site. The pipeline will be placed beneath the beds of these streams using trenching in summer when the streams are dry (no flow). All crossings will be completed in as short a timeframe as possible, and most likely within a single working day. Disturbed beds and banks will be stabilised and restored to their previous contours and disturbed riparian areas will be stabilised and allowed to revegetate. Only natural bed material disturbed by the trenching process will be deposited in the bed.

If surface flows are present in the ephemeral watercourses when works cannot be delayed until they are dry, the pipelines will be installed beneath the beds using trenchless methods. Where possible however, trenching will be delayed until summer when no surface flow is present.

The access track from Robinsons Bay Stream to the tank platform will cross an ephemeral stream twice. Crossings will involve placing permanent single-span bridges across the stream in each location. The works will be undertaken only when the stream contains no surface water. No materials will be placed within the bed or banks, and the hydraulic capacity of the stream will be maintained beneath the bridges to prevent them impeding flows, protect them from potential flood flows of at least 5% AEP, and to maintain the stream capacity and fish passage when water is present.

By using trenchless techniques or installing the pipelines in dry conditions, the potential adverse effects on each watercourse will be avoided or otherwise minimal.

10.14.3 Construction Noise Management

Noise will be generated by vehicles travelling to and within the ATWIS sites, earthmoving plant and machinery and wet weather storage tank and subsurface wetland construction at the Old Coach Road storage and Robinsons Bay Valley sites, and the installation of the pipelines and irrigation infrastructure. While the area around the ATWIS sites is not densely populated, the scheme is primarily located within the Banks Peninsula rural zone, and the sensitivity of the setting to noise generation will be elevated given the low ambient noise environment of rural areas. Careful consideration will therefore be given to managing the generation of noise and the effects of it on receivers.

The construction methodology will be confirmed in due course by the appointed contractor, but the applicant will require the use of appropriate construction plant (e.g. use of effective mufflers), methods and timing to minimise the potential for noise impacts on surrounding the environment. As a minimum, all construction-related noise will be required to remain within the limits set out in NZS 6803:1999 Acoustics - Construction Noise as is required by the CDP, however the applicant will require contractors to minimise noise generation to the extent practicable. The contractor’s methods to minimise noise will be set out in a Noise Management Plan (NMP) to be prepared as part of the ATWIS’ overarching EDSCP.

Construction noise can be limited by restricting the hours of operation to standard construction hours of Monday to Friday 0700 – 1900, and Saturday 0700 to 1500. No works will be undertaken on Sundays or public holidays other than where needed to address an adverse effect or in response to an emergency.

With the appropriate mitigation measures set through a NMP, noise effects associated with the construction phase can be appropriately mitigated and minor overall.

10.14.4 Construction-phase Dust and Air Quality

Earthworks and construction activities can generate dust and odours that can migrate beyond the originating site and result in adverse effects on adjacent activities, properties, roads and general air quality. Dust can be generated by vehicles moving over unconsolidated surfaces, disturbance of dry fine-particle soils such as loess, material stockpiles and construction activities. The effects of dust on nearby activities can be objectionable, offensive or unsafe and can affect the safety and wellbeing of receivers. Odour can result from the exposure of buried putrescible materials such as old landfills, or from stockpiled cleared vegetation that begins to decompose.

Off-site dust during construction of the ATWIS will be most likely during windy conditions when undertaking earthworks, moving materials or generated by construction traffic. Significant dust generated from construction at the Old Coach Road storage site could be problematic if not appropriately controlled, particularly for nearby landowners as well as traffic travelling on SH75. Similarly, dust generated from pipeline construction along SH75 could affect traffic safety if not managed. The earthworks needed to form the tank platforms and structures at the Robinsons Bay Valley site could also generate nuisance dust beyond the site boundary. Minor earthworks at the irrigation sites to form tracks, install irrigation infrastructure and undertaken mass planting could also generate nuisance dust off-site.

Dust generation can be minimised using various methods, such as limiting the area of soil exposed at any time, by compacting, covering, revegetating or dampening (watering) disturbed areas as soon as possible after disturbance, by minimising the amount and speed of traffic driving over unconsolidated surfaces, and by avoiding the stripping or placing of soil and dusty construction materials (e.g. gravel) during windy conditions as far as practicable. All areas to be disturbed and finished surfaces will be either reinstated to pre-construction condition or better or will be revegetated or surfaced in a manner that prevents the generation of dust and particulates off site.

Works that may generate dust are expected to be comparatively brief and limited to during and immediately following earthworks within the project footprint. Disturbed land will be stabilised (such as by compaction, surfacing, mulching or planting) and other dust control methods such as irrigation and water carts will be used as needed. With the application of such methods, off-site dust generation will be minimal and temporary, as will any associated adverse effects.

None of the sites include any identified landfills or other sites that could generate odour when exposed. There is also very little vegetation clearance (and therefore stockpiling) needed given the largely pastoral vegetation cover currently dominating the sites. Any vegetation that is cleared will be removed from the site in a timely manner for disposal at an appropriate location.

While the specific timing, methods and sequencing of works cannot be determined until a contractor is appointed and targeted mitigation methods are specified, the applicant will require the appointed contractor to identify comprehensive methods to manage air quality as part of the ATWIS' overarching EDSCP. A range of dust management measures are set out in ECan's '*Erosion & Sediment Control Toolbox for Canterbury*' (ESCT) which will be used to inform the measures adopted by the contractor and approved through the EDSCP. With the application of appropriate management methods, the ATWIS construction phase is not expected to result in adverse effects beyond the scheme's site boundaries that are more than minor or that result in objectionable, offensive, or dangerous conditions.

10.14.5 Construction Traffic

Transporting plant, machinery, construction materials and personnel to and from sites prior to and following works will generate additional traffic movements over the construction period. Construction-related traffic will use established public roads in all cases and is not expected to result in significant adverse effects on the network given the relatively minor additional volume expected. The works will not require large volumes of imported materials, or material to be removed and transported offsite.

The effects of construction traffic will be minimised by appropriate transport planning and traffic management, to be set out in a Traffic Management Plan (TMP). The TMP will also address traffic management and safety consistent with Waka Kotahi requirements for all works within legal road reserve, such as for placing the primary pipeline within the shoulder of the Christchurch-Akaroa Highway.

Although unlikely, any damage to roads resulting directly from transport of vehicles, goods or materials associated with the ATWIS construction will be repaired as needed, either as part of standard road maintenance or otherwise by agreement with the road controlling authority.

Site management at each construction site will include measures to minimise the migration of sediment and deleterious material onto public roads, and may include tramp rods, wheel washing or similar. Any such material that is carried onto the carriageway will be cleaned as soon as practicable to maintain traffic safety.

Construction activities resulting in vehicle traffic, dust and noise are temporary in nature, and provided they are appropriately managed the associated adverse effects can be effectively avoided, remedied or mitigated.

10.14.6 Soil Erosion and Sediment Risk

The ATWIS sites are located within areas identified on the LWRP Planning Maps as High Soil Erosion Risk (HSER) areas. The soils in HSER areas have elevated potential for instability and erodibility when disturbed, and excavations can result in discharges of highly turbid water from construction sites if not adequately controlled. Once vegetation is cleared, HSER soils become vulnerable to mobilisation, either by wind, rainfall or gravity (often facilitated by rainfall).

The proposed wet weather flow storage tank and the subsurface wetland at the Old Coach Road storage site will involve approximately 9,000 m^3 of earthworks, with approximately 6,350 m^3 of cut to form a level platform for the structures. Approximately 2,250 m^3 of the cut material will be used to form the subsurface wetland basin with the excess material either distributed and recontoured or removed from the site. While the site is comparatively level, care will be required in the construction phase to manage soil and slope stability and minimise the erosion and dust generation risks.

Earthworks on the Robinsons Bay Valley site include formation of a vehicle access track from Robinsons Bay Valley Road to the tank platform, formed to approximately 3.0 – 4.0 m wide and metalled. The remaining earthworks will mainly consist of forming the tank platform, involving approximately 50,000 m^3 (cut and fill), cut slopes battered at 2:1 up to approximately 6.0 m high, and placement of fill at a 2:1 gradient up to approximately 12 m deep. The tank platform site will be located on a comparatively low gradient spur, however careful erosion and sediment control measures will be required at this site given the broader topography.

No earthworks are proposed at the Hammond Point site beyond those associated with installing the infrastructure for the surface drip irrigation network so the potential for soil erosion is minimal.

All three sites will also be extensively planted in indigenous vegetation, although the extent of soil disturbance from planting activities will be comparatively minimal, with the highest soil erosion risk associated with the proposed bulk earthworks.

The basis for effective soil erosion and sediment control follows four fundamental principles as detailed in the ECan ESCTB:

- Control of run-on water
- Separation of 'clean' from 'dirty' water
- Protection of the land surface from erosion (e.g. by wind and rain); and
- Prevention of sediment migration from the site.

Measures to minimise and control sediment migration during and immediately following works will involve but not be limited to:

- Minimising the area of land to disturbed at any one time
- Minimising the length of time that the disturbed land is left exposed or otherwise stabilised
- Excavating land during fine weather (where possible) and protecting exposed areas from rainfall (e.g. by mulching, covering, revegetating, or reinstating surfaces)
- Minimising stockpiling on site and removing stockpiles of construction materials as soon as practicable at following the completion of works.

The time between stripping vegetation and stabilising exposed surfaces will be minimised to limit the duration that soils are exposed to wind and rain. No earthworks will occur during heavy rainfall, and stormwater runoff from construction sites will be intercepted and contained by purpose-designed erosion and sediment controls to minimise the potential for sediment or sediment-laden stormwater to leave the site. Earthworks will be staged across each site as necessary to appropriately manage erosion and sediment risks.

Based on the construction methodology and mitigation measures proposed, the potential adverse effects on slope stability, and from soil erosion and sediment risks will be minimal.

10.15 Natural Hazards

The scheme is proposed for the coastal environment and volcanic landscape of Akaroa Harbour and will consequently be exposed to a range of potential natural hazards. An assessment of the scheme's exposure to natural hazard risk in the Geotechnical Investigation Report considered the location, topography and site characteristics of the Old Coach Road storage site and both irrigation sites (Appendix Q).

The main potential natural hazard risks relate to slope stability, with parts of the scheme also exposed to potential seismic risk, flooding and inundation and coastal processes such as erosion, storm surge and sea level rise. The natural hazard risks to the scheme were assessed in respect of:

- Geology, geomorphology, hydrology and likely hydrogeology (site walkover)
- Potential soil erosion
- Site seismicity
- Potential for flooding and flooding-related soil erosion
- Potential for natural fires to start or spread because of reforestation.

These hazards are described in the following sections. The assessments conclude that, subject to confirmation of field conditions following detailed design, adoption of the recommendations in the Geotechnical Investigation Report, and appropriate operation of the scheme, no present natural hazard risks are likely to be exacerbated or scheme infrastructure unduly exposed to natural hazard risks.

10.15.1 Geological Risk

The geology of the sites is set out in the Geotechnical Investigation Report attached as Appendix Q to this document. Site investigations confirmed the mapped geology and that loess soils are present across the scheme. Several areas of historic instability were identified **(Figure 10-2):**

- Figure 10-2Along the coastline and the southeast boundary of Hammond Point; and
- At the southern end of the Old Coach Road storage site.

Figure 10-2: Robinsons Bay Valley irrigation site, showing areas of potential instability

Structures and significant earthworks at the WWTP and Robinsons Bay Valley sites will avoid identified areas of historic and potential slope instability so no significant additional loads will be imposed on those areas. Construction-phase and operational stormwater and irrigation application rates will also avoid these areas or upslope areas nearby. The stability of the WWTP / Old Coach Road site and the Robinsons Bay Valley irrigation site will therefore not be compromised by either the development of the land, or the irrigation activity.

No structures or significant earthworks are proposed for the Hammond Point Irrigation site or Jubilee Park, and they are not subject to identified geological instability risk.

No irrigation is proposed for the Hammond Point irrigation site on land that is close to the coastal cliffs or areas of identified historic instability to the west and south site boundaries. Irrigation to the Hammond Point and Robinsons Bay Valley irrigation sites will be carefully managed to avoid ponding, runoff or exacerbation of tunnel gullying (Hammond Point) and will be actively monitored. Extensive planting proposed for the irrigable areas and surrounding land will help to maintain stability by uptake of applied wastewater as well as through root binding by planted vegetation. The potential for slope instability on these sites resulting from construction or irrigation will therefore be minimal.

10.15.2 Seismic Risk

Significant infrastructure development can be at risk from potential seismic events and can present other risks to the community and the environment if damaged as a result of seismic events.

The seismicity of the Robinsons Bay Valley and Old Coach Road sites (as steep sites holding significant scheme infrastructure) is set out in the Geotechnical Investigation Report in respect of potential earthquake shaking and ground rupture. The level of shaking that the sites could be exposed to, expressed as a peak ground acceleration at different probabilities is provided by NZS1170, the New Zealand Loadings Code. This code includes the learnings from the Canterbury Earthquake Sequence and is to be used for the design of structures such as the WWTP and storage tanks.

While faults are known to be present beneath Banks Peninsula following data gathered during the Canterbury Earthquake Sequence, there are no known areas where rupture of a fault would disturb the ground surface or present an elevated risk to any part of the scheme’s infrastructure.

10.15.3 Flooding and Erosion Risk

The main infrastructure at potential risk on the Robinsons Bay Valley site are the storage tanks, located along the ridge of a low spur with natural drainage channels to the east and west. There are no water bodies near the tanks that would be considered to present an erosion or flooding risk to the tanks given their location midway up the slope. All other scheme infrastructure on this site will be set well back from any ephemeral or permanent watercourse and typically elevated above anticipated flood lines.

Construction of the storage tank platforms and access track will expose fresh loess that will be erodible during rainfall events and this will need to be managed appropriately for stability and to minimise erosion risk during the construction phase. All exposed areas will be stabilized as soon as practicable using an appropriate method for the site and circumstances.

There are no watercourses at or near the Hammond Point irrigation site that would present a flood or fluvial erosion risk. Jubilee Park is also not subject to high flood or erosion risk despite the proximity of Ōinaka / Grehan Stream's north and south branches given the nature of the catchments and the channelization of the streams in their lower reaches.

10.15.4 Fire Risk

Planting substantial areas of indigenous vegetation across the scheme could provide potential fuel for fires, whether triggered by natural processes such as lightning strikes, or other ignition sources. Significant fire damage to the vegetation in the irrigation areas could substantially impact scheme infrastructure and functionality.

The fire risk associated with vegetating the irrigation sites will be consistent with other indigenous forest areas (whether natural or planted). The irrigated areas are expected to retain higher moisture levels in soils and plants when compared to other Banks Peninsula forested areas in late summer, helping to reduce the potential availability of dry vegetation (fuel) on these sites, or the rate and extent of spread and potential broad scale infrastructure damage if fire takes hold. The concept designs of both irrigation sites also include firebreaks as shown on the concept landscape plans in Appendix C.

Treated wastewater flowing from the WWTP or stored in the Robinsons Bay storage tanks or subsurface wetland can also provide firefighting supply if needed.

The potential for adverse environmental effects to result from a fire event will depend on the extent of any infrastructure damage more than vegetation losses and is a risk that will be actively managed and addressed through the operator's management plan. If significant fire damage occurs to one of the irrigation sites, the remainder of the scheme will be available to receive treated wastewater. The capacity to uptake applied water and contaminants would likely be reduced while repairs were made to infrastructure and vegetation cover was re-established, however the scheme does not rely on irrigating to specifically forest cover and irrigating to land covered in grass will still be effective. Overall, despite the increase in potential fire fuel resulting from the vegetated irrigation areas, the proposal will not present a particular or elevated fire risk.

10.15.5 Coastal Processes

Coastal processes, particularly in response to changes in sea level can adversely affect the resilience and operation of community infrastructure. Interruption to or damage of such infrastructure can significantly affect communities, including the economic effects of protection, repair and maintenance over time. Hammond Point is the only ATWIS site potentially exposed to risk from coastal processes.

The Geotechnical Investigation Report identified potential for slope instability across the coastal cliffs along the northern and western boundaries of the Hammond Point site. The assessment also noted historic landslides and slope instability in the southwest and southeast parts of the site.

The irrigation area at the Hammond Point site is elevated 40 m – 70 m above current mean annual sea level and is well east (landward) of the coastal cliffs. The area to be irrigated also avoids the previous slips and instabilities.

The Hammond Point site and any related infrastructure is not exposed to elevated risk from coastal processes, and careful management of application rates coupled with extensive planting will appropriately address the slope stability risk present.

10.16 Climate Change Effects

Section 7(i) requires decision makers to have particular regard to the effects of climate change when making decisions regarding the use, development and protection of natural and physical resources. As of 30 November 2022, following amendments to the RMA[51] decision makers are also required to have regard to the effects of activities on climate change in a broader sense than was previously provided for under S104E – *Applications relating to discharge of greenhouse gases*.

[51] Resource Management Amendment Act 2020

The effects of climate change on the ATWIS and of the scheme on climate change are addressed in the following sections.

10.16.1 Effects of Climate Change on the ATWIS

The anticipated and modelled effects of future climate change may alter the magnitude of natural hazard events to which the sites are exposed. In general terms it is expected that the Banks Peninsula climate will be warmer with more frequent extreme rainfall events. An estimate of climate change effects in Canterbury is provided in the NIWA report *Climate change projections for the Canterbury Region* dated February 2020.

Projections show that rainfall extremes are more likely, with more high intensity rainfall events, as well as longer periods of drought. Depending on the climate change scenario and timeframe the projections vary from small increases to small decreases in annual rainfall within a range of +/- 10% (Figure 10-3).

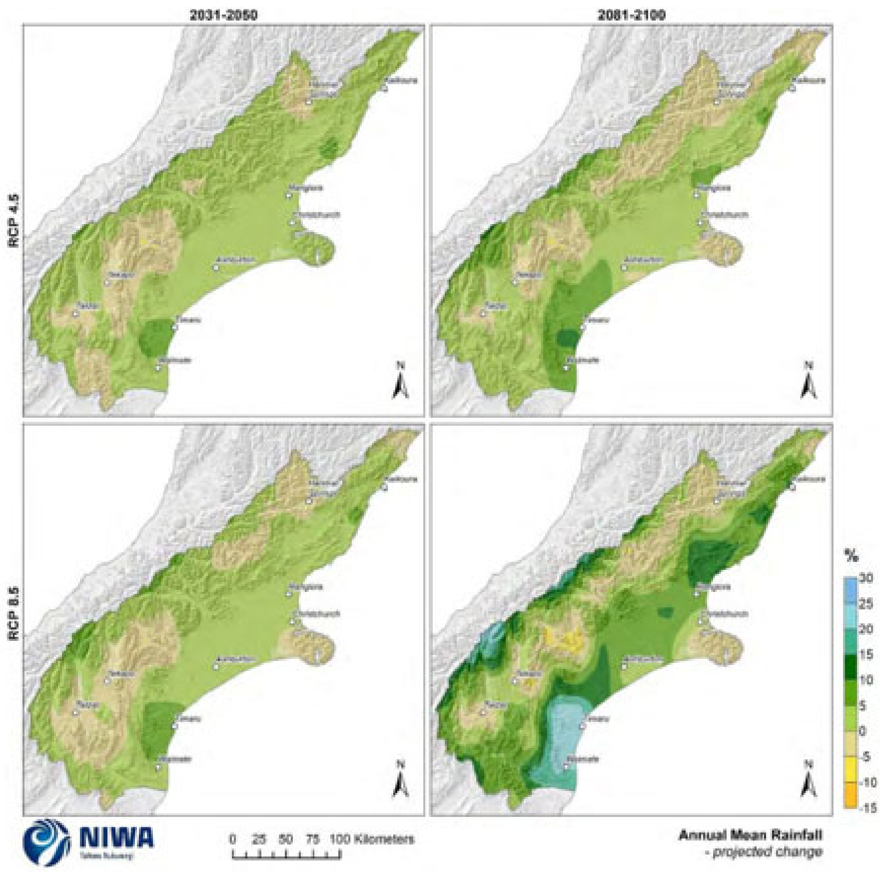

Figure 10-3: Projected changes in mean annual rainfall

Figure 10-3 shows the projected annual mean rainfall changes forecast using NIWA's Regional Climate Model for 2040 – 2050, under the RCP4.5 (top panels) and RCP8.5 (lower panels) climate change scenarios. The panels on the left are for 2031 – 2050, and the panels on the right are for 2081 – 2100. Source: *Climate change projections for the Canterbury Region*; NIWA, February 2020.

Increased drought is not of concern for this scheme as it will generally reduce treatment flows and increase the ability to irrigate to the receiving sites. High intensity rainfall is also unlikely to significantly increase the water balance of the scheme as flows from Akaroa to the scheme are limited to the treatment plant and therefore the Robinsons Bay storage tanks and the irrigation sites, rather than the intensity of rainfall. Higher intensity rainfall on the Robinsons Bay site could lead to instability of the loess soils on steep slopes, however planting trees and removing stock from the site will reduce the potential for instability relative to the current land use at the site in high intensity rainfall events i.e. the proposal would not increase the current or future natural hazard risk from slope stability at the site as it relates to high intensity rainfall events.

The combined impact of temperature and rainfall changes on the ability of the receiving environment of each irrigation site to assimilate treated wastewater can be measured via changes in Potential Evapotranspiration Deficit (PED). This variable measures the difference between the available water in topsoil and that which can be used by plants. As PED increases it indicates that there is additional capacity for water to be applied to the soil to promote optimum plant growth.

As evident in Figure 10-4, changes in PED within the scheme area are forecast to be positive i.e. the soil will demand more applied water to promote optimum plant growth. This has the effect of allowing more treated wastewater to be irrigated to the soil to overcome the PED deficit and will reduce the storage required to balance inflows from the WWTP and outflows to irrigation. By designing the scheme storage volume for current climate conditions, a conservative solution for future climate conditions has resulted.

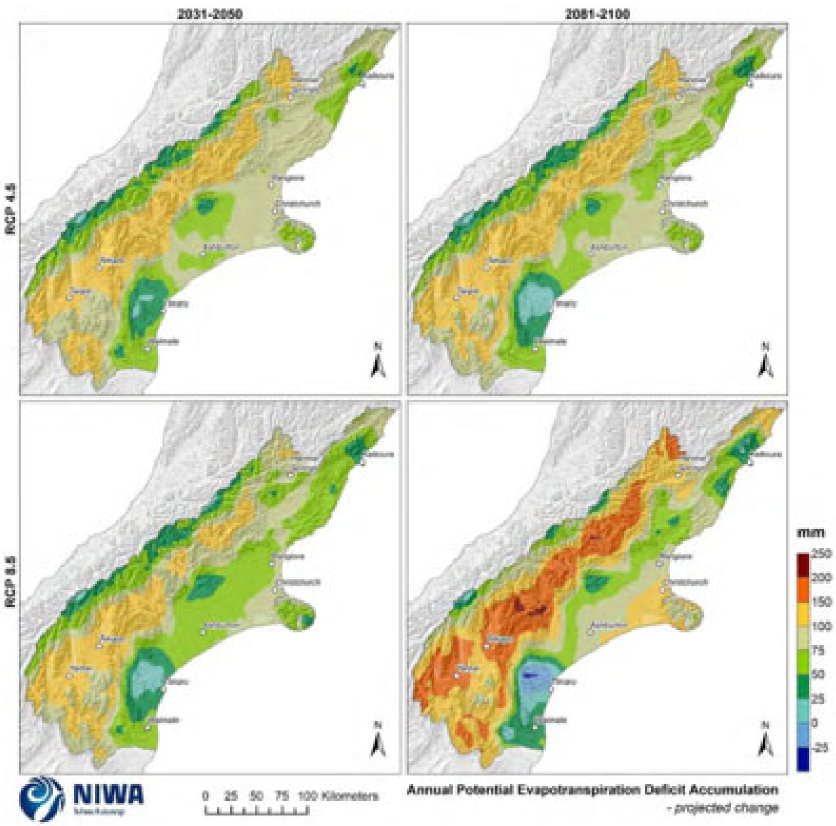

Figure 10-4: Predicted changes in PED under climate change scenarios

The ability of the ATWIS to accommodate high intensity rainfall events was also modelled[52] (Appendix U) to determine the sensitivity of the scheme to anticipated climate change effects. The effect on rainfall across the Akaroa wastewater network and the proposed irrigation areas was expected to be similar to current conditions or increase by up to 5% depending on the RCP4.5 climate change scenario, where the intensity of rainfall events is expected to increase but the duration and frequency will decrease. The modelling found that the projected changes are not expected to significantly affect the operation of the scheme if the proposed treated wastewater storage capacity is provided. With adequate storage capacity, the scheme will be able to accommodate the anticipated high rainfall events and avoid the need for secondary discharge pathways from the scheme (e.g. to the harbour). Furthermore, when the anticipated evapotranspiration and soils moisture deficits are taken into account, projections indicate that climate change will actually increase the capacity in the irrigation areas to receive the forecast volumes of treated wastewater.

The anticipated and modelled effects of climate change have been taken into account in designing the scheme, including the irrigable land required, the amount of storage needed, and the ability of the receiving environment to assimilate the applied irrigation. Consequently, climate change effects are anticipated to have minimal adverse effect on the resilience and operation of the scheme, or the resulting environmental effects on the receiving environment.

10.16.2 Effects of the ATWIS on Climate Change

Specific assessment of greenhouse gas (GHG) emissions from the ATWIS over the consent term sought has not been undertaken, however an initial high level assessment of the impact of the Inner Bays Irrigation scheme including in

[52] *Akaroa Recycled Water Scheme - Irrigation Model Results for Recycled Water Disposal at Robinsons Bay with Supplementary Wetland*, PDP, 27 January 2022. (Appendix U)

comparison to the existing WWTP and harbour outfall was undertaken by Beca[53] in 2020. That assessment considered emissions generated in building the Inner Bays scheme (capital emissions) as well as operating it (operational emissions).

The Beca assessment was made for comparative purposes as an initial step and does not constitute a full carbon impact assessment. While the assessment took into account capital (materials, construction and transport) and operational emissions it did not include the more complex aspects of such assessments.

The assessment considered carbon sequestration based on information provided by the Ministry for Primary Industries which assumes sequestration in native trees up to 50 years of growth when trees reach maturity and uptake reduces. The consent term sought is less than 50 years, so the assumption is that sequestered carbon will remain in the trees beyond the term of any consent granted, provided they remain unharvested.

The assessment found that over the conceptual 35 year term of the Inner Bays Irrigation scheme, discharging treated wastewater to indigenous vegetation would result in approximately 8,900 tonnes of captured (stored) carbon. In contrast, the alternative harbour outfall proposed at the time (a new mid-harbour outfall via Childrens Bay) would result in approximately 1,300 tonnes of carbon *emitted* to the atmosphere. Of the four scheme alternatives considered in the Beca report, the Inner Bays Irrigation scheme was found to achieve carbon neutrality at approximately the 10 year mark and was the most significant net carbon sink out of the schemes that were assessed. The Inner Bays Irrigation scheme was assessed as having an overall positive impact towards achieving New Zealand's Net Zero 2050 target.

The ATWIS has a smaller footprint than the original Inner Bays Irrigation scheme (i.e. it does not include the proposed Takamātua irrigation site). It also includes more extensive planting and retiring of farmland at the Robinsons Bay Valley site than planned under the Inner Bays scheme, although will provide a similar area of planting within the irrigation and riparian areas in the lower slopes. Consequently the emissions from the ATWIS are assumed to be similar to, or potentially less than those assessed for the Inner Bays scheme, resulting in an overall positive effect on climate change given the capacity to sequester GHG emissions. A comprehensive assessment would be required to confirm the extent of any emissions and sequestration and the extent of any positive effect on climate change.

10.17 Effects Assessment Summary

The assessment of the effects above shows that the construction and operation of the proposed scheme will generally result in effects ranging from positive to moderate, with most adverse effects considered minor following mitigation. No significant adverse effects were identified, provided that appropriate mitigation and remediation of effects is adopted, and the scheme is operated appropriately.

11 Effects Management

A range of monitoring requirements and mitigation measures are proposed to enable the identified environmental effects to be appropriately managed. The measures proposed are reflected in the effects assessment reports appended to this document. The following sections provide an overview of the monitoring and mitigation measures proposed.

11.1 Construction Effects Management

11.1.1 Construction Environmental Management Plan

All construction will be undertaken in accordance with a Construction Environmental Management Plan (CEMP) incorporating a comprehensive EDSCP to manage the construction effects of building this scheme. Construction activities will be managed to minimise disruption to the community, avoid or minimise adverse effects on receiving environments, and meet the project milestones required under resource consent CR204086[54].

The CEMP will include a range of project-specific information and management methods to address environmental effects, and will include but not be limited to:

- A description of proposed works and activities
- The location and extent of all works, and a high level programme and construction sequence

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[53] *Akaroa Wastewater Summary of Land Disposal and Reuse Investigations*, CH2M Beca Limited, July 2020
[54] CRC204086 – *To discharge contaminants to water* from the existing Akaroa Wastewater Treatment Plant at Takapūneke.

- Contact details for key staff, their roles and a communication protocol between the consent holder, contractors, affected parties and the public;
- A description of the sub-management plans to be included such as for noise, construction-phase stormwater, erosion, dust and sediment, hazardous substance storage and spill management and construction traffic management, along with monitoring procedures and protocols.

The CEMP will be provided to both consent authorities for review prior to commencing works. Specific matters to be addressed will include the following:

- Earthworks and High Soil Erosion Risk Management

The potential effects of earthworks in High Soil Erosion Risk (HSER) areas will be managed through measures to be specifically developed for the ATWIS construction phase and reflected in a project-specific Erosion, Dust and Sediment Control Plan (EDSCP).

The EDSCP will draw on best practice measures for disturbing loess soils, and as set out in ECan's Erosion and Sediment Control Toolbox (ESCTB) and will be provided to the consent authorities prior to commencing works. Where the effects of earthworks in the HSER areas are managed consistent with the measures described in ECan's ESCTB, adverse effects on soil stability, soil erosion, dust, surface water quality and sediment migration will be controlled and minimised to the extent practicable. All measures will be installed before construction commences, maintained to be effective throughout construction, and removed only once disturbed areas are appropriately stabilised.

Earthworks will be planned, sequenced and undertaken to minimise the extent of ground disturbance and vegetation removal, and the visual effect of the works to the extent practicable.

Pipeline crossings of waterways will either use trenchless methods or be undertaken only when no water is present and the bed and banks are dry. Works within the bed and banks of waterways will be completed in as short a timeframe as practicable, and all disturbed areas appropriately reinstated to minimise sediment mobilization when the waterway next contains flowing water.

Tracks (temporary or permanent) will be formed in a manner that minimises the extent of necessary earthworks and follow an alignment that makes best use of land contours and established vegetation to minimise visual prominence.

Construction-phase stormwater will be retained on site and discharged to land as a first preference. Where soakage to land is not feasible, construction-phase stormwater discharges to waterways are to be minimised to the extent practicable and limited to 50 g/m^3 or meeting the LWRP Schedule 5 visual clarity standards to the extent practicable.

- Construction Plant and Machinery

Construction plant and machinery is to be weed-free when transported to construction sites and is to be appropriately maintained to minimise the potential for loss of fuels, lubricants or hydraulic fluids.

No refuelling, repairs or maintenance is to occur in a location where uncontrolled spills of fuel or fluids may enter a watercourse or waterbody.

Plant and machinery will avoid operating in any watercourse and will cross watercourses where water is present using a structure that prevents contact with the water.

All fuel, lubricants and hydraulic fluids on site are to be stored in an appropriately secure container in an impervious or bunded area suitable to contain the volume of fluids stored in the event of a spill. Adequate spill kits will be retained on site whenever plant, machinery and fuel are present, and staff trained in their use.

- Archaeology and Heritage Management

The archaeological assessment report also notes the potential for items or sites of heritage or archaeological value to be encountered during works to place the scheme pipelines, and recommends an Archaeological Authority is sought in respect of the works proposed in the lower Robinsons Bay Valley and the pipeline routes. The assessment also recommends an Archaeological Site Management Plan be prepared to apply to archaeological work undertaken under the Archaeological Authority, including protocols for safeguarding existing values and the accidental discovery of items or sites of value. The applicant accepts the recommendations in the assessment report and will seek an archaeological authority separately.

11.1.2 Landscape, Wetlands and Terrestrial Ecology

No earthworks or building activities will occur within any natural wetland as identified in the Terrestrial Ecology Assessment Report, or on site during the construction phase. Wetland plants may be supplemented by planting of native wetland species as appropriate to support and enhance wetland viability, in line with the recommendations in the Terrestrial Ecology Assessment report.

Vegetation, including in the irrigable areas, riparian areas, and for screening purposes will be established as early as practicable according to the construction programme and maintained in a healthy and viable state. Where practicable and appropriate, existing established vegetation will be retained to retain the existing values associated with it.

Structures such as the Robinsons Bay Valley storage tanks and associated infrastructure will be finished in recessive colours and use materials with low reflectivity values (no more than 40% LRV).

The recommendations set out in the Terrestrial Ecology Assessment and Landscape and Visual Assessment Reports will be adopted as relates to the establishment, facilitation and ongoing management of plants and land management.

11.2 Operational Effects Management

11.2.1 Treated Wastewater Quality

The operation of the WWTP will require close monitoring of the treatment process by the WWTP operator and consent holder so that it is run in an optimal manner that provides a consistently high standard of treated wastewater. The volume and quality of treated wastewater leaving the WWTP will be monitored to achieve the output parameters set out in Table 4-1.

11.2.2 Irrigation Scheme Design and Operation

Irrigation of treated wastewater to land will be managed to enable effective soakage of applied wastewater to land, and to avoid to the extent practicable or otherwise minimise the extent or duration of surface ponding and overland flow. All irrigation will be set back at least 20 m from watercourses (including ephemeral watercourses).

The operation of the scheme is fundamental to managing the effects, specifically the rate, method, area, and volume of irrigation. Section 8.2.8 of the Aqualinc report describes the concept.

Trees are to be planted across the Robinsons Bay and Hammond Point sites in rows approximately 2.0 m apart at approximately 1.2 m centres or as otherwise appropriate to achieve the requirements of the scheme such as appropriate planting density and canopy closure. Planting will occur as far in advance of commissioning as practicable so that plants are established before irrigation commences. Irrigation with freshwater may be necessary in the initial stages to support successful establishment.

Up to four irrigation drip lines will be laid equally spaced between each tree row, with drippers at 30 – 50 cm centres, depending on the final design. Conceptually, treated wastewater would be applied at a drip rate of up to 2 L/hr, delivering approximately 8,400 m^3/ha/y at a mean daily depth of 2.3 mm/d. Careful management of the application rates is a fundamental part of minimising the effects of the scheme, and rates will be adjusted as necessary to optimise soakage and avoid surface ponding or runoff. The soakage rates are also expected to change over time as groundcover changes from pasture-dominated vegetation to closed canopy, eventually forming a leaf litter layer beneath established trees. Further adjustments to irrigation rates and / or the dosing regime may be necessary as the character of the irrigable land evolves, and this flexibility to respond to environmental changes and adapt the scheme in response to monitoring outcomes is central to the applicant's effects management approach.

The irrigation concept recommends pulsing irrigation, allowing short (e.g. 23 minute) run times per zone, followed by an equal rest period, then a repeat run time, followed by a longer rest period. Doing so will maximise the time that applied water and nutrients are held in the root zones for uptake and provide a ready means of controlling application to mitigate against potential for surface ponding or runoff.

Jubilee Park will be irrigated using sub-surface drip irrigation methods with drip lines conceptually placed at approximately 40 cm centres and 20 cm deep. Under the proposed deficit irrigation approach, a mean of 297 mm of irrigation would be applied per year requiring 18 hours of operation annually with a dripper flow rate of 2 l/h, or 36 hours at 1 l/h. This approach will minimise the opportunity for drainage below the root zone, while maintaining healthy grass cover, and will minimise (or eliminate) measurable effects on Ōinaka / Grehan Stream or Childrens Bay in Akaroa Harbour.

11.3 Proposed Monitoring

The successful operation of the ATWIS and management of its effects will involve monitoring the construction and operational phases of the project. The applicant proposes the following monitoring:

Construction Phase:

- The effectiveness and integrity of erosion, stormwater and sediment control measures to be monitored daily, and particularly following rainfall events. The measures will be assessed and adjusted if necessary.

Wastewater Quality:

- Monitoring and annual reporting of the quality of treated wastewater leaving the treatment plant to irrigation will be critical for minimising adverse effects in the receiving environment. Close monitoring of the treatment process and of the quality of treated wastewater will be undertaken, including for:
  - *E. coli*
  - Total Nitrogen
  - BOD5
  - Dissolved Reactive Phosphorus
  - Ammonia Nitrogen
  - Lead
  - Copper
  - Chromium
  - Cadmium
  - Zinc
  - Sodium

Irrigation

- Close monitoring of application rates and soil moisture (saturation) levels will be undertaken, including visual monitoring for any ponding or surface flows, and for other indicators such as seepage from Hammond Point coastal cliffs.
- Assessment of indigenous vegetation establishment and growth, plant mortality, canopy closure, density, regeneration and pest damage will be undertaken also, as a critical component of the scheme.

Freshwater Quality

- Surface water quality monitoring sites on Robinsons Bay Stream, including one near Sawmill Road downstream of the irrigation area, and one upstream of the irrigation area as a control site will be established. Water quality samples will be collected regularly from each site, and analysed for specified contaminants as set out in the proposed conditions in Appendix X. Any contaminants from the scheme that enter the stream will be evident in the proposed water quality monitoring which will provide an accurate indication of the effectiveness of the treatment and irrigation process and indicate if any necessary changes to the scheme may be required.

- Ecological monitoring (macrophyte and periphyton biomass assessments) will be undertaken in accordance with the methods set out in the NPS-FM 2020. Periphyton biomass, QMCI, MCI and ASPM will be calculated and compared to the NPSFM 2020 attribute bands and the LWRP targets for Banks Peninsula. The outcome of these assessments will further indicate whether process changes may be required.

Groundwater

- Groundwater depth and quality will be monitored beneath and near to the irrigation sites. The parameters are set out in the proposed conditions in Appendix X.

Harbour Water Quality

- Monthly monitoring of harbour water quality is proposed for three locations, including in Robinsons Bay and to the south of Hammond Point.

Soil Quality

- Periodic sampling of soils from within the irrigation zones and testing for accumulated contaminants, as specified in the conditions in Appendix X to monitor for sodium blocking and contaminant accumulation. Baseline soil monitoring will be undertaken before irrigation starts, with biennial and four-yearly monitoring to be undertaken.

All monitoring results will be reported to the consent authorities annually or as otherwise required by consent conditions.

11.4 Scheme Management

If monitoring indicates an environmental effect that requires intervention to avoid, remedy or mitigate it, a range of options are available to the consent holder in response. These may include but are not limited to:

- Further reducing inflows into the WWTP by reducing I&I into the wastewater network
- Introducing additional treatment steps to the WWTP process
- Extending the area of land irrigated on the Robinsons Bay Valley site to include the ‘less suitable’ land identified in site mapping
- Extending the area of land irrigated by purchasing additional land in the inner harbour area

- Adjusting the irrigation regime to, for example change the irrigation application rate, alter the scheme configuration, or change the dose / rest / dose pattern, duration or frequency.

The appropriate response will depend on the effect that requires management, and the outcome will be closely monitored to provide feedback on its effectiveness and enable further adjustments to be made if necessary.

11.5 Proposed Conditions

The applicant has proposed a suite of consent conditions to address the anticipated and potential effects of the project. The proposed conditions are set out in **Appendix X** to this document.

The proposed conditions align with conditions on consents for similar activities previously issued by ECan and CCC. This approach means the conditions will require mitigation measures and monitoring methods that have been effective in managing adverse effects for similar activities. For example, the conditions proposed for earthworks in high soil erosion risk areas over the construction phase require the consent holder to apply erosion, sediment and dust control measures to manage construction-related risks. The conditions proposed for managing construction-phase stormwater discharges require proven methods from ECan's 'Erosion and Sediment Control Toolbox' to be applied, to minimise the adverse effects of stormwater discharges with elevated levels of suspended solids, and to monitor the effects of discharges on Robinsons Bay Stream.

The proposed conditions include requirements to monitor the receiving soils, groundwater, surface water (Robinsons Bay Stream) and coastal water (in Robinsons Bay and south of Hammond Point) environments prior to irrigation commencing to establish baseline conditions. Monitoring following commissioning of the scheme would then be able to compare pre- and post-irrigation results so the effects of the activity including trends can be determined. The conditions have been developed from recommendations in the technical reports informing the effects assessment and are in line with the anticipated effects of the scheme.

Groundwater monitoring is required for specified parameters to understand how irrigation will affect groundwater and any groundwater users. Monitoring of the quality of Robinsons Bay Stream concentrates on chemical parameters and ecological indicators in line with the LWRP requirements. Monitoring the stream quality will indicate any resulting changes attributable to the activity, and whether adjustments are needed to the scheme to address any adverse effects. Coastal water quality monitoring in Robinsons Bay is proposed, however it is expected that the effect of the scheme on coastal water will be very difficult to discern from background quality, so coastal ecological monitoring is not proposed. Soil monitoring across the irrigation sites is proposed to identify if sodium blocking unexpectedly develops, or contaminants such as heavy metals accumulate over time.

The results of all monitoring will inform the consent holder and consent authority as to the effects of the scheme, and whether adjustments are needed to further minimise any adverse receiving environment effects.

12 Legislative Framework

12.1 Resource Management Act

12.1.1 Section 5

Section 104 RMA directs decision makers to have regard to a range of matters subject to Part 2 of the statute. Part 2 contains section 5 setting out the purpose and principles of the RMA, which fundamentally are to promote the sustainable management of natural and physical resources. Sustainable management is defined by the RMA as:

> *" … managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while—*
>
> *a. sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *b. safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *c. avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

Part 2 contains section 6 – *Matters of National Importance* which decision makers must recognise and provide for. Further matters which decision makers must have particular regard to are set out in Section 7 – *Other Matters*. Section 8 – *Treaty of Waitangi* requires decision makers to take into account the Treaty principles.

The provisions of Part 2 have been taken into account and are reflected in the national and regional planning documents relevant to this application. Further detailed analysis of the proposed activity under the specific provisions of Part 2 is therefore not necessary[55] however for completeness they have been addressed at a general level below. An assessment of the policy provisions of the relevant statutory plans is contained in Appendix W of this document. The assessment along with the analysis of the effects of the activity shows that the proposal will generally achieve the sustainable management purpose of the RMA, as framed in Part 2. Consideration of the specific matters in Part 2 (Sections 6 – 8) and other relevant parts of the RMA is set out in the following sections.

12.1.2 Section 6

The scheme recognises and provides for the relevant Section 6 matters.

As determined in the effects assessment in Section 10 of this document, the scheme will preserve, and contribute to restoring the natural character (s6(a)) of the coastal environment as affected by historic land clearance. The natural character of Robinsons Bay Stream will similarly be preserved, and potentially enhanced. The proposal does not constitute the inappropriate use or development of those features.

No significant indigenous vegetation or habitats of indigenous fauna (s6(c)) will be affected by the scheme which is proposed for land primarily in exotic pasture. The extensive planting of indigenous vegetation proposed will provide significantly more habitat for indigenous flora and fauna, particularly as the vegetation matures, resulting in a significant net gain in such habitat.

By providing opportunities for the public to access the irrigation sites, both of which were previously in private ownership, the scheme will enhance public access to and along the coastal marine area (Hammond Point), and Robinsons Bay Stream (s6(d)).

A key driver for the scheme is to acknowledge and provide for the relationship of Māori and their culture and traditions with ancestral waters (s6(e)), particularly as associated with harbour water quality and the status of Akaroa Harbour as a Taiapure. In particular, the scheme involves replacing the current harbour discharge with the irrigation of treated wastewater to land, acknowledging that discharging human waste directly to water is culturally unacceptable and undermines the relationship of Māori with water. The selection of the irrigation sites and their development has taken into account areas, places and items of cultural significance including waahi tapu and other taonga, in close consultation with representatives of Ōnuku Rūnanga.

The heritage values present within the project area, particularly in the Robinsons Bay Valley have been extensively investigated and identified, and measures are proposed to safeguard them as part of the scheme design (s6(f)).

The assessment shows that the scheme is not unduly exposed to significant natural hazard risk, and mitigation of the identified risks is proposed as part of the scheme development and operation.

12.1.3 Section 7

Particular regard was had to the relevant matters of Section 7 when designing the scheme and assessing the scale and significance of its effects.

The scheme has been developed in consultation with and endorsed by representatives of Ōnuku Rūnanga and Ngāi Tahu (s7(a) and (aa)). Removing wastewater discharges from the harbour in favour of the scheme's land-based approach better enables the exercise of kaitiakitanga (guardianship) and embodies the ethic of stewardship (responsible management of resources), particularly in respect of harbour and indigenous biodiversity values.

The scheme represents the efficient use of land, water and air as natural resources (s7(b)). It provides for the irrigation of treated wastewater to land rather than the harbour and increases the indigenous vegetation and associated habitat, intrinsic and biodiversity values in the harbour basin. These values are achieved while enabling access to the irrigation sites for public recreation and enjoyment. By using treated wastewater to irrigate Jubilee Park, the scheme also enables the efficient use of treated wastewater for non-potable purposes, including by offsetting the need to use potable water to irrigate the park. The subsurface wetland is also an efficient use of land, serving as a storage facility for treated wastewater as well as enhancing biodiversity and associated intrinsic values by providing a habitat for indigenous wetland plants.

The assessment in the LVIA report concludes that amenity values (s7(c)) across the scheme sites will be enhanced, including by the extensive planting of indigenous vegetation and landscaping proposed. The planted areas will supplement existing pockets of indigenous vegetation that have survived milling and conversion to other land uses, or

[55] As consistent with the decision in *R J **Davidson** Family Trust v Marlborough District Council [2017] NZHC 52*

that have naturally re-established. Overall, by enabling the removal of wastewater discharges to the harbour, the scheme will tangibly help to enhance the quality of the environment (s7(f)) by substantially improving the standard of wastewater treatment achieved, as well as enhancing biodiversity and recreational, amenity and intrinsic values (s7(d)). Particular regard was had to the anticipated effects of climate change (s7(i)) when designing the scheme, taking into account the effects on the operation of the scheme, and its resilience to related effects (e.g. changes in rainfall and storm intensity and frequency). The scheme is resilient to the anticipated effects of climate change including less frequent but more intense rainfall events and the effects on irrigation and land stability. The scheme is not particularly exposed to coastal hazard risk with only the Hammond Point site near the CMA, noting that the irrigable area is elevated above, and inland from the current CMA boundary.

12.1.4 Section 8

The applicant has actively engaged with tangata whenua over many years through representatives of Ōnuku Rūnanga and Ngāi Tahu, leading to the development of this proposal and this application.

Removing the existing WWTP from Takapūneke and the active protection of the harbour and its associated spiritual and cultural values is a key driver for implementing the proposed irrigation scheme. The scheme is a direct result of early, meaningful and ongoing engagement with Ōnuku Rūnanga, including refinement of the land irrigation concept in the design of the scheme, and the landscaping proposed for the Old Coach Road site. The applicant's partnership approach is reflected in the design of the scheme, including being 100% land-based to remove all direct discharges to water (fresh or coastal), incorporating mahinga kai species into the indigenous plant species to be used for the scheme, and adopting the design for the boardwalk and plantings at the subsurface wetland developed by members of Ōnuku Rūnanga.

12.1.5 Section 9

Section 9 of the RMA prevents the use of land in a manner that contravenes a national environmental standard, a regional plan rule or a district plan rule unless existing use rights apply, or the use is authorised through a resource consent.

The relevant national environmental standards, regional and district plan rules have been identified in Section V of this document, and resource consent applied for where appropriate.

12.1.6 Section 13

Section 13(1) of the RMA prevents the use, disturbance, drainage or reclamation, or introduction of any plant or substance in, on, under or over the bed of any lake or river unless such activity is allowed by a national environmental standard, or a rule in a regional or district plan, or is authorised by a resource consent.

The relevant national environmental standards, regional and district plan rules have been identified in Section V of this document, and resource consent applied for where appropriate.

12.1.7 Section 15

Section 15(1)(d) of the RMA prevents the discharge of any contaminant into land from an industrial or trade premise, to land where it may enter water, or directly to water unless that discharge is allowed by a rule in a national environmental standard (NES), a rule in an operative or proposed regional plan, or is authorised by resource consent.

There are no rules in a relevant NES or regional plan that permit the proposed discharges. The rules of the LWRP and the CARP identify that wastewater discharges from community sewage schemes to land or water, and contaminants to air respectively require resource consent to be lawful.

12.1.8 Section 104

Section 104 of the RMA sets out the matters that decision makers must have regard to when considering applications for resource consent, and states:

(1) When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to–

- *(a) any actual and potential effects on the environment of allowing the activity; and*
- *(ab) any measure proposed or agreed to by the applicant for the purpose of ensuring positive effects on the environment to offset or compensate for any adverse effects on the environment that will or may result from allowing the activity; and*
- *(b) any relevant provisions of—*
  - *(i) a national environmental standard:*
  - *(ii) other regulations:*

(iii) *a national policy statement:*

(iv) *a New Zealand coastal policy statement:*

(v) *a regional policy statement or proposed regional policy statement:*

(vi) *a plan or proposed plan; and*

(c) *any other matter the consent authority considers relevant and reasonably necessary to determine the application.*

The actual and potential effects of the proposed discharges, including positive effects are described in Section 10.1 of this document.

The relevant documents set out in Section 104(1)(b) are addressed in the following sections. Those documents were prepared to give effect to Part 2 of the RMA, and therefore the lower order provisions take precedence in the decision-making process. The provisions of Part 2 provide high level guidance in the event of incomplete, conflicting or unclear plan-level provisions.

12.1.9 Section 105

Clause 6(1)(d)(ii) of the Fourth Schedule RMA directs that an application for resource consent to discharge contaminants must include a description of *"any possible alternative methods of discharge, including discharge into any other receiving environment"*. A description of alternatives is also required by s105(1)(c) RMA which requires decision makers, when determining an application for a discharge permit that contravenes section 15 or 15B of the RMA, to have regard to:

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

These matters are discussed in turn below.

- ***The nature of the discharge and the sensitivity of the receiving environment***

The nature of the scheme's discharges is described in Sections 4.2 and 5 of this document. A description of the receiving environments, an assessment of the effects of the discharges, and the receiving environments' sensitivity to those effects is made in Sections 6 and 10. The assessment found that given the volume and characteristics of the discharges, the irrigation methods and the assimilative capacity and nature of the receiving environment, the overall effects on the receiving environment will be minor at most.

- ***The applicant's reasons for the proposed discharge***

The reasons for the proposed discharges are set out in Sections 8 and 9 of this document. Primarily, the applicant seeks approval to discharge treated wastewater to land to enable the decommissioning and removal of the existing WWTP, ending treated wastewater discharges to the harbour, and to provide the community with a sustainable, culturally and environmentally appropriate means of managing wastewater. The commentary in Section 8 and 9 describes the background behind, and some of the drivers for the proposal, and the extensive consideration of alternatives which underpin the applicant's reasons for the discharge permits sought.

- ***Alternative methods of discharge***

The applicant has heavily invested in consultation, engagement, investigations and concept design for a range of alternative wastewater management options and is committed to implementing the scheme as proposed as the best option to manage Akaroa's wastewater in an appropriate and practicable manner. A comprehensive assessment of alternatives was undertaken over an extended period, as is described in more detail in Section 8 of this document.

12.1.10 Section 107

Section 107(1) of the RMA prevents the granting of applications to discharge contaminants to land or water that contravene s15 of the RMA, if after reasonable mixing the discharge would result in:

(c) *the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials:*

(d) *any conspicuous change in the colour or visual clarity:*

(e) *any emission of objectionable odour:*

(f) *the rendering of fresh water unsuitable for consumption by farm animals:*

(g) *any significant adverse effects on aquatic life.*

The assessment of the effects of wastewater irrigation on the receiving environment is set out in Section 10 of this document. It indicates that the discharge will not result in any of the effects identified in s107(1)(c) – (g) in any receiving water. Consequently, s107 does not prevent the application to discharge treated wastewater to land from being granted.

Despite the restrictions set out in s107(1), the consent authority may grant applications for resource consent for activities that result in the effects in s107(1)(c) – (g) if the exceptions provided for in s107(2) are met, being:

(a) that exceptional circumstances justify the granting of the permit; or

(b) that the discharge is of a temporary nature; or

(c) that the discharge is associated with necessary maintenance work —

and that it is consistent with the purpose of this Act to do so.

There are no applicable exceptional circumstances relevant to the proposal and the discharges will not be a result of necessary maintenance work. Neither will the discharges be temporary nor associated with maintenance. Regardless, as the effects of s107(1)(c) – (g) will not occur, the application does not rely on the exceptions provided for by s107(2).

12.2 National Planning Instruments

12.2.1 New Zealand Coastal Policy Statement

The New Zealand Coastal Policy Statement (NZCPS) sets out a policy framework to guide the use, development and protection of natural and physical resources in the coastal environment. The assessments in this document identify that the coastal marine area of the inner harbour will be one of the secondary receiving environments following the irrigation of treated wastewater to land and identify that the Hammond Point irrigation site and a minor portion of the Old Coach Road site are within the coastal environment. Consequently, the provisions of the NZCPS apply and the relevant matters are addressed in the policy assessment set out in Appendix W. The assessment identified that overall, the ATWIS will not prevent the relevant NZCPS objectives from being achieved and will be consistent with the relevant policies.

12.2.2 National Policy Statement for Freshwater Management

The National Policy Statement for Freshwater Management 2020 (NPS-FM) sets an objectives and policies to promote the sustainable management of freshwater through the concept of Te Mana o te Wai which sets a hierarchy of obligations for how people use water. The concept prioritises the health and wellbeing of waterbodies and related ecosystems, followed by the health needs of people, and then the ability of people and communities to provide for their social, cultural and economic wellbeing. The concept of Te Mana o te Wai is relevant to the management of all freshwater, including groundwater and the Robinsons Bay Stream in respect of the proposed ATWIS.

The provisions of the NPS-FM relevant to this proposal are set out and evaluated in Appendix W. Overall, the assessment finds that the ATWIS will generally achieve the objective and be consistent with the policies.

12.2.3 Proposed National Policy Statement for Indigenous Biodiversity

A National Policy Statement for Indigenous Biodiversity (NPS-IB) is being prepared by central government. The NPS-IB aims to protect, maintain and restore indigenous vegetation in a way that recognises tangata whenua as kaitiaki, and provides for the social, economic and cultural wellbeing of people and communities. An exposure draft was released for submissions in June 2022, and the development programme shows the intention to gazette the document in 2023.

At the time this application was prepared, the NPS-IB was not in its final or formal form or hold weight in decision-making processes under the RMA, however noting the substantial positive effect of the ATWIS in respect of restoring indigenous biodiversity, the scheme has been considered in the context of the exposure draft.

The substantial planting of indigenous vegetation across the three sites as proposed has been assessed as providing a significant positive benefit for indigenous biodiversity and habitat in the terrestrial ecology assessment in Appendix B. In that respect, the ATWIS will help to achieve the restoration of indigenous vegetation envisaged in the NPS-IB's sole objective. While many of the policies set out in the exposure draft are focussed on the protection of existing values, particularly in significant natural areas, the planting proposed through the scheme will be consistent with providing for the community's social, cultural and economic wellbeing (Policy 10) and the restoration of indigenous biodiversity and increase in indigenous vegetation cover as promoted by Policy 13 and 14 of the exposure draft respectively.

While the final form of the NPS-IB and its provisions was unknown at the time this application was prepared, assessment against the exposure draft provisions indicates that the ATWIS will not frustrate, and may support the outcomes sought through the NPS-IB.

12.2.4 National Environmental Standard for Sources of Human Drinking Water

The National Environmental Standard for Sources of Human Drinking Water (NES) is a regulation made under the RMA that sets requirements to protect sources of human drinking water from contamination. The NES requires regional councils to ensure that effects on drinking water sources are considered when making decisions on resource consent applications and when preparing regional plans. Specifically, councils are required to:

- Decline applications for discharge or water permits if those activities are likely to result in community drinking water becoming unsafe for human consumption following existing treatment processes;
- Be satisfied that permitted activity rules in regional plans will not result in community drinking water supplies becoming unsafe for human consumption following existing treatment processes;
- Place conditions on resource consents requiring the notification of drinking water suppliers if significant unintended events occur (e.g. contaminant spills) that may adversely affect sources of human drinking water.

Sources of drinking water include natural water bodies such as lakes, rivers or groundwater used to supply communities with drinking water. The standard applies to source water before it is treated, and only sources used to supply human drinking water i.e. not water supplied for stock or other non-consumptive uses.

There are no community water supply takes (including drinking water suppliers as defined in section 8 of the Water Services Act 2021) from, affected by or in proximity to any of the areas where treated wastewater is proposed to be irrigated.

12.3 Regional Planning Documents

12.3.1 Canterbury Regional Policy Statement

The Canterbury Regional Policy Statement (RPS) sets objectives and policies for the Canterbury region to help achieve the integrated management of natural and physical resources across all regional and district plans in the region. The assessment of the relevant provisions of the RPS are set out in Appendix W and concludes that the ATWIS is generally consistent with the direction of the objectives and policies that apply.

The assessment finds that the ATWIS generally aligns with the RPS policy framework, specifically the following key provisions:

- Objective 5.2.2 in respect of the benefits of providing infrastructure to the community that promotes sustainable management of natural and physical resources consistent with RMA principles.
- Policy 5.3.6 regarding enabling the development and use of wastewater infrastructure as long as adverse effects on significant natural and physical resources are avoided, or otherwise mitigated if not practicable, and other effects are controlled.
- Objective 7.2.1 addressing sustainable management of freshwater and Objective 7.2.4 regarding the integrated management of freshwater resources.
- Objective 8.2.6 regarding the protection and improvement of coastal water, and Policy 8.3.9 in respect of direct discharges of wastewater to water.
- Objective 9.2.1 and Policy 9.3.4 in respect of halting the decline of indigenous biodiversity.

12.3.2 Canterbury Regional Land and Water Plan

The Canterbury Land and Water Regional Plan (LWRP) sets resource management objectives, policies and rules to guide the integrated management of land and freshwater resources in Canterbury. The LWRP applies from the landward edge of the Coastal Marine Area (CMA) inland across the region.

The assessment of the relevant provisions of the LWRP is set out in Appendix W. The assessment shows that the ATWIS will achieve the objectives and is generally consistent with the policies that apply. The following provisions are key:

- Objective 3.2 in respect of the integrated management and connectedness of land and water resources.
- Objective 3.3 regarding the contribution of regionally significant infrastructure to community and environmental wellbeing.
- Objective 3.8 in relation to the quality and quantity of water and its life-supporting capacity.
- Policies 4.12 and 4.14 in respect of discharges of contaminants to land and the effect of those discharges on water and soil quality, as well as Policy 4.14B in regard to Ngāi Tahu values.
- Policy 4.39 which directs that discharges of nutrients from community wastewater schemes are minimised.

Section 10 of the LWRP provides sub-regional provisions for Banks Peninsula. None of the provisions apply to the area of the proposal and the region-wide objectives, policies and rules prevail.

12.3.3 Canterbury Air Regional Plan

The ATWIS proposal was assessed against the rules of the CARP and found to be a permitted activity. Consequently it is inherent that the proposal will help to achieve the objectives of the CARP and will be consistent with the relevant policies as relates to maintaining air quality. An assessment of the CARP policy framework was not therefore undertaken.

12.3.4 Canterbury Regional Coastal Environment Plan

The RCEP defines 'coastal environment' as *'an environment in which the coast usually is a significant part or element. The coastal environment will vary from place to place depending upon the extent to which it affects or is (directly) affected by coastal processes and the management issue concerned. It includes three distinct but interrelated parts: the Coastal Marine Area; the active coastal zone; and the land backdrop'*. Parts of the ATWIS that are within the coastal environment include the Hammond Point Irrigation site and a portion of the Old Coach Road storage site.

An assessment of the RCEP policy framework as relates to the proposed activities in, and effects on the Coastal Environment was undertaken and is set out in Appendix W. The assessment draws on the effects assessments set out in the LVIA report and the Estuary Ecology report, concluding that the development and operation of the ATWIS will support the achievement of the relevant RCEP objectives and will be consistent with the relevant policies, particularly:

- Objective 6.2 and Policy 6.2 in respect of the natural character and amenity values of Banks Peninsula's coastal environment; and
- Objective 7.1 and Policy 7.7 regarding the effects on the quality of coastal waters and related ecosystems and values.

12.4 Christchurch District Plan

The CDP sets the regulatory context for the integrated use, protection and development of land and built resources across Christchurch District. Chapter 3 sets out the CDP's strategic direction and includes high level activity specific provisions. Particularly relevant to this application are *Infrastructure* Objectives 3.3.12(a) and (c):

> *(a) The social, economic, environmental and cultural benefits of infrastructure, including strategic infrastructure, are recognised and provided for, and its safe, efficient and effective development, upgrade, maintenance and operation is enabled;*
>
> *(c) The adverse effects of infrastructure on the surrounding environment are managed, having regard to the economic benefits and technical and operational needs of infrastructure.*

In particular, the ATWIS aligns well with the following key provisions:

- Objective 8.2.4 and Policies 8.2.4.3 and 8.2.4.4 in respect of the purposes and benefits of earthworks
- Objective 9.1.2.1.2 and Policy 9.1.2.2.10 addressing the enhancement of the city's biodiversity
- Objectives 9.5.2.1.2 and 9.5.2.1.3 regarding the acknowledgement, recognition, and protection of Ngāi Tahu cultural values
- Objective 11.2.2 and Policy 11.2.2.1 in respect of appropriate management of the adverse effects of utilities
- Objective 17.2.1.1 and Policies 17.2.2.2 and 17.2.2.8 regarding activities that use rural resources, including productive land and the quality of the rural environment in Banks Peninsula.

The assessment concluded that overall the ATWIS will achieve the objectives and be consistent with the relevant policies of those chapters.

12.5 Other Documents

Section 104(1)(c) RMA directs that consideration is to be given to any other matters considered relevant and reasonably necessary to determine the application. These 'other matters' are addressed in the following sections.

12.5.1 The Mahaanui Iwi Management Plan 2013

The Mahaanui Iwi Management Plan 2013 (MIMP) provides a policy framework for the protection and enhancement of Ngāi Tahu values. The ATWIS was assessed in the context of the objectives and policies of the MIMP as set out in Appendix W to this document and summarised below. The relevant matters in the MIMP are set out in Section 5.2 *Ranginui*, Section 5.3 *Wai Māori*, Section 5.4 - *Papatūānuku*, Section 5.5 – *Tane Mahuta*, Section 5.6 – *Tangaroa*, and Section 6.8 *Akaroa Harbour*.

Section 5.2 *Ranginui* is relevant in respect of potential for discharges of dust to air during the construction phase, and of operational discharges to air.

The provisions of Section 5.3 *Wai Māori* are relevant in respect of the interaction between the ATWIS, groundwater, surface water and the coastal water of the harbour. In particular, the MIMP policies discourage the use of water as a means of managing or transporting waste, given the cultural values associated with water including as a source of food.

The provisions of Section 5.4 – *Papatūānuku* were considered given the importance of protecting the mauri of land and soil, considering the assimilative capacity of the land involved in the scheme. Issue P8 and associated policies are particularly relevant as they address discharges of contaminants to land, safeguarding the life-supporting capacity of soils, and acknowledging the cleansing abilities of Papatūānuku.

Section 5.5 – *Tane Mahuta* addresses provisions related to indigenous biodiversity, indigenous vegetation and invasive weed control. Particularly relevant are Objective 3 and Policy TM3.1 which support the enhancement and restoration of indigenous vegetation across Canterbury as a means of restoring the mauri of the land, and Ngāi Tahu's relationship to places and resources.

Section 5.6 – *Tangaroa* is particularly relevant, with Objective 3 seeking the elimination of discharges to the CMA. This objective is supported by Policies TAN2.2 and TAN2.3 requiring existing direct discharges of *inter alia* wastewater to coastal water to cease, and that no new approvals for such discharges are granted.

Section 6.8 – *Akaroa Harbour* sets objectives and policies that explicitly include eliminating contaminants from the harbour, and integrated management, development and decision making that includes Ngāi Tahu as tangata whenua.

The full assessment provided in Appendix W indicates that the ATWIS will generally help to achieve the objectives set out in the MIMP and is generally consistent with the relevant policies.

12.5.2 Te Rūnanga o Ngāi Tahu Freshwater Policy Statement

Te Rūnanga o Ngāi Tahu's Freshwater Policy Statement describes Ngāi Tahu's relationship with freshwater, how Ngāi Tahu wishes to work with other agencies in managing freshwater, and the environmental outcomes sought.

The relevant matters are assessed in Appendix W. The ATWIS generally aligns with achieving Objectives 6.2 and 6.3 and is consistent with Policy 2.

12.5.3 Heritage New Zealand Pouhere Taonga Act 2014

The archaeological and heritage assessment contained in Appendix N notes that it is an offence to damage or modify any archaeological site unless an authority to do so has been issued by HNZPT. The assessment report recommends that an authority is secured prior to commencing any works that may risk destroying, damaging or disturbing any pre-1900 sites or items, including along the pipeline route and at the Robinsons Bay Valley irrigation site.

The applicant intends to secure an Archaeological Authority based on the information in, and the recommendation of the archaeological assessment prepared for this scheme. The intention is to secure the authority prior to commencing works that will disturb land and potentially risk impacting archaeological values. In addition, the applicant will prepare and implement an Archaeological Site Management Plan (ASMP) setting out protocols for investigations, recording of items and undertaking works in the vicinity of visible archaeological items, monitoring of works where unknown features or items are more likely to be disturbed, and defining an accidental discovery protocol. The ASMP will help to avoid or minimise the effect of the proposed scheme on both known and undiscovered archaeological sites, items or values, and make sure they are appropriately recorded before any unavoidable effects occur.

12.5.4 Reserves Act 1977

When preparing applications for resource consents for the scheme in 2014, the Council requested a legal opinion in respect of the status of Jubilee Park, and the implications for the proposed development of the Terminal Pump Station and related infrastructure. The applicant was advised in 2013 that, although Jubilee Park is held in title CB45A/1127, it is legally a reserve for 'Reclamation and Public Recreation' purposes and is subject to the Reserves Act 1977.

The establishment of scheme infrastructure on land included in the Jubilee Park certificate of title may therefore require approvals under the Reserves Act 1977 as distinct from the resource consents applied for through this application.

12.6 Summary of Policy Assessment

While there are many aspects to the ATWIS and some tension between some of the relevant provisions identified in the assessment in Appendix W, overall the proposed scheme generally aligns well with the relevant objectives and policies of the applicable documents.

The scheme will help to achieve many of the relevant objectives, particularly in relation to the provision of effective and sustainable infrastructure to minimise the adverse effects of community wastewater management, the removal of direct wastewater discharges to coastal water, the restoration of indigenous vegetation and biodiversity, and safeguarding landscape and amenity values. The scheme is generally consistent with the policy frameworks in respect of providing critical infrastructure while also safeguarding the community's cultural, social and recreational wellbeing, and the quality of natural and physical resources. Overall, the ATWIS aligns well with the relevant key policy provisions.

13 Conclusion

The proposed ATWIS will enable wastewater treatment at Takapūneke to cease and the historically and culturally significant site to be restored. It will also bring an end to discharges of Akaroa's treated wastewater to Akaroa Harbour while also avoiding those discharges to fresh surface waterbodies. The construction of the scheme including all storage and irrigation facilities and the WWTP itself is fundamental to providing for high quality treated wastewater to irrigate to land (including reuse at Jubilee Park), reflecting current national and regional policy drivers and recognising the environmental, social and cultural benefits.

The key to achieving the anticipated scheme outcomes is to:

- sufficiently reduce I&I in the wastewater network
- treat inflows to a high standard including a mean total nitrogen concentration of 10 g/m^3
- provide adequate covered storage for raw and treated wastewater
- control the irrigation process so that it is efficient and does not cause ponding or runoff; and
- carefully monitor the quality of the wastewater and the effect on the receiving environments and adapt the scheme if necessary.

If the scheme does need to be adapted in response to monitoring outcomes, it may involve adjusting the treatment process, changing the irrigation rate and / or regime, or irrigating over a wider area including additional sites.

The assessment of the effects of the activity on environmental values and community values demonstrates that the scheme will result in several positive effects, including on landscape, cultural and biodiversity values, while minimising adverse effects on receiving environments to the extent that they are generally less than minor.

The proposal is also generally consistent with the relevant policy provisions of the applicable statutory plans and documents and is consistent with the purpose of the RMA as expressed in Part 2 of that statute.

Appendices

We design with community in mind

Appendix A Aqualinc Research Limited Report - Irrigation Assessment

aqualinc

AKAROA TREATED WASTEWATER IRRIGATION SCHEME

PREPARED FOR
Christchurch City Council (through Stantec)

4/10/2022

PREPARED BY
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Disclaimer

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TABLE OF CONTENTS

Appendices

List of tables

Table of Figures

Table of abbreviations

amsl	above mean sea level
bgl	below ground level
cm	centimetre
cm/h	centimetres per hour
d	day
DIN	Dissolved inorganic nitrogen
g	gram
g/m^3	grams per cubic metre
h	hour
ha	hectare
kg	kilogram
kg N/ha/y	Kilograms of nitrate per hectare per year
kg/m3	kilograms per cubic metre
kg/y	kilograms per year
L	litre
lph	litres per hour
m	metre
m bgl	metres below ground level
m^3	cubic metre
m^3/ha/y	cubic metres per hectare per year
m^3/s	cubic metres per second (cumecs)
mg	milligram
mg/L	milligrams per litre
min	minute
mm	millimetre
mm/d	millimetres per day
mm/y	millimetres per year
N	Nitrogen
Nitrate-N	Nitrate nitrogen
R^2	A statistical measure of fit that indicates how much variation of a dependent variable is explained by the independent variable(s) in a regression model
s	second
TN	Total nitrogen
WW	wastewater
y	year

EXECUTIVE SUMMARY

Christchurch City Council (CCC) is planning to build a new wastewater treatment plant (WWTP) at Akaroa. CCC proposes to irrigate the treated wastewater from the new WWTP to land in the wider Akaroa area.

The proposal is to irrigate the land using a surface drip irrigation system at two locations - Robinsons Bay Valley and Hammond Point. The land at the two sites will be planted with native vegetation to utilise applied water and nutrients.

Treated wastewater will also be used to irrigate Jubilee Park in Akaroa using subsurface drip irrigation. This involves two areas, one being the “cricket pitch”, the other a reserve area at the northern end of the park. The purpose of this irrigation is to maintain grass cover on these areas during extended dry periods.

Aqualinc Research Ltd (Aqualinc) was contracted by Stantec New Zealand (Stantec) to provide technical information to assist CCC in making an application for a consent to irrigate the land with treated wastewater.

This required:

- Establishing baseline environmental conditions – field investigations.
- Developing an irrigation design concept.
- Estimating the potential effects of the design concept on the local environment (water quantity and quality).

Robinsons Bay Valley and Hammond Point

Irrigated areas

Table 1 summarises the proposed irrigable areas at the two sites.

Table 1: Proposed irrigable areas

Site	Total farm area (ha)	Proposed irrigable area (ha)
Hammond Point	11.9	3.8
Robinsons Bay Valley	118.1	31.9
Total	**130.0**	**35.7**

Irrigation Configuration

For the Robinsons Bay Valley and Hammond Point sites, CCC proposes to plant native trees in lines 2 m apart with surface driplines placed between each of the tree rows. A dripper flow rate of 2 litres per hour (lph) with drippers spaced at 30-50 cm in the dripline will provide a 50 cm wetted zone along each dripline.

Four driplines spaced 0.5 m apart between each tree row will maximise wetted soil area and minimise drainage through the soil profile.

Irrigation volumes

The volume of treated wastewater available for irrigation and the depth of water applied within the proposed area (35.7 ha) assuming four driplines per tree row is as follows.

Table 2: Annual application volumes (m^3/y), wetted areas (ha) and depths applied (mm/y)

	Annual volume applied (m^3/y)	Total wetted area (ha)	Depth applied (mm/y)
Average	205,500	35.7	576
Maximum	220,800	35.7	618
Minimum	193,400	35.7	542

Drainage volumes

Some of the applied water (rainfall and/or irrigation water) will drain through the soil profile into the underlying material where it may move into waterways in the wider catchment.

Assuming 99%[1] of water draining through the soil profile contributes to streamflow and assuming four driplines per tree row, the average flow in Robinsons Bay Stream is predicted to increase by 2%.

Nutrient loads

CCC proposed to treat the wastewater to achieve a total nitrogen concentration of 10 g/m^3. This equates to a dissolved inorganic nitrogen concentration (DIN) of 8.6 g/m^3. The loading rates on the two sites are shown in Table 3.

Table 3: Nitrogen loading rates on the two sites

	Total load in irrigation water (kg N/ha/y)	DIN load over irrigable area (kg/ha/y)	DIN total load over wetted area (kg/y)
Robinsons Bay Valley	57.5	49.5	1,580
Hammond Point	57.5	49.5	188

Nutrient movement

DIN in the irrigation water could make its way into waterways via drainage through the soil profile. This includes Robinsons Bay Stream for the Robinsons Bay Valley site and Akaroa Harbour for Hammond Point.

The resulting N concentrations depends on land use (land cover and use), concentration of N in the irrigation water, uptake of N by trees and denitrification in the soil. It also depends on the nature of the receiving environment.

Robinsons Bay Stream

We have calculated the effect of the proposed irrigation on Nitrate-N concentrations in Robinsons Bay Stream for the following options:

1. Existing land use
2. Base Case: Includes (a) 13.5 kg/ha uptake/denitrification from the trees planted on the 31.9 ha irrigated area, and (b) 2 kg/ha offset from destocking the 31.9 ha area.

---

[1] 1% is assumed to go to deep percolation and not enter streams.

3. Preferred: As for the Base Case, but with (a) 23 ha additional infill/riparian planting that is assumed to have the 13.5 kg/ha uptake and denitrification as the irrigated area, and (b) the 2 kg/ha offset from destocking this additional 23 ha area. In this scenario we have assumed that the riparian trees can access the leached N, so the 13.5 kg/ha uptake from Meister and Robinson applies.
4. Destock 2: As for Preferred, with the remaining area of the property (63.2 ha) destocked. We note that although this area may end up being planted in trees, we haven't applied the 13.5 kg/ha uptake to it, as the uptake number was based on trees with wastewater applied.
5. Conservative: No uptake or offset on any part of the property.

A full explanation of the analysis is given in Section 10.5 and Section 10.6 of this report. The results are summarised in Table 4 for a 10 g/m^3 total N input in wastewater.

Table 4: Change in Nitrate-N concentrations in Robinsons Bay Stream

	Existing Stream Nitrate-N (g/m^3)	Change in concentration (g/m^3)	Resulting concentration (g/m^3)
Existing land use	0.030	0.000	0.030
Preferred scenario	0.030	0.086	0.116
Destocking 1	0.030	0.057	0.087
Destocking 2	0.030	0.047	0.077
Conservative	0.030	0.126	0.156

Hammond Point

There is no baseline information to calculate an existing load for the Hammond Point farm.

The additional Nitrate-N load resulting from irrigation of 3.8 ha at Hammond Point is 122.1 kg/y after allowing for potential uptake by trees and denitrification in the soil (about 30% of applied N) and destocking the irrigated area. If the entire property is destocked, there would be a further offset of 16.2 kg/y.

The total increase in load assuming no uptake (the most conservative approach) is 181 kg N/ha/y.

Jubilee Park

As the purpose of irrigating Jubilee Park is to maintain grass cover during low rainfall periods, an alternative design specification is appropriate. Indicatively, a dripline spacing of 40 cm will be required to adequately irrigate the area (stop the soil drying out too much) in Jubilee Park. The spacing can be confirmed at the detailed design stage.

The potential for drainage under Jubilee Park will be minimised by deficit irrigating - managing the irrigation applications to only apply water when needed to maintain soil moisture above a minimum threshold sufficient to prevent the grass browning off. This will be simple to achieve using soil moisture monitoring.

With deficit irrigation, sufficient moisture will be retained to keep the grass green, but drainage through the soils will be only slightly higher than under unirrigated conditions (590 mm/y on average compared to 560 mm/y with no irrigation). The applied nitrogen in irrigation water will be taken up by the grass, resulting in little or no leaching to waterways.

1 INTRODUCTION

1.1 Background

Akaroa's treated wastewater is currently discharged into Akaroa Harbour. Christchurch City Council (CCC) have proposed an alternative – to use the treated wastewater to irrigate land in the Akaroa vicinity. CCC plans to build a new wastewater treatment plant (WWTP) at Akaroa and use the treated wastewater from the new plant to irrigate land to be planted with native trees.

The irrigation areas cover two sites - Robinsons Bay Valley and Hammond Point. Irrigation in these areas will be with surface driplines. In addition, CCC propose to irrigate Akaroa's Jubilee Park using subsurface drippers to keep the playing surfaces green during drought conditions.

Aqualinc has been engaged by Stantec New Zealand (Stantec) to provide recommendations for the conceptual design of the drip irrigation systems for the irrigation of treated wastewater from the proposed Akaroa WWTP. The recommendations are to enable an assessment of the environmental effects of the proposal for inclusion in resource consent applications for the project.

1.2 Scope of Work

The scope of work included:

- Carrying out field measurements to establish baseline environmental conditions.
- Developing an irrigation design concept – flow rates, dripline spacings, potential irrigable areas, application rates and volumes, including testing alternative scenarios.
- Assessing the potential effects of the design concept on streams (water quantity and quality).

1.3 Objectives of Work

The objectives of the work were to:

- Establish baseline environmental conditions that can be used to assess changes in those conditions due to the proposed irrigation.
- Determine general irrigation system parameters that can be used for assessment of changes in stream flows and nitrate concentrations in streams. These parameters could be used for future detailed irrigation system design.
- Document the potential changes in stream flows and nitrate concentrations in streams for a range of potential design scenarios. This information will be used by other parties to assess the effects of the changes on the stream environment.

2 SITE DESCRIPTION

The general location of the proposed irrigation scheme is shown in Figure 1.

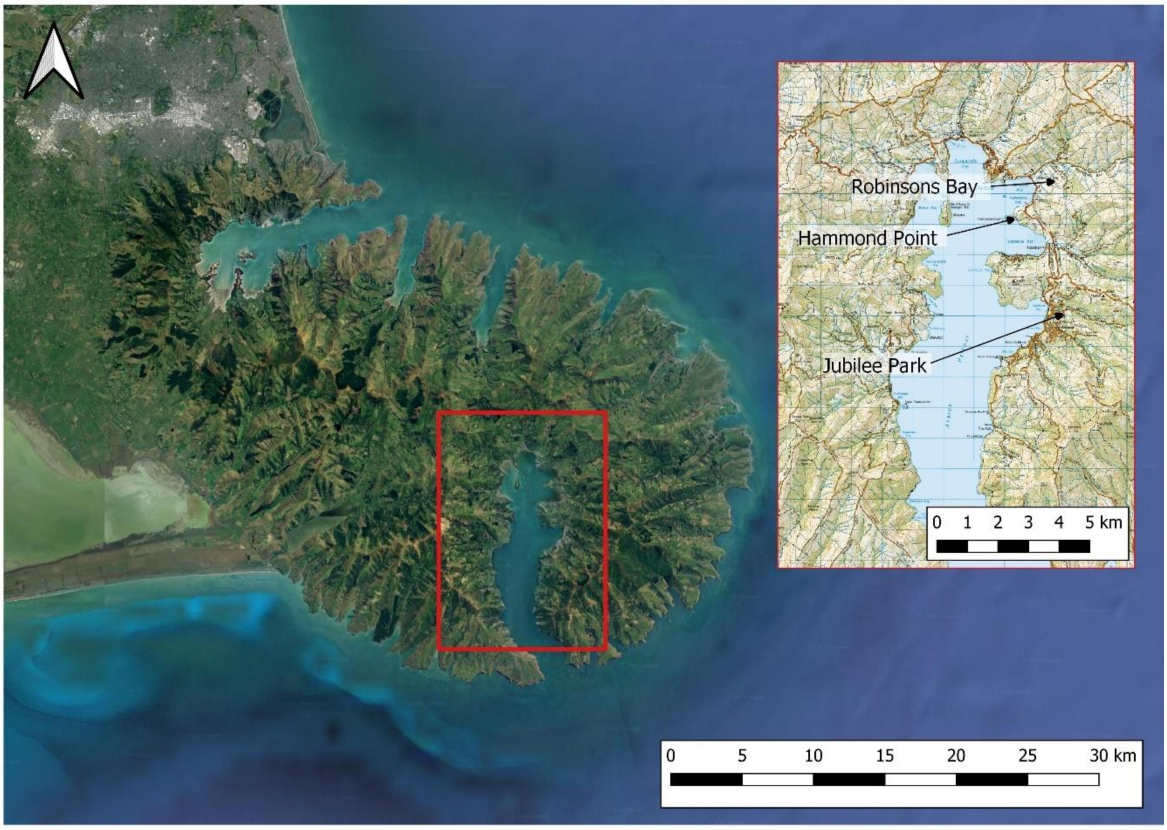

Figure 1: General location of proposed irrigation scheme

Further details of the proposed irrigated areas are given below.

2.1 Robinsons Bay Valley

The Robinsons Bay Valley site is location on Robinsons Bay Valley Road (Figure 2). It is currently grazed with sheep and cattle. Elevation of the site ranges from 30 m to over 350 m amsl. There are small areas of flat land in this area, but most of the area has moderate to steep gradients.

Robinsons Bay Stream flows around the north of the site. Gullies of various lengths and depths intersect the more evenly graded areas of the land. Most gullies are dry and will only have flowing water in them during heavy rainfall events. At times, water from the gullies could flow into Robinsons Bay Stream.

The soil is predominately fine-grained loess, with large rocks on the surface in some areas. Again, CCC propose surface drip irrigation of native trees for this site.

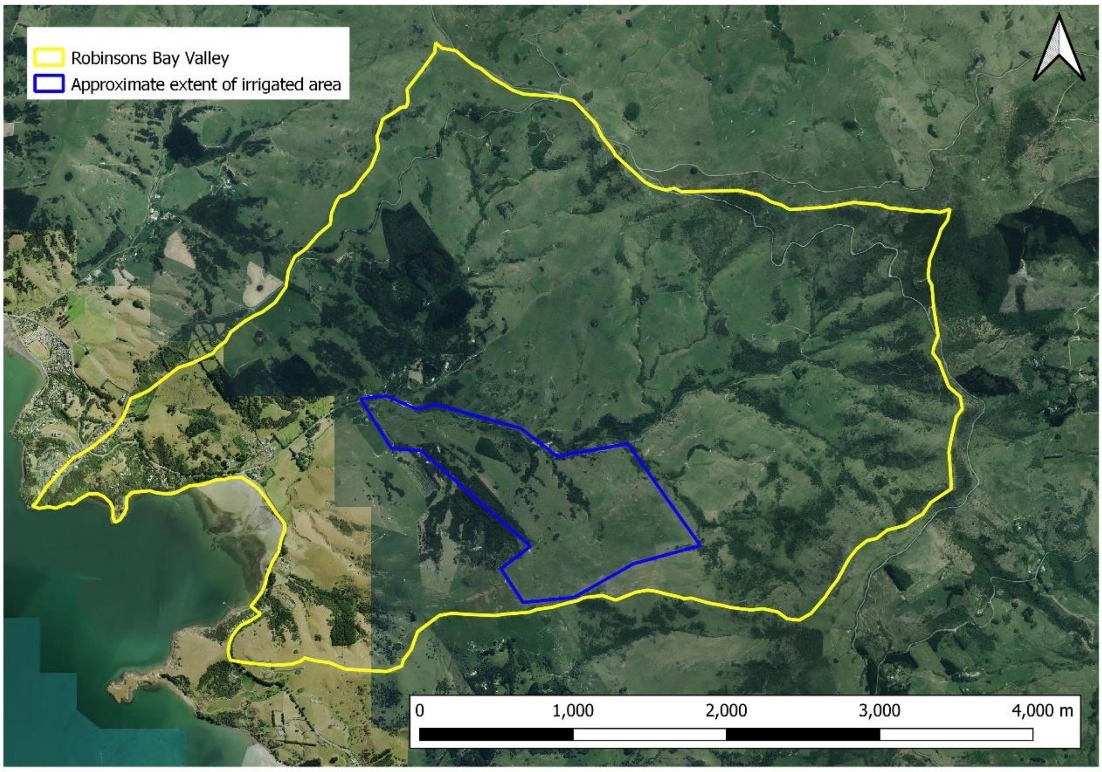

Figure 2: Location of irrigation sites at Robinsons Bay Valley

2.2 Hammond Point

The Hammond Point irrigation area is located to the west of SH75 (Figure 3). The site is 40 to 70 m above mean sea level (amsl).

There is a small portion of flattish land at the high point of the site near to SH75 that slopes off to the sides. The south-eastern boundary is defined by a steep forested face. The north-western area is gently sloping to the access road that passes through the block. Below the access road, some of the land is too steep to irrigate, while the rest is potentially irrigable where the land slopes more evenly towards Akaroa Harbour.

The soil is predominately fine-grained loess. There are no streams/waterways on the site. There is a small ephemeral stream to the south in the vegetated gully but given the separation distance (greater than 110 m) and land cover between the stream and irrigated area, the stream is very unlikely to be impacted by irrigation.

The area is currently used for grazing of cattle and sheep. Surface drip irrigation of native trees is proposed for this location.

Figure 3: Location of irrigation sites at Hammond Point

2.3 Jubilee Park

Jubilee Park, which is located on the Rue Lavaud in the Akaroa urban area (Figure 4), is a reserve that includes a sports field, including a cricket pitch. The sports field is on reclaimed land and was developed in 1886-1888[2]. Grehan Stream runs through the reserve.

The playing field experiences water stress during dry summers. CCC proposes to install sub-surface drip irrigation in the field to keep the grass green during dry periods. North of Grehan Stream, there are two smaller areas of the reserve that can also be potentially irrigated.

[2] Akaroa Historical Review. A Report Prepared For: Keri Davis-Millar Planner, City Plan Team Christchurch City Council June 2009.

Figure 4: Locations of irrigation sites at Jubilee Park

3 POTENTIAL IRRIGABLE AREAS

3.1 Methodology Used to Determine Irrigable Areas

Indicative potential irrigable area maps were provided by Stantec to Aqualinc. These were based on initial mapping by Pattle Delamore Partners (PDP) but Stantec had removed areas that would be unavailable for irrigation for various reasons, including slope (greater than 19˚) and proposed 20 m setback distances from boundaries and waterways.

Aqualinc assessed the maps and completed further slope analysis to refine the potential irrigable areas. We obtained the 1 m digital elevation model (DEM) from the 2018 – 2019 Banks Peninsula LiDAR survey[3] for the areas and calculated the land slopes in ArcGIS. This suggested there were substantial areas that were additional steep/undulating that might need to be removed. In addition, land that was within a heritage area was removed.

The analysis was followed by a site visit/walkover to further assess irrigation feasibility, aided by background information from CCC regarding PDP's original assessment. We found during the site visit that some of these areas, despite having slopes greater than 19˚, were irrigable and the mapping was revised. In addition, some areas that had been identified as potentially irrigable were removed due to the existence of unmapped ephemeral streams, boggy areas and springs or due to Stantec having identified geotechnical risks with the land. Allowance was also made for proposed storage tanks.

The resulting areas have been mapped and classified. Land that is less suitable to irrigate such as small and/or remote pockets, land that may be too wet, rocky or steep has been classified as "less suitable".

The larger and more accessible areas have been classified as "most suitable".

3.2 Irrigation Areas

The potentially irrigable areas for Robinsons Bay Valley and Hammond Point are presented in Figure 5 as Figure 6 respectively.

[3] https://data.linz.govt.nz/layer/105032-canterbury-banks-peninsula-lidar-1m-dsm-2018-2019/

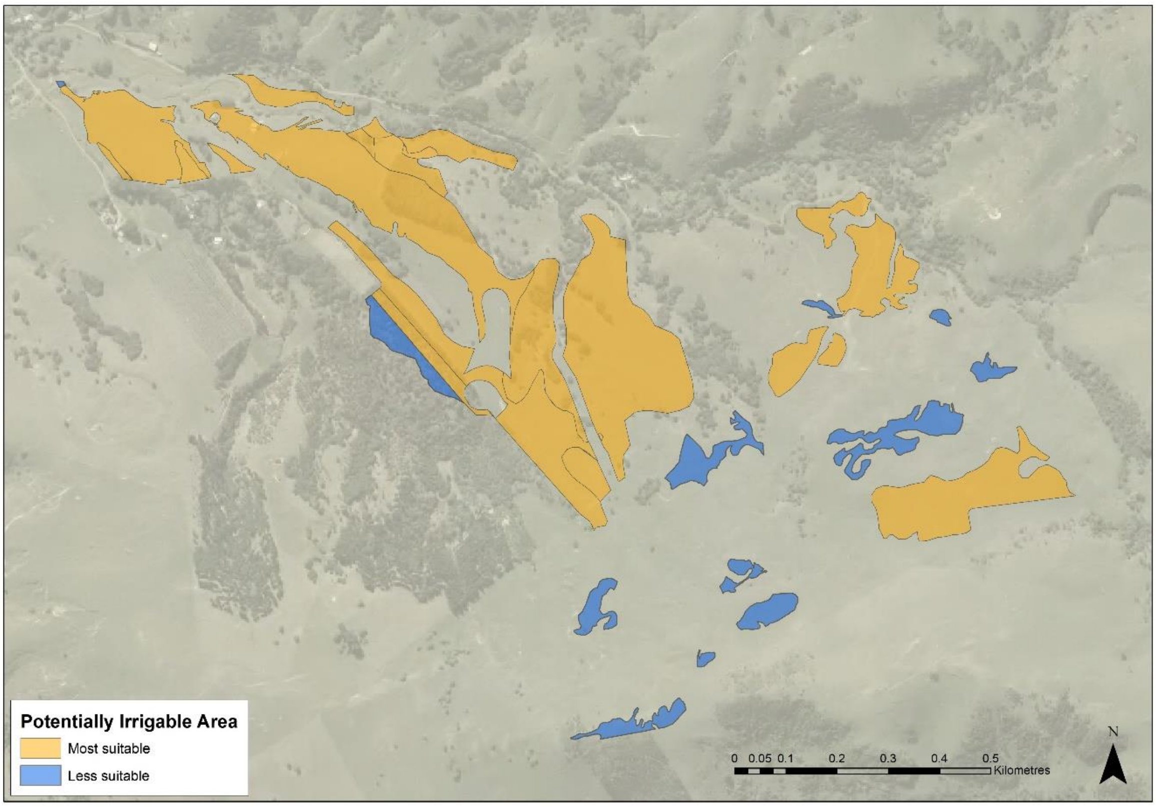

Figure 5: Potential irrigation areas for Robinsons Bay Valley.

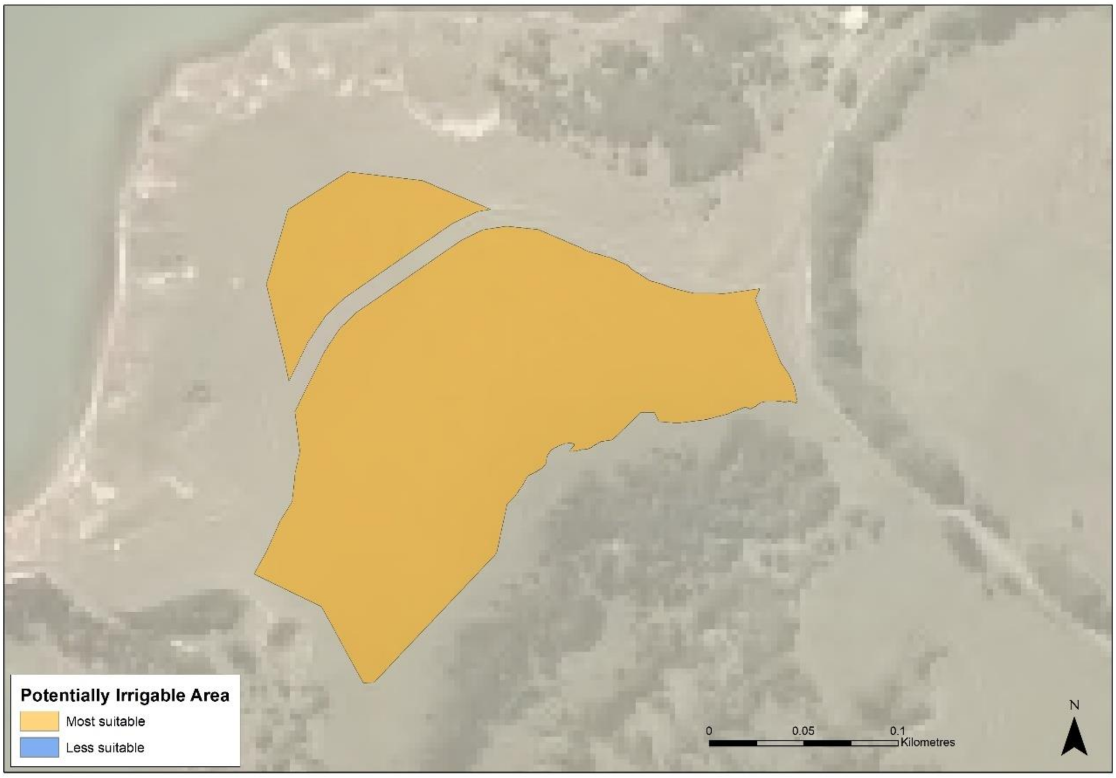

Figure 6: Potential irrigation areas for Hammond Point

3.3 Summary of Potential Irrigable Areas

A summary of the potential irrigable area is given in Table 5.

Table 5: Most suitable and less suitable irrigable area for each site.

Site	Most suitable area (ha)	Less suitable area (ha)	Maximum potential area (ha)
Hammond Point	3.8	0.0	3.8
Robinsons Bay Valley	31.9	5.0	36.9
Total	**35.7**	**5.0**	**40.7**

Maximum potential area includes the area identified as less suitable.

4 DESCRIPTION OF THE ENVIRONMENT

The proposed irrigated areas are on Banks Peninsula near to the Akaroa township. Topography over the area ranges from flat in areas close to Akaroa Harbour and at the coastal side of Akaroa Township to steep hilly country further from the harbour.

Many small streams, some ephemeral, flow from the hill country down into the harbour. Streams close to Akaroa township are used to provide water for the town.

Base flow for the streams generally comes from rainfall infiltrating through the soil and seeping out of groundwater into the waterways. Springs are common over the area, with some at high elevations.

Streams are subject to flooding during high rainfall events. The floods tend to be short-duration, with flows rising and falling quickly in response to rainfall.

4.1 Waterbodies Relevant to Irrigated Areas

The following streams are relevant to each of the potential irrigable areas.

- Robinsons Bay Stream (for the Robinsons Bay Valley area)
- Grehan Stream (for the Jubilee Park area)

Flow for these streams comes from direct runoff during high rainfall events or seepage from subsurface flow (groundwater).

There are no flowing streams on or bordering the Hammond Point potential irrigable area.

The existence of groundwater in Banks Peninsula is highly variable and well yields are generally low. Most well water comes from fractures in the basalt underlying the top-soil rather than from traditional rainfall-fed gravel aquifers. In fact, there are no known “aquifers” in the vicinity of the irrigation areas.

Shallow groundwater generally occurs in flat or gently sloping areas close to streams, indicating that there is interchange between groundwater and stream flow in some areas.

4.2 Monitoring Sites

Baseline data on water bodies that are relevant to the irrigated areas is very limited. For that reason, a monitoring programme was initiated to provide additional flow and water quality data for the relevant water bodies.

We established monitoring sites at the Hammond Point, Robinsons Bay Valley and at Jubilee Park to enable the collection of baseline data to provide an improved overview of the current state of the environment.

Monitoring commenced at the end of September 2021 and was carried out on a semi-regular basis through to February 2022. As the sampling occurred in spring and summer it did not correspond to the greatest period of potential drainage to groundwater (winter). Rainfall was generally light during the sampling period.

4.2.1 Baseline monitoring

The monitoring included:

- Groundwater levels – to determine depth to groundwater and groundwater fluctuations.

- Barometric pressure – to correct for pressure effects if groundwater was found to be confined, and to correct water level sensors for barometric pressure.
- Groundwater chemistry – to understand the source of groundwater.
- Surface water flow – to provide a baseline of flows to enable the environmental effects of additional drainage due to irrigation on stream flows to be assessed.
- Surface water quality – to provide a baseline of water quality to enable the effects of additional nutrient loss due to irrigation to be assessed.
- Soil chemistry – to provide a baseline soil chemistry dataset that could be used to assess impacts of irrigation on soil chemistry.
- Soil moisture – to provide an indication of the amount of rainfall draining through the soil profile (we used this to qualitatively check Irricalc water balance modelling results).
- Soil temperature – not used specifically but recorded, as temperature sensors are attached to soil moisture sensors.

4.2.2 Monitoring sites

The groundwater and surface water measurement sites were established upstream and downstream of the proposed irrigated areas. Choice of sites considered accessibility, ownership of the sites, and for the surface water sites, permanence of flow and suitability of the cross-section for gauging. A detailed description of the sites is included in Appendix C.

The number of monitoring sites are summarised in Table 6.

Table 6: Number of monitoring sites

Parameter	Hammond Point	Robinsons Bay Valley	Jubilee Park
Piezometers	1(dry)	2	0
Surface water sites	0	3	2
Soil moisture/temperature sites	2	2	1
Soil chemistry (composite)	1	1	1

The piezometers were installed by McMillan Drilling NZ to enable groundwater levels and groundwater quality data to be determined. Bore logs are included in Appendix E. Note that the piezometer at Hammond Point was dry.

Surface water sites were established by Aqualinc to collect stream flow and stream water quality data.

Soil moisture sites were also established by Aqualinc to collect data on current drainage through soil profiles at each site.

4.2.3 Methods used

Groundwater levels were collected using an electric water level meter. Water level loggers were placed in two piezometers to determine fluctuations in groundwater levels in the vicinity of the proposed irrigation areas. A barometric pressure logger was installed to enable the correction of this data if groundwater was confined.

Water quality samples were collected using a bailer after purging the piezometers for approximately three volumes of bore water. A bailer was used due to the very slow recovery in the piezometers.

Surface water flows were gauged at 0.2 m intervals across each stream using a redback RB01 current meter or OTT™ current meter for low flows. A spin test was conducted to ensure the current meters were working correctly at each site. There were occasions when flows were too high or low to gauge and at these sites a visual estimate of flow was taken. Field parameters and water quality samples were collected at each site.

Telemetered soil moisture monitoring sites consisting of two Teros 11 soil moisture sensors at each site were installed in the proposed irrigation area. The two sensors measured soil moisture in the normal root zone (100 mm depth) and below the root zone (300 mm depth). The 300 mm sensors were used to gain an indication of water draining to groundwater. Soil temperature was also recorded at 100 mm depth.

Composite soil samples were collected at each site. This was done by removing the turf at the site and inserting a soil corer. This was carried out for a variety of locations at each site and then composited.

4.3 Summary

A summary of the data is provided in Appendix D. The full data is provided in Appendices D to G.

4.3.1 Streams

The Robinsons Bay Stream catchment is steep and undulating. Robinsons Bay Stream and its tributaries pass through significant areas of the proposed irrigated area and is generally unmodified in those areas. Nitrate-N concentrations averaged 0.07 g/m^3 upstream, 0.05 g/m^3 between the upstream and downstream sites and 0.05 g/m^3 at the downstream monitoring sites.

The Grehan Stream channel through Akaroa township and through Jubilee Park is highly modified and channelized. Measured nitrate-N concentrations in Grehan Stream averaged 0.29 g/m^3 at the upstream monitoring site and 0.13 g/m^3 at the downstream site.

The monitoring showed that Robinsons Bay and Grehan stream flow is highly variable, which reflects the steep upper catchments and rainfall events that occurred during the study period. These large differences in flow also caused large differences in observed water chemistry.

4.3.2 Groundwater

The Robinsons Bay Valley groundwater appears to not be directly connected to either surface water or to rainfall events in the vicinity of the two piezometers. The lack of response may be due to slow infiltration through the loess or a low permeability horizon limiting flow through the loess into groundwater at those locations. However, the existence of groundwater shows that there is a possible connection between rainfall infiltration and/or stream recharge.

No shallow groundwater (<10 m) was observed at the Hammond Point Road site, reflecting the piezometer's position at the crest of a hill.

Groundwater nitrate levels are low in the upper Robinsons Bay Valley with an average value of 0.08 g/m^3. The values increase lower down the valley, with ROB GW2 having an average value of 3.27 g/m^3.

5 IRRIGATION PARAMETERS

5.1 Proposed Layout of Irrigation System

5.1.1 Robinsons Bay Valley and Hammond Point sites

CCC proposes to plant native trees in the irrigable areas. While the final landscape plan has not been established, the starting position is that the tree rows will be 2.0 m apart and trees will be about 1.2 m apart in the rows. On the steeper areas, to best utilise the land, it may be preferable to run the tree rows along, rather than perpendicular to, the contour. This will be decided by the landscape experts.

Trees may be planted and established up to 4 years before the irrigation system is installed.

Driplines will be laid on the ground surface between each of the tree rows.

The number of driplines between each tree row determines the percentage of the total area that is irrigated, the volume of irrigation water that will be applied by each dripline to distribute the total volume supplied from the WWTP and the resulting drainage through the soil profile.

Assuming a wetted strip of 50 cm along each dripline with a 2 m tree row spacing, the potential number of driplines per tree row ranges from one (25% of the total area would be irrigated) to four (100% of the total area could be irrigated).

Four driplines equally spaced between each tree row will maximise wetted area and minimise drainage though the soil profile, and for that reason is preferred. A single dripline will result in the least wetted area and the greatest drainage through the soil profile.

Depending on tree species and growth rates (noting that the trees may not be irrigated when first planted), we assume that the groundcover between the rows of native vegetation will initially be in pasture (as most of it is now). We note that the potential irrigable areas are currently farmed. Once the native tree canopies establish, the pasture cover will reduce or disappear.

From an irrigation perspective, water and nutrient uptake by the native trees will depend on root growth of the trees. A rule of thumb is that effective root volumes generally reflect the canopy drip zone.

Initially, it is possible that the trees will not access all of the irrigation water directly as the roots will not all be in the soil wetted by the driplines. Regardless, the applied water will be available to be taken up by the vegetation in the irrigated strip between the tree rows, whether it be trees or pasture.

Over time, the trees will grow, roots will spread out into the full irrigated area and the existing interrow vegetation will be supressed. It will reach a point where most if not all of the applied water will be used by the trees. The remainder will be evaporated at the soil surface or drain through the soil profile. Runoff is likely to be minimal under a full canopy situation.

5.1.2 Jubilee Park

The Jubilee Park site is proposed to be irrigated using subsurface drip.

The primary purpose of the irrigation is to maintain grass cover on the park during dry summer periods. To ensure that there are little or no “dry” patches between the drippers a closer dripline spacing than proposed on the other sites will be needed so that overlap between the wetted soil strips arising from irrigation will occur.

The application volumes will be managed to ensure that no more water than necessary is applied to maintain grass cover. This will minimise the likelihood of drainage and runoff occurring.

5.2 Application Parameters

To quantify the volume of irrigation water that can be distributed onto land using drip irrigation, the following parameters have been assessed.

- Area available for irrigation (hectares). See Section 3.
- Irrigation application volumes (m^3/ha/day).
- Losses to drainage below the plant root zone.
- Potential for surface ponding and runoff.
- Rainfall interception.

5.2.1 Irrigation application volumes

Because drip irrigation infrastructure is proposed, the volume of water applied per hectare depends on the following.

- Dripper flow rate (litres per hour).
- Dripper run times (hours per day, hours per year).
- Dripper spacing in the lines.
- Dripline spacing, which determines the number of driplines.

5.2.2 Losses to drainage

Losses to drainage will depend on:

- Soil properties.
- Climate (rainfall and evapotranspiration (ET)).
- Water uptake by the trees, dependent on the canopy and root spread.
- Volume and frequency of irrigation water applied.

5.2.3 Ponding and runoff

Drip systems can result in some ponded water at the ground surface. This can occur at the dripper with surface irrigation or result from upwelling of water to the surface from subsurface irrigation. The extent that it occurs in practice depends on soil properties, the volume of water applied in one event, antecedent soil moisture and rainfall. Applying excess water during wet conditions will probably cause some surface ponding.

If the ground has pasture cover, ponding will be less evident and ponded water will often quickly soak into the soil after an irrigation event ceases. However, if there is little cover on the surface and the land slope is steep, water has the potential to move over the soil surface creating runoff. Cumulative runoff can then occur, which can be problematic.

Runoff due to irrigation can be mitigated with good irrigation design (running driplines along the contour), good irrigation management (not over-irrigating, keeping run times short) and maintaining good ground cover. Also, the proposed 20 m setback distances from streams will reduce the opportunity for runoff from irrigation to enter streams.

5.2.4 Rainfall interception

For a developed forest, a proportion of measured rainfall will be intercepted by the tree canopy and ground litter and be evaporated from the canopy and ground surface. Rainfall interception is the difference between measured rainfall and rainfall reaching the soil surface.

The amount of rainfall intercepted depends on a wide range of factors such as canopy architecture, leaf properties, ground cover, depth and intensity of rainfall, wind strength and wind direction. For that reason, interception is highly variable and very site specific. The amount of rainfall intercepted and evaporated may range from zero to over 50% of a rainfall event.

While canopy interception of rainfall will not have a measurable effect on the application of water from a drip system as the drip system is under both the canopy and ground surface cover, it will potentially have an impact on soil moisture status and on drainage through the soil profile.

Canopy interception on its own is not the key issue. The key issue is how interception changes the soil water balance, as it is that, that determines drainage through the soil profile.

Ignoring canopy interception will have little impact on the soil water balance while trees are small, which will be the case when native trees are first established. However, as the trees develop, a lower proportion of rainfall will reach the ground, which will reduce the depth of water applied to the soil and potentially reduce drainage through the soil profile. The larger trees will be more reliant on irrigation to grow, and uptake of irrigation water by the trees will increase.

Canopy interception of rainfall also has an impact on plant transpiration. Transpiration is the primary means by which water returns to the atmosphere. Leaf wetting reduces water loss through reduced transpiration, thereby partly counterbalancing the effects of interception.

The interception of water by the canopy and subsequent reduction in transpiration has direct implications for the soil water balance. Overall, interception will cause a reduction in water applied to the soil surface but depending on the degree of suppression of water uptake resulting from leaf wetting, the overall effect on drainage will be less, that is there could be more drainage compared to considering interception alone. We have elected to take a conservative approach and not allow for canopy interception, knowing that by taking that approach, our calculations of drainage through the soil profile and impacts on the environment will be overstated.

5.3 Modelling

5.3.1 Hydrus 2D/3D Modelling

To determine the movement or spread of water from drippers through the soil profile, hydraulic modelling was carried out using Hydrus 2D/3D for Windows.

HYDRUS is a software package for simulating water, heat, and solute movement in two- and three-dimensional (2D/3D) variably saturated media. The software package consists of a computational computer program and an interactive graphics-based user interface.

The HYDRUS software has been developed by leading (award winning) scientists in the field of vadose zone hydrology (Rien van Genuchten and Jirka Simunek)[4]. Both are Fellows of AGU (American Geophysical Union), AAAS (American Association for Advancement of Science, SSSA (Soil Science Society of America) and ASA (American Society of Agronomy).

The HYDRUS software is a standard tool used in both research and consulting applications.

Our aim was to use Hydrus to determine the following:

- The dripper spacing that would likely produce a wetted strip along the dripline.
- Establish what the likely spread of water could be between the driplines.

[4] Šimůnek, J., M. Th. van Genuchten, and M. Šejna, Recent developments and applications of the HYDRUS computer software packages, Vadose Zone Journal, 15(7), pp. 25, doi: 10.2136/vzj2016.04.0033, 2016

- Whether the hydraulic properties of the soil would limit the amount of water that could be applied.
- The circumstances under which surface ponding causing the potential for runoff would occur.
- An indication of drainage through the soil profile.

5.3.2 Irricalc

To determine the overall catchment mass balances of water, we have used an Aqualinc in-house version of the Irricalc soil water balance model for the following scenarios:

- Pasture under dryland conditions.
- Pasture under drip irrigated conditions.
- Native trees under dryland conditions.
- Native trees under drip irrigated conditions.

These four scenarios have been included to enable the analysis to cover the combination of irrigated and unirrigated trees and pasture.

The key outputs from the Irricalc software are:

- Evapotranspiration (plant water uptake).
- Drainage[5] through the soil profile.

The application parameters determined by the Hydrus modelling (application volumes and return intervals) were used as inputs for the Irricalc modelling.

5.4 Soils

Soil hydraulic properties for Robinson Valley and Hammond Point were obtained from a review of several reports and publications that described the soils in the Akaroa locality. The soil description for these sites is best known as Barrys Bay Loess (deep silt loam). While Griffiths (1973)[6] describes the soil composition as 21% clay, 25% silt and 54% fine sand, it is more likely to be similar to that described by Jowett (1995)[7], i.e. 9% sand, 71.5% silt and 19.5% clay.

Griffiths and Jowett have described the soil as having varying depths with a lower permeability horizon in some locations. PDP also identified lower permeability zones when carrying out infiltration tests in the area (PDP (2016)[8]).

For Robinsons Valley and Hammond Point, soil water movement was modelled down to 1 m depth, which broadly corresponds to tree rooting depths. This depth is appropriate to determine water movement through the soil profile.

At this time, we do not have specific soil properties for Jubilee Park. We have assumed that the soil is shallow silt loam. However, at least some of the Park is on reclaimed land. If irrigation is installed in Jubilee Park, further soil details will be obtained at the time of final irrigation design.

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[5] In Irricalc, this collectively includes deep drainage, lateral drainage and runoff
[6] Griffiths, E., (1973) Loess of Banks Peninsula. New Zealand Journal of Geology and Geophysics. 16:3. 657-675.
[7] Jowett, T.W.D., (1995) An investigation of the geotechnical properties of loess from Canterbury and Marlborough. University of Canterbury Thesis.
[8] Pattle Delamore Partners Ltd. (2016). Infiltration testing results for Akaroa Treated Wastewater Disposal via Irrigation – Robinsons Bay and Pompeys Pillar.

5.4.1 Soil properties

We have adopted the following soil parameters based on the properties of Barry's Bay deep silt loam.

- Profile available water (PAW): 157 mm down to 600 mm, 262 mm to 1 m.
- Readily available water (RAW): 96 mm to 600 mm depth, 160 mm to 1 m depth.
- Saturation: 45%.
- Field capacity: 37%.
- Stress point: 21%.
- Permanent wilting point: 11%.
- Surface infiltration rate: 6.6 cm/h [8]
- Vertical hydraulic conductivity: 2 cm/h.
- Bulk density: 1,500 kg/m^3.
- Tree and pasture rooting depths: 1 m and 600 mm respectively

PDP (2016) recommend a PAW of 150 mm for Barrys soil, but do not specify the depth over which it is calculated. The NZFSL[9] gives Barry's Bay soils as having PAW values of 150 – 249 mm, which is similar to the PAW values we have used in our modelling. This minor difference will make little or no difference to the results of the modelling.

To confirm the final design of the irrigation system, in particular dripper spacing and flow rate, we recommend that further soil tests be completed to determine specific soil properties sufficient to refine the Van Genuchten parameters for Hydrus modelling. This refinement will not change the application volumes but may change the recommended dripline spacings and flow rates for final design.

5.5 Climate

5.5.1 Base climate data

Climate data used for the modelling included rainfall and potential evapotranspiration (PET) time-series. As there was no single climate station with long term gap-free rainfall and PET data for the Akaroa area, time-series of rainfall for four stations and PET for one station were used, as shown in Figure 7. Locations of climate stations were retrieved from NIWA[10] and these were used to create a continuous record.

[9] https://soils.landcareresearch.co.nz/tools/fsl/maps-fsl/
[10] https://cliflo.niwa.co.nz/

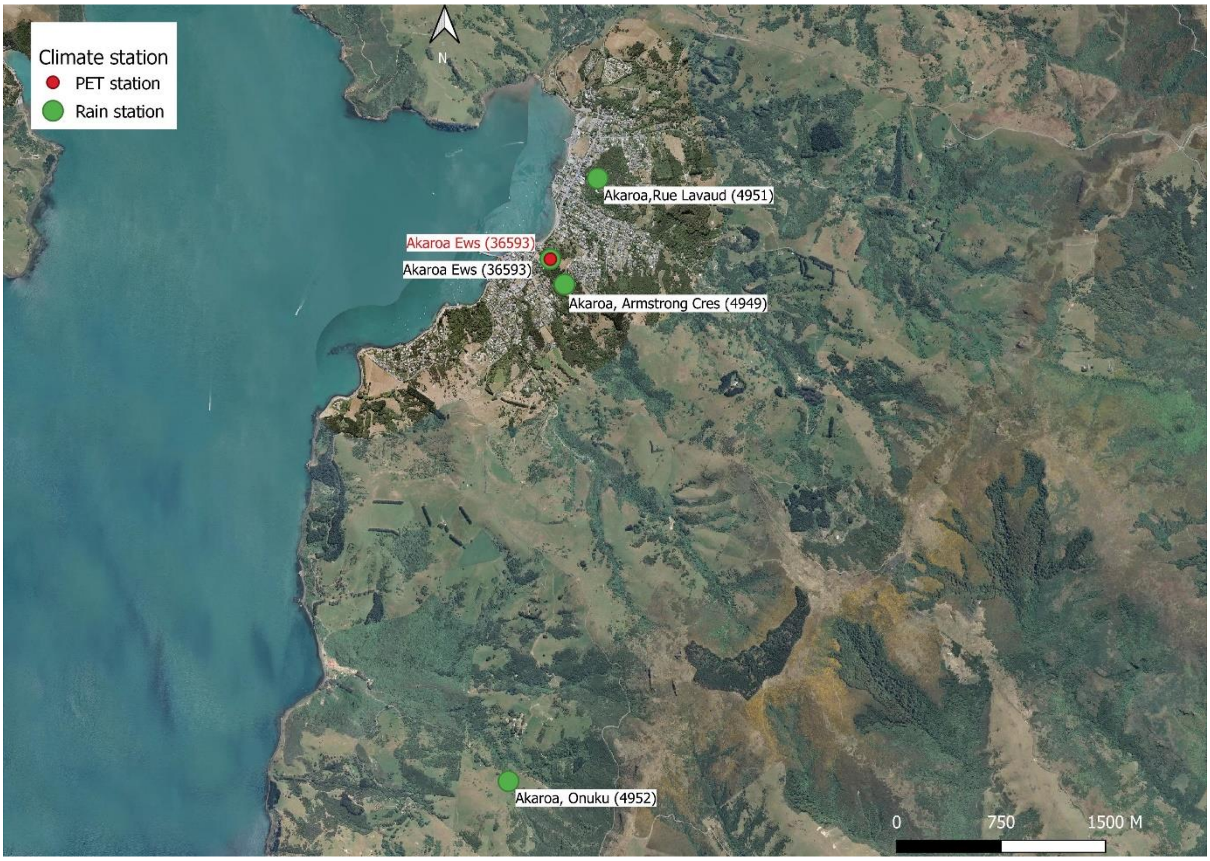

Figure 7 Locations of climate stations.

Table 7 summarises the rainfall data, including the length of the measured records available for four stations.

Table 7: Rainfall data

NIWA agent number	Station name	Data available		Site used for extension/gap-filling
		From	To	
36593	Akaroa EWS	20/12/08	09/07/21	Akaroa, Armstrong Cres (4949)
4949	Akaroa, Armstrong Cres	01/07/1970	01/04/1995	Akaroa,Rue Lavaud (4951) Akaroa, Onuku (4952)
4951	Akaroa,Rue Lavaud	02/12/1977	27/12/2007	
4952	Akaroa, Onuku	25/06/1970	01/01/2010	

Only Akaroa EWS (NIWA agent no 36593) has rainfall data up to the present day. Data from this station was extended to cover the model simulation period (1/7/1970 - 30/6/2021) as described below.

Rainfall data from Akaroa, and Armstrong Cres (NIWA agent no 4949) was extended and gap filled using the regression relationships with data from other nearby stations (see Table 7). There was a strong relationship between the rain measured at these three stations, with an R^2 value[11] of 0.94 for the relationship between rainfall at Armstrong Cres and Rue Lavaud, and an R^2 value of 0.76 for the relationship between rainfall at Armstrong Crescent and Onuku.

The resulting rainfall time-series for Armstrong Crescent for the 1/7/1970 to 1/1/2010 period was related to the Akaroa EWS data based on a comparison of monthly values for the overlap period, to generate rainfall data for the station at Akaroa EWS to cover the model simulation period.

For PET, measured data was available from the Akaroa EWS station for the period from 22/12/2008 to 30/06/2021. For the period prior to 2008, extended and gap-filled data from Aqualinc's Climate Time Series Extension method (Kerr, 2017)[12] was used. These two datasets were combined to give a PET time series for the period from 1/7/1970 to 30/6/2021.

5.5.2 Climate data used in modelling

We have used two models in our analysis – Hydrus and Irricalc (refer to Section 5.3 for details).

For the Irricalc modelling, we used daily rainfall and PET covering 42 years, from 1/7/1970 – 31/6/2021.

For Hydrus, we used hourly data. The hourly PET was estimated by dividing each daily value by 24. While this is not strictly correct as daytime values are higher than night-time values, assuming uniform hourly PET values has minimal impact on the overall water balance.

Initially, we ran a large number of Hydrus model scenarios to determine initial design parameters and to examine the sensitivity of model parameters to change. We chose two periods of two weeks each: one period with no rainfall representing dry summer (from 25 December 2011 to 8 January 2012), and one with the maximum two-week moving average of rainfall representing a wet winter period (from 30 July 2012 to 13 August 2012), as shown in Figure 8. Note that there were significant rainfall events at the start and end of the two weeks of the winter period.

[11] R-Squared is a statistical measure of fit that indicates how much variation of a dependent variable is explained by the independent variable(s) in a regression model.

[12] Kerr, T. 2017. Climate Time Series Extension Data: Process Description. Aqualinc internal report prepared with support of Environment Canterbury.

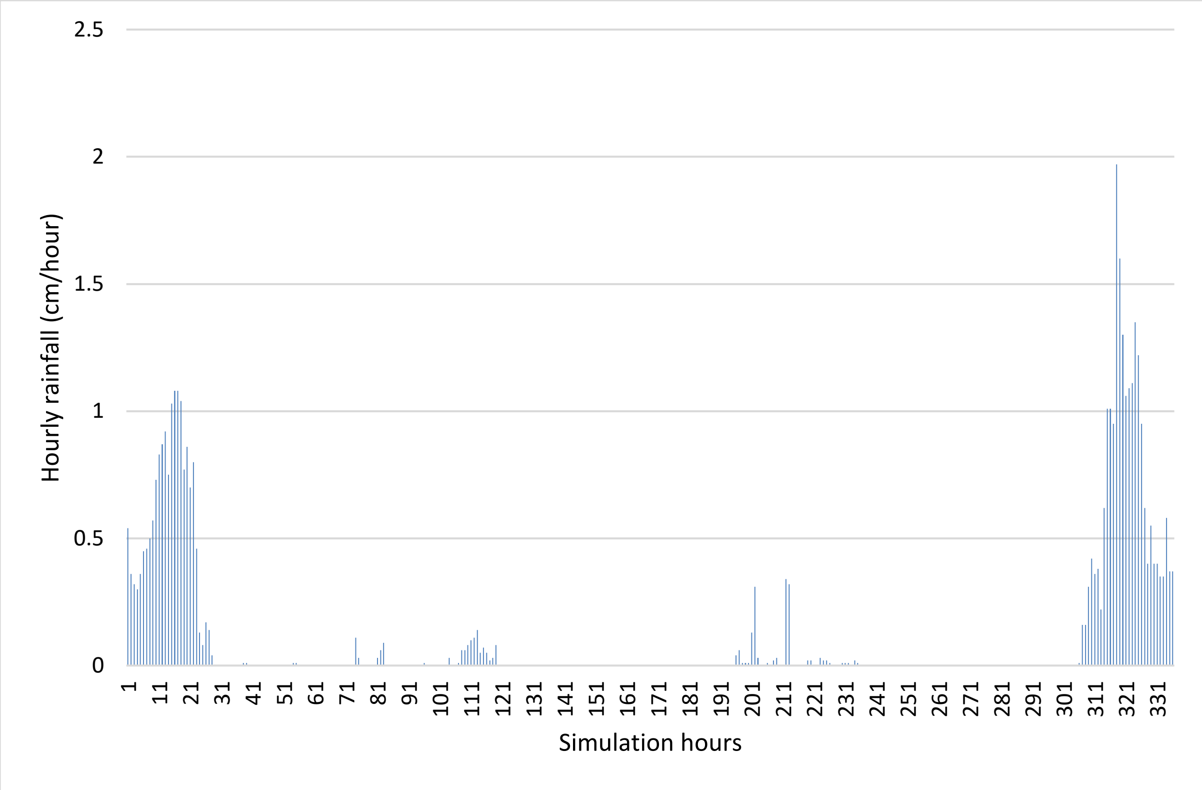

Figure 8: Hourly rainfall data from 30 July 2012 to 13 August 2012 (winter)

Following the modelling of the two-week periods, we completed specific model runs for the period from 1 September 2012 to 31 August 2014 (2 years). These runs encompass the two two-week scenarios described above.

5.6 Native Tree Properties

The ability of plants to use soil moisture depends on:

- Plant root distribution
- Plant crop factors

These are described below.

5.6.1 Plant root distribution

Water uptake depends on plant variety, the root distribution of plants and in a drip irrigated situation, the proximity of those roots to the drippers.

CCC have indicated to us that the primary native plantings in the irrigated areas will likely be kanuka. For the irrigation options, we have examined water uptake using Hydrus modelling on the assumption that mature manuka trees are growing on the land blocks. Manuka has been used as a proxy for kanuka because it is similar in form to kanuka and information on root distribution of manuka is available (Watson and O'Loughlin, (1985)[13]). The representative parameters for root distribution that we have used are given in Table 8.

[13] Watson, A., O'Loughan, C., (1985). Morphology, strength, and biomass of manuka roots and their influence on slope stability. Forest Research Institute, New Zealand Forest Service, New Zealand

Table 8: Parameters for root distribution (Watson and O'Loughlin, 1985)

Parameter	Value
Maximum tree rooting depth	100 cm
Depth of maximum intensity	30 cm
Maximum rooting radius	100 cm
Radius of maximum intensity	50 cm

We understand that kanuka is preferred by CCC to manuka, and if so, root distribution may be more extensive than we have assumed. It also follows that water uptake by kanuka could be higher than for manuka, which will result in lower drainage through the soil profile than we have calculated. In terms of impacts on the environment, using manuka rather than kanuka is therefore a conservative approach.

5.6.2 Crop water demand

Potential evapotranspiration (PET) is based on a pasture reference crop. It is calculated from climate data for 100 mm high pasture that is not under water or any other stress. For the reference crop, crop water demand equals potential evapotranspiration.

To determine crop water demand for other crops, PET values for the reference crop are adjusted by a factor to account for plant form/size, time and stage of growth, leaf area, and soil moisture.

Crop factors (CF) relate crop water demand to potential evapotranspiration (PET) as follows;

Crop water demand = PET x CF

We have used the following crop factors (Table 9) for the modelling.

Table 9: Crop factors for calculating PET for native trees and pasture

Month	Native trees[14]	Pasture
Jun	0.7	1.0
Jul	0.7	1.0
Aug	0.7	1.0
Sep	0.7	1.0
Oct	0.8	1.0
Nov	0.9	1.0
Dec	1.0	1.0
Jan	0.9	1.0
Feb	0.8	1.0
Mar	0.8	1.0
Apr	0.8	1.0

[14] Chunwei Liu, Ge Sun, Steven G. McNulty, Asko Noormets, Yuan Fang (2016) Environmental controls on seasonal ecosystem evapotranspiration/potential evapotranspiration ratio as determined by the global eddy flux measurements.

Month	Native trees[14]	Pasture
May	0.8	1.0
Jun	0.7	1.0

Initially, after planting trees, CCC intends to lightly graze the pasture between the tree rows to control pasture and weed growth. This could result in drainage to groundwater being similar to the current land use situation. By the time irrigation is installed and operating, trees will be up to 4 years old and the tree crop factors will dominate water use. The modelling will account for the increased drainage due to tree crop factors being lower than pasture.

6 TREATED WASTEWATER FLOWS

The flows delivered from the WWTP to the irrigation fields depend on:

- Flows from the Akaroa sewerage system into the WWTP.
- Storage.
- Maximum daily application depths (the irrigation design and operation).
- Seasonal application depths.
- The percentage of land actually irrigated within the land designated for irrigation.

6.1 Wastewater Treatment Plant Flows

PDP (2018)[15] carried out water balance modelling of the inflows and outflows for the proposed WWTP system. Stantec provided Aqualinc with copy of a PDP spreadsheet[16] that included the results of the modelling based on an irrigated area of 40 ha (PDP Option 4).

For the flows to the irrigation areas, PDP used three "nominal irrigation" application depths; 2.75 mm/d (Dec-Feb), 2.15 mm/d (Mar-May and Sep-Nov), and 1.5 mm/d (Jun-Aug). In the PDP model, where water would be available from the WWTP, these depths were applied daily except on days where rainfall exceeded 50 mm. On those days, no water was supplied for irrigation.

We have used the PDP nominal application depths as our starting point for irrigation supply from the WWTP because the PDP modelling was based on a defined area (40 ha) that we can use to define application depths for the irrigable area (35.7 ha from Table 5). Also, the PDP modelling has taken into account the predicted flows into the WWTP and the storage associated with the supply.

A summary of the WWTP volumes and depths applied over 40 ha (PDP spreadsheet) and the revised area of 35.7 ha, assuming the volume is spread evenly over the area is given in Table 10.

Table 10: WWTP annual application volumes and depths

	WWTP volumes (m^3)	Depth applied over 40 ha (mm/y)	Depth applied over 35.7 ha (mm/y)
Average	205,500	514	576
Maximum	220,800	552	618
Minimum	193,400	483	542

6.2 Storage

In the PDP model, treated wastewater from the WWTP was routed directly to irrigation or to storage and then to irrigation. The storage was used as a buffer to absorb peak flows.

CCC are proposing to install storage tanks on land in the Robinsons Bay Valley irrigation area. While land will be irrigated using treated wastewater directly from the WWTP, irrigation will also be able to gravity feed from the storage tanks or be pumped from the tanks to higher areas of land. We have

[15] PDP (2018) Irrigation Model Results for Land Disposal of Treated Wastewater at Goughs Bay, Robinsons Bay and Pompeys Pillar.
[16] PDP Spreadsheet: 20210614_002_Qcap_noIIRed_Output_40ha.xlsx

accounted for land for tank siting when determining the most suitable land area for irrigation in Robinsons Bay Valley.

6.3 Application Depths

6.3.1 Daily application depths

We have used the PDP daily application volumes for determining depths of application on 35.7 ha and from those we have calculated the volume of water draining through the soil profile (Table 10).

The summer peak daily delivery volume from the WWTP (from the PDP spreadsheet) is 1100 m^3/day.

Because the PDP volumes were based on an irrigated area of 40 ha, we have increased the PDP application depths for the 35.7 ha area by a factor of 1.12 to maintain the same total volume of application to the 35.7 ha.

To maintain the same volume of application, the daily application depths designed to be applied by the irrigation system (the daily design rate) depend on the number of driplines and the actual area wetted by each dripline. Reduced irrigated area such as resulting from one dripline per tree row results in increased application depths applied to the soil and increased drainage through the soil profile.

For the various dripline spacing options, the PDP daily application depths have been multiplied by the following factors to determine maximum daily design rates for each spacing (Table 11). The wetted areas are based on the driplines creating a 50 cm wetted strip along each dripline (refer to Section 7.3).

Table 11: Adjustment factors to PDP application depths

Scenario	Wetted area as percentage of total area	Application depth multiplier	Maximum daily design rate (mm/d)
Single dripline between tree rows	25%	4.48	12.3
Two driplines between tree rows	50%	2.24	6.2
Three driplines between tree rows	75%	1.49	4.1
Four driplines between tree rows	100%	1.12	3.1
Base Case (PDP volumes applied to 40 ha)	100%	1.00	2.75

An application depth of 2.75 mm/d over 40 ha is equivalent on a 35.7 ha system to an irrigation application depth of 12.3 mm/d for a single dripline system, 6.2 mm/d for a two-dripline system, 4.1 mm/d for a three-dripline system and 3.1 mm/day for a four-dripline system. Run times per day range from 46 minutes for a four-dripline system to 185 minutes for a single dripline system.

Because the irrigation system operation will be fully controllable, the actual depths applied in an irrigation event may vary from the design rates depending on the operation of the system. For example, the irrigation system operator may choose to apply twice the daily depth of water once every two days. Alternatively, the operator may choose to apply the daily depths in two events per day to mitigate the risk of ponding and runoff. A fully controllable irrigation system enables a wide range of application strategies to be tested to determine the strategy that delivers the best outcomes – little or no runoff due to irrigation, optimal uptake by trees, reduced drainage, and to enable the system to be turned off for public access or maintenance.

6.3.2 Annual application depths and drainage volumes

Using Irricalc, we have determined the relationship between daily design rates based on 1-4 driplines per tree row and annual drainage through the soil profile for pasture and trees (Figure 9). This includes both the irrigated and unirrigated areas for pasture and trees as outlined in Table 11.

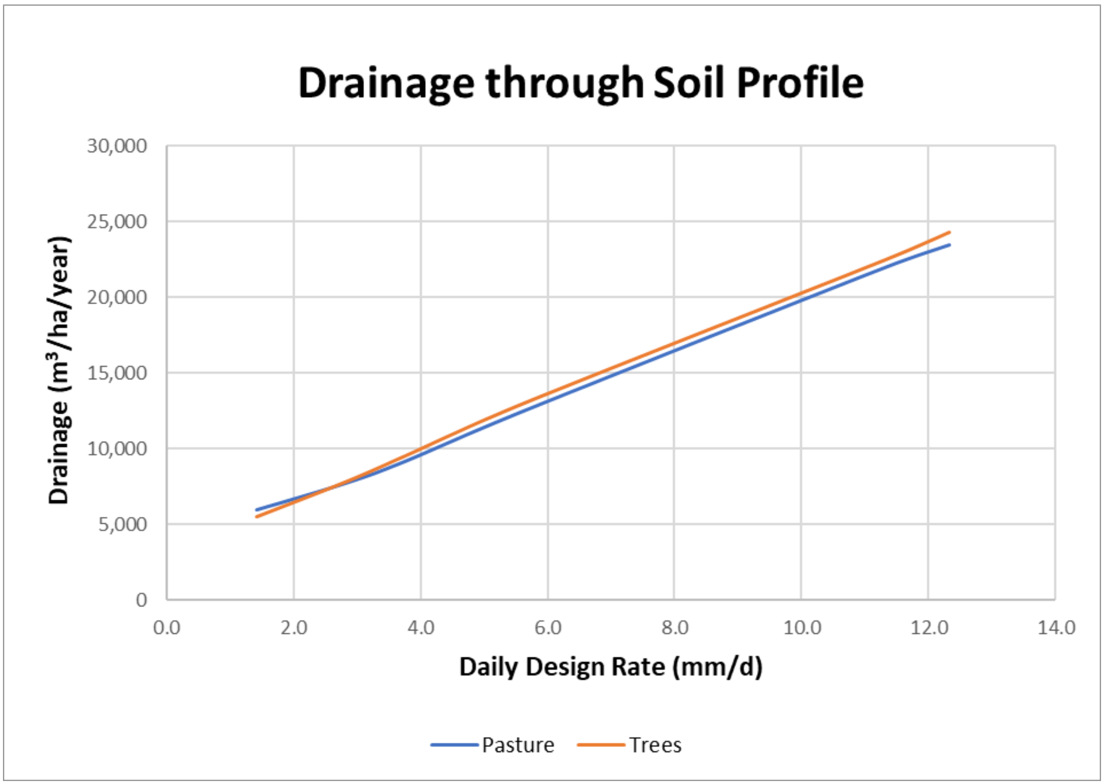

Figure 9: Drainage through the soil profile for a range of daily design rates

Figure 9 shows that drainage on the irrigated land increases linearly with increasing daily design rate. To minimise drainage through the soil profile, four driplines per tree row are recommended. This results in a maximum daily design rate of 3.1 mm/d.

Based on the PDP Option 4 data (Table 10), typical annual application depths over 40 ha are predicted to be 483-552 mm/y, with an average of 514 mm/y after allowing for turning off during rainfall events greater than 50 mm/d or reduced applications during restricted supplies from the WWTP.

The annual application volumes and depths in the wetted areas for four driplines is given in Table 12 for a total potential irrigated area of 35.7 ha.

Table 12: Annual application volumes and depths

	Volume (m^3/y)	Four driplines depth (mm/y)
Average	205,500	576
Maximum	220,800	618
Minimum	193,400	542

Meister et al (2020)[17] recommend annual irrigation depths of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula, at least initially, of 500– 800 mm/y. These depths are consistent with the four-dripline option. Meister et al indicate that higher application depths again may be feasible.

It is possible to apply large annual depths of water through a drip system, but high application depths will result in increased drainage to groundwater and potentially, surface runoff under wet conditions. Surface runoff can be mitigated by good irrigation management practices.

In our opinion, annual application depths will be primarily limited by the effect of drainage water and contaminants moving through the soil profile into sensitive environments, not on whether it is physically possible to apply the water.

[17] Meister et al (2020) A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula.

7 HYDRUS MODELLING

The approach we took to determine suitable irrigation design parameters for surface and subsurface drip systems was to use Hydrus (Section 5.3.1) to model a range of scenarios to determine the ability of water to infiltrate the soil, the potential for surface ponding, water lateral spread (soil wetted volumes) and drainage through the soil profile.

Once the design parameters had been determined, we applied those parameters to specific irrigation scenarios to complete the conceptual design and then used Irricalc (Section 5.3.2) for the catchment-scale assessments.

7.1 Hydrus Model Parameters

The input parameters used for the Hydrus soil water balance modelling were:

- Dripper spacing: 30 cm, 50 cm.
- Dripper flowrate: 1 lph, 2 lph.
- Subsurface dripline depth: 20 cm.
- Modelled soil depth: 1 m.
- Manuka tree row spacing: Nominally 2 m (from CCC), with the tree placed 25 cm from the closest dripline.
- Manuka rooting depth: 1 m (from Watson and O'Loughlin (1985)).

These parameters were either based on information provided to us or selected based on our experience of what is relevant in these circumstances.

7.2 Irrigation Scenarios

The scenarios we have analysed using Hydrus are:

- Dripline placement: surface, and subsurface
- Dripper run times: variable - set to apply a specified daily volume.
- Layout: (a) single dripline. (b) driplines at 50 cm spacing (equivalent to a four-dripline option).
- Land slope: flat, 4, 9 and 19-degree slopes.
- Plant water uptake: pasture and/or manuka trees

These scenarios covered the range of options that could be considered for design of the irrigation for the sites.

7.3 Initial Hydrus Modelling

Initially we modelled the operation of a single line of drippers (surface and subsurface) without plant water uptake assuming bare soil at an initial soil moisture content of 33% (slightly drier than field capacity) to determine the wetted volumes that would occur under or around the drippers for applied daily volumes over the range of 2 – 24 litres per dripper per day.

The simulation results for 30 cm dripper spacing and 2 lph dripper flow are summarised in Table 13.

Table 13: Spread of water over various daily application volumes

Daily volume of application (L/dripper/d)	Run time (h/d)	Wetted width (cm)
2	1	40
10	5	45
14	7	48
18	9	52
48	24	74

This analysis was used to determine the likely closest spacing that could be recommended for irrigation water application.

Table 13 shows that the spread of water increases with increasing daily application volumes. At low application volumes (2 L/dripper/d for example), the modelling predicted that water spread will be in the order of 40 cm. Higher application volumes result in a greater spread of water. We are recommending a dripline spacing of 50 cm.

The analysis also supported a dripper spacing of 30-50 cm along the dripline for efficient irrigation. We recommend a spacing of 30 cm, as it will deliver a wetted strip (overlap) along the dripline. A 50 cm spacing will tend to deliver a series of circular wetting patterns at low volumes.

For given soils, the volume of water applied tends to drive the degree of water spread. While we recommend a flow of 2 lph and dripper spacing of 30 cm, different combinations of dripper flow rates, dripper spacings and run times could be used equally as well to distribute the required irrigation water volumes. This will be finalised during the final design process.

7.3.1 Infiltration

The Hydrus analysis showed that the soil is capable of absorbing large quantities of water. The highest application volume modelled of 48 litres per day shown in Table 13 is equivalent to an application depth of about 22 mm/d, which, under the water volumes available from the WWTP, could amount to an annual application of over 4,000 mm/y.

The ability of the soil to infiltrate the applied water is consistent with PDP's statement that their maximum irrigation application depth per day (2.75 mm/d) is much less than the long-term acceptance rate of the soils.

7.3.2 Multiple driplines

While the analysis of single driplines without overlap was appropriate for native tree irrigation at 50 cm dripline spacing, close-spaced multiple driplines will be required for irrigation of Jubilee Park to ensure uniform cover.

The interaction between multiple driplines with a dripline spacing of 50 cm was modelled for the various discharge volumes on Barrys Bay loess and found to prevent significant dry strips between the driplines at the higher application volumes. However, we note that Jubilee Park is reclaimed land and there will be local variability in soil properties and application volumes will be low. We believe that a 40 cm dripline spacing will be more appropriate. Once consents are secured and before the irrigation design is finalised, field testing must be carried out to be able to either confirm this spacing or amend it to suit the local conditions.

7.3.3 Effect of plant water uptake

When root water uptake is included in the modelling, the soil moisture distribution becomes more uneven, i.e. drier in the vicinity of the manuka tree roots. Importantly, this analysis shows that plant water uptake will depend on root placement and that drip zones that are not traversed by tree or pasture roots will be wetter than zones that have root water uptake.

7.3.4 Surface ponding

The modelling showed that there is some potential for surface ponding to occur, both directly on the land surface under the driplines or from moisture moving up to the surface from buried driplines.

We found that the potential for ponding depends primarily on the degree of wetting of the soil profile due to rainfall. We do not expect any ponding during summer when the soil surface is unsaturated (assuming the soil surface does not become hydrophobic). In winter, if the soil surface is saturated, ponding will be more likely to occur. Our analysis indicates that the surface ponding will be a small percentage (<1%) of the total water applied during very wet periods.

Ponding in itself does not normally cause runoff. In fact, under drip systems, significant runoff is very rare. In most circumstances, ponded water infiltrates quickly into the soil at or near to the location of the drippers.

The potential for runoff resulting from ponding depends on factors such as ground slope and groundcover, antecedent soil moisture conditions and applied volumes. Noting that irrigation is not proposed during rainfall events greater than 50 mm/d and noting that irrigation volumes will be low in winter, it is our view that runoff resulting from irrigation applications can be minimised or perhaps prevented through appropriate irrigation management – not irrigating during wet periods, small application volumes at one time and pulsing of applications if necessary. As part of the operational strategy, we recommend that the operation is monitored visually in the field and the application volumes adjusted to prevent runoff.

7.3.5 Land slope

A wide range of land slopes exist over the proposed irrigated areas.

While Jubilee Park is flat, the areas proposed to be under irrigated native trees (Robinsons Bay Valley and Hammond Point) varies from flat to 20 degrees slope or more.

Our Hydrus modelling has shown that once water has infiltrated into the soil, land slope will have virtually no impact on the movement of water through soils (as gravity dominates). It will also have very little impact on plant water uptake. On that basis, for hydraulic assessments, we assumed that the land is flat.

Land slope is important from a practical perspective of planting and maintaining trees, and for installing and maintaining driplines. While it is relatively easy to lay driplines on slopes, installing mainlines and submains may be more challenging, especially across slope. This will be an issue that will need to be addressed during final design of the system.

Where driplines are placed on steep downhill slopes, it will be important to select a dripline type that prevents drainage from the drippers after each irrigation event. Otherwise, water will drain out of the pipes into lower areas potentially causing excess watering and ponding. Anti-draining dripline is readily available.

7.4 Findings of Initial Analysis

The initial analysis has allowed us to determine the following:

- A dripper spacing along the dripline of 30 cm is appropriate for design.

- Dripline spacings greater than 50 cm will, in all probability, not result in significant overlap between wetting patterns. This means that each dripline can be treated as an independent line if dripline spacings are 50 cm or greater.
- The result of having dripline spacings wider than about 50 cm is that the irrigation field will be a series of wetted strips separated by unirrigated (dryland) strips.
- On the Robinsons Bay Valley and Hammond Point sites, we recommend four driplines spaced 50 cm apart between each tree row to minimise drainage through the soil profile.
- If a fully wetted area is required (such as for Jubilee Park), dripline spacings will need to be relatively close. We recommend they be spaced 40 cm apart, based on our initial assessments. Before the irrigation design is finalised, field testing must be carried out to be able to either confirm this spacing or amend it to suit the local conditions.
- We understand that trees will be planted up to four years before irrigation is installed and that the tree line spacing will be 2 m apart. The tree root volumes initially are likely to be insufficient to take up all the water applied to the land initially. This will change as the tree roots spread across the area between the tree lines.
- Prior to full canopy coverage, pasture will take up the wastewater.
- The soil has the capability of taking in high volumes of irrigation water through the drip system. This could be as high as 4,000 mm/y, if required. Soil hydraulic capacity is not likely to limit application volumes.

8 CONCEPTUAL SYSTEM DESIGN

8.1 Conceptual Layout

A drip irrigation system consists of the following key components:

- A water source: Treated wastewater from the WWTP.
- A primary pumping system to move water from the source to the in-field irrigation system: this will be provided at the WWTP.
- Filtration: provided at the WWTP.
- Mainlines: the main pipelines used to transfer water from the WWTP to the irrigation areas. This includes the pipeline to the storage tanks in Robinsons Bay Valley.
- Branch or secondary mains: pipelines to transfer water from the mainlines to control valve stations.
- Control valve stations: a combination of components to provide pressure and flow control to irrigation blocks. The primary purpose is to turn irrigation blocks on and off.
- Irrigation blocks or zones: a group of submains and driplines that operate as a single unit.
- Submains: pipelines that take water from the control valve station and feed it into driplines.
- Driplines: lateral tubes with integrated drippers.
- Drippers: devices integrated into the lateral tubes to control the flow of water to the ground surface and trees.
- Stations: a group of irrigation blocks that operate at the same time.

A conceptual layout of a drip irrigation system is given in Figure 10.

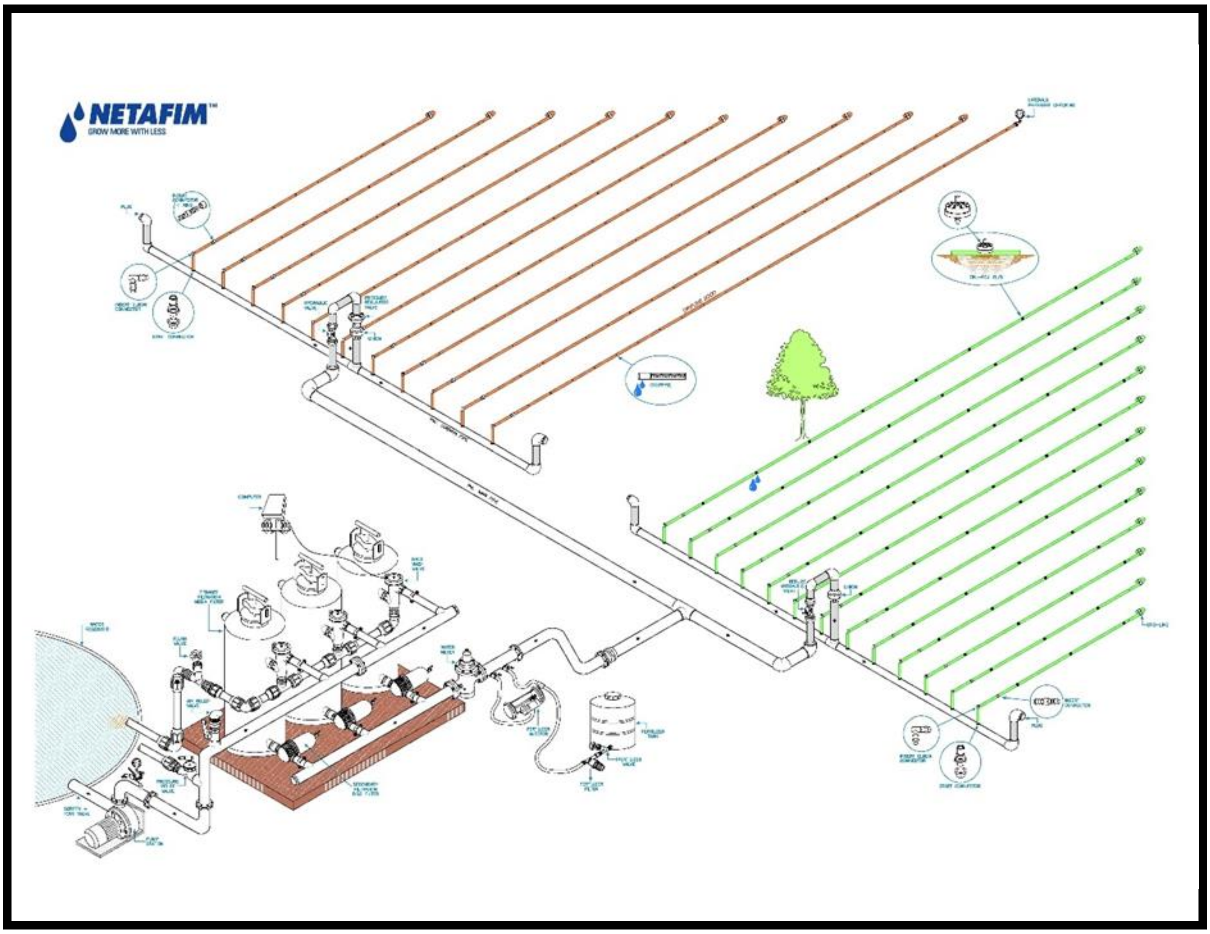

Figure 10: Conceptual drip irrigation system layout (courtesy of Netafim Irrigation)

While Figure 10 illustrates a fully pumped system, there will be a mix of pumped and gravity-fed sections on the Robinsons Bay Valley site, and possibly at Hammond Point.

8.2 Robinsons Bay Valley and Hammond Point Irrigation Areas

The area of land available to irrigate the native tree plantations proposed for Robinsons Bay Valley and Hammond Point has been described in Section 3. The actual depth of application depends on the irrigation system parameters, pipeline layout (specifically the number of driplines) and the volumes of water coming from the WWTP.

8.2.1 WWTP supply

Whenever possible, treated wastewater will be supplied directly to the irrigation blocks from the WWTP.

The summer peak daily delivery volume from the WWTP (from the PDP spreadsheet) is 1100 m^3/day. Assuming this volume is put through the irrigation system in 24 hours, an average flow of 13 L/s is required. To allow for downtime and to allow for the high degree of variability in the irrigation system layout, we suggest that the irrigation system be designed to apply the 1100 m^3/day in a notional time of 12 hours. This results in an irrigation design flow of 25 L/s.

The assumed operating hours per day is a key design parameter as it directly affects pipe, pumping and block sizes.

When the flow coming from the WWTP exceeds the capacity of the irrigation system to accommodate the full flow (for example, irrigation is turned off during and after heavy rainfall), treated wastewater will be stored in tanks on land within the Robinsons Bay Valley irrigation area.

As soon as the capacity of the irrigation system exceeds the flow from the WWTP, the excess capacity in the irrigation system will be used to irrigate from the storage tanks, thereby emptying the tanks.

This approach means that the tanks will be used to buffer inflows only when required and will be empty most of the time.

If the system design is based on 12 hours per day operation, there will be additional capacity in the system to empty tanks quickly and efficiently.

8.2.2 Filtration

To prevent blockages, drip irrigation systems almost always require water that is filtered to remove contaminants greater than 100 microns or 125 microns, depending on dripline manufacturers' requirements. Because treated wastewater will be supplied directly to the irrigation areas from the WWTP, water will need to be filtered at the WWTP. We have assumed that the treatment process will produce treated wastewater suitable for drip irrigation.

Because of the possibility of contaminants entering the system between the WWTP and the storage tank outlets, we recommend that a secondary filtration system (such as ring filters) be installed at the tanks.

8.2.3 Mainlines and branch mains

These will be located and selected (size and type) during the detailed design process.

8.2.4 Control valve stations

These will include items such as electric solenoid valves, pressure control where required, vacuum breakers and any other components needed to control and protect the irrigation system. We expect that control valve station components will be installed underground in lockable valve boxes to protect them from vandals and frost.

8.2.5 Irrigation blocks (zones)

Irrigation blocks will be configured to deliver irrigation water efficiently to the native tree areas. Block sizes will vary according to the shape of land parcels, locations of tree rows and varying topography within the sites. As far as possible, blocks will be configured so that water use by trees will be similar within each block. This will mean that where it is realistic to implement, sunny aspects will be separated from shady aspects, wetted areas separated from drier areas, and stony soils separated from non-stony areas. The number of irrigation blocks and flows of each block will be decided during final design.

8.2.6 Driplines

Due to the varying land contour, these will be pressure compensating, which means that they will be able to work efficiently over 25 m elevation variations. As far as possible, driplines will run along the contour, and submains perpendicular to the land contour.

Although we have notionally suggested dripper spacings of 0.3 m and dripper flow rates of 2 lph, the final dripper spacings and flows will be determined during the detailed design process.

8.2.7 Irrigation stations and zones per station

The number of stations and the number of irrigation blocks that will be run together on each station will be determined during final design.

Ideally, the irrigation system will be operated as equally-sized stations with a total flow equal to the flow being supplied from the WWTP. In practice, due to potentially uneven block and station flows, some variation will occur. This will be accommodated within the design. Flows being produced by the WWTP will also vary on a continuous basis. Storage within the WWTP and the storage tanks on the Robinsons Bay Valley site will be able to be used to smooth delivery flows to manage the station flows.

8.2.8 Irrigation operation

Each irrigation block will be controlled with an automatic solenoid valve, which means that any block can be irrigated for any time. In practice, the system will be configured so that stations with their associated blocks run sequentially in a cycle according to the availability of irrigation water.

The number of irrigation stations and the run times of each station depends on dripper flow rates and dripper spacings.

If a dripper flow of 2 lph and dripper spacing of 0.3 m is used and the notional daily operating time is 12 hours per day, the system will irrigate a zone area of about 0.7 ha with a run time of 14 minutes per day per station on average. Under this configuration, the system would need to include about 60 stations and therefore at least the same number of blocks to operate in this way.

Decreasing dripper flow to 1 lph and increasing dripper spacing to 0.5 m would increase the zone area to 2.3 ha with a run time of 46 minutes per day. The system would need 16-20 stations under this configuration to irrigate the 35.7 ha. This will be a much more practical option than trying to run 60 stations for 14 minutes per day.

The final number of blocks/stations will be determined during final design.

We suggest that irrigation applications be pulsed so that, for example, under the 1 lph/0.5 m dripper spacing option, a block would operate for 23 minutes, turn off for 23 minutes and then turn on for 23 minutes. This provides an easily available method for mitigating against surface ponding and potential runoff.

Because of the flexibility provided by automatic control, we also suggest that the system be operated on a cycle longer than one day. If, for example a four-day cycle was selected, the second option would operate for 92 minutes, turn off for 92 minutes and then turn back on for 92 minutes. The station would then be off for the next four days after which time it would repeat the cycle if needed. Taking this approach will also maximise the time that nutrient is held within tree root zones.

8.2.9 Maintenance

Most of the irrigation system will be relatively trouble-free. However, some aspects of the irrigation system will require maintenance from time to time.

The pipeline between the WWTP and the tanks may need to be flushed with clean water. This is something that will be addressed at detailed design. The flush water will be discharged through the drip irrigation system.

Driplines may also require periodic flushing. Flush velocities will be addressed at the detailed design stage, but, given the high quality of irrigation water delivered from the WWTP, flushing is expected to be infrequently required. The usual approach is to flush more frequently initially, say monthly, and if driplines stay clean, extend the flushing frequency out over time until a suitable flushing interval is identified. It could be six monthly, or even annually.

As the driplines are to be placed on the ground surface, they may be damaged by animals (rabbits, for example) or by humans (vandalism, or unintentional damage). Because drippers are integrated into the lateral pipelines, the most likely damage, it if occurs, will be to the dripline pipe (leaks). These faults are easily repaired by replacing the damaged dripline.

We recommend that (a) an inspection plan be put in place so that driplines are visually inspected at a defined time interval, and (b) a system be implemented to allow public reporting of damage to be reported to CCC. Visual inspections could start monthly to coincide with flushing and be extended out as conditions allow.

8.3 Jubilee Park

We assume that the potential irrigated area is approximately 1 ha (to be confirmed). Irrigation will be subsurface driplines at 20 cm depth.

Assuming a dripper flow of 2 Lph, dripper spacing of 30 cm and dripline spacing of 40 cm, a 1 ha field will contain 83,333 drippers. For each hour of operation, 167 m^3 of irrigation water could be applied, which equates to an application depth of 16.7 mm.

If the dripper flow rate was 1 Lph, 8.35 mm would be applied for each hour of operation.

The potential for drainage under Jubilee Park can be minimised by deficit irrigating – i.e. managing the irrigation applications to only apply water when needed to maintain soil moisture above a minimum threshold sufficient to prevent the grass browning off. This will be simple to achieve using soil moisture monitoring.

Under a deficit irrigation scenario, on average 297 mm of irrigation water could be applied annually to Jubilee Park to keep it green. This would require 18 hours of operation annually for a dripper flow rate of 2 Lph, or 36 hours of operation annually for dripper flows of 1 Lph.

9 IRRICALC MODELLING

The performance of the irrigation system at a catchment level depends on the configuration of the system. The analysis must include consideration of the physical layout of driplines and the uptake by the trees at various growth stages.

We have used the results of the Hydrus modelling to feed into the IrriCalc software analysis to determine the overall water balance for a catchment on a per hectare basis. IrriCalc allows a longer time-series (i.e. multiple decades) to be modelled, which fully accounts for climate variability.

9.1 Irrigation Scenarios

Plant water uptake will depend on the configuration of the irrigation system, the layout and the stage of growth of pasture and trees.

There are four situations to consider:

1. Pasture under unirrigated conditions.
2. Pasture under drip irrigated conditions.
3. Native trees under unirrigated conditions.
4. Native trees under drip irrigated conditions.

Each of the above situations has been analysed using IrriCalc. A summary of the drainage under various combinations of unirrigated and irrigated pasture and trees was given in Section 6.3.2 (Summarised in Figure 9).

Figure 9 shows that the difference in drainage between pasture and trees is relatively small. This means that plant type (pasture or trees) is not a major determinant of drainage through the soil profile. Drainage will therefore be determined primarily by how much of the land is irrigated or unirrigated and on the design capacity (mm/day) of the irrigation system.

9.1.1 Robinsons Bay Valley and Hammond Point irrigation development scenarios

Total water uptake and nutrient uptake at any time will depend on what percentage of each of the four situations listed in Section 9.1 applies.

The primary current use is pasture for livestock grazing. This is represented by pasture under unirrigated conditions.

Initially, when the trees are planted, there will be small strips of trees growing under unirrigated (or potentially irrigated) conditions with the inter-rows being pasture growing under unirrigated conditions. After three or four years, the tree canopy will expand and the pasture area will reduce.

If an irrigation system is installed soon after tree planting, whether the trees are actually irrigated will depend on dripline placement. That will depend on the development programme. If a single dripline is initially installed, we recommend that the dripline be placed close to the tree line. This would mean that the trees would be irrigated from one side and most of the grass inter-row would be unirrigated.

The situation can be improved with a second dripline installed close to the tree line on the opposite side. While this would still mean that the pasture inter-row was largely unirrigated, the trees would be better served by a dripline on each side of the row.

Over time, tree roots will move into the inter-row, and the canopy will grow over the area and supress the pasture. The irrigation water uptake area will vary according to dripline position. This will depend on the stage of growth of trees at the time irrigation is installed.

If the tree rows are irrigated when the trees are small, we recommend a single dripline be placed on one side of the tree row as it would sustain tree growth during drought conditions when trees are establishing. As trees develop, a second dripline should be added on the other side of each tree row.

When the canopy has expanded, a third dripline should be added in the centre of the row between the other two driplines. To reduce drainage further, a fourth dripline should be added in the inter-row.

A summary of the assumed percentages of irrigated and unirrigated pasture and trees under six scenarios covering a progressive development programme is given in Table 14. The table includes assumes values for canopy/tree root coverage and how that could be related to the number of driplines.

Table 14: Summary of assumed inter-row percentage of area covered by each scenario

Scenario	Number of driplines	Canopy/ root coverage (%)	Dripline placement	Pasture Unirrigated (%)	Pasture irrigated (%)	Trees unirrigated (%)	Trees irrigated (%)
Dryland	0	0	-	100	0	0	0
1	One dripline	25	25 cm from tree row on one side	62.5	12.5	12.5	25
2	Two driplines	50	25 cm from tree row on each side	50	0	0	50
3	Three driplines	75	25 cm from tree row on each side plus one in centre	0	25	25	50
4	Three driplines	100	25 cm from tree row on each side plus one in centre	0	0	0	75
5	Four driplines	100	Four equally spaced driplines	0	0	0	100

The average annual drainage through the soil profile will depend on what irrigation infrastructure is in place (the number of driplines), the volume of irrigation water put through the irrigation system (which is expected to increase over time from current volumes to the long-term predicted volumes) and the tree development stage (that will ultimately be full cover).

The long-term position is represented by Scenario 5 in Table 14. Scenario 5 (four driplines per tree row), will result in 100% of the land being irrigated, provides the lowest drainage because the daily design rate is as low as it can be (3.1 mm/d from Table 11) on 35.7 ha of land.

Under Scenario 5, the average daily depth applied is 2.3 mm/d. This will result in an average annual drainage through the soil profile in the order of 8,400 m^3/ha/y or 301,000 m^3/y over the 35.7 ha.

9.1.2 Jubilee Park

We recommend that Jubilee Park will be irrigated with close-spaced drippers and driplines and on that basis we expect that irrigation coverage will be 100%.

The potential for drainage under Jubilee Park can be minimised by deficit irrigating (See Section 8.3). This will be simple to achieve using soil moisture monitoring.

We have used Irricalc to model the irrigation water applications for the following parameters.

- Soil plant available water: 60 mm. This is a low value, which we have used in the absence of detailed soils information for Jubilee Park. Using a low value is a conservative approach that will likely overstate drainage through the soil profile.
- Depth of water applied: 6 mm every 2 days when required. This provides a supply rate of 3 mm/d, which will be sufficient to keep soil moisture high enough to keep grass green.
- Soil moisture trigger level: 40%. This means that the soil will dry out sufficiently to mean that the 6 mm of applied water will not fully refill the soil profile. This will help to retain a soil moisture deficit and reduce the opportunity for drainage through the plant rooting zone.

The Irricalc modelling results show that, with deficit irrigation, sufficient moisture will be retained to keep the grass green by applying on average 297 mm/year of irrigation water. Drainage through the soils will be only slightly higher than under unirrigated conditions (590 mm/y on average compared to 560 mm/y with no irrigation). This is because all of the applied water is used by the grass and the additional drainage is due to rainfall falling on partially irrigated land.

Drainage will still occur during wet periods, such as in winter, but this will be driven by rainfall, not from the application of irrigation water.

10 CATCHMENT SCALE ANALYSES

10.1 Conceptual Quantitative Water Balance

We have modelled the catchment run-off using daily climate time-series data from 1/7/1972 – 30/4/2021.

The natural mean daily flow into streams in the catchments was calculated based on a dryland soil moisture balance. This flow is represented by the sum of surface runoff and subsurface flow that will eventually appear as streamflow.

From our review of the geology of Banks Peninsula, we have concluded that the potential irrigated area contains various depths of loess over basalt (igneous rock). While shallow groundwater has been identified in the Robinsons Bay Valley Catchment, there is unlikely to be large reserves of deep groundwater in Robinsons Bay Valley. We do know that small quantities of groundwater can be found at depth in fractured basalt.

We have concluded that the amount of drainage water that is likely to recharge deep groundwater is small. Drainage water may also follow a subsurface pathway that bypasses surface waterways. While we do not have detailed knowledge of deep groundwater pathways, it is our opinion that some drainage water will bypass Robinsons Bay Stream and either be stored in the underlying geological structures or find its way into Akaroa Harbour.

There is insufficient data to conceptualise the system in detail. For the Robinsons Bay Valley Catchment modelling, we have conservatively assumed that 99% of the drainage water will end up in Robinsons Bay Stream.

In Hammond Point, we found no evidence of shallow groundwater. Our assumption is that drainage from that area will find its way directly into Akaroa Harbour.

The conceptual water balance for the unirrigated scenario is shown in Figure 11.

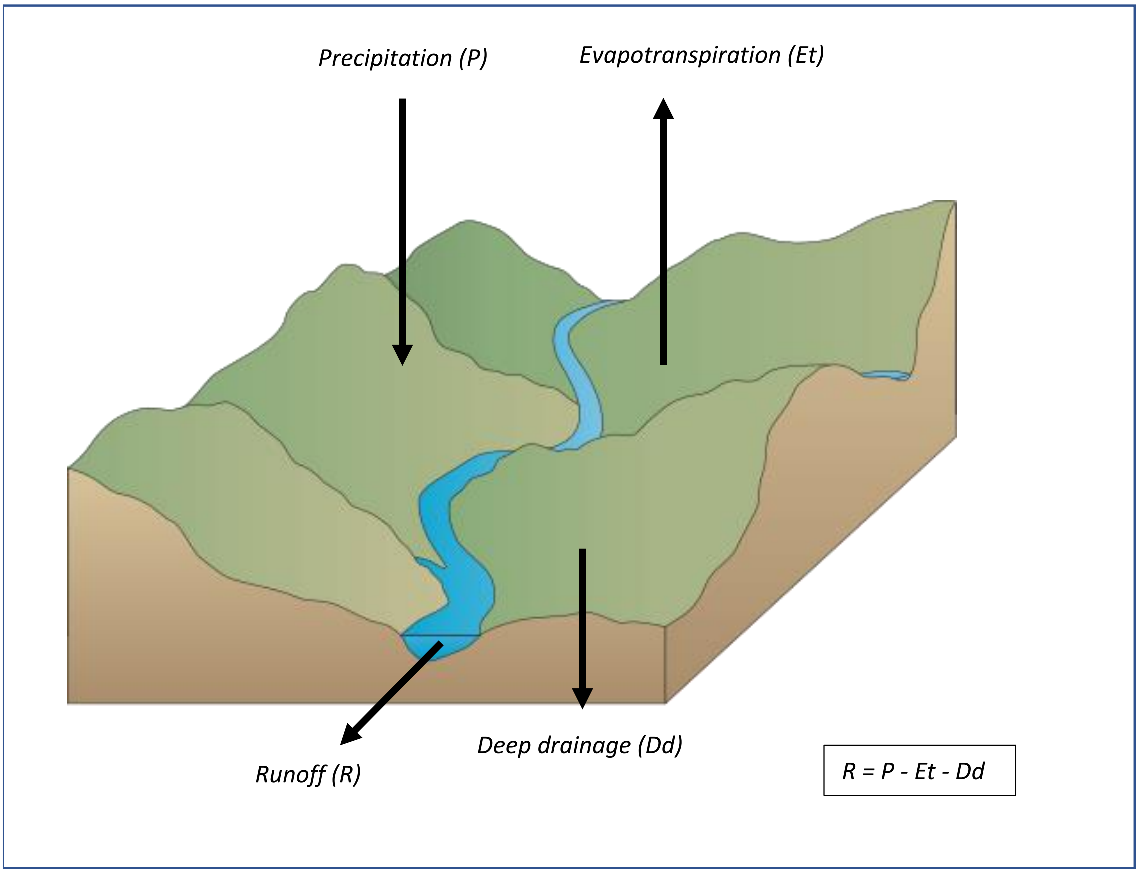

Figure 11: Conceptual water balance model for dryland (pre-irrigation) catchment

To assess the impact of the proposed irrigation on the catchment water balances, an irrigation component was added into the conceptual water balance model, as shown in Figure 12. We assessed the effect of the irrigation on the overall catchment water balance by comparing the flow from the dryland and irrigated scenarios in each catchment.

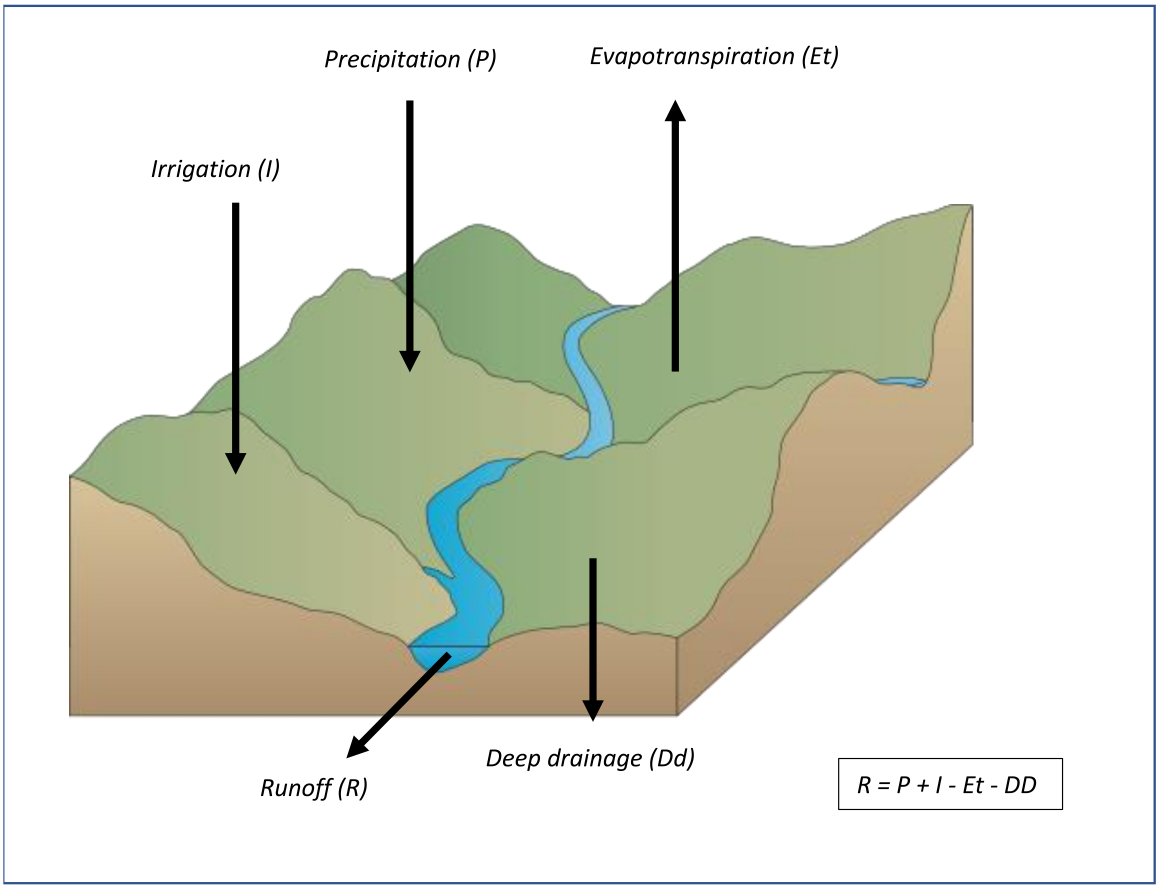

Figure 12: Conceptual water balance model including irrigation in the catchment

10.2 Nitrogen Balance

10.3 Literature review

A literature review identified limited information to quantify the potential for N leaching under native trees irrigated with treated wastewater.

Some relevant information is presented in Meister et al (2021)[18], which is a follow up to the Meister et al (2019)[19] report. Figure 13 below describes the nitrogen fluxes relevant to the application of treated wastewater.

[18] Meister et al (2021) A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninnsula
[19] Meister et al (2019) Impacts of nitrogen application to pasture and native plantings on Banks Peninsula

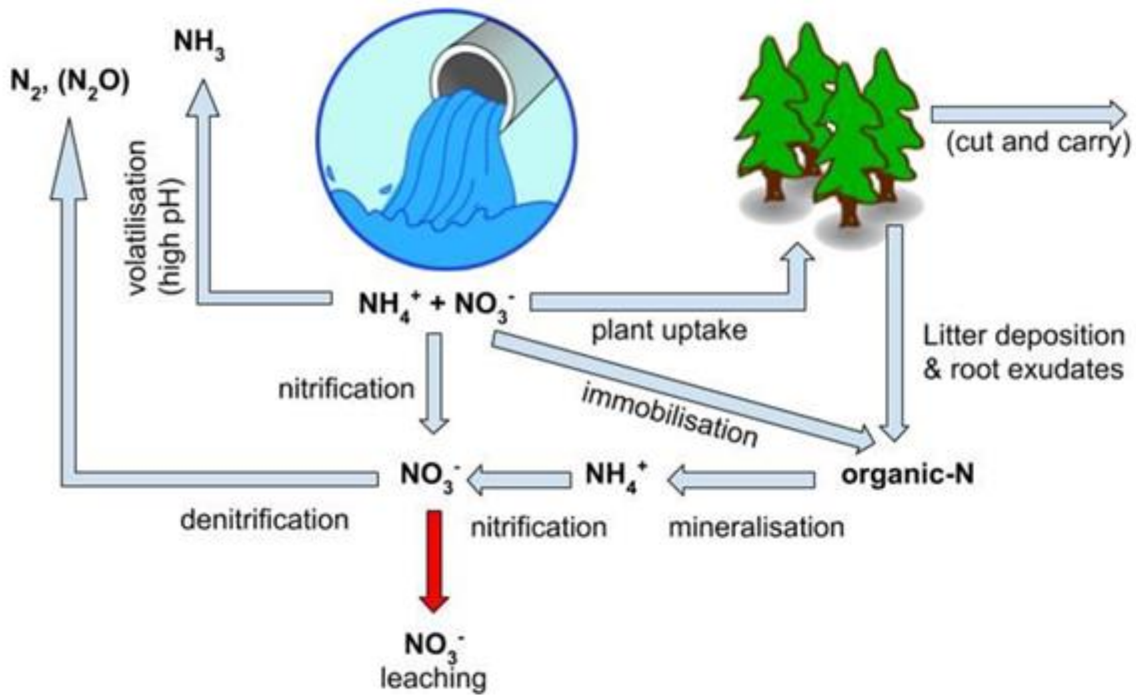

Figure 13: Nitrogen fluxes under treated wastewater applications (from Meister et al (2021))

The nitrogen fluxes reported in Meister et al (2021)[16] were based on three scenarios:

- Cut and carry pasture
- Grazed pasture
- Native trees (actively growing - not harvested)

While Meister et al reported that N leaching under cut and carry pasture was negligible, the paper provided little information on N leaching under native tree plantations. The paper presented estimated N uptake values based on a tree nitrogen content of 1% of dry weight, which equated to 50 kg N/ha/y. However, the paper reported that, assuming the trees are not harvested, N in the soil will eventually reach an equilibrium via leaf fall and tree senescence and little or no further uptake will occur. From that point, additional applied N will be lost through leaching or denitrification.

Further information is provided in the Meister et al (2021) report from their Pipers Valley trial site in Banks Peninsula, where N leaching under the control (unirrigated) set of native plants ranged from 4 to 35 kg N/ha/y.

We note that the potential N leaching under the application of treated wastewater to pasture was 2-47 kg N/ha/y, based on calculations made from measurements taken in 2018 (from Meister et al, 2021 Table 5).

At the Pipers Valley trial site referred to by Meister et al, after 2.5 years, the researchers found that the applied N was mostly stored in the trees or was stored in the soil. N concentrations at 0.6 m soil depth were relatively low, so they concluded that N leaching would be low.

Murray Davis (Davis, 2014)[20] reported N concentrations in streams in forested areas in NZ. In situations where land was converted from pasture to trees, he found that N in streams fell in the initial 2-4 years and then came to an equilibrium until trees were harvested, when the cycle was repeated. He stated that other than leaching, the only way that N is removed from a forested catchment is by fire or harvesting of trees. The implication of this is that while trees are actively growing (as in Pipers Valley) trees will store N but when the trees mature, they will naturally recycle rather than remove N.

The 2000 NZ Guidelines for utilisation of sewage effluent on land (NZ Land Treatment Collective, 2000)[21] states that forests take up and store nutrients, but they return a portion back to the soil. N uptake is low for the first 1-2 years, peaks at canopy closure and then decreases significantly as litter fall and decomposition supplies the tree needs. This is consistent with the work by both Davis and Meister et al.

While the Pipers Valley research found little or no evidence of N leaching, the assessments were done in the early years of native tree establishment, so did not cover the long-term. The researchers noted that there was no indication of luxury uptake of plant nutrients, that is the trees only took up the N they needed.

With respect to the Akaroa proposal, cut and carry pasture is not proposed. While, in theory, all applied N could make its way into waterways within the catchment, it is highly likely that some of the N will be taken up by trees or will not end up in drainage water for the following reasons.

- There will be some volatilisation in the air because of the surface drip application.
- There will be some denitrification in the soil.
- Trees will continue to take up N because they will continue to grow and store nitrogen.
- At some point in the future, some trees may be harvested.
- Some of the drainage water may bypass streams and ultimately end up in Akaroa Harbour.

While the majority of applied N will be taken up by trees in the short-term, Meister and Robinson (2022)[22], in a paper prepared for CCC, conservatively estimated that, in the long-term, for a mature stand of NZ-native vegetation, about 13.5 kg N/ha/yr will be lost from the system through non-returned plant uptake and denitrification from soil. They concluded that the remainder of the nitrate will leach.

As a result of the Meister and Robinson (2022) uptake estimates, in predicting the change in N concentrations in the Robinsons Bay Valley Catchment we have considered two uptake scenarios.

1. 13.5 kg N/ha/y of applied N will be volatilised or denitrified or taken up/removed by trees as suggested by Meister and Robinson.
2. All applied N from irrigation water will drain into groundwater and end up in the streams.

10.4 Land Use

The existing N concentrations in Robinsons Bay Stream is a reflection of current and historical land use.

We engaged Lumen Environmental Ltd (Lumen) to provide N leaching estimates for the Robinsons Bay Valley farm for the current/historical land use and for the farm if it was destocked.

[20] Davis, M. (2014). Nitrogen leaching losses from forests in New Zealand. New Zealand Journal of Forestry Science 2014 2014, 44:2.
[21] New Zealand Land Treatment Collective (2000). Guidelines for utilization of sewage treatment on land. NZLTC & Forest Research, Rotorua, New Zealand.
[22] Meister, A, and Robinson, B. (2022) An assessment of the likely fate of nitrate irrigated onto NZ-native vegetation with Treated Municipal Wastewater in Robinsons Bay, Banks Peninsula. Institute of Environmental Science and Research and PreUniversity of Canterbury

Lumen completed Overseer nutrient budgets for nitrogen and phosphorus in accordance with OverseerFM Best Input Standards, for the Robinsons Bay Valley Farm. The background data and results are reported in a memo prepared by Lumen (Messman, N. (2022)[23]). The results are summarised in Table 15. The Lumen memo is included in Appendix A.

Table 15: Overseer modelling results for dissolved inorganic nitrogen (DIN) and phosphorus losses on Robinsons Bay Valley farm

Scenario	Area (ha)	N loss (kg/y)	N loss (kg/ha/y)	P loss (kg/y)	P loss (kg/ha/y)
Current land use	118	756	6	201	1.7
Proposed - destocked	118	465	4	198	1.7
Change	0	-291	-2	-3	0

Lumen concluded that if the entire 118 ha (105 ha effective after adjusting for 13 ha of trees and scrub), Robinsons Bay Valley farm was retired from farming the predicted decrease in N loss would conservatively be around 291 kg N/yr across the farm. The decrease in N loss is solely due to the reduction in N deposited by grazing animals rather than any N uptake by new vegetation such as native plantings. The modelling excluded estimates of N uptake by trees.

Lumen also concluded that the predicted decrease in P loss is small because the number of grazing animals does not have much of an impact on this. P loss from the property is mostly driven by climate and vegetation (both of which are not changed in the modelled scenarios). The addition of a riparian margin and increased areas of natives would likely decrease the P loss.

10.5 Nitrogen Catchment Balance Scenarios

Following the work by Meister and Robinsons (2022) and by Messman (2022), we have assessed the N loss to Robinsons Bay Stream for the following four scenarios:

1. Base Case: Including (a) 13.5 kg/ha uptake/denitrification from the trees on the 31.9 ha irrigated area, and (b) the 2 kg/ha offset from destocking the 31.9 ha area.
2. Destock1: As for the Base Case, but with (a) 23 ha additional infill/riparian planting that is assumed to have the 13.5 kg/ha uptake and denitrification as the irrigated area, and (b) the 2 kg/ha offset from destocking this additional 23 ha area. In this scenario we have assumed that the riparian trees can access the leached N, so the 13.5 kg/ha uptake from Meister and Robinson applies. This is the scenario that is preferred by CCC.
3. Destock2: As for Destock1, with the remaining area of the property (63.2 ha) destocked. We note that although the remaining area may end up being planted in trees, we haven't used the 13.5 kg/ha uptake on it, as this number was based on trees with wastewater applied.
4. Conservative: No uptake, offset or destocking on any part of the property.

There is assumed to be no additional uptake from planting outside of the irrigated area at Hammond Point.

The Total Nitrogen (TN) in the treated wastewater targeted by CCC is 10 g/m^3. This corresponds to a dissolved inorganic nitrogen (DIN) concentration of 8.6 g/m^3 (Nitrate-N equivalent). DIN values have been used to calculate the N concentrations in the receiving environment.

[23] Messman, N (2022). Nutrient modelling Robinsons Bay Version 1. Lumen Environmental Ltd, 5th September 2022

To test the sensitivity of the N concentrations in the receiving environment to N concentrations in the treated wastewater, we have modelled TN ranging from 5-20 g/m^3, which corresponds to a DIN of 3.9 - 18 g/m^3. This sensitivity analysis has been completed for both the Robinsons Bay Valley site and the Hammond Point site.

The relationship between TN and DIN has been supplied by Stantec and is made up as shown in Table 16.

Table 16: Components of nitrogen in treated wastewater

Modelled TN (g/m^3)	NH_4^+ (g/m^3)	Organic N (g/m^3)	NO_3^- + NO_2^- (g/m^3)	DIN (g/m^3)
5	0.1	1.1	3.8	3.9
8	0.1	1.4	6.5	6.6
10[24]	**0.4**	**1.4**	**8.2**	**8.6**
12	0.5	1.5	10.0	10.5
16	0.5	1.8	13.7	14.2
20	1.0	2.0	17.0	18.0

In Table 16:

- In providing DIN it is assumed that near to full nitrification occurs. Hence, DIN is the sum of ammonia (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) nitrogen.
- Total Nitrogen Kjeldahl Nitrogen (TKN) speciation is as follows:
  - Ammonia
  - Organic nitrogen
  - Ammonia can vary in treated wastewater;
    - it is practical to assume that not all ammonia is nitrified
    - ammonia is nitrified in soils and is covered by DIN
  - Denitrification is a function of the treated wastewater TN limits and is a project design requirement.
- Summary:
  - The TN selected drives process design, which then influences the extent to which denitrification is required to achieve the consent TN concentration.
  - Denitrification is not included in the table as it is an outcome of the process.

10.6 Robinsons Bay Valley Catchment Nitrogen Mass Balances

10.6.1 Pre irrigation (status quo) scenario

Based on the estimated annual runoff and the median measured nitrate concentration from Robinsons Bay Stream, a status quo (pre-irrigation) catchment nitrate load was estimated for the Robinsons Bay Valley Catchment.

Baseline nitrate values for Robinsons Bay Stream are the median of all samples collected by Aqualinc and EOS Ecology at the downstream site in the catchment. Where there was less than five days between the sample dates, the samples were considered to be duplicates and the value from the EOS Ecology dataset was excluded. This approach provided us with 18 samples from Robinsons Bay Stream.

[24] A TN of 10 g/m^3 is preferred by CCC.

The median measured Nitrate-N in Robinsons Bay Stream was 0.0295 g/m^3. Wet-weather values were substantially higher than this: 0.51 g/m^3 on 3/8/21 and 0.188 g/m^3 on 16/12/2021. We know from the monitoring data that Robinsons Bay Stream is receiving nitrate in pulses after substantial rain events.

We did not expect that there would be an exact match between the modelled runoff values and the field measurements, as the flow gaugings provide a limited number of spot measurements over a period of less than one year. The mean gauged flows are for comparison only. However, they are in the right order of magnitude. In all cases the proposed irrigation (wetted) areas are a small proportion of the total catchment area, and therefore the change to the catchment water balance as a result of the additional irrigation water discharge is also small.

Also, we did not expect the Nitrate -N concentrations in Robinsons Bay Stream to reflect the N losses calculated by Lumen for the property. The Robinsons Bay Stream concentrations indicate a significantly lower catchment load than indicated by Lumen for the property, most likely because the larger catchment includes significant bush and non-farmed areas, and because there is likely to be some denitrification in the catchment.

Our catchment modelling assumes that the load from the catchment arrives evenly throughout the year because we do not know how long the transport pathway from various parts of the catchment to Robinsons Bay Stream will take. For this reason, we have modelled the catchment balance on an average annual basis, even though the inputs to the modelling are daily time-steps (as from IrriCalc).

10.6.2 Post irrigation scenarios

Post-irrigation scenarios as described in Section 10.5 were compared to give an estimate of the change in catchment runoff and nitrate concentration under each scenario. Post irrigation was based on 205,500 m^3/y inflow[25] from the WWTP.

The results of the catchment nitrogen mass balance analysis for the Preferred Scenario are summarised in Table 17 for the Robinsons Bay Valley Catchment and in Table 18 for the Hammond Point Catchment. A full list of results for all scenarios is given in Appendix A.

As a lot of the leached nitrate from the irrigated area is also likely to enter Robinsons Bay Stream and be flushed out in pulses after rain events, using mean annual values will tend to overstate Nitrate-N stream concentrations during baseflow (low-flow) periods.

10.7 Hammond Point Catchment Mass Balance

For Hammond Point, as there are no streams or groundwater for the site, there are no measured surface water or groundwater concentrations to allow a baseline to be back-calculated. Therefore, no post-irrigation concentration has been calculated. Likewise, there are no streamflow gaugings for Hammond Point. Although a change in total catchment runoff has been calculated, this is likely to occur as subsurface discharge to the coast.

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[25] This conservatively assumes that all treated wastewater is applied to the Robinsons Bay and Hammond Point catchments and does not make any allowance for irrigation of Jubilee Park.

10.8 Catchment Mass Balance Tables

10.8.1 Robinsons Bay Valley

Table 17: Summary of catchment water and nutrient balance results for Robinsons Bay Valley; Preferred scenario.

Catchment and land					Dry land NO_3–N		Irrigation water inputs										Stream flow						Stream Nitrate-N			
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Catchment (kg)	Load over Catchment (kg/ha/y)	Volume (m^3/y)	Total N in treated WW (g/m^3)	DIN (Nitrate-N equivalent) concentration (g/m^3)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area and riparian / infill areas (kg/y)	Plant uptake / denitrification (kg/y)	Lowest gauged streamflow, for comparison (m^3/s)	Highest gauged streamflow, for comparison (m^3/s)	Mean modelled status quo stream flow (m^3/s)	Mean stream flow post irrigation (m^3/s)	Increase due to irrigation (m^3/s)	Change due to irrigation (%)	Median measured (g/m^3)	Estimated post irrigation (g/m^3)	Increase due to irrigation (g/m^3)	Increase due to irrigation (%)
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	5	3.9	716	0.5	6.1	22.5	22.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.018	-0.012	-41%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	8	6.6	1,212	0.9	10.3	38.0	38.0	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.058	0.028	93%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	10	8.6	1,580	1.2	13.4	49.5	49.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.087	0.057	191%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	12	10.5	1,929	1.4	16.3	60.5	60.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.115	0.085	285%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	16	14.2	2,608	1.9	22.1	81.8	81.8	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.170	0.140	467%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	20	18	3,306	2.4	28.0	103.6	103.6	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.226	0.196	654%

Notes:

1. Dryland N load is back-calculated from the water quality measurements in Robinsons Bay Stream and the modelled average annual run-off. It is based on a limited number of measurements, assuming that the measurements are representative of the long-term value.
2. Gauged stream flows are not used in the modelling/analysis, as there are only a limited number of spot gaugings. These are included for comparison only.

10.8.2 Hammond Point

Table 18: Summary of catchment water and nutrient balance results for Hammond Point; Preferred scenario

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Coastal Seepage					
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Property (kg)	Load over Property (kg/ha/y)	Volume (m^3/y)	Total N in treated WW (g/m^3)	DIN (Nitrate-N equivalent) concentration (g/m^3)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest measured seepage, for comparison (m^3/s)	Highest gauged seepage, for comparison (m^3/s)	Mean modelled status quo catchment discharge (m^3/s)	Mean catchment discharge post irrigation (m^3/s)	Increase due to irrigation (m^3/s)	Change due to irrigation (%)
65	11.9	3.8	3.8	5.86%	71	6	21,895	5	3.9	85	1.3	7.2	22.5	22.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	8	6.6	144	2.2	12.1	38.0	38.0	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	10	8.6	181	2.8	15.2	47.5	47.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	12	10.5	230	3.5	19.3	60.5	60.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	16	14.2	311	4.8	26.1	81.8	81.8	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	20	18	394	6.1	33.1	103.6	103.6	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%

Notes:

1. There are no streams to allow pre or post irrigation concentrations to be determined. This is why the measured seepage values are reported as N/A (i.e. not applicable) Reported values are total catchment runoff, which is likely to be shallow subsurface discharge to the coast.
2. There are no measured surface water nitrate concentrations to back-calculate a dryland loading for the entire catchment, therefore no future concentration has been calculated.
3. A dryland Nitrate-N load for the property was estimated using the nutrient budget prepared by Lumen for the Robinsons Bay Valley property (see Appendix A).

10.9 Summary of Results

10.9.1 Robinsons Bay Valley

A summary of the results of the catchment mass balances for Robinsons Bay Valley is given in Table 19.

Table 19: Summary of results for Robinsons Bay Stream for a treated wastewater TN concentration of 10 g/m³.

Scenario	Median stream flow (L/s)	Increase in stream flow (L/s)	Resulting stream flow (L/s)	Median measured N concentration in stream (g/m³)	Increase in N concentration in stream (g/m³)	Resulting N concentration in stream (g/m³)
Base Case	386	8	394	0.030	0.086	0.116
Preferred	386	8	394	0.030	0.057	0.087
Destock 2	386	8	394	0.030	0.047	0.077
Conservative	386	8	394	0.030	0.126	0.156

10.9.2 Hammond Point

A summary of the results of the catchment mass balances for Hammond Point is given in Table 20.

Table 20: Summary of results for a treated wastewater TN concentration of 10 g/m³.

Scenario	Mean modelled catchment discharge (L/s)	Increase in catchment discharge (L/s)	Resulting catchment discharge (L/s)	Increase in N load in catchment (kg N/y)
Base Case	18	1	19	129.7
Preferred	18	1	19	122.1
Conservative	18	1	19	181.0

10.9.3 Jubilee Park

Assuming a TN concentration of 10 g/m³ (DIN of 8.6 g/m³) in the irrigation water, and a depth of 297 mm/y is applied over 1 ha, the applied nitrate-N load will be 25.5 kg/y. Assuming that this nitrogen is evenly mixed in the drainage water, the 30 mm of additional drainage (refer to Section 9.1.2) would result in a an additional leaching loss of approximately 1.4 kg/y of nitrogen if there was no plant uptake. In practice, most of the applied nitrogen will be taken up by the grass as it is efficiently applied with irrigation water during the summer months when needed most by the grass. This will result in little or no leaching to waterways. If nitrogen fertilizer is currently applied, it may be possible to replace some or all of the nitrogen fertilizer with the nitrogen in the irrigation water.

11 CONCLUSIONS

11.1 Robinsons Bay Valley and Hammond Point

- Our estimate of the most suitable potential irrigable area on Robinsons Bay Valley and Hammond Point is 35.7 ha.
- On these sites, the soil has the ability to take up large quantities of water, up to 22 mm/d. Irrigation water infiltration into the soil from drip irrigation under the proposed layout is not likely to be limited.
- Hydrus modelling has shown that a dripper flow rate of 2 litres per hour (lph) with drippers spaced at 30 cm along the dripline could provide a continuous wetted strip along each dripline. The dripper wetted strip will extend about 25 cm on each side of the dripline forming a wetted strip about 50 cm wide.
- The Hydrus modelling has also predicted that ponding resulting from irrigation is likely to be minimal.
- Four driplines per tree row is recommended to minimise the potential for ponding and runoff, and to minimise drainage through the soil profile.
- The total amount of water that can potentially be taken up by trees and pasture is insensitive to plant mix. The amount of plant water uptake primarily depends on whether the areas are irrigated or not. Significantly more water is used by plants in irrigated areas than in dryland areas.
- With the average annual volume of treated wastewater set at 205,000 m^3/y, the annual depth of irrigation water applied will be 576 mm).
- Drainage through the soil root zone under the driplines is insensitive to plant mix (trees or pasture). The recommended irrigation configuration results in 8,400 m^3/ha/y or 301,000 m^3/y to be applied over 35.7 ha. The average daily depth is 2.3 mm/d.
- Drainage through the root zone overall has the potential to affect flows and Nitrate-N concentrations in Robinsons Bay Stream.
- The change in flow in Robinsons Bay Stream depends primarily on the irrigated area relative to catchment area. The estimated average annual increase in flow due to irrigation in Robinsons Bay Stream is 8 L/s (1.9%). The increase in discharge from Hammond Point to the Coast is expected to be in the order of 1 L/s (4%).
- The increase in Nitrate-N concentrations in Robinsons Bay Stream resulting from the proposed irrigation depends primarily on nitrate concentration in the irrigation water combined with the irrigated area relative to catchment area, and on the degree of N uptake by trees.
- N uptake by trees and other factors such as denitrification is estimated to be 13.5 kg N/ha/y.
- The impact of destocking the land is estimated to be 2 kg N/ha/y.
- The mean Nitrate-N concentration of Robinsons Bay Stream, based on available water quality measurements is 0.03 g/m^3.
- Assuming a treated wastewater TN content of 10 g/m^3 (DIN concentration of 8.6 g/m^3) and allowing for N uptake and destocking the irrigable area, the increase in Nitrate-N concentration in Robinsons Bay Stream is estimated to be 0.086 g/m^3 resulting in a stream concentration of 0.116 g/m^3.

- As further mitigation, and preferred by CCC, if N uptake in surrounding areas (23 ha) is included in the calculations, the expected change is 0.057 g/m^3.
- If the upper part of the property is destocked, the expected change reduces to 0.047 g/m^3, which results in a stream concentration of 0.077 g/m^3.
- Under the most conservative approach where all applied N is assumed to end up in waterways, the Nitrate-N concentrations in Robinsons Bay Stream are predicted to increase by 0.126 g/m^3 to 0.156 g/m^3.
- As there are no streams likely to be affected by application of irrigation water to Hammond Point, the additional load that drains through the soil profile is expected to discharge into Akaroa Harbour.
- There is insufficient information to estimate the current N load discharging into the Harbour from Hammond Point. The expected increase in load due to irrigating the proposed 3.8 ha of the property is 129.7 kg N/ha/y.
- Under the most conservative approach where all applied N is assumed to discharge to the Coast, the Nitrate-N load is predicted to increase by 181 kg N/ha/y.

11.2 Jubilee Park

- A dripline spacing of about 40 cm is expected to be required to maintain green playing surfaces and spaces in Jubilee Park.
- Applying the principles of deficit irrigation to Jubilee Park will result in very low irrigation applications. The result will be highly efficient irrigation, minimal additional drainage below the plant root zone and very low Nitrate-N losses to groundwater.

Nutrient modelling Robinsons Bay

Version 2
5th September 2022
Prepared by Nicole Mesman, CNMA

1. Introduction

Lumen Environmental has carried out Overseer nutrient budgets (in accordance with OverseerFM Best Input Standards) for the Christchurch City Council's 118 ha total (105 ha effective) Robinsons Bay farm. This was done to determine the nutrient loss from farming the block in comparison to the predicted loss from the block if it was retired from farming. The block was modelled as follows:

- 500 MA ewes lambing at 140% with 20% replacements raised on farm.
- Farm split into two blocks based on topography: a lower block of 42 ha effective with slope 16-25 deg and an upper block of 63 ha effective with slope of more than 26 deg.
- Total of 12.6 ha of native bush and oak trees
- Pasture is unimproved browntop and cocksfoot with natural clover
- Soils: 57.1 ha of Clar_2a.1 and 47.9 ha of Clar_2a.2.
- There is no fertiliser applied and no supplements imported.

2. Results

Table 21: Nitrogen and phosphorus loss from the current and proposed farm

Block	Area (ha)	N Loss (kg)	N Loss (kg/ha)	P Loss (kg)	P loss (kg/ha)
Current - Whole farm	118	756	6	201	1.7
Proposed - Whole farm	118	465	4	198	1.7
Change in nutrient loss		**-291**	**-2**	**-3**	**0**

3. Conclusions

If the entirety of the 118 ha (105 ha effective) Robinsons Bay farm was retired from farming the predicted decrease in N loss would conservatively be around 291 kg N/yr across the farm. The decrease in N loss is solely due to the reduction in N deposited by grazing animals rather than any N uptake by new vegetation such as native plantings. The Overseer model is not able to accurately analyse this. The predicted decrease in P loss is small because the model predicts that the number of grazing animals does not have much of an impact on this. P loss from the property is mostly driven by climate and vegetation (both of which are not changed in the proposed scenario modelled). The addition of a riparian margin and increased areas of natives would likely decrease the P loss.

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Appendix B: Catchment Mass Balance Results

B.1 Robinsons Bay Valley

Table 22: Summary of catchment water and nutrient balance results for Robinsons Bay Valley; Base Case scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Stream flow						Stream Nitrate-N			
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Catchment (kg)	Load over Catchment (kg/ha/y)	Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest gauged streamflow, for comparison (m³/s)	Highest gauged streamflow, for comparison (m³/s)	Mean modelled status quo stream flow (m³/s)	Mean stream flow post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)	Median measured (g/m³)	Estimated post irrigation (g/m³)	Increase due to irrigation (g/m³)	Increase due to irrigation (%)
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	5	3.9	716	0.5	6.1	22.5	22.5	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.047	0.017	55%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	8	6.6	1,212	0.9	10.3	38.0	38.0	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.086	0.056	188%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	10	8.6	1,580	1.2	13.4	49.5	49.5	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.116	0.086	287%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	12	10.5	1,929	1.4	16.3	60.5	60.5	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.144	0.114	380%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	16	14.2	2,608	1.9	22.1	81.8	81.8	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.199	0.169	563%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	20	18	3,306	2.4	28.0	103.6	103.6	63.8	430.7	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.255	0.225	750%

Table 23: Summary of catchment water and nutrient balance results for Robinsons Bay Valley; Preferred scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Stream flow						Stream Nitrate-N			
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Catchment (kg)	Load over Catchment (kg/ha/y)	Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area and riparian / infill areas (kg/y)	Plant uptake / denitrification (kg/y)	Lowest gauged streamflow, for comparison (m³/s)	Highest gauged streamflow, for comparison (m³/s)	Mean modelled status quo stream flow (m³/s)	Mean stream flow post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)	Median measured (g/m³)	Estimated post irrigation (g/m³)	Increase due to irrigation (g/m³)	Increase due to irrigation (%)
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	5	3.9	716	0.5	6.1	22.5	22.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.018	-0.012	-41%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	8	6.6	1,212	0.9	10.3	38.0	38.0	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.058	0.028	93%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	10	8.6	1,580	1.2	13.4	49.5	49.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.087	0.057	191%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	12	10.5	1,929	1.4	16.3	60.5	60.5	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.115	0.085	285%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	16	14.2	2,608	1.9	22.1	81.8	81.8	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.170	0.140	467%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	20	18	3,306	2.4	28.0	103.6	103.6	110	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.226	0.196	654%

Table 24: Summary of catchment water and nutrient balance results for Robinsons Bay Valley; Destock2 scenario.

Irrigation water inputs										Stream flow						Stream Nitrate-N			
Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking whole property (kg/y)	Plant uptake / denitrification (kg/y)	Lowest gauged streamflow, for comparison (m³/s)	Highest gauged streamflow, for comparison (m³/s)	Mean modelled status quo stream flow (m³/s)	Mean stream flow post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)	Median measured (g/m³)	Estimated post irrigation (g/m³)	Increase due to irrigation (g/m³)	Increase due to irrigation (%)
183,806	5	3.9	716	0.5	6.1	22.5	22.5	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.008	-0.022	-74%
183,806	8	6.6	1,212	0.9	10.3	38.0	38.0	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.048	0.018	59%
183,806	10	8.6	1,580	1.2	13.4	49.5	49.5	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.077	0.047	157%
183,806	12	10.5	1,929	1.4	16.3	60.5	60.5	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.105	0.075	251%
183,806	16	14.2	2,608	1.9	22.1	81.8	81.8	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.160	0.130	433%
183,806	20	18	3,306	2.4	28.0	103.6	103.6	236	741	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.216	0.186	621%

Table 25: Summary of catchment water and nutrient balance results for Robinsons Bay Valley; Conservative scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Stream flow						Stream Nitrate-N			
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Catchment (kg)	Load over Catchment (kg/ha/y)	Volume (m^3/y)	Total N in treated WW (g/m^3)	DIN (Nitrate-N equivalent) concentration (g/m^3)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest gauged streamflow, for comparison (m^3/s)	Highest gauged streamflow, for comparison (m^3/s)	Mean modelled status quo stream flow (m^3/s)	Mean stream flow post irrigation (m^3/s)	Increase due to irrigation (m^3/s)	Change due to irrigation (%)	Median measured (g/m^3)	Estimated post irrigation (g/m^3)	Increase due to irrigation (g/m^3)	Increase due to irrigation (%)
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	5	3.9	716	0.5	6.1	22.5	22.5	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.086	0.056	188%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	8	6.6	1,212	0.9	10.3	38.0	38.0	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.126	0.096	321%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	10	8.6	1,580	1.2	13.4	49.5	49.5	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.156	0.126	419%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	12	10.5	1,929	1.4	16.3	60.5	60.5	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.184	0.154	513%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	16	14.2	2,608	1.9	22.1	81.8	81.8	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.239	0.209	696%
1,369	118.1	31.9	31.9	2.33%	356	0.260	183,806	20	18	3,306	2.4	28.0	103.6	103.6	0.0	0.0	0.028	0.713	0.386	0.394	0.007	1.92%	0.030	0.295	0.265	883%

Notes:

1. Dryland N load is back-calculated from the water quality measurements in Robinsons Bay Stream and the modelled average annual run-off. It is based on a limited number of measurements, assuming that the measurements are representative of the long-term value.
2. Gauged stream flows are not used in the modelling/analysis, as there are only a limited number of spot gaugings. These are included for comparison only.

B.2 Hammond Point

Table 26: Summary of catchment water and nutrient balance results for Hammond Point; Base Case scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Coastal Seepage					
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Property (kg)	Load over Property (kg/ha/y)	Volume (m^3/y)	Total N in treated WW (g/m^3)	DIN (Nitrate-N equivalent) concentration (g/m^3)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest measured seepage, for comparison (m^3/s)	Highest gauged seepage, for comparison (m^3/s)	Mean modelled status quo catchment discharge (m^3/s)	Mean catchment discharge post irrigation (m^3/s)	Increase due to irrigation (m^3/s)	Change due to irrigation (%)
65	11.9	3.8	3.8	5.86%	71	6	21,895	5	3.9	85	1.3	7.2	22.5	22.5	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	8	6.6	144	2.2	12.1	38.0	38.0	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	10	8.6	181	2.8	15.2	47.5	47.5	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	12	10.5	230	3.5	19.3	60.5	60.5	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	16	14.2	311	4.8	26.1	81.8	81.8	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	20	18	394	6.1	33.1	103.6	103.6	0.0	51.3	N/A	N/A	0.018	0.019	0.001	4.07%

Table 27 Summary of catchment water and nutrient balance results for Hammond Point; Preferred scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Coastal Seepage					
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Property (kg)	Load over Property (kg/ha/y)	Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest measured seepage, for comparison (m³/s)	Highest gauged seepage, for comparison (m³/s)	Mean modelled status quo catchment discharge (m³/s)	Mean catchment discharge post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)
65	11.9	3.8	3.8	5.86%	71	6	21,895	5	3.9	85	1.3	7.2	22.5	22.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	8	6.6	144	2.2	12.1	38.0	38.0	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	10	8.6	181	2.8	15.2	47.5	47.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	12	10.5	230	3.5	19.3	60.5	60.5	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	16	14.2	311	4.8	26.1	81.8	81.8	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	20	18	394	6.1	33.1	103.6	103.6	7.6	51.3	N/A	N/A	0.018	0.019	0.001	4.07%

Table 28 Summary of catchment water and nutrient balance results for Hammond Point; Destock2 scenario.

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Coastal Seepage					
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Property (kg)	Load over Property (kg/ha/y)	Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking whole property (kg/y)	Plant uptake / denitrification (kg/y)	Lowest measured seepage, for comparison (m³/s)	Highest gauged seepage, for comparison (m³/s)	Mean modelled status quo catchment discharge (m³/s)	Mean catchment discharge post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)
65	11.9	3.8	3.8	5.86%	71	6	21,895	5	3.9	85	1.3	7.2	22.5	22.5	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	8	6.6	144	2.2	12.1	38.0	38.0	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	10	8.6	181	2.8	15.2	47.5	47.5	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	12	10.5	230	3.5	19.3	60.5	60.5	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	16	14.2	311	4.8	26.1	81.8	81.8	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	20	18	394	6.1	33.1	103.6	103.6	23.8	51.3	N/A	N/A	0.018	0.019	0.001	4.07%

Table 29: Summary of catchment water and nutrient balance results for Hammond Point; Conservative scenario

Catchment and land					Dryland Nitrate-N		Irrigation water inputs										Coastal Seepage					
Catchment area (ha)	Property area (ha)	Irrigable area (ha)	Wetted area (ha)	Wetted area (% of catchment)	Total over Property (kg)	Load over Property (kg/ha/y)	Volume (m³/y)	Total N in treated WW (g/m³)	DIN (Nitrate-N equivalent) concentration (g/m³)	Nitrate-N load (kg/y)	Nitrate-N average over catchment (kg/ha/y)	Nitrate-N average over property (kg/ha/y)	Nitrate-N average over irrigable area (kg/ha/y)	Nitrate-N average over wettted area (kg/ha/y)	Offset from destocking irrigated area (kg/y)	Plant uptake / denitrification (kg/y)	Lowest measured seepage, for comparison (m³/s)	Highest gauged seepage, for comparison (m³/s)	Mean modelled status quo catchment discharge (m³/s)	Mean catchment discharge post irrigation (m³/s)	Increase due to irrigation (m³/s)	Change due to irrigation (%)
65	11.9	3.8	3.8	5.86%	71	6	21,895	5	3.9	85	1.3	7.2	22.5	22.5	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	8	6.6	144	2.2	12.1	38.0	38.0	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	10	8.6	181	2.8	15.2	47.5	47.5	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	12	10.5	230	3.5	19.3	60.5	60.5	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21,895	16	14.2	311	4.8	26.1	81.8	81.8	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%
65	11.9	3.8	3.8	5.86%	71	6	21895.0	20	18	394	6.1	33.1	103.6	103.6	0.0	0.0	N/A	N/A	0.018	0.019	0.001	4.07%

Notes:

1. There are no measured surface water nitrate concentrations to back-calculate a dryland loading, therefore no future concentration has been calculated.
2. There are no measured surface water nitrate concentrations to back-calculate a dryland loading for the entire catchment, therefore no future concentration has been calculated.
3. A dryland Nitrate-N load for the property was estimated using the nutrient budget prepared by Lumen for the Robinsons Bay Valley property (see Appendix A).

Appendix C: Field Monitoring Sites

C.1 Robinsons Bay Valley

Seven monitoring sites were established for the Robinsons Bay Valley area. These were three surface water sites (ROB SW1, ROB SW2 and ROB SW3), two groundwater sites (ROB GW1, ROB GW3) and two soil moisture sites (ROB SM1 and ROB SM2). The location of these sites is shown in Figure 14, and the grid references are in Table 30.

Figure 14: Robinsons Bay Valley sites

Table 30: Robinsons Bay Valley locations

Site Name	Easting (NZTM)	Northing (NZTM)
ROB SW1	1598672	5154766
ROB SW2	1598205	5154880
ROB SW3	1597588	5154995
ROB GW1	1598772	5154658
ROB GW3	1597795	5154878
ROB SM1	1598835	5154386
ROB SM2	1598219	5154784

C.1.1.1 Robinsons Bay Valley surface water sites

The surface water sites are located in the Robinsons Bay Stream. ROB SW1 is located under the upper Robinsons Bay Valley Road bridge. This site has concrete on both banks and a mobile boulder bed (Figure 15).

Figure 15: ROB SW1

ROB SW2 is located downstream on the flatter mid-reaches of the river. This site has rock and grass both banks and a mobile gravel bed (Figure 16).

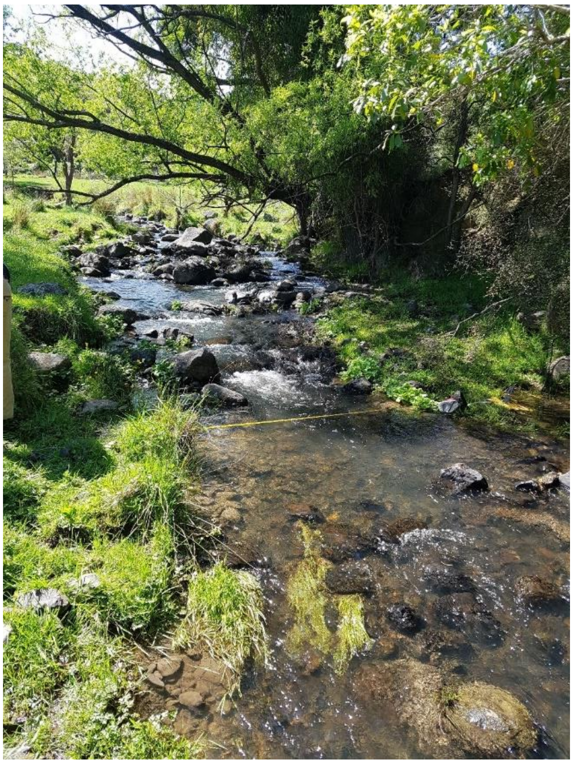


Figure 16: ROB SW2

ROB SW3 is located is located just upstream of the bridge on Sawmill Road. This site has rock on both banks and a mobile gravel and boulder bed (Figure 17).

Figure 17: ROB SW3

C.1.1.2 Robinsons Bay Valley groundwater sites

Two piezometers were sampled for water level and chemical parameters. One of these piezometers was drilled in September 2016 for a previous study (ROB GW3) and the other piezometer was drilled in September 2021 (ROB GW1). The piezometers were screened to intercept the shallow groundwater in the area and all piezometers reached groundwater. ROB GW1 was drilled close to a side branch of Robinsons Bay Stream and therefore most likely incepts water connected to Robinsons Bay Stream. The construction details for these piezometers are shown in Appendix C.

C.1.1.3 Robinsons Bay Valley soil moisture sites

Two soil moisture sites were installed on the site. ROB SM1 was located on steep land on the highest point on the site and ROB SM2 is located on a relatively flat land. These sites are representative of the site.

C.2 Hammond Point

Three monitoring sites were established for Hammond Point. These were one groundwater site (HAM GW1) and two soil moisture sites (HAM SM1 and HAM SM2). The location of these sites is shown in Figure 18. The grid references for these sites are shown in Table 31.

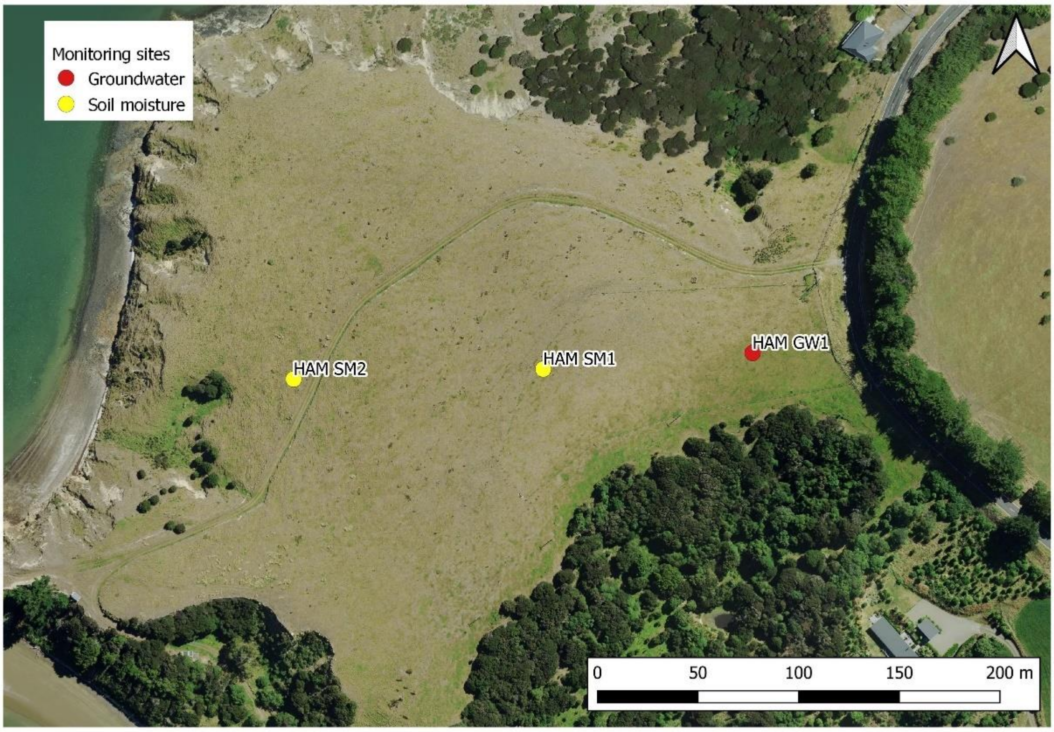


Figure 18: Hammond Point monitoring sites

Table 31: Hammond Point locations

Site Name	Easting (NZTM)	Northing (NZTM)
HAM GW1	1596621	5153390
HAM SM1	1596517	5153382
HAM SM2	1596393	5153377

C.2.1.1 Hammond Point groundwater site

One piezometer was drilled in September 2021 at this site (HAM GW1). Due to access difficulties at the site and because there was no groundwater intercepted in this piezometer, no other piezometers were drilled. Ham GW1 was dry on all sampling occasions. The construction details for the piezometer are shown in Appendix C.

C.2.1.2 Hammond Point soil moisture sites

Two soil moisture sites were installed at Hamond Point. HAM SM1 was located on the flattish land on the highest point on the site and HAM SM2 is located on a relatively steep slope to the west of the site. These sites are representative of the site.

C.3 Jubilee Park

Three monitoring sites were established for the Jubilee Park site. These were two surface water sites (AKA SW1 and AKA SW2) and one soil moisture site (AKA SM1). The location of these sites is shown in Figure 19. The grid references for these sites are shown in Table 32.

Figure 19: Akaroa monitoring sites

Table 32: Akaroa Playing Field Locations

Site Name	Easting (NZTM)	Northing (NZTM)
AKA SW1	1597700	5150217
AKA SW2	1597530	5150205
AKA SM1	1597440	5150034

C.3.1.1 Surface water sites

The surface water sites for Jubilee Park were located on Grehan Stream. AKA SW1 was dictated by the restricted access due to housing and therefore a location in a reserve on Rue Grehan was chosen. This site was shallow in depth with a grassy slope on one bank, and concrete on the other and a shifting rocky substrate in the bed (Figure 20).

Figure 20: AKA SW1

AKA SW1 was located adjacent to the playing field at the Rue Jolie Bridge. This was at the transition to a tidal reach. Gauging could not be undertaken up gradient of this site as Grehan Stream is very overgrown and is an Inanga spawning habitat. Again, the location had a grassy and muddy bank on one side and concrete on the other with a mobile rocky bed. On occasions, this site could not be gauged due to the influence of the tide. The site is shown in Figure 21.

Figure 21: AKA SW2

C.3.1.2 Jubilee Park soil moisture sites

The soil moisture site was located at the southeast corner of Jubilee Park. This site was chosen because it was not on a playing field and because there was a suitable post where the telemetry equipment could be mounted. We consider that this site is representative of the entire site. There was a malfunction in the logger when the site was initially installed and so the logger was replaced. Therefore, the length of data for this site is shorter than for the other sites.

Appendix D: Summary of Monitoring Data

D.1 Groundwater Levels

Table 33 gives a summary of water level data from all sites monitored. Groundwater levels did not vary significantly over the time period monitored. All groundwater level data can be found in Appendix D.

Loggers were also installed in ROB GW1 and ROB GW3 to gain a better temporal understanding of the groundwater level in the area. These loggers were installed on 16/12/2021.

Table 33: Summary of groundwater level data

	ROB GW1	ROB GW3
First Date	19/10/21	20/10/21
Last Date	16/02/22	16/02/22
Number	6	5
Minimum (m bgl)	2.64	1.84
Maximum (m bgl)	3	2.09
Mean (m bgl)	2.90	2.02

D.1.1.1 Robinsons Bay Valley

Figure 22 shows the manual groundwater levels at Robinsons Bay Valley site. Figure 23 shows that the logged levels did not respond significantly to rainfall.

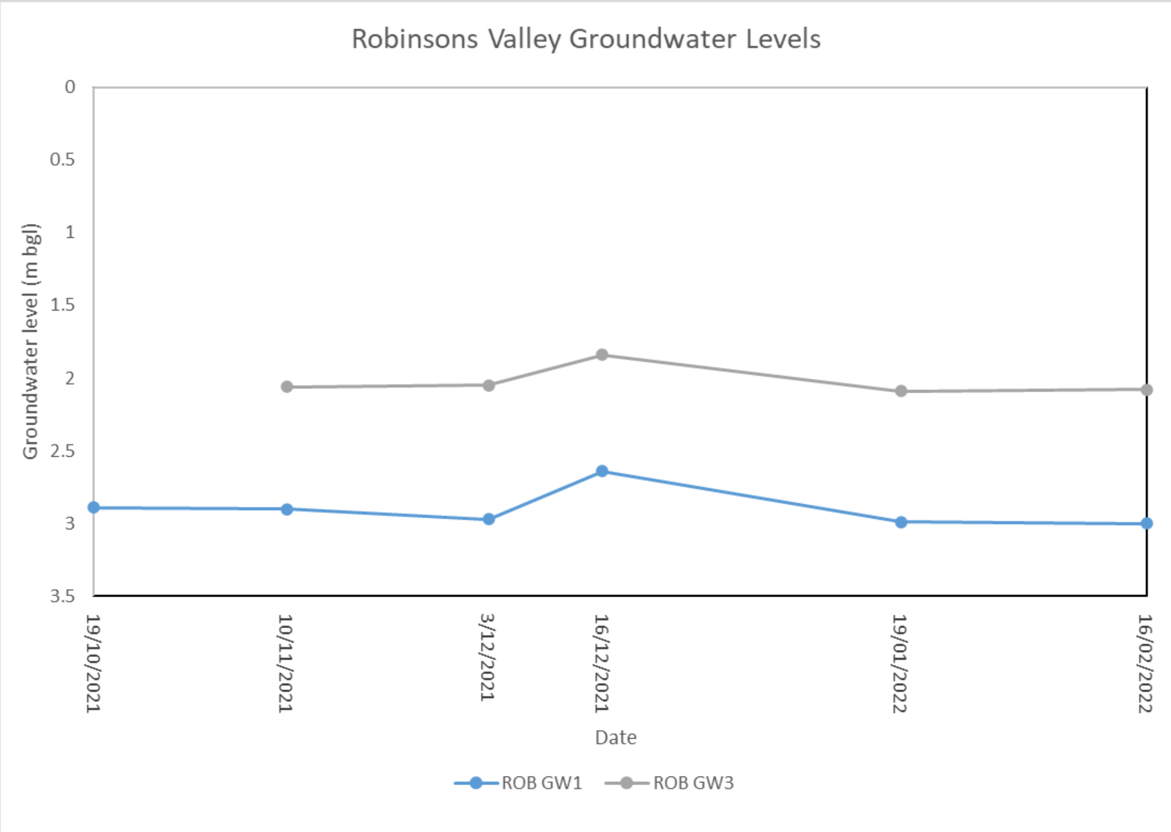


Figure 22: Groundwater levels in Robinsons Bay Valley

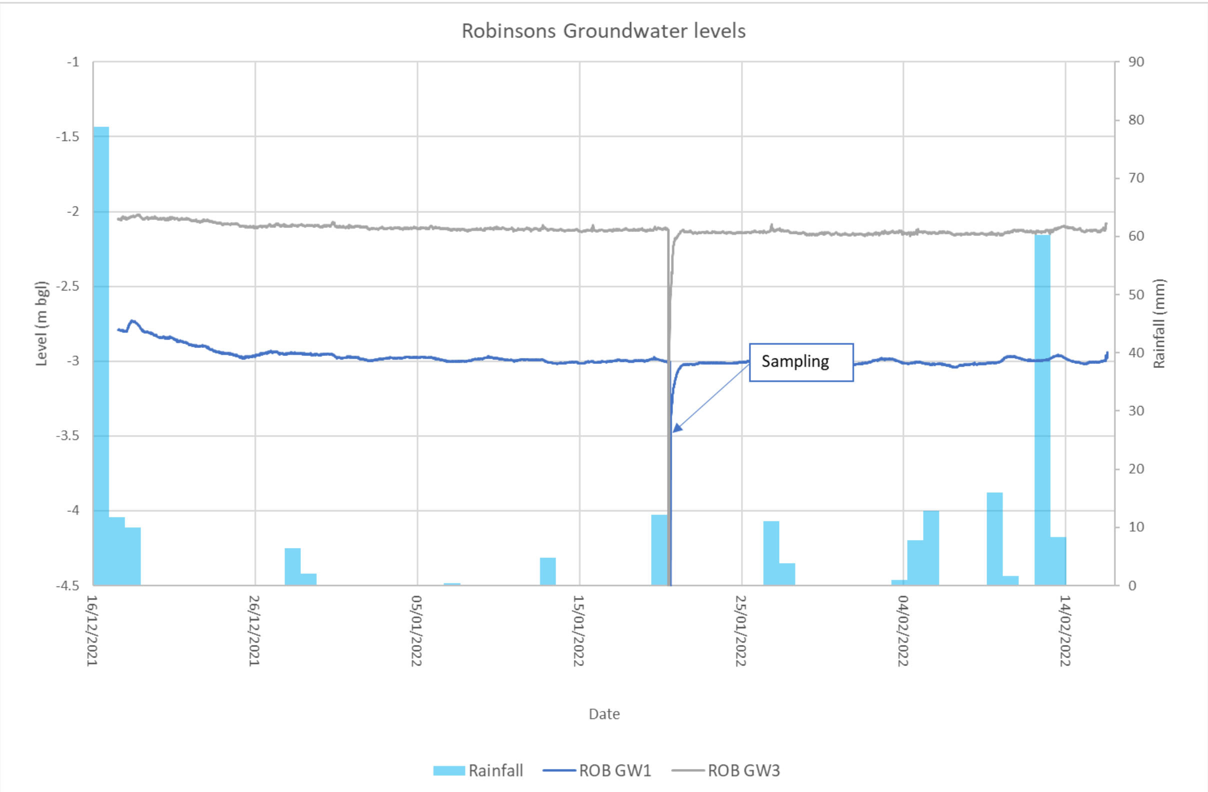


Figure 23: Robinsons Bay Valley logged groundwater level

D.2 Groundwater Chemistry

Table 34 presents a summary of chemistry data for the groundwater sites, with all chemistry data presented in Appendix E. There are no notable anomalies in the data.

Table 34: Summary of groundwater chemistry data

		DO (g/m3) (field)	Specific Conductivity (uS/cm)	pH (field)	Turbidity (NTU)	pH	Total Alkalinity (g/m3 as CaCO3)	Dissolved Sodium (g/m3)	Total Ammoniacal-N (g/m3)	Nitrite-N (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Total Kjeldahl Nitrogen (TKN) (g/m3)	Total Phosphorus (g/m3)	Escherichia coli (cfu/100ml)
ROB GW1	First Date	10/11/21	10/11/21	10/11/2021	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21	10/11/21
	Last Date	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/12/21	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22
	Number	7	7	6	5	5	5	5	5	5	5	5	5	5	5
	Minimum	0.26	177	6.14	1,220	7.0	82	44	0.03	0.00	0.01	0.02	1.48	2.10	0
	Maximum	2.77	361	6.94	6,100	7.5	107	52	0.14	0.01	0.21	0.22	4.40	8.30	150
	Mean	1.31	239	6.65	3,258	7.2	96	47	0.07	0.01	0.08	0.08	2.69	4.74	68
ROB GW3	First Date	20/11/21	20/10/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21	20/11/21
	Last Date	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22	16/02/22
	Number	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Minimum	1.01	294	6.61	220	6.7	87	65	0.00	0.00	3.20	3.20	0.25	0.61	0
	Maximum	1.85	472	6.94	2,500	7.4	102	68	0.11	0.02	3.40	3.40	1.55	7.80	200
	Mean	1.36	344	6.73	938	7.0	93	66	0.02	0.00	3.27	3.27	0.79	2.67	51

D.3 Surface Water Flow and Quality

A summary of surface water flow data is shown in Table 35. All surface water quality data can be seen in Appendix F.

Table 35: Surface water flow data

LOCATION					
Date	**AKA SW1 (m^3/s)**	**AKA SW2 (m^3/s)**	**ROB SW1 (m^3/s)**	**ROB SW2 (m^3/s)**	**ROB SW3 (m^3/s)**
29/09/2021	0.0131	0.0013	0.0221	0.0294	0.0404
19/10/2021	0.0081	0.0092	0.0964	0.085	0.1271
9/11/2021	0.0065	Tidal	0.0407	0.0638	0.0497
2/12/2021	0.0023	Tidal	0.0244	0.0494	0.0475
17/12/2021	0.0914	0.1064	0.5087	0.6658	0.7125
19/01/2022	Minimal Flow	Tidal	0.0322	0.0345	0.0277
15/02/2022	0.0236	0.0304	0.0843	0.0731	0.088
Summary					
First Date	29/09/21	29/09/21	29/09/21	29/09/21	29/09/21
Last Date	15/02/22	15/02/22	15/02/22	15/02/22	15/02/22
Number of gaugings	6	4	7	7	7
Minimum Value (m^3/s)	0.002	0.001	0.022	0.029	0.028
Maximum Value (m^3/s)	0.091	0.106	0.509	0.666	0.713
Mean Value (m^3/s)	0.024	0.037	0.116	0.143	0.156

D.3.1.1 Akaroa/Jubilee Park

Figure 24 shows a graph of Grehan Stream surface water flow and Akaroa rainfall. The rainfall data was obtained from the Akaroa AWS (36593) site run by NIWA. The AKA SW2 site backs up when the tide is high and therefore, we couldn't accurately gauge flow on these occasions. There was a major rainfall event on 16/12/2021 which is reflected in the high flows obtained on 17/12/2022. There was minimal flow in Grehan Stream on 19/1/2022 and again it wasn't possible to accurately gauge flow on this occasion.

With the limited data available, it doesn't appear that there is a consistent behaviour in terms of the stream gaining or losing.

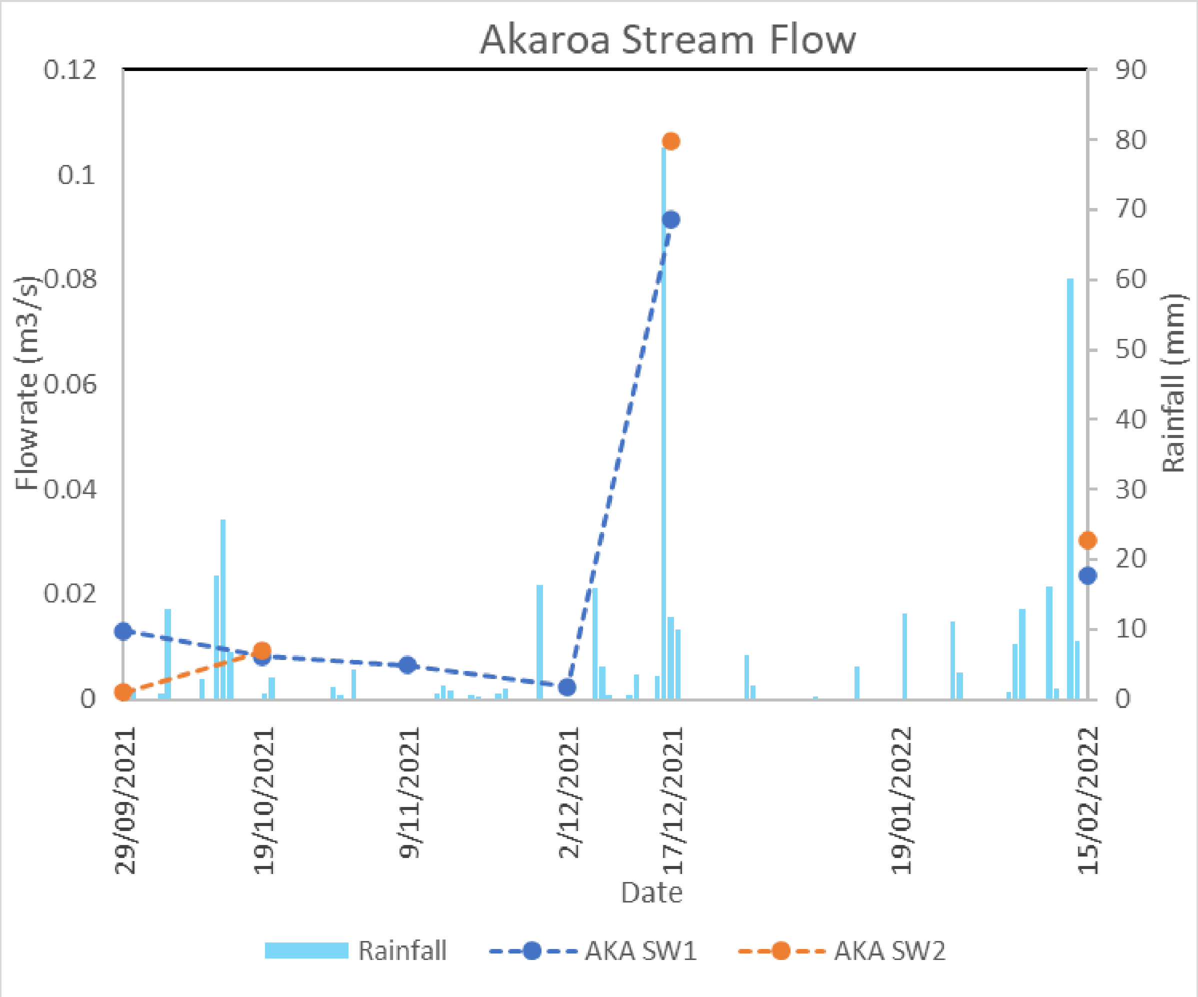


Figure 24: Grehan Stream flow and rainfall data

D.3.1.2 Robinsons Bay Valley

Figure 25 shows a graph of the Robinsons Bay Stream flow and Akaroa rainfall. The flow also responded to the major rainfall event on 16/12/2021. During lower flow conditions, there may be some increase in flow downstream, although this is variable and could possibly be gauging error. During the high flow event, there appears to be an increase between the upstream site (ROB SW1) and the sites lower in the catchment, although it is difficult to know how much surface runoff could be affecting flows on this occasion.

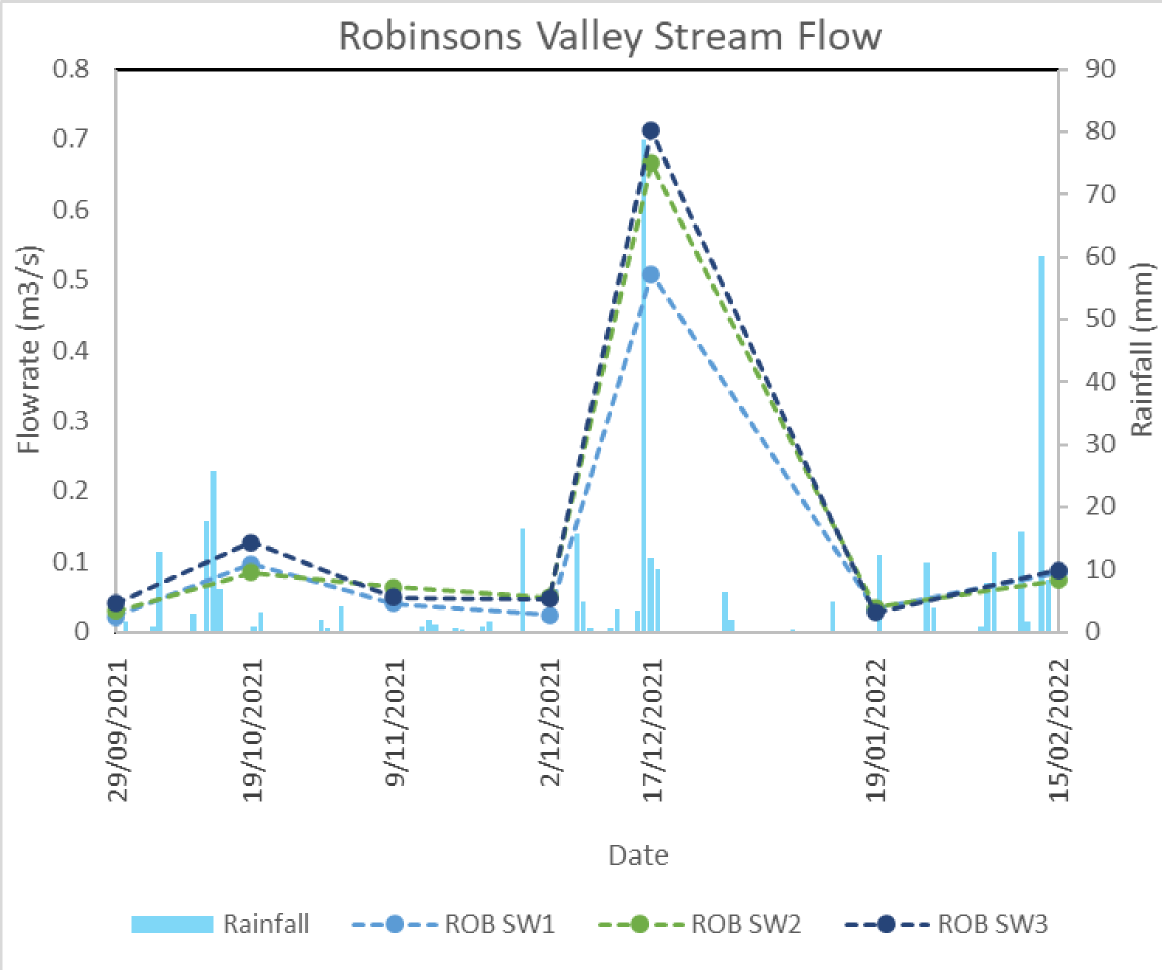


Figure 25: Robinsons Bay Stream flow and Akaroa rainfall data

Table 36 shows a summary of the surface water chemistry results. All surface water quality data can be found in Appendix F.

Table 36: Summary of surface water chemistry results

		DO (g/m3) (field)	Specific Conductivity (uS/cm)	pH (field)	Turbidity (NTU)	pH	Total Alkalinity (g/m3 as CaCO3)	Dissolved Sodium (g/m3)	Total Ammoniacal-N (g/m3)	Nitrite-N (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Total Kjeldahl Nitrogen (TKN) (g/m3)	Total Phosphorus (g/m3)	Escherichia coli (cfu/100ml)
AKA SW1	First Date	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021
	Last Date	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022
	Number	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Minimum	4.43	78	6.8	1.76	7.4	19	13	0.00	0.00	0.01	0.01	0.00	0.04	60
	Maximum	10.87	1,629	7.9	9.30	7.8	48	20	0.00	0.00	0.66	0.62	0.60	0.08	8700
	Mean	8.70	327	7.3	4.02	7.6	35	18	0.00	0.00	0.29	0.21	0.17	0.05	1553
AKA SW2	First Date	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021
	Last Date	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022
	Number	5	5	5	7	7	7	7	7	7	7	7	7	7	7
	Minimum	6.14	78	7.1	1.70	7.4	19	14	0.00	0.00	0.01	0.01	0.00	0.03	29
	Maximum	10.86	163	8.3	9.00	8.4	51	22	0.01	0.00	0.65	0.66	0.39	0.08	5,000
	Mean	9.31	116	7.6	3.11	7.7	37	18	0.00	0.00	0.13	0.14	0.16	0.05	929
ROB SW1	First Date	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021
	Last Date	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022
	Number	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Minimum	5.52	95	7.3	1.17	7.5	22	17	0.00	0.00	0.00	0.00	0.12	0.04	70
	Maximum	11.14	195	7.7	33.00	8.2	52	24	0.02	0.01	0.31	0.32	0.76	0.42	4,900
	Mean	9.54	139	7.5	6.29	7.9	42	21	0.00	0.00	0.07	0.07	0.29	0.12	864
ROB SW2	First Date	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021
	Last Date	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022
	Number	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Minimum	4.96	83	7.3	0.96	7.5	19	15	0.00	0.00	0.00	0.00	0.11	0.04	9
	Maximum	11.12	198	7.9	20.00	8.0	53	23	0.00	0.01	0.18	0.18	1.02	0.13	,5400
	Mean	9.04	138	7.6	4.52	7.9	42	21	0.00	0.00	0.05	0.05	0.33	0.06	1149
ROB SW3	First Date	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021	29/09/2021
	Last Date	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022	16/02/2022
	Number	7	7	7	7	7	7	7	7	7	7	7	7	7	7
	Minimum	5.71	87	7.2	1.20	7.5	20	16	0.00	0.00	0.00	0.00	0.12	0.04	40
	Maximum	10.72	200	7.9	18.90	8.0	54	23	0.02	0.01	0.19	0.19	0.51	0.11	5,100
	Mean	9.14	141	7.7	4.53	7.9	43	21	0.00	0.00	0.05	0.05	0.21	0.06	1,090

D.4 Soil Chemistry

Soil chemistry data can be found in Appendix H. Only one set of samples are provided. A further sample for each site has been taken and results have not yet been received from the laboratory.

D.5 Soil Moisture Data

Soil moisture monitoring data is shown in Figures 17-23[26]. Two sensors are installed at each site, with an upper sensor measuring soil moisture between 0 and 200 mm, and a deeper one at 250 to 350 mm depth.

The figures show the shallow soil moisture and the deep soil moisture in millimetres, as well as temperature. When soil moisture increases in the deep sensor, it indicates that drainage is occurring under the root zone. A gradual increase or decrease is unlikely to indicate drainage to groundwater. However, a rapid increase and spike followed by a rapid recession indicates there is some recharge occurring. Currently we only have data for a short time period and our interpretation of the behaviour of the soils is interim at this stage.

D.5.1.1 Akaroa/Jubilee Park

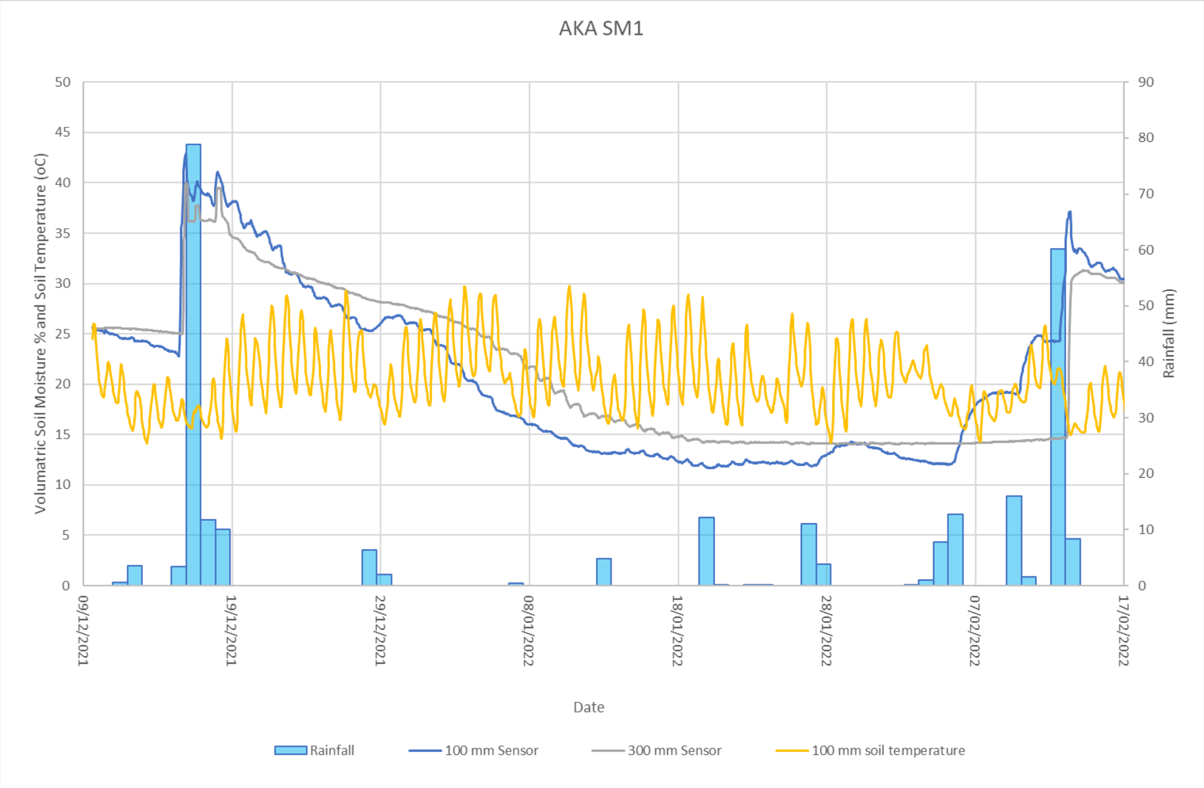


Figure 26: AKA SM1

[26] Note that the sensor at Akaroa failed and had to be replaced

The effects of the rainfall event on 16/12/2021 and 13/2/2022 can clearly be seen in both shallow and deep sensors. However, it doesn't appear that significant recharge occurred between these two events, based on the data from the deep sensor.

D.5.1.2 Hammond Point

The effects of most rainfall events can clearly be seen in both shallow and deep sensors, at both sites. The effects of rainfall can be seen much more clearly in the deeper sensor at this site, and there could be some recharge occurring on some occasions.

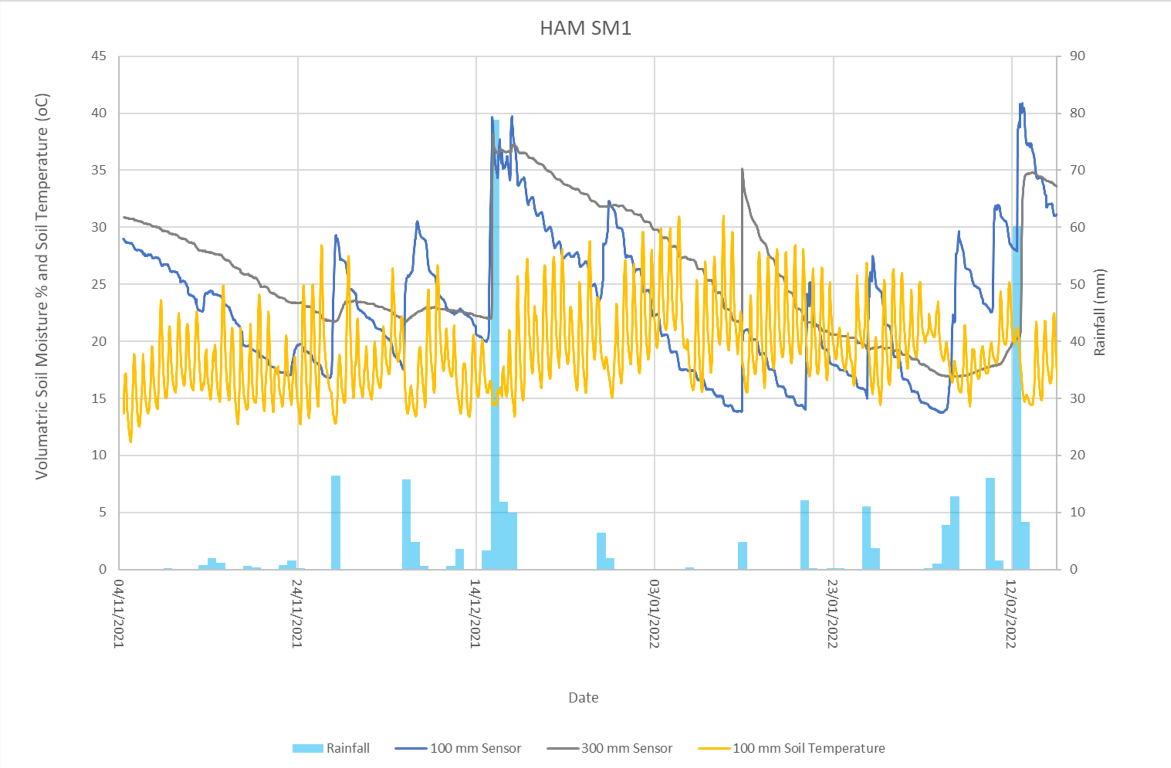


Figure 27: HAM SM1

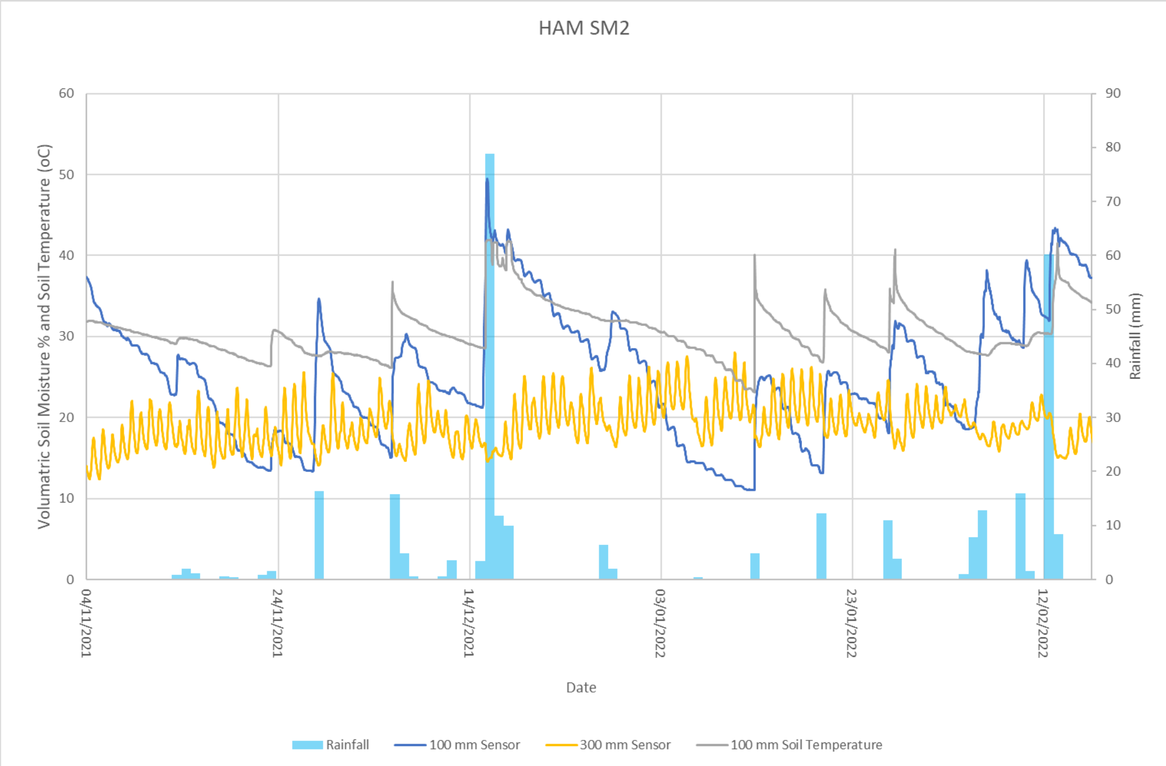


Figure 28: HAM SM2

D.5.1.3 Robinsons Bay Valley

The effects of the rainfall event on 16/12/2021 and 13/2/2022 can clearly be seen in both shallow and deep sensors, with more muted response by the deeper sensor to other rainfall events. The response in the deeper sensor at this site is less pronounced than at the Hammond Point site.

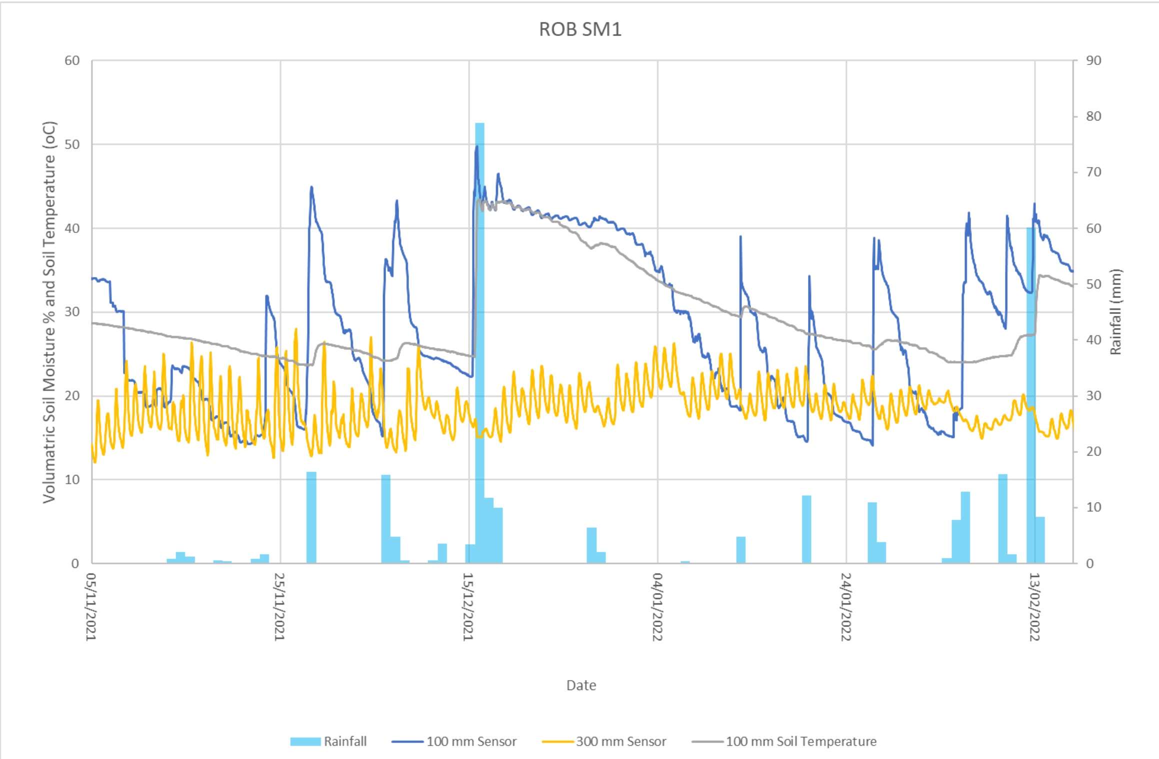


Figure 29: ROB SM1

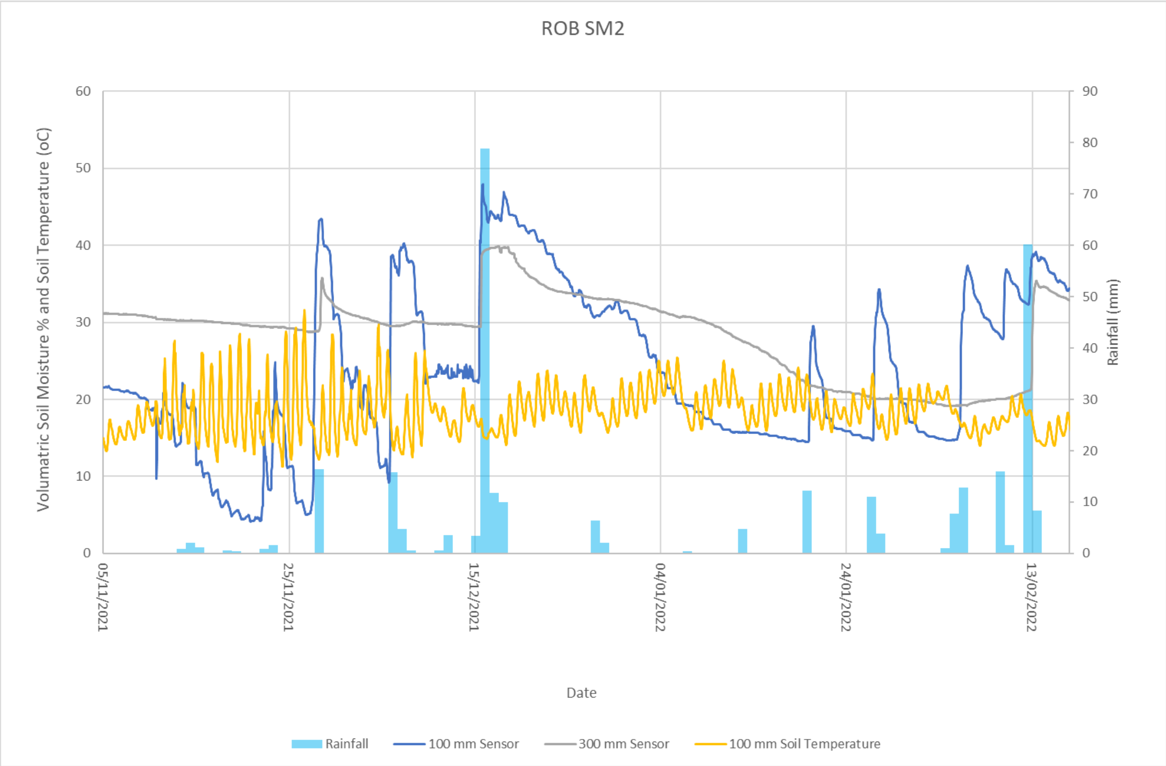


Figure 30: ROB SM2

HAM GW1

McMILLAN Drilling

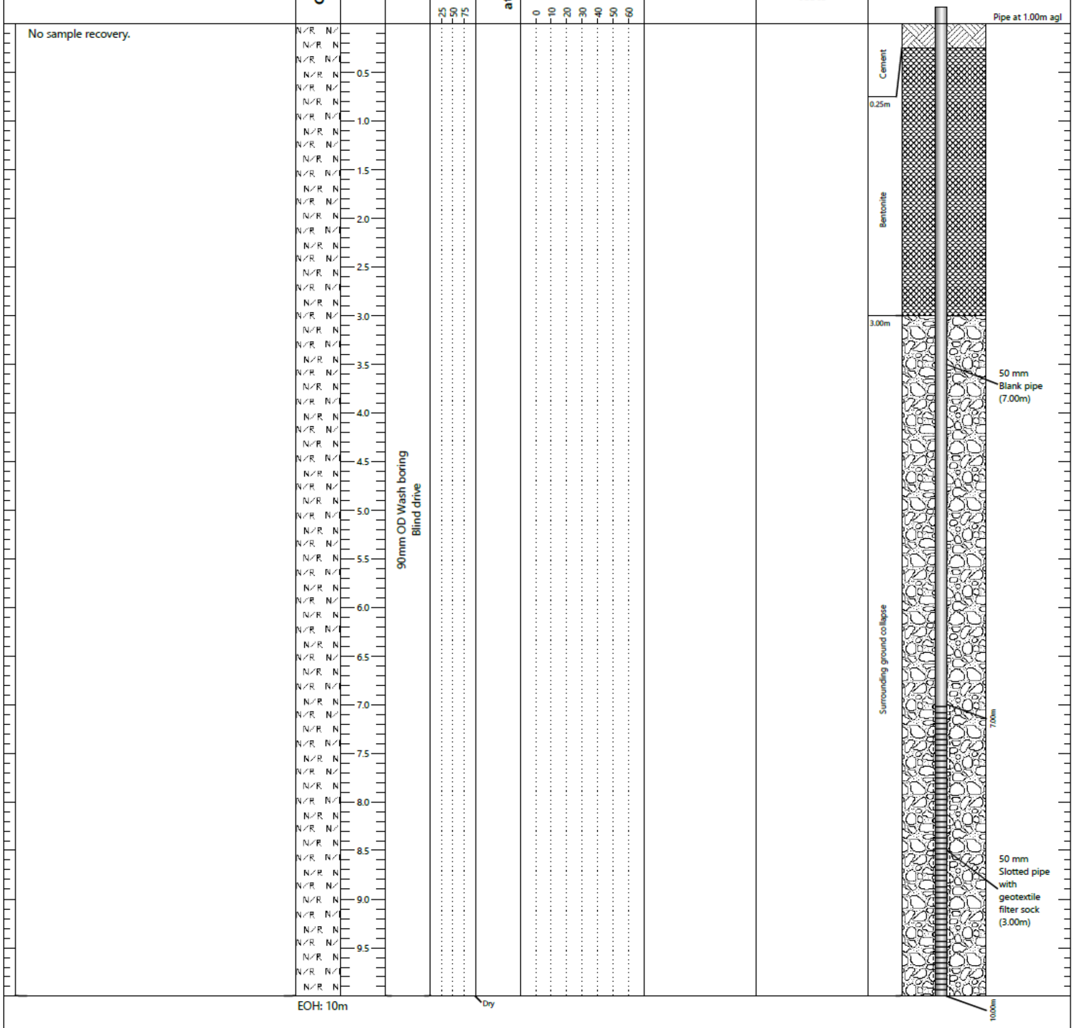
Client: Aqualinc Research		**Bore No.:** HAM BH001
Project: Various locations, Akaroa		**Job No.:** 20236

Site Location: Christchurch Akaroa Road, Takamatua (Hammond Point) **Date:** 7/9/2021 - 7/9/2021

Grid Reference: 1596626.61m E, 5153397.87m N (NZTM) - Map or aerial photograph **Rig Operator:** K. Morris

Elevation: 0.00m **Datum:** Ground **Equipment:** AMS VTR9570 - track

Description	Graphic Log	Depth	Method	Runs and recovery	Water at hole depth	SPT (NZS 4402) N-value Uncorrected	In-Situ Tests	Samples - Permeability tests	Installation & Resources



Remarks

Additional Resources:
Core boxes: -
Concrete: 2 bags
Bentonite: 0.5 bag

Generated by GEROC Core-GS

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 10m
Page 1 of 1
Created: 10/09/2021 11:19:32

ROB GW1

McMILLAN Drilling	**Client:** Aqualinc Research	**Bore No.:** ROB BH001
	Project: Various locations, Akaroa	**Job No.:** 20236

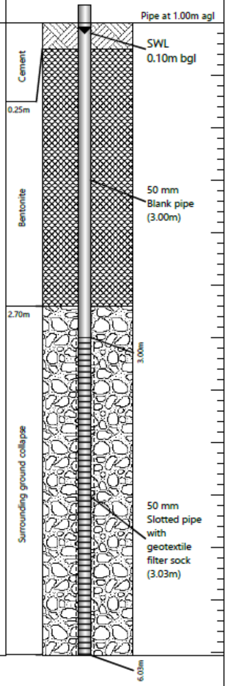
Site Location: Robinsons Bay Valley Road, Robinsons Bay | **Date:** 9/9/2021 - 9/9/2021

Grid Reference: 1598770.9m E, 5154665.48m N (NZTM) - Map or aerial photograph | **Rig Operator:** K. Morris

Elevation: 0.00m | **Datum:** Ground | **Equipment:** AMS VTR9570 - track

Description	Graphic Log	Depth	Method	Runs and recovery (25 50 75)	Water at hole depth	SPT (NZS 4402) N-value Uncorrected (0 10 20 30 40 50 60)	In-Situ Tests	Samples - Permeability tests	Installation & Resources
No sample recovery.	N/R	0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5	70mm OD Wash boring Blind drive						

EOH: 6.03m



Remarks

Additional Resources:
Core boxes: -
Concrete: 2 bags
Bentonite: 0.5 bag

Generated by GEROC Core-GS

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 6.03m
Page 1 of 1
Created: 10/09/2021 11:19:32

ROB GW3

Bore Log

McMILLAN Drilling GROUP	**Client:** Pattle Delamore Partners	**Bore No.:** BH003
	Project: Akaroa Wastewater Upgrade	**Job No.:** 16343

Site Location: Robinsons Bay Valley Road, Robinsons Bay
Grid Reference: 1597795.4mE 5154878.11mN NZTM
Rig Operator: K. Morris
Rig Model & Mounting: Geoprobe 8140LC - track
Date Commenced: 28/09/2016
Date Completed: 28/09/2016
Elevation (m): 0.00
Datum: Ground

Description	Method	Drivability	Recovery	Depth	Graphic Log	SPT N-value (Uncorrected)	In-Situ Tests (Uncorrected)	Samples - Permeability tests	Installation & Resources
TOPSOIL.	Sonic core drilling		80%	0.00–0.50m					Stand-up Protective Surround; Cement (2 bags) to 0.40m
CLAY; light brown. (0.50m)				0.50–1.80m					Bentonite (2.5 bags) 0.40m–3.38m; 50 mm Blank pipe (3.6m)
Clayey GRAVEL. (1.80m)			100% / 100% / 100%	1.80–6.08m					Filter sand (2 bags) from 3.38m; 3.58m; 50 mm Slotted pipe (2.5m); 6.08m

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0

EOH: 6.08m

Remarks

Geotechnical investigation borehole BH003

Static water levels:
3.86m bgl at casing depth of 6.08m; 28/9/2016

500 liters water added

Drivability

1 Easy Push - No Hammer \ Fast Penetration
2 Relatively Easy Push - Light Hammer \ Relatively Fast
3 Medium Push - Consistent Hammer \ Medium
4 Hard Push - Full Hammer \ Somewhat Slow
5 Very Hard Push - Full Hammer \ Very Slow

Additional Resources:

Plastic Liner / PVC Splits	m	-
Core boxes	no.	3
Flush Mounted Toby Box		
- Standard	ea	
- Environmental	ea	
Above Ground Protective Surround	ea	✔
Geotextile Sock	m	-
Hand Clear Location	ea	
Decontaminate Equipment	ea	

Generated by GEROC Core-GS

120 High Street, Southbridge 7602, Canterbury, New Zealand ph: (03) 324 2571 fax: (03) 324 2431 web: www.drilling.co.nz

Hole Depth: 6.08m
Page 1 of 1

Created: 4/10/2016 12:09:23 p.m.

Appendix F: Groundwater Chemistry Data

Sample Name	Date	Time (summertime)	Field DO (g/m3)	Specific Conductivity (uS/cm)	pH (field)	Turbidity (NTU)	pH	Total Alkalinity (g/m3 as CaCO3)	Dissolved Sodium (g/m3)	Total Ammoniacal-N (g/m3)	Nitrite-N (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Total Kjeldahl Nitrogen (TKN) (g/m3)	Total Phosphorus (g/m3)	Escherichia coli (cfu/100ml
ROB GW1	29/09/2021	16:30	2.77	186	-	-	-	-	-	-	-	-	-	-	-	-
ROB GW1	19/10/2021	11:00	1.41	360.9	-	-	-	-	-	-	-	-	-	-	-	-
ROB GW1	10/11/2021	10:00	0.26	176.8	-	1,220	7.5	99	52	0.028	<0.002	0.025	0.027	1.48	2.10	<10
ROB GW1	3/12/2021	14:16	0.51	247	6.55	6,100	7	103	45	0.143	0.008	0.014	0.022	3.4	8.3	<10
ROB GW1	16/12/2021	11:00	2.6	252	6.66	3,800	7	89	44	0.064	0.01	0.21	0.22	4.4	4.7	50
ROB GW1	20/01/2022	2:10	0.82	245	6.86	1,870	7	107	48	0.062	0.004	0.036	0.04	1.89	2.7	140
ROB GW1	16/02/2022	14:00	0.79	205	6.94	3,300	7.5	82	46	0.047	0.003	0.094	0.098	2.3	5.9	150
ROB GW3	20/10/2021	10:55	1.61	472.2	6.94	220	6.8	95	65	0.105	<0.002	3.2	3.200	0.98	0.61	<10
ROB GW3	10/11/2021	13:10	1.44	294	6.75	320	7.4	88	68	<0.010	<0.002	3.2	3.200	0.48	0.73	<10
ROB GW3	3/12/2021	13:10	1.01	316	6.61	1,450	6.9	91	65	0.014	<0.002	3.3	3.3	0.9	3.5	<10
ROB GW3	16/12/2021	12:20	1.85	335	6.67	340	6.7	93	67	<0.010	<0.002	3.4	3.4	0.25	1.18	200
ROB GW3	20/01/2022	12:30	1.03	333	6.7	2,500	7	102	66	<0.010	0.023	3.2	3.2	1.55	7.8	37
ROB GW3	16/02/2022	13:30	1.22	315	6.69	800	7.4	87	67	0.013	<0.002	3.3	3.3	0.59	2.2	70

Appendix G: Surface Water Chemistry Data

Sample Name	Date	Time (summer time)	Lab Number	DO (mg/L) (field)	Specific Conductivity (uS/cm)	pH (field)	Turbidity (NTU)	pH	Total Alkalinity (g/m3 as CaCO3)	Dissolved Sodium (g/m3)	Total Ammoniacal-N (g/m3)	Nitrite-N (g/m3)	Nitrate-N (g/m3)	Nitrate-N + Nitrite-N (g/m3)	Total Kjeldahl Nitrogen (TKN) (g/m3)	Total Phosphorus (g/m3)	Escherichia coli (cfu/100ml
AKA SW1	29/09/2021	14:25	2720843.5	4.43	1629	7.11	3.40	7.8	39	20	0	0	0.56	0.570	0.10	0.040	60
AKA SW1	20/10/2021	8:35	2740875.7	4.62	144.9	6.93	1.82	7.6	30	16.2	0	0	0.1	0.101	0.00	0.038	160
AKA SW1	9/11/2021	9:00	2763200.2	9.91	112.6	7.55	1.79	7.7	41	19.7	0	0	0.66	0.067	0.11	0.043	120
AKA SW1	3/12/2021	8:35	2789355.6	10.46	120.1	7.6	2.90	7.8	48	20	0	0	0.008	0.009	0.13	0.054	290
AKA SW1	16/12/2021	15:10	2803429.6	10.55	78.2	6.82	9.3	7.4	18.9	13.1	0	0.004	0.61	0.62	0.6	0.083	1300
AKA SW1	19/01/2022	2:30	2834564.1	10.07	111	7.86	7.2	7.6	33	17.1	0	0.003	0.016	0.019	0.26	0.084	8700
AKA SW1	16/02/2022	15:30	2875882.2	10.87	90.6	7.25	1.76	7.6	32	17.1	0	0	0.109	0.11	0.00	0.042	240
AKA SW1	1/06/2022	14:45	3005958.7	9.88	131.2	7.38	2.1	7.8	52	18.3	0	0.002	0.054	0.0566	<0.10	0.053	55
AKA SW1	6/07/2022	8:20	3029617.1	12.27	133.1	7.4	2.3	7.8	56	21	0.018	<0.002	0.188	0.19	<0.1	0.023	18
AKA SW2	29/09/2021	13:30	2720843.4		162.7	7.07	1.70	8.4	40	20	0	0	0.018	0.020	0.14	0.033	29
AKA SW2	20/10/2021	8:15	2740875.6				1.70	7.6	32	16.7	0	0	0.083	0.084	0.00	0.034	63
AKA SW2	9/11/2021	8:00	2763200.1				1.91	7.7	43	21	0.013	0	0.059	0.060	0.10	0.043	100
AKA SW2	3/12/2021	8:30	2789355.7	9.8	124.2	7.46	2.40	7.7	51	22	0	0	0.005	0.006	0.12	0.061	440
AKA SW2	16/12/2021	15:20	2803429.7	10.47	78	8.32	9	7.4	18.6	13.6	0.011	0.004	0.65	0.66	0.39	0.081	560
AKA SW2	19/01/2022	3:20	283456.2	9.27	118.1	7.68	3.2	7.6	39	17.6	0	0.002	0.006	0.008	0.19	0.075	5000
AKA SW2	16/02/2022	14:30	2875882.1	10.86	95	7.68	1.88	7.6	33	16.6	0	0	0.106	0.108	0.16	0.043	310
AKA SW2	1/06/2022	14:10	3005958.6	9.36	130.9	7.47	6.2	7.8	52	21	0.01	0.002	0.044	0.046	0.18	0.078	150
AKA SW2	6/07/2022	8:25	3029617.2	10.24	135.6	7.45	1.63	7.8	59	23	0.011	0.003	0.149	0.152	0.12	0.032	100
ROB SW1	30/09/2021	11:25	2720843.1	5.52	194.9	7.72	2.00	8.2	50	24	0	0	0.003	0.004	0.19	0.044	70
ROB SW1	20/10/2021	10:15	2740875.1	8.55	165.8	7.26	2.50	7.8	35	18.4	0	0	0.049	0.050	0.41	0.420	99
ROB SW1	9/11/2021	14:00	2763200.7	10.34	123.9	7.52	1.94	7.9	47	22	0	0	0.031	0.032	0.12	0.050	130
ROB SW1	3/12/2021	14:30	2789355.1	10.35	130.7	7.48	1.41	8	52	22	0.018	0	0.019	0.02	0.16	0.053	220
ROB SW1	16/12/2021	10:45	2803429.1	10.48	95	7.57	33	7.5	22	17	0.013	0.007	0.31	0.32	0.76	0.167	4900
ROB SW1	19/01/2022	13:40	2834564.1	10.42	140	7.49	1.17	7.8	49	22	0	0	0.008	0.009	0.19	0.066	370
ROB SW1	16/02/2022	9:40	2875882.7	11.14	120		2	7.8	40	21	0	0	0.045	0.046	0.18	0.053	260
ROB SW1	1/06/2022	9:30	3005958.1	10.41	142	7.86	2.1	8	57	23	<0.010	<0.002	0.13	0.132	<0.10	0.052	190
ROB SW1	6/07/2022	13:10	###########	12.71	144.2	7.24	0.75	7.9	53	21	<0.010	<0.002	0.141	0.142	<0.10	0.041	40
ROB SW2	30/09/2021	14:15	2720843.3	4.96	198	7.5	1.59	8.0	50	23	0	0	0.033	0.034	0.18	0.044	9
ROB SW2	20/10/2021	10:35	2740875.2	5.46	167.3	7.25	2.70	7.8	37	19.7	0	0	0.045	0.046	1.02	0.035	117
ROB SW2	9/11/2021	13:40	2763200.6	10.24	131.6	7.82	3.10	8.0	49	23	0	0	0.028	0.029	0.11	0.054	500
ROB SW2	3/12/2021	14:25	2799355.2	10.23	138.5	7.76	1.18	8	53	23	0	0	0.012	0.013	0.12	0.052	290
ROB SW2	16/12/2021	11:00	2803429.2	10.66	83.2	7.5	20	7.5	19.4	15.3	0	0.005	0.178	0.183	0.56	0.127	5400
ROB SW2	19/01/2022	10:20	283456.11	10.64	138.8	7.94	0.96	7.9	49	23	0	0	0	0	0.17	0.063	1400
ROB SW2	16/02/2022	9:55	2875882.6	11.12	108.9	7.56	2.1	7.8	38	19.2	0	0	0.036	0.037	0.14	0.047	330
ROB SW2	1/06/2022	10:10	3005958.2	10.28	147.5	7.64	1.08	8	57	23	<0.010	<0.002	0.119	0.12	0.12	0.049	130
ROB SW2	6/07/2022	13:00	3029617.1	12.89	148.2	7.63	1.13	8	57	23	<0.010	<0.002	0.154	0.155	<0.1	0.041	56
ROB SW3	30/09/2021	13:05	2720843.2	7.03	199.9	7.77	1.81	8.0	49	23	0	0	0.047	0.048	0.14	0.042	40
ROB SW3	20/10/2021	10:50	2740875.3	5.71	173.4	7.21	5.60	7.8	38	20	0	0	0.048	0.049	0.17	0.053	180
ROB SW3	9/11/2021	12:40	2763200.5	9.91	134.6	7.82	1.57	8.0	49	23	0	0	0.022	0.022	0.12	0.053	310
ROB SW3	3/12/2021	13:00	2789355.3	9.95	141	7.73	1.41	8	54	22	0	0	0.013	0.014	0.14	0.053	320
ROB SW3	16/12/2021	12:00	2803429.3	10.58	86.5	7.57	18.9	7.5	20	15.7	0	0.005	0.188	0.193	0.51	0.109	5100
ROB SW3	19/01/2022	11:10	2834564.9	10.11	138.8	7.93	1.25	7.9	50	22	0	0	0	0	0.23	0.066	1400
ROB SW3	16/02/2022	11:00	2875882.5	10.72	111.4	7.59	1.2	7.8	39	20	0.015	0	0.026	0.028	0.16	0.043	280
ROB SW3	1/06/2022	10:50	3005958.3	10.17	148.9	7.75	1.52	8	58	24	<0.010	<0.002	0.091	0.092	0.12	0.053	80
ROB SW3	6/07/2022	12:25	3029617.1	12.8	150.5	7.69	0.81	7.9	57	23	<0.010	<0.002	0.145	0.147	<0.10	0.04	23

Appendix H: Soil Chemistry Data

Sample Name	Date	pH	Olsen Phosphorus (mg/L)	Potassium(me/100g)	Calcium (me/100g)	Magnesium (me/100g)	Sodium (me/100g)	CEC (me/100g)	Total Base Saturation (%)	Volume Weight (g/ml)	Organic Matter (%)	Total Carbon (%)	Base Saturation (%) K	Base Saturation (%) Ca	Base Saturation (%) Mg	Base Saturation (%) Na	MAF Units K	MAF Units Ca	MAF Units Mg	MAF Units Na
AKA Soil	10/11/2021	5.6	18	0.65	5.5	2.51	0.42	17	53	0.94	9	5.2	3.8	32	14.5	2.5	13	7	53	18
HAM Soil	10/11/2021	5.7	23	1.08	5.8	2.75	0.36	18	56	0.9	10.5	6.1	6.1	32	15.4	2	20	7	56	15
ROB Soil	10/11/2021	5.6	13	0.83	5.7	3.31	0.29	20	51	0.92	9.9	5.7	4.2	29	16.7	1.5	16	7	69	12

Sample Name	Metals Lab No	Total Recoverable Phosphorus (mg/kg dry wt)	Total Nitrogen (g/100 g dry wt)	Total Recoverable Arsenic (mg/kg dry wt)	Total Recoverable Cadmium (mg/kg dry wt)	Total Recoverable Chromium (mg/kg dry wt)	Total Recoverable Copper (mg/kg dry wt)	Total Recoverable Lead (mg/kg dry wt)	Total Recoverable Mercury (mg/kg dry wt)	Total Recoverable Nickel (mg/kg dry wt)	Total Recoverable Zinc (mg/kg dry wt)
AKA Soil	2764011.1	810	0.47	3	<0.10	12	10	33	<0.10	8	60
HAM Soil	2764011.3	820	0.47	2	0.17	11	17	10.5	<0.10	7	131
ROB Soil	2764011.4	720	0.45	<2	<0.10	13	6	11.1	<0.1	7	56

Appendix B Terrestrial Ecology Report

Baseline and Terrestrial Ecology

Effects Assessment

Akaroa Treated Wastewater Irrigation Scheme
October 2022

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October 2021, updated April 20th 2022, 27th June 2022, 24th October 2022

Contents

List of appendices

List of figures

Executive Summary

From field observations and interpretation of published data, it can be stated unequivocally that the proposed Akaroa Treated Wastewater Irrigation Scheme (ATWIS) will have no detrimental ecological impact on existing natural/terrestrial or wetland remnant ecosystems or values. This is because the gentle slopes to be irrigated and revegetated (initially with early successional indigenous trees) are currently almost exclusively dominated by exotic grasses and associated forbs and retain no continuous history from the primordial vegetation-soil ecosystem. The natural seepages are dominated by exotic rushes, apart from one outside the irrigation zone, and are a consequence of past destruction of the former forest ecosystem, not a pre-existing wetland. Individual remnant native shrubs, trees or tussocks below the irrigation areas are largely non-functional in their present isolated state. The effect on the contained waterways has been modelled and shows the proposed scheme and its nutrient budget to be largely neutral compared to existing conditions, management, and dynamics.

It is accepted that the successional trajectory will be different under the ATWIS compared to natural soil/vegetation development, but there is nothing lost from the existing transformed environment, and indeed, there will be benefits to the wider landscape and its ecological integrity. A new ecosystem will evolve, compatible with indigenous microbiota and micro- to macro-wildlife and will thereby enhance indigenous landscape connectivity.
Adverse effects are therefore assessed to be minor to negligible with some alteration of hydrological balance of soils and therefore species capability and assembly on already modified hill slopes compared to some theoretical original state in a climate that no longer exists.

On the contrary, the additional native vegetation and eventually ‘noble’ podocarp trees will sequester carbon, Nitrogen, and some Phosphorous, providing substantial net gains in landscape conservation/biodiversity regeneration processes, and in designated areas can be part of a long rotation, sustainable cultural harvest product if there is the local interest. Among the multiple benefits will be the primary one of protecting the water quality in the harbour. Biodiversity gains will be in terms of indigenous forest and wetland, and associated wildlife, along with amenity, cultural sensitivity, learning and potential for sustainable harvest.

Provision of appropriate and evolving information will ensure that the unfolding narrative of the site can be told and that the landscape will be legible from a natural and cultural heritage perspective.

1 Introduction

Colin Meurk Consultancy (CMC), under the auspices of University of Canterbury, was engaged to carry out a terrestrial ecological evaluation of the Christchurch City Council (CCC) properties in the Akaroa Basin, Banks Peninsula in relation to existing natural values, likely impacts of proposed wastewater treatment irrigation, and opportunities for mitigation and enhancement.

A reconnaissance visit to the wastewater treatment plant site (WWTP) and associated irrigation areas was made on 6th May 2021 and more formal systematic surveys of those sites were conducted on 10th and 24th September 2021 on fine days. The intent and purpose of the assessment was to:

- review the Banks Peninsula Natural Areas report and other relevant published material (HD Wilson),
- make a base line inventory and broad-scale mapping of indigenous species and ecosystems,
- identify any rare or endangered species/habitats and recommend mitigations, if necessary (note: the assessment did not consider lizard or invertebrate values present),
- conduct an effects assessment of the proposed scheme that identifies and quantifies the positive and adverse effects of the proposal,
- prepare an indicative species list suitable for establishment under drip-irrigation and define appropriate restoration and monitoring protocols.

2 Background

The scheme concept involves treating wastewater from Akaroa in a new purpose-built WWTP on high ground immediately north of Akaroa at Old Coach Road (the Old Coach Road Site) and irrigating the highly treated wastewater to land over now two sites further north (Sawmill Road = the Robinsons Bay Valley Site, and the Hammond Point Site), after a third site in Takamātua Valley was deemed superfluous to requirements. Those two sites are located within the Akaroa Harbour basin and are currently used for agricultural purposes (Figure 2-1). Under the proposed scheme, the treated wastewater will be irrigated using drip irrigation to land, with the irrigation areas to be planted in indigenous vegetation. A total area of approximately 40 ha is proposed (McIndoe et al. (Aqualinc) 2022), subject to confirmation following field assessments and scheme design (Figure 2-2, Figure 2-3 and Figure 2-4). It is intended that all sites will, apart from the extensive indigenous afforestation, also be developed for passive recreational use (CCC 2017) with appropriate interpretation of natural, cultural, and technical history. All sites will have ecologically informed landscaping to ensure the vegetation is compatible with natural patterns and character. It will also have to reflect the supplementary hydrology and the interpretation adjusted accordingly.

Figure 2-1 shows the indicative location and areas of the proposed treated wastewater irrigation, in Robinsons Bay Valley and Hammond Point, and the WWTP site as originally proposed in the 'Inner Bays' scheme concept and described in the Christchurch City Council's public consultation material dated April 2020[1]. Figure 2-2, Figure 2-3 and Figure 2-4 show the current proposed irrigation areas in each of the three locations.

[1] Akaroa-Wastewater-Options-booklet-CIT0630-FINAL2.pdf (ccc.govt.nz)

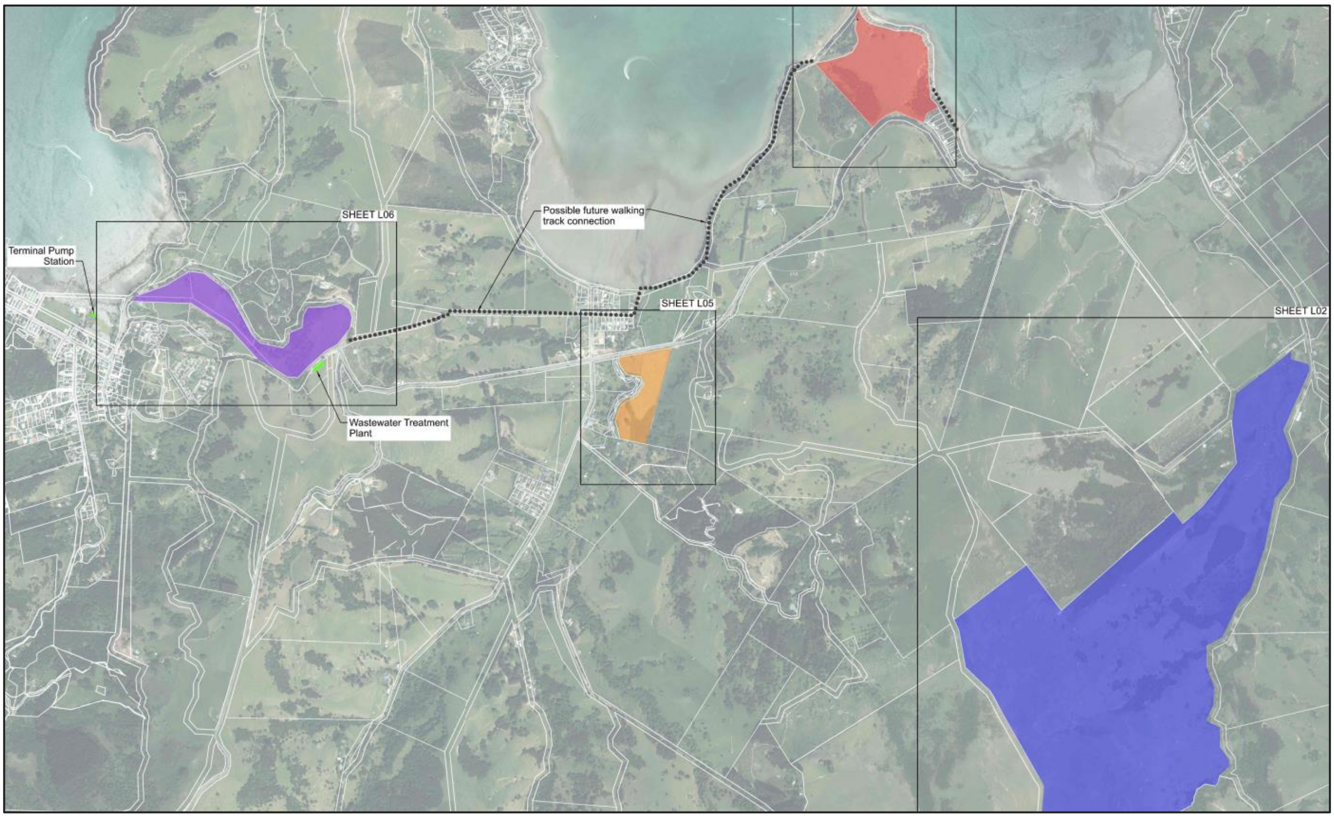

Figure 2-1: Indicative Treated Wastewater Irrigation Areas

Figure 2-1 Indicative Irrigated areas are 36.9 ha at Robinsons Bay Valley – blue; 3.8 ha at Hammond Point – red; the now excluded 3.7 ha at Takamātua – orange; and ca 3 ha at WWTP site on Old Coach Road – purple (also labelled Akaroa – Takamātua in Appendix A).

This assessment of the preferred option is therefore a necessary consequence of the requirement for wastewater deriving from the wider Akaroa settlement to be treated and disposed of in an ecologically, culturally, and economically sensitive manner. This follows exhaustive examination of all practical alternatives while addressing as many community needs and concerns as possible – by Christchurch City Council in conjunction with BECA.

In the satellite images (Figure 2-2, Figure 2-3, Figure 2-4, Figure 3-1, Figure 4-3 and Figure 4-7) that prescribe the proposed irrigation areas for the three sites, the underlying vegetation patterns are evident (from Aqualinc 2022). These broadly show the distribution of secondary (predominantly indigenous) wooded vegetation (as darker bushy elements) and intervening grassland – largely exotic pasture (pale or green). Some areas of oak woods and eucalyptus forest are visible respectively in the centre and southwest edge of the Robinsons Bay Valley site (Figure 2-3 and Figure 6-1).

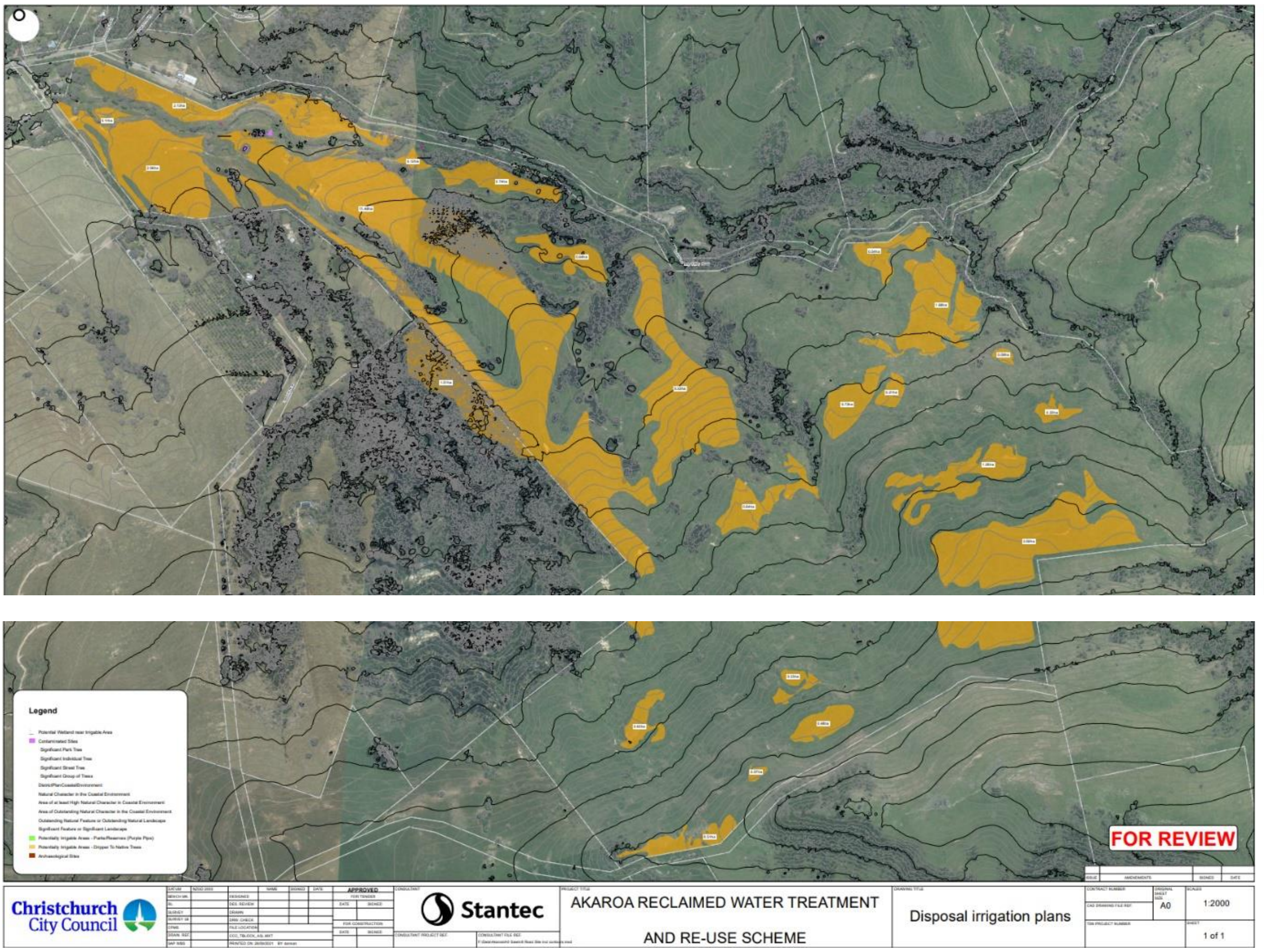

Figure 2-2: Earlier draft map of proposed irrigation areas for the Robinsons Bay Valley site (yellow)

Figure 2-2 shows expanded irrigation in the east on gentle slopes and under conifer/eucalyptus plantation; with separation from bush remnants.

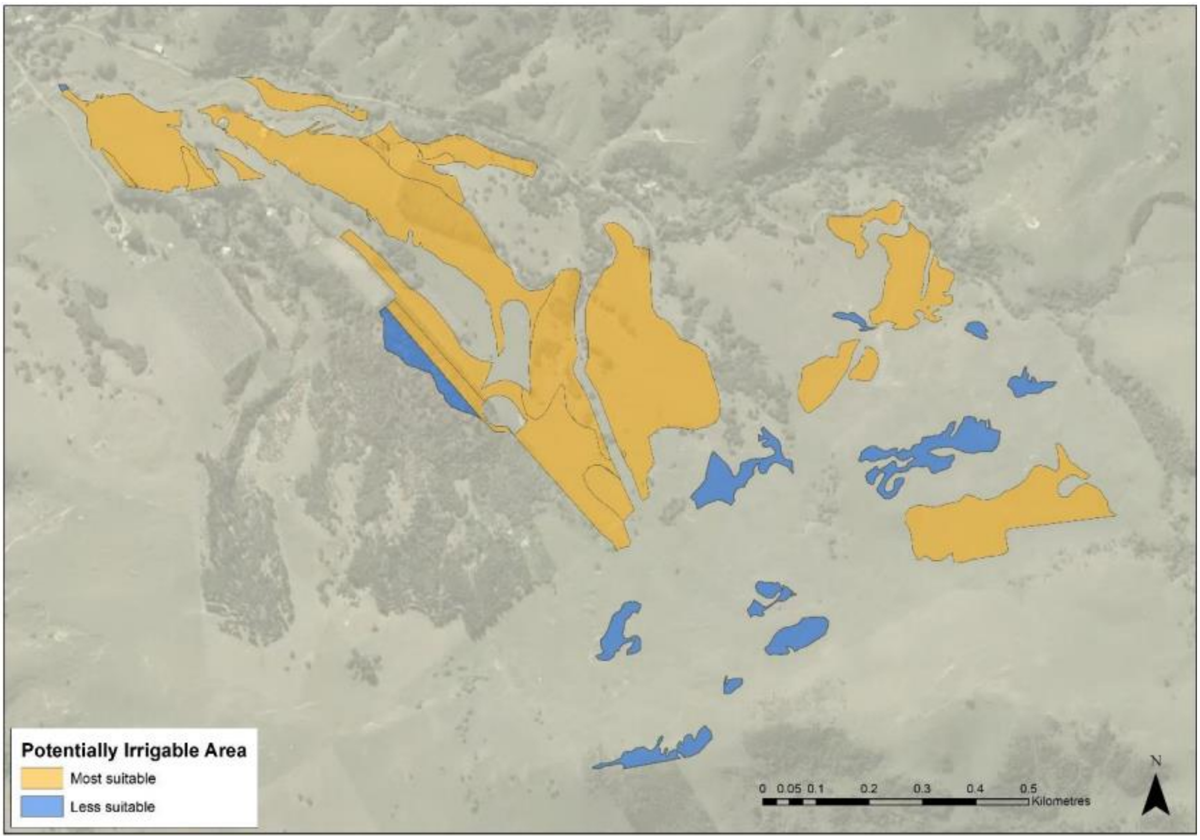

Figure 2-3: Aqualinc Report (2022)

Figure 2-3 shows the current proposed ‘most suitable’ (31.9 ha) and ‘less suitable’ (5 ha) areas for irrigation in the Robinsons Bay Valley site. The boundary of the property is shown in Figure 3-1.

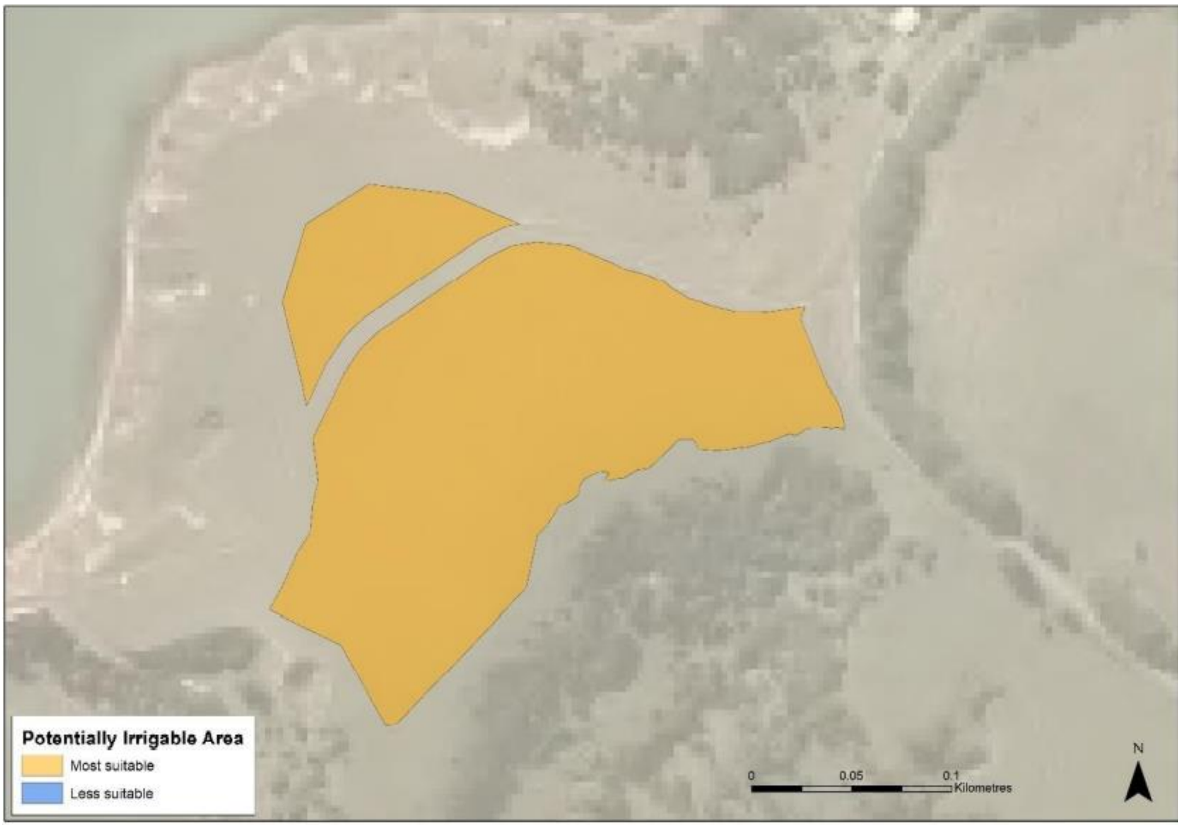

Figure 2-4: Proposed irrigation of Hammond Point

Figure 2-4 shows the Hammond Point area regarded as equally suitable for irrigation – 3.8 ha (Aqualinc Report, 2022).

3 Review of Relevant Existing Information

3.1 Prevailing conditions of sites

All proposed irrigation sites are on landforms with <19^0 slopes and which are setback from natural vegetation and streams to avoid erosion, contamination of water, impacting forest and wetland remnants or regeneration, and any other significant effects on the normal hydrology of native forest remnants, largely in gullies. A further check on risks to any natural wetlands (see next section) is that Aqualinc's models excluded areas that a site inspection showed were (ephemerally) wetter than surrounding land – seepages, springs, streams. Overall, the properties comprise a range of topographies from hills including gullies and interfluvial flat to sharper ridges, colluvial lower slopes, and valley floor floodplains and terraces. The typical soils are Pallic, on deep loess under ca 1100 mm rainfall (NIWA) and are prone to summer drought, but generally provide a deep fine-textured substrate for roots to penetrate and enjoy the water-holding capacity of such soils. There is some outcropping basalt rock and on foot-slopes colluvial deposits of mixed basalt rock and loess. The Robinsons Bay Valley Road edge includes a river terrace that may be subject to occasional flooding. This accounts for a very small part of this site being regarded by Aqualinc as 'less suitable' for irrigation. Mostly this applies to sites that are isolated, on steeper slopes, adjacent to gullies or under exotic forest.

3.2 Information provided by the applicant

There is limited additional information available that is pertinent to this assessment. The consultation document from CCC (2017) spells out the areas to be treated and the nature of that treatment (land uses). The effects on terrestrial environments will be to increase soil moisture and make it more conducive to ground-rooted rain forest type species, but not for rain forest epiphytes or species with delicate foliage which require greater air humidity and continual precipitation than normally occurs in eastern Canterbury – regardless of managed soil moisture.

3.3 Wetlands

Areas that have been identified as wetlands, at the time of preparing this report, as sourced from Environment Canterbury's (ECan) website, are highlighted in purple in Figure 3-1 and Figure 3-2. However, these maps are currently offline while the data is updated and so these images are only indicative.

Figure 3-1: Identified Wetlands (purple)

Figure 3-1 shows wetlands in and near the Robinsons Bay Valley Irrigation Site from the now redundant ECan GIS layer, and the extent of the City Council property outlined in red.

The full extent of the properties within which the proposed irrigation will occur is outlined in red in Figure 3-1 and Figure 3-2 with Robinsons Bay Valley Road and Sawmill Road bordering the north and northwest boundaries respectively. The total area to be irrigated will be approximately 40 ha and will not include the whole of any of the properties. Note also, that the ECan identified wetlands in the area lie almost exclusively outside the Council properties and in the case of the Robinsons Bay Valley site, outside the proposed irrigated area.

The irrigation will potentially create new wetlands in lines of seepages on valley sides. The precise location of these will be hard to predict until the irrigation begins, but once that is clear, then it would be proposed that native filtration wetland species be planted. These would include harakeke, ti kouka, pukio, toetoe, and rushes – as per earlier reports prepared for Port Hills seepages[2].

Figure 3-2: Identified Wetlands (purple) near Hammond Point and the formerly proposed Takamātua Valley Irrigation sites

3.4 Water and Nutrient Balance

The anticipated rates of application of treated wastewater (ca 700 mm) are equivalent to or less than the annual rainfall. A total of 1500 mm is at the lower end of the rainforest spectrum, but only in terms of plants rooted in the ground – not epiphytes. As such matai associates will more comfortably live with the otherwise expected totara dominance. That is, essentially any Banks Peninsula forest species will grow on these irrigated sites, including species that have very limited natural distribution (rimu, miro, nikau). It is anticipated that there will be surplus water being added to the stream flow – but it will have been filtered through soils, and by a train of forest and grass roots between the application areas on flattish ridge tops and the streams, generally over 100 m away.

Possible application rates of nitrate are 21, 35, 55, 75, or 95 kg N/ha/yr depending on the level of treatment of the wastewater, with the most likely rate of application being <55 kg N/ha which is comparable to existing sheep/cattle grazing inputs. Of the Nitrogen applied, it is modelled that 15kg/ha/yr will be taken up by the woody vegetation, and more than 10 kg/ha/yr will be 7amiliarizi or denitrified (Metz & Robinson 2022, Brett Robinson pers. comm.). This leaves a maximum (conservative) amount of ~< 50 kg N/ha/yr potentially entering the Robinsons Bay Stream and eventually some of it into the harbour. This may produce localised eutrophication but is unlikely as denitrification will occur along the way as accounted for in Aqualinc's modelling[3].

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[2] Meurk, C.D., Trangmar, B., Basher, L. 1997. Opportunities for stabilisation and enhancement of Port Hill's watercourses. Landcare Research Contract Report: LC9798/74.

[3] Reported in Aqualinc Research Limited, 2022: *Akaroa Treated Wastewater Irrigation Scheme*,

3.5 Literature review

Available literature on vegetation and plants in and near the project area was investigated.

Wilson's (1992) report describes existing reserves in the Akaroa Ecological District. The RAP (Recommended Areas for Protection) 24 – Chaney-Shuttleworth reserve (p 201) is the nearest and now also the Humphrey Rolleston covenants. Both have original matai and totara trees, as well as significant native canopy and understorey species including tree ferns.

RAP 29 – Takamātua (p270) 100-600 m sequence – above the originally proposed wastewater irrigation area – has totara, matai, and kahikatea. Well-grown totara and matai are present in immediately adjacent properties and old stumps of (probably) totara were found both in adjacent land (Figure 4-11) and within the irrigation areas (Figure 4-12). A further lowland sequence was reported at Wainui (RAP 12 Mat White, p 241), 0 – 550 m sequence, and with the notable presence of mamaku tree fern.

These are some of the nearest original remnant models for future restoration of the irrigation sites. Notwithstanding the artificially higher moisture provision associated with the irrigation lines, there will be some natural (limited) habitats that would have had similar hydrology and there are other areas within the various sites that will be protected and not provided with any artificial treatment. These sites will be available as 'control treatment' sites representing a natural regenerative/restoration situation in contrast to the irrigated forest.

Importantly, none of these sites will be affected by the ATWIS as they are either in different valleys, higher up the catchment, or on the other side of the harbour.

4 Assessment Methodology

Following consideration of available relevant literature, wetland maps (National Inventory), irrigation maps and the familiarising reconnaissance, a systematic field evaluation was conducted to determine the relationship between topography, environment/drainage, vegetation, and projected irrigation effects. This was at three scheme sites: Robinsons Bay Valley, Hammond Point, and the WWTP site at Old Coach Road, and Takamātua valley floor (as a floodplain comparison). All areas that appeared to have indigenous vegetation were visited (Figure 4-1 to Figure 4-8). This focused on representative areas of gully bush remnant, intervening grassland/pasture, wetlands identified by the Landcover database (LCDB), and by interpolation to similar topographies or visual indicators (rushes standing above grazed pasture), and any other vegetative or landform features (rock outcrops, exotic forests). The particular focus was on land under the critical slope of 19 degrees that was anticipated to be irrigated. The largely homogeneous pasture on such sites was sampled by random walks along and across topographic gradients and recording representative plant species on the natural history citizen science platform – *iNaturalist NZ–Mātaki Taiao*.

In addition to records made on *iNaturalist* above, species notes were made and from these two sources, lists were compiled that generally reflect the range of species at each site from the traverses and in the indigenous tree/bush and wetland remnants identified on the satellite images. This compilation is presented in Appendix A. INaturalist data also includes other records that have been made within the defined boundaries by other observers unrelated to the survey. These records are principally bird species.

Plants, habitats, or sites of special or remnant interest, that were visible in satellite images, and directly viewed or inferred from the traverses, were visited in order to identify any natural values that may be adversely impacted by irrigation or related works and therefore should be protected.

Some grasses were not flowering yet, nor had retained old seed heads, so positive identification at a distance of some such species was not possible without closer examination of vegetative parts. However, from experience, the only indigenous turf grass or sedge species that might survive in such highly modified pasture (*Microlaena stipoides* and *Carex resectans* or similar) were looked for but not seen in any of the traverses. Neither were any occasionally present broadleaved native, ground cover plants (grassland 'flatweeds'), such as *Oxalis exilis*, *Dichondra, Lobelia,* or *Leptinella*, observed in the pasture.

From the above, the broad-scale maps of remnant native bush and trees, significant wetland, and low-value pasture was verified, and any notable species and biosecurity issues identified. This was conducted in relation to the proposed waste-water management and identification of any potential biodiversity conflicts.

4.1 Survey Traverses

4.1.1 Robinsons Bay Valley Irrigation Site

The traverses of the Robinson's Bay Valley site are largely captured in Figure 4-1 and Figure 4-2 as meandering lines between specific observations. Figure 4-1 shows the traverse of the upper Robinsons Bay Valley site undertaken on 6th May 2021 (6 flags on left side to middle of figure), and 10th September – predominantly in the east of the property.

Figure 4-1: Upper Robinsons Bay Valley Traverse #1 – with flags indicating observations on iNaturalist NZ.

Figure 4-2: Upper Robinsons Bay Valley Traverse #2 – with flags indicating observations on iNaturalist NZ

Figure 4-2 shows the traverse of the upper Robinsons Bay Valley site on 24th September – predominantly in west and south of the property.

4.1.2 Hammond Point Irrigation Area

A circle was traversed around the plateau ridge to confirm that the entire proposed irrigation area comprised cultivated pasture of exotic species with a few rushes (facultative wetland species) near the stock yards at the roadside – see Figure 4-3.

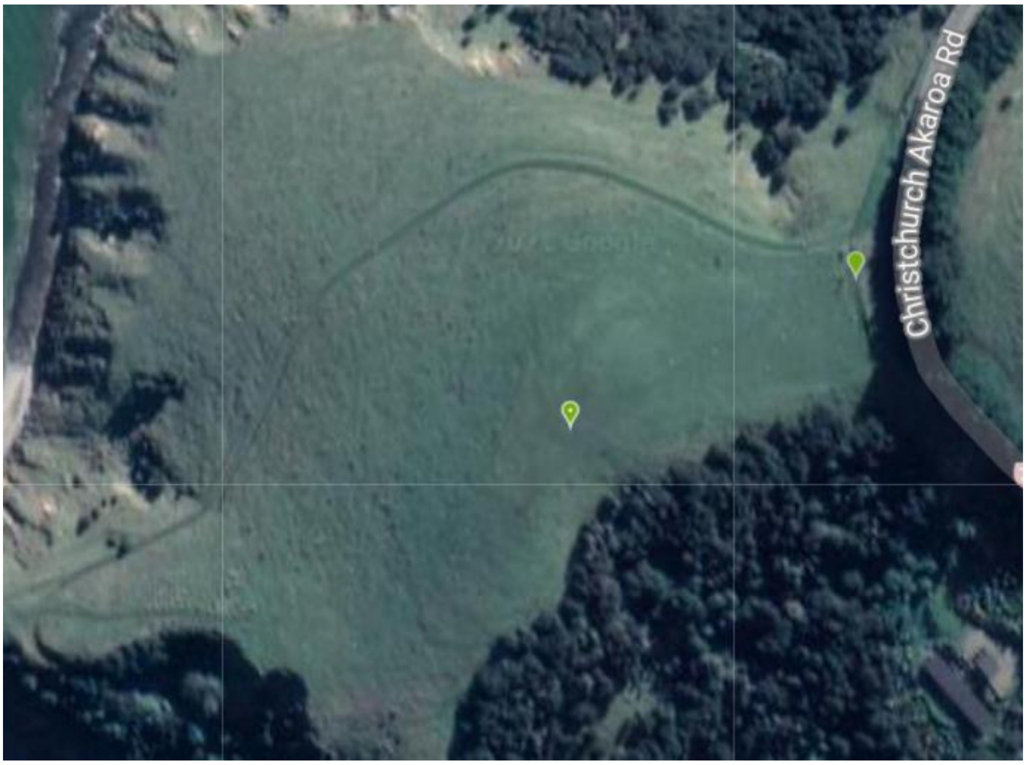

Figure 4-3: Hammond Point irrigation site

Figure 4-4: Hammond Point irrigation site with uniform exotic pasture grass (crested dogs tail shown) and rushes near the road (1st record above).

4.1.3 Takamātua

A traverse through the edge of the road frontage and into the back paddock confirmed that the entire valley floor comprises cultivated crop species (Figure 4-5, Figure 4-6 and Figure 4-13) and/or pasture of exotic grasses and clover. There are two ancient kahikatea trees on the site – remnants of a former floodplain podocarp forest – one in the front paddock and one in the rear paddock as shown in Figure 4-5 and Figure 4-6.

Figure 4-5: Takamātua site with observations

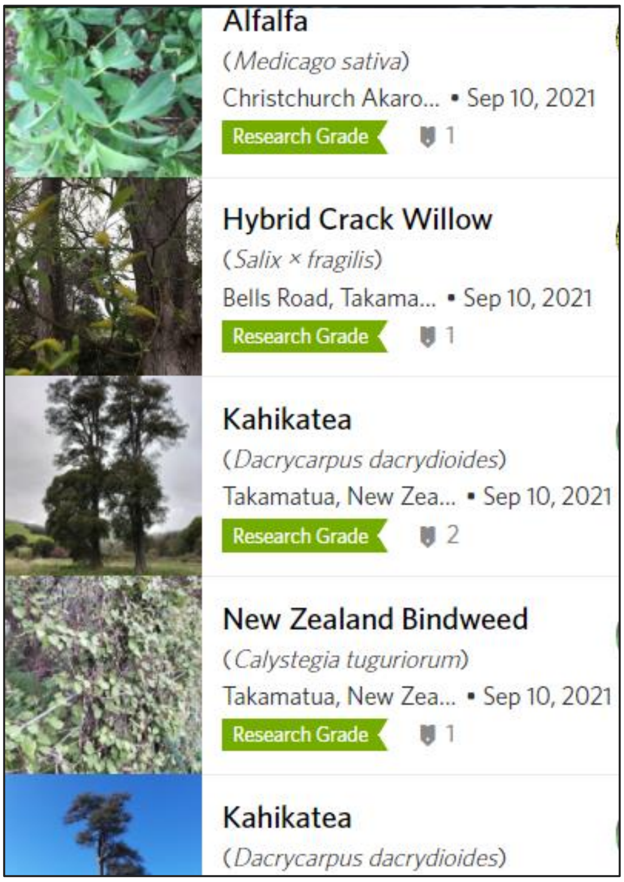

Figure 4-6: Takamātua site with observations supporting the assessment; relevant, predominant plant records

4.1.4 Old Coach Road Site

A traverse through and around the perimeter confirmed that the entire proposed irrigation area comprised cultivated pasture or hay paddock of exotic species Figure 4-7 and Figure 4-8.

Figure 4-7: Wastewater Treatment Plant (WWTP)

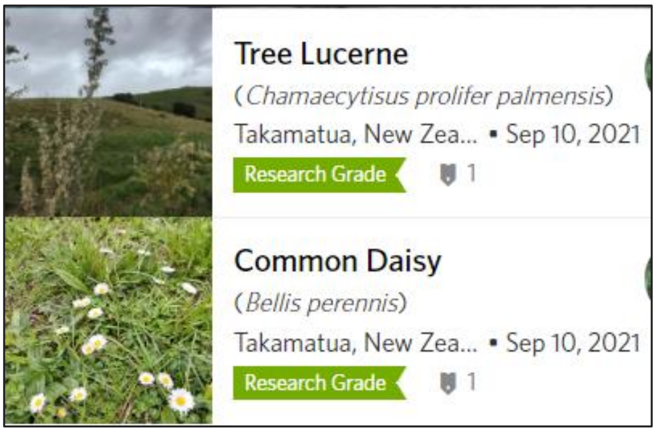

Figure 4-8: Site with relevant plant observations supporting the assessment

4.2 Assessment of Results

The outcome of the site inventory (site-specific species inventory) is recorded in the spreadsheet attached (Appendix A) and in the links to spatially classified sites provided below. These document the species observed in each of the locations. This generally shows a uniform exotic pasture mix in the grassland areas especially including those proposed for irrigated, indigenous reafforestation. In gullies and occasional isolated trees scattered through the grassland is a typical list of Banks Peninsula secondary bush species. There are some seepages with one occasional (otherwise common, non-threatened) native tall rush but dominantly exotic wet-tolerant herbaceous species such as Yorkshire fog, creeping bent, starwort, jointed rush, monkey musk, watercress, buttercups, docks, and white clover. There were a very few rocky outcrops that would not be affected by the scheme, other than to be part of a wider weed management programme.

4.3 Species Summary

From all sites (including non-scheme Takamātua) 139 plant species (55 native), 14 birds (9 native), 1 indigenous skink, 1 butterfly, and 5 exotic mammals were identified (Appendix A). Of the 84 exotic species, 12 are regarded as serious, invasive pest plants (wide red highlight in appendix) which should be eradicated as soon as possible, and 11 others are regarded as weeds (narrower highlight), although in this context not serious enough to warrant attempted eradication. The four sites are further split in the Appendix A table and species indicated against each habitat.

4.3.1 Robinsons Bay Valley Irrigation Area

Observations from the traverses of Robinsons Bay Valley site are recorded on *iNaturalist NZ – Mātaki Taiao* and available in the links below. These are summarised in the first 25 columns of data in Appendix A. The first link is of the 43 species observed by the writer and the second link is the cumulative (269) records of 123 species from the catchment by 31 observers; of which 25 are bird and 61 are plant species. Some of the bird records derive from the tui monitoring programme. The remaining 37 species are invertebrates and fungi.

https://inaturalist.nz/observations?nelat=-43.75396036058652&nelng=173.02608842554037&place_id=any&swlat=-43.77100707766817&swlng=172.95551652554423&user_id=meurkc&verifiable=any

Observations · iNaturalist NZ (269 observations of 123 spp)

Land at the top of the Robinsons Bay Valley site was largely outside of the proposed irrigation range and vegetated in exotic pasture as in the lower interfluvial slopes. The small areas designated for irrigation to the bottom right of the image, just below the top/back boundary (Figure 2-2 and Figure 2-3) has only pasture with no native shrubs or trees observed. There are some lowland ribbonwoods and coprosmas just outside this irrigation zone and there are dominant native shrubs on outcrops and ridges above and south of the property boundary, all being outside the affected area.

The wooded vegetation at Robinson's Bay Valley site (dark canopy as viewed in satellite imagery and mapped in Figure 2-3, Figure 3-1 and Figure 6-1) is predominantly indigenous kanuka, with scattered kowhai, houhere, ribbonwood, ngaio and some richer woodland associations in patches along the gullies with mahoe, tree fuchsia, pittosporums, kaikomako, five-finger, vines and ground cover of ferns (see Figure 4-9, Figure 4-10 and Figure 4-11). There is a scattered understorey of coprosma, kawakawa, and nettle. Approximately 95% of this is outside the proposed irrigated areas, and the other 5% is of scattered individual trees or small patches of mainly kanuka, ribbonwood and coprosma that have been heavily grazed underneath over many year with a corresponding absence of indigenous ground cover ferns or understorey shrubs. Evidence of the original emergent totara and matai trees exists as stumps of the former across the landscape (Figure 4-11 and Figure 4-12).

There are several exotic plantations in or adjacent to the properties – oak, eucalyptus, macrocarpa, and pine. Depending on stock access these have indigenous species prolifically regenerating beneath them. Both the eucalyptus area on the western boundary, and the oak woodland in the north centre of Robinsons Bay Valley are planned for irrigation which, with weed, pest, and grazing animal control, will continue promulgating forest regeneration, as will be achieved in both the relatively small areas of irrigated kanuka woodland and that in the gullies beyond the drippers. Utilising exotic nursery plants to support regeneration, eventually back to indigenous forest, is related to the minimum interference management (MIM) approach employed by Hugh Wilson at Hinewai. It needs to be clarified that there are six prerequisites to the success of this method – no harm is done to existing natural habitat, there is a nearby seed source and presence of seed vectors (fruit-eating wildlife), there is adequate moisture (ensuring litter breakdown), there is freedom from browsing mammals, absence of fire, and a weed management plan. It must also be recognised that any non-indigenous tree/shrub canopy that acts as a nursery will modify the natural trajectory of succession due to the influence of soil and litter properties, shade quality, nutrient uptake, or N-fixation. The requirements are largely fulfilled in this and other sites (surrounded by seed sources and dispersers, with plenty of moisture provided). Successional shift has already occurred so nothing is lost here, however browsing control will be essential, including in the irrigated areas, once there is canopy closure.

Most of the intervening space is almost entirely exotic pasture species maintained by cattle and some sheep grazing.

Wetlands identified in the vicinity of the project area are mostly outside of the irrigation areas and are of low quality comprising, in the most part, native rushes (three common species, one of which is ubiquitous) and exotic lush pasture species. No indigenous wetland ground cover or turf species were identified in these wet seepages. As they have intermittently hydric soils (gleyed and mottled), and indicator (facultative or obligate) wetland plant species – predominantly exotic and/or very common indigenous rushes – these seepages are technically 'natural wetlands' (NPSFM 2020). Overall, of the 28 species recorded in seepages and wet pasture, 39% were upland facultatives, 25% were facultative, 25% facultative wetland species and 11% obligate wetland species (the latter mainly in minor streams). They are, however, all outside the planned irrigated land (the most significant is well east of the irrigation line), are composed entirely of exotic or common native rushes, or will not lose any of their wetland values – and potentially gain some – due to irrigation and potential planting. There may be some more visible water flow in the streams compared to their current ephemeral status. This will be expanded upon following the hydrological and freshwater ecology analysis. It should also be noted that the wetland rules under the NPS are still being litigated as earlier definitions and boundaries have been found difficult to practically apply in real world situations.

Most of the wet seepages were accessible to cattle (and to lesser extent sheep). There was evidence of consequent moderate to severe pugging resulting in bare, disturbed ground vulnerable to erosion and sediment load in run-off. It was especially noticeable at the time of the field survey probably because of recent heavy rain and softened ground. It is clearly intended that heavy (cattle) animals, that are attracted to wet/soft ground, will be excluded from the scheme. One additional riparian/seepage species observed was the coarse *Carex virgata* tussock sedge on the stream terrace at the northern boundary of the property within 50 m of Robinsons Bay Valley Road. Direct irrigation should be excluded from this vegetation.

Rocky bluffs/knolls with mixed grey shrubland and other rock ledge inhabiting species are mostly found above and outside the boundaries of the irrigation site; and these won't be affected by wastewater treatment but weed management of these will be important for the integrity of the overall landscape complexity and biodiversity. Furthermore, the natural values of these sites within the broader catchment context should be recognised and care taken to avoid any disturbance due to construction or routing of infrastructure across or through such habitats. In some cases, extensive sheep grazing will be compatible with retaining the existing values.

Vegetation maps (the satellite/aerial photos – Figure 2-3 as well as Figure 6-1) show broadly the relative locations and extent of exotic forest, indigenous forest/woodland, exotic pasture, rush-dominated seepages, and proposed irrigated land. The green band along the western boundary (Figure 6-1) is eucalyptus forest. It is intended that most of the irrigated land will over time be progressively re-wooded and natural regeneration facilitated. This will increase habitat, natural character, and landscape connectivity thus adding to critical mass of wildlife foraging and breeding territory. Recreation trails may be incorporated which can potentially link to wider track/access systems within the Harbour basin and provide a valuable and informative walking/cycling experience.

Figure 4-9: Mid valley of Robinsons Bay Valley Road

Figure 4-9 shows the Northeast edge of the Robinsons Bay Valley irrigation site, down the road and on the left with a mosaic of pasture on the interfluves and scattered secondary low forest in patches and in gullies. A more continuous natural secondary forest is on the right (shady) side of road/valley and is illustrated more directly in Figure 4-10. This secondary forest contains scattered medium age totara as well as a wide mix of other native forest species including kowhai, houhere, five-finger, pittosporums, titoki, and kaikomako.

Figure 4-10: Dense remnant and secondary indigenous forest on sheltered/regenerative slopes adjacent to the Robinsons Bay Valley site

Figure 4-10 is indicative of expected coverage of irrigated land in about 10 years' time due to enhanced water and nutrient availability.

Figure 4-11: Land adjacent to eastern-most edge of the Robinsons Bay Valley irrigation site with scattered trees

Figure 4-11 (open woodland) and larger forest patches in gullies and edge of grazed land. Old totara stumps of former primary forest are evident.

Figure 4-12: Remnant totara stumps, evidence of previous forest vegetation

Figure 4-12**:**, The totora stumps are from over a century ago, that once formed over 90% coverage of Banks Peninsula prior to colonial settlement (Wilson 2013a, b).

4.3.2 Hammond Point Irrigation Area

The links below provide the iNaturalist data, supplemented by field notes.

https://inaturalist.nz/observations?nelat=-43.77133365997011&nelng=172.96276787333468&place_id=any&subview=map&swlat=-43.77346414644254&swlng=172.95396069073163
Observations · iNaturalist NZ (5 observations of 5 spp)

The Hammond Point irrigation site is entirely exotic pasture on the plateau and irrigation will not affect any indigenous species or vegetation (Figure 4-3). There are some low value rushes near the road (Figure 4-4) and 12 exotic grasses and flatweeds were recorded (Appendix A). It is anticipated that the additional effective rainfall from irrigation (<60 mm per year), added only at times when storm events are not forecast, will be largely balanced by evapotranspiration from the developing forest cover. Accordingly, any ‘natural’ albeit degraded secondary vegetation (mainly kanuka with some houhere) on the slopes below are not expected to experience a changed hydrological regime nor therefore soil/ecosystem characteristics.

The proposed landscape/planting plan (Figure 6-2) comprises the irrigation treatment (discussed generically below), enhancement planting of indigenous species on the slopes, and some coastal scrub-tussock on the headland.

4.3.3 Takamātua Area

The following links present the iNaturalist data observed by the writer and the larger body of information (mainly birds) recorded by other random visitors.

https://inaturalist.nz/observations?nelat=-43.77909213924158&nelng=172.98384407587278&place_id=any&subview=map&swlat=-43.78335248348702&swlng=172.96622971066668

Observations · iNaturalist NZ (147 observations of 32 spp)

The Takamātua area (Figure 4-13) is land currently used for agricultural purposes, including crops and exotic pasture. The historical farming has avoided eliminating two mature kahikatea trees on the floodplain and regenerating indigenous forest species along the stream banks of the south-eastern boundary of the site.

Figure 4-13: The Takamātua Site with lucerne hay crop in foreground

Figure 4-13 shows the Takamātua site, dominated in the left foreground by a lucerne hay paddock. One remnant kahikatea tree is in the paddock to the right just out of view and another is behind and visible through the exotic deciduous poplar trees in the middle distance (see also Figure 4-5 and Figure 4-6). There are many (35) native and exotic species reported along the fence and wooded riverbank (Appendix A).

4.3.4 Old Coach Road WWTP and Wastewater Management Area

The proposed, intermittent wastewater holding area (Utility or WWTP Hay Paddock site on the corner of Christchurch-Akaroa Rd and Old Coach Rd; (Figure 4-7, Figure 4-8, Figure 4-14, Figure 6-3 and Figure 6-4) is entirely exotic pasture with exotic shelter trees, and some recent roadside plantings (Figure 4-14). No indigenous plants or vegetation will be affected by irrigation or water detention. Only a few of these common species are registered on iNaturalist NZ (see links below) although 7 exotic pasture species are listed in Appendix A with larger numbers in adjacent slopes and where there will be greater restoration and amenity value.

https://inaturalist.nz/observations?nelat=-43.79135640444258&nelng=172.9752610343474&place_id=any&subview=map&swlat=-43.79348617751124&swlng=172.96645385174435 .

Observations · iNaturalist NZ (4 observations of 3 spp)

On those slopes below the plateau (as visible in Figure 4-7, Figure 4-8 and outlined in Figure 6-3), leading down to the proposed amenity areas above the town, is secondary bush of kanuka, kohuhu, ngaio, karamu, kowhai, akeake, kawakawa, with a few small trees of kahikatea, some pines, tree lucerne, koromiko, bracken fern and a patch of ‘old man’s beard’ vine. This latter noxious weed will need to be vigorously controlled and prevented from spreading.

The proposed WWTP will be built in an area immediately northeast of Old Coach Road, adjacent to an existing water reservoir on land owned by the applicant. The land opposite the WWTP site, partially circled to the north, west and southwest by State highway 75, will accommodate a covered storage pond for buffering untreated wastewater inflows, and a subsurface wetland for storing treated wastewater, in emergencies, or when ground conditions in the irrigation areas do not permit treated wastewater to be irrigated to land (expected to occur infrequently, such as once every ten years).

Figure 4-14: Indigenous vegetation on the Akaroa WWTP site road boundary

Figure 4-14 Existing tanks on the other side of Old Coach Road are obscured by these foreground trees.

The construction of the subsurface wetland and the Jubilee Park community amenity area provides opportunity to substantially increase indigenous biodiversity values in this location through planting of wetland species and other indigenous vegetation around the perimeter to screen the structures from the State Highway and visually integrate them into the landscape. A list of potential species for the wetland is included in Appendix B to this report, in the context of the indicative plan (Figure 6-4).

4.4 Inferred Natural Patterns of the Akaroa Basin

From the above field observations, literature and species records the following broad vegetation patterns are discerned for the catchment – currently or potentially and which historically occurred:

- Rocky bluffs with NZ stonecrop, grasses, hot rock ferns, lichens, etc.
- Dry ridges with kowhai, kanuka, cabbage tree/ti kouka, narrow-leaved lacebark/houhere, ribbonwood/manatu, kohuhu, ngaio, totara, broadleaf, five-finger, fierce lancewood, golden akeake/akiraho and small leaved shrubs of coprosma and olearia.
- Sheltered, mesic gully forest supports the above plus kaikomako, tree fuchsia/kotukutuku, titoki, rohutu, turepo, patete, lemonwood/tarata, lancewood/horoeka, large-leaved coprosmas, vines and ferns. Matai would have been a signature species of these sites with kahikatea, pokaka and tree ferns present.
- Floodplains and gullies have kahikatea, and nearby matai and pokaka (at Wainui), and otherwise potentially similar species to the gully forest.
- Seepages have rushes and currently marsh foxtail, buttercups, lotus, but naturally NZ flax/harakeke, toetoe, ti kouka, tussock sedges (pukio), mikimiki and manuka.

Now visible parts of the landscape are dominated by exotic wattle, alder, pines, gums, grey willow, and associated ivy and other invasive vines, shrubs, and ground covers.

The existing grasslands and seepages are believed to be entirely anthropogenic. The logic behind this is that 170 years ago these sites were completely forested with structured podocarp forest (dominated by emergent kahikatea, pokaka, matai and totara on a wet to dry soil moisture gradient). With the combination of milling, fire, cattle and sheep grazing, over-sowing exotic pasture species, and in some places cultivation, any existing open spaces are induced and have been maintained as exotic pasture for the past century. A few remnant trees escaped the initial burning, some recovery and/or regeneration has occurred in the gullies, where protected from stock or in the case of kanuka is unpalatable, and a few rushes dispersed back into some of the seepages.

The general pattern outlined here is the basis for restoring a more natural landscape that reflects ecological integrity, notwithstanding the supplementary water some of the area will receive.

5 Overall Effects Assessment

There will be little or no additional impact on existing natural values on any of the proposed irrigation sites due to the proposed change in land use and vegetative cover, since almost all the affected areas are currently dominated by exotic pasture and have historically been transformed from forest. There are some very limited areas of existing native secondary forest and individual native trees within the designated irrigated zones of the Robinsons Bay Valley site only. It is recommended that no such existing trees will be removed. They are already in an ecologically highly degraded state and increased new forest around them will increase their value as wildlife habitat and contribution to landscape function. All the identified wetland seepages across the sites are highly modified and/or outside the prescribed irrigation areas. The few cases of associated native tall rushes (wiwi) have resulted from self-establishment within a grazing regime. They are classed as Facultative Wetland species (Clarkson 2013) which means they most commonly grow in at least ephemerally wet ground but have some drought tolerance. They are some of the few indigenous plants that are relatively unpalatable to stock. All are commonplace species, and indeed will probably spread due to irrigation, dispersal and establishment in the at least initial, light sheep grazing situation. They are however, induced from the historic opening-up of the original forest cover, and when sheep grazing is removed they will initially be overtaken by tall exotic grasses then a succession back to forest specifically guided by management.

It should be noted that an artificially irrigated new native forest is a construct and as such will be different to the 'natural' forest ecosystems or be reminiscent of the more mesic forests of the harbour basin. However, the irrigation areas will provide an important seed source and foraging locations/stepping stones for native wildlife, and visual continuity to the landscape. As such there will be new and significant benefits to the wider ecological connectivity of the Akaroa Basin as a direct result of the proposed changes in land use at the three irrigation sites, and the subsurface wetland and associated plantings at the Old Coach Road site to a lesser but still important extent. The fruits from these planted sources will raise the food bank for native wildlife that will disperse the seed and thereby assist the regenerative processes in the wider landscape in more natural soil/hydrological situations.

There can be no doubt this project will result in a net higher biodiversity and conservation value for the Akaroa Basin than (for example) exotic plantation forest or maintained exotic pasture as currently /prevails at each location.
While the effects of the proposal are expected to be overwhelmingly positive from both a biodiversity and carbon sequestration perspective, some additional measures will further enhance the benefits of the proposed scheme:
It is expected that cattle will be destocked from the properties so ongoing damage of wetlands due to cattle pugging will cease. Large grazing animals should continue to be excluded from the sites on an ongoing basis as young plantings establish, noting that some lighter grazing animals such as sheep will be used to keep weed/grass growth in check until indigenous plantings establish, mature, and form a more or less continuous canopy that shades/suppresses the grass and other weed competition.

The full red highlighted species (Appendix A) need rigorous control, but the other identified weed species are unlikely to prosper in the anticipated management regime – which will be succeeding towards forest.
It is anticipated that there are the usual exotic mammalian predators present (mustelids, rodents, hedgehogs, cats, dogs, possums). So, for a rich native wildlife to be a part of a future ecosystem here, the pests will need to be rigorously controlled or exterminated. Similarly, the presence of mammalian herbivores will threaten the palatable indigenous plants and hinder regeneration in the existing and new forests. These mammals are already on or have been on the Peninsula - possums, rabbits, hares, sheep, cattle, horses, goats, wallabies, pigs, deer. There are currently endeavours through the Banks Peninsula Conservation Trust, CCC, ECan, NZ Department of Conservation, rūnanga and landowners to control or eliminate wild populations of these species to prevent planting being compromised, and to enable natural regeneration of future canopy and ground cover plants.

It is therefore expected that wild exotic animal control will be initiated then supported, potentially with the assistance of local agencies and the community, on an ongoing basis. This is distinct from the, at least initial, use of light sheep grazing in conjunction with the establishment of unpalatable native woody plants in the irrigation sites. Whereas sheep are not such heavy shrub browsers as cattle, deer, and goats, they will ideally be excluded from the regenerating secondary forests outside the irrigated places.

One possible marginal or minimal adverse effect on natural values could be the seepage of a portion of irrigated water into surrounding 'natural' gully vegetation. This could potentially change the successional pathway of these habitats, but only in the same sense as the wider irrigated forest will be on a more mesic course. However, it is expected that most of the irrigated water, applied at the modest rate proposed, will typically be evapo-transpired *in situ* with little or no runoff or seepage. This will be ensured if total supplement (adds only the equivalent of 60 mm per year or <10% of natural rainfall) is managed around any forecast storm events.

Existing mapped seepages (Figure 3-1 and Figure 3-2) can be enhanced through planting of pukio, harakeke, toetoe, ti kouka and mikimiki, bordered by wet ground podocarp forest species – dominated by kahikatea and pokaka (see Appendix B).

Other forest restoration will draw on the indigenous species listed in the spreadsheet attached in Appendix C, bearing in mind that the irrigation will permit more drought-intolerant species to be included in the proposed species mix. In particular, matai and possibly red beech, even rimu and miro, could be incorporated in addition to the drier forest associates of totara. The existing and initial plantings of kanuka/kowhai will be expected to change over time towards podocarp forest.

6 Proposed Planting and Restoration Scheme, Background Explanation, Site Management & Monitoring Protocols

The following maps (Figure 6-1, Figure 6-2, Figure 6-3 and Figure 6-4) are the current landscape plan propositions for the three sites of the scheme (CCC landscape architects/planners), to be interpreted in conjunction with Appendices B and C.

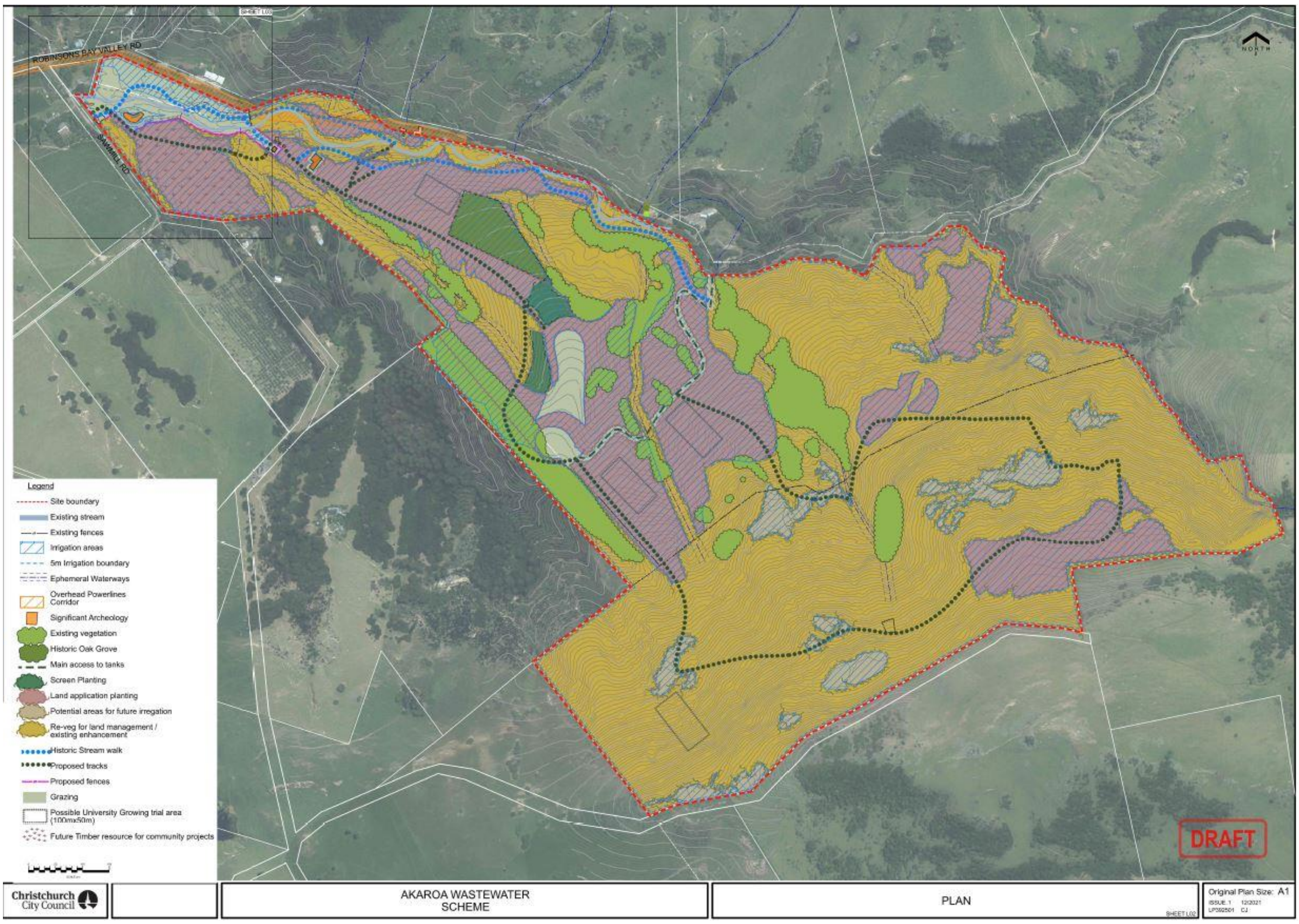

Figure 6-1: Higher resolution view of indicative irrigation areas

Figure 6-1 is from the landscape plan proposed for the Robinsons Bay Valley site by CCC. This later plan excludes an earlier retention pond and instead makes provision for future cultural/community harvest of native timber products however this is still being negotiated. The “existing vegetation” map element is largely indigenous secondary forest as described in the text, except for the green band along the western boundary which is eucalyptus forest.

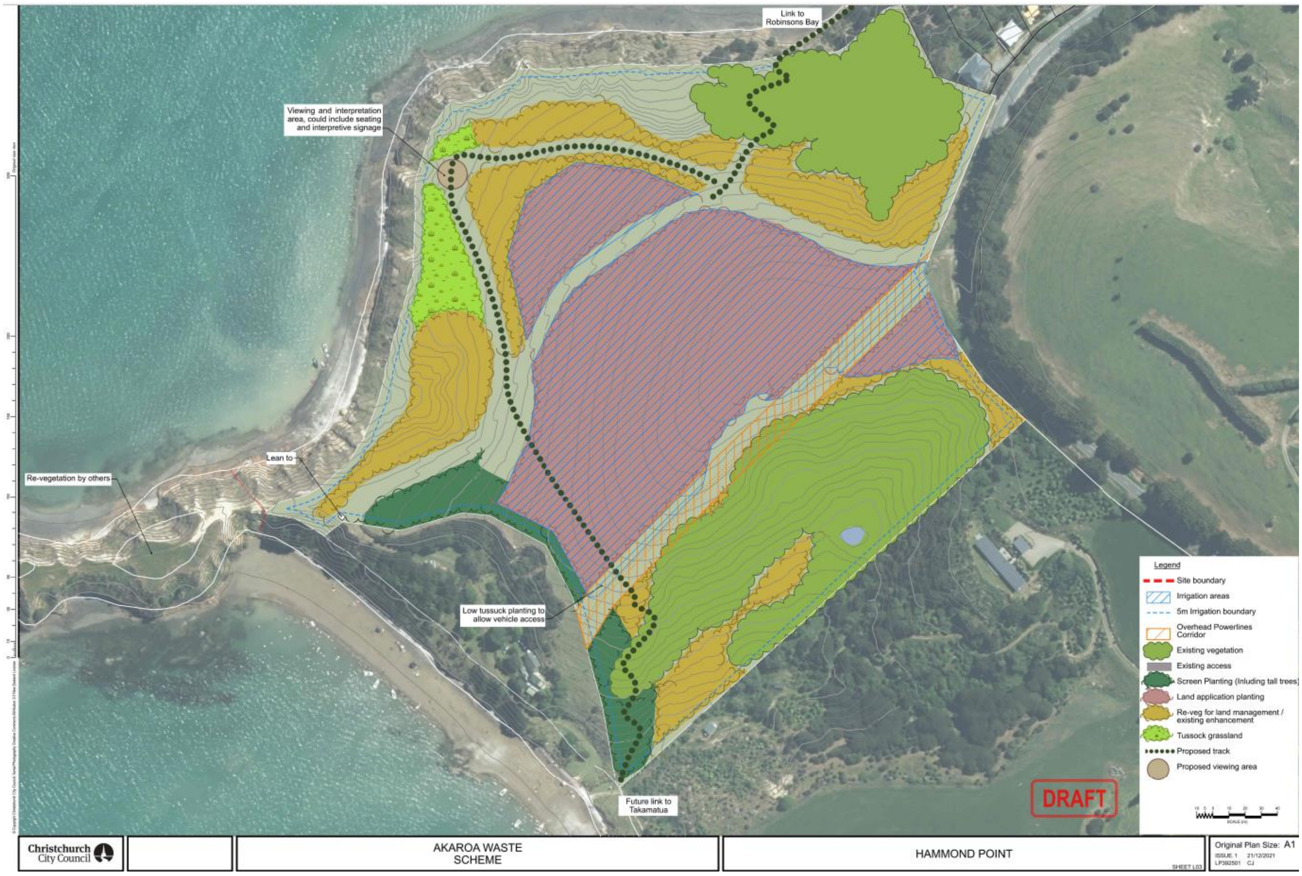

Figure 6-2: Hammond Point irrigation/existing vegetation map

Figure 6-2 Dark and medium green map units are existing secondary forest and proposed enhancement planting; orange is revegetation around the border of the irrigation/land application area (pink). “Existing vegetation” is primarily secondary indigenous low forest.

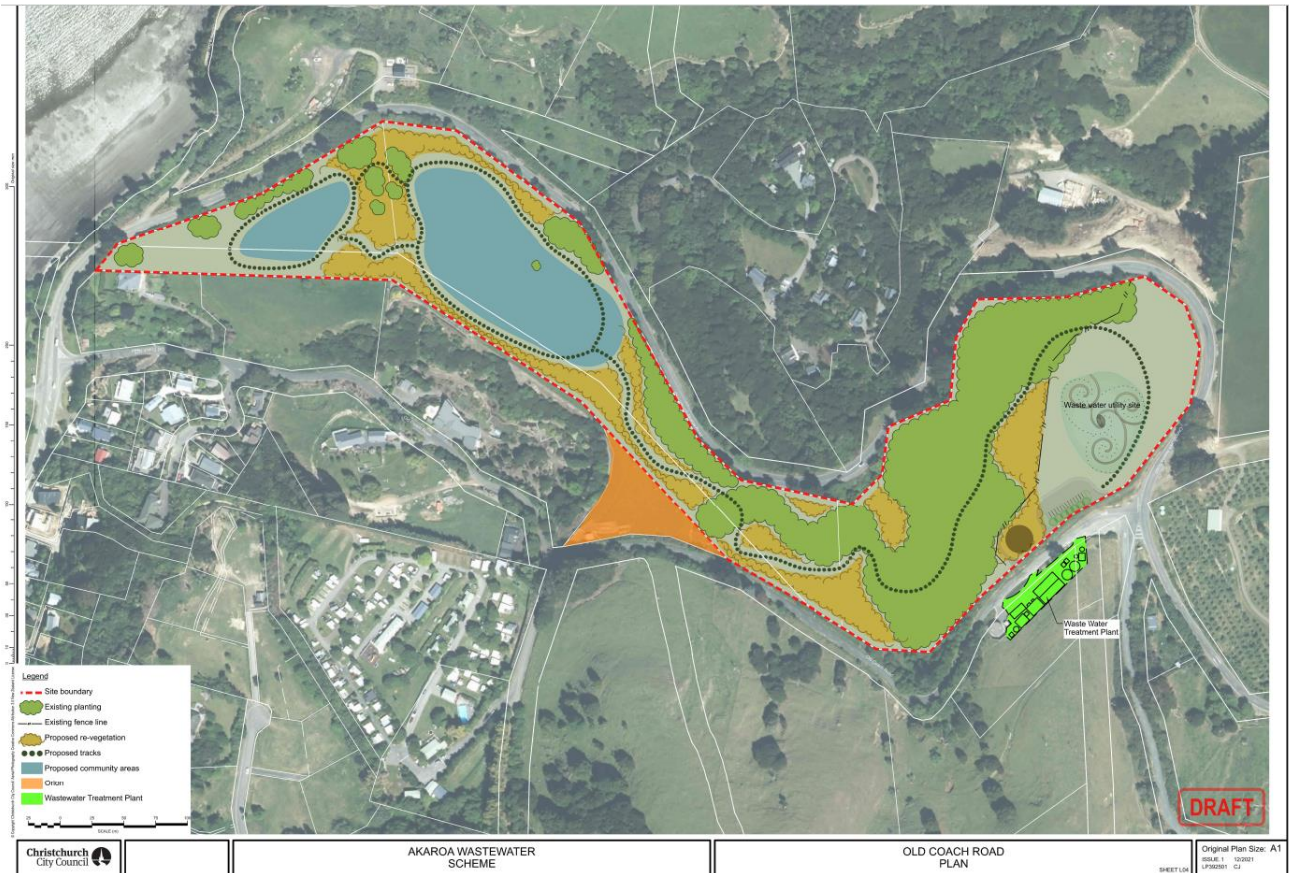

Figure 6-3: Vegetation (green), irrigation/detention-storage (light grey), and restoration planting (pale brown)

Figure 6-3 is the plan for the Old Coach Rd WWTP. Future amenity areas are in blue.

Figure 6-4: Indicative Stylised Design for the water treatment area

Figure 6-4 shows the “existing planting” map element (green) is mainly secondary forest/shrubland rather than planting per se.

Irrigation will be on slopes <19^{0}. The reticulation arrangement is expected to comprise parallel, contour-oriented planting rows 2 m apart with trees at 1.2 m spacings along the rows. Installing the drip lines (one to four between each plant row) will be determined in a detailed plan to maximise uptake and minimise runoff (see Aqualinc 2022). It is suggested that if just the one dripline is employed it might be positioned about 1.2 m above the next lowest plant-line (that is, 0.8 m below the uppermost). It is anticipated that the water halo from drip lines will cause moist to saturated soil conditions for extended periods, up to 0.3 m below the dripline and 0.2 m above (average 0.5 m diameter moisture halo – Aqualinc 2022). However, all the intervening soil will be moistened through marginal effects and consequent impeded drainage. The trees will be planted 4 years before the wastewater irrigation is turned on, however freshwater might be flushed through, especially in the event of severe drought in the first few summer seasons to ensure establishment survival. The roots of these planted trees will be expected to access these moister soil conditions within a year with a consequent transpirational dewatering effect and boost to growth.

Given the recommended 30cm dripper spacing in 4 dripper lines between each tree row (McIndoe et al. 2022) for total saturation and the likely cost impact of additional driplines, a compromise might be 2 dripper lines per plant row with one line 0.2 m below the upper plant row and the second 0.3 m above the next lower row. With expected greater subsurface migration of water downslope, and growth of roots towards water source this might result in optimum wetting and uptake of water.

It may be that occasional wider gaps would be retained to provide for motorised (quadbike) access for maintenance. Irrigation will only be carried out until land is deemed to be saturated and cannot take more without causing overland flow. At that point, treated wastewater will be held in the storage tanks.

The rate of Nitrogen (N) application – as the key indicator contaminant – is anticipated to be 40 Kg N/ha/year, an order of magnitude less than many other land treatment systems (Meister & Robinson 2022). Of this, broadly, an estimated 13.5 Kg/ha/year will be extracted in accumulating biomass, denitrified and/or volatilised from soil and litter. This leaves ca. 27 Kg/ha/year lost to drainage/leaching and ultimately the harbour which compares with ca. 25 kg/ha/year for non-fertilised grazed pasture now. There is also recent evidence suggesting N_2O emission maybe a substantial portion of this nitrogen export (Brett Robinson pers. comm. 2022). Native trees will take up a large part of the total application in early stages of growth but will level out after 10-20 years, however the podocarps (totara and matai) will be slower accumulators over a very long time – in the order of centuries.

The following comments and planting regimes assume the irrigation system is working well as intended. However, there is some concern that not providing irrigation to kanuka for 4 years will result in very slow canopy closure and pasture growth with some mortality in drought years – all requiring more intensive sheep grazing. It is therefore recommended that irrigation (at least of freshwater) should be brought on sooner if the first summers are exceptionally dry.

The trees will then be well-established after 4 years with root systems spreading in all directions from the stems. It is proposed that the planting/irrigated zones will be heavily (sheep) grazed immediately prior to planting – rather than controversially applying widespread herbicide - to reduce grass competition during the establishment phase. Grass growth will be rampant before tree canopy closure is achieved in about 3-5 years, although possibly somewhat faster if some irrigation is supplied.

There is debate about employing sheep to manage the inter-tree grass for the first few years of establishment, as this would necessitate a restricted list of browse-tolerant species – kanuka, manuka, tauhinu (shrub), akiraho, and akeake (and after year 3 - totara and matai at 10 m spacing from each other). The problem here is that most of these species are small-leaved and therefore do not rapidly form a closed canopy. Akeake is an exception to that but is likely to be affected by browsing. Sheep grazing can be employed to maintain a short turf indefinitely between establishing kanuka (see Appendix D). But it is likely that N-uptake is less than with broadleaved species like karamu (Alexandra pers. comm.). If sheep are not used and a greater range of more leafy species are planted at the beginning (houhere, tarata, kohuhu, karamu, shining karamu, ti kouka, manatu, makomako) then there will be a higher maintenance requirement in the first few years. A possible scheme would be for these 8 species to be planted at every 100th (kanuka/manuka) plant with appropriate protection from grazing. This will accelerate visual and ecological progress towards a self-maintaining, more diverse and dense canopy. Nevertheless, other kanuka-sheep systems have and are being initiated and monitored elsewhere on Banks Peninsula and so far appear to be working positively (Di Carter, CCC, pers. comm. Appendix D). One of the concerns about relying on monocultures is the susceptibility of kanuka and manuka to attack by leaf roller and scale insects. However, this has not been detected on Banks Peninsula to date.

Yet another alternative schema is to establish sheep-fenced blocks (20 x 20 m) on a 100-200 m grid through the WWT irrigation land. These clusters would then be planted with 200 indigenous broad-leaved trees, incorporating 10 podocarps, initially mulched then mechanically weeded carefully until canopy closure is achieved which with irrigation would be expected in 2-3 years. The proposed broadleaved and taller roosting trees including podocarp species are indicated in Appendix C: houhere, tarata, kohuhu, karamu, shining karamu, ti kouka, manatu, makomako, horoeka, broadleaf, totara, and matai. The benefit of these mixed models would be that there will at least be pockets of more rapid canopy closure, more bird food and roosts that will advance the succession process.

When the water is turned on it will move through the topsoil to subsoil within the irrigated spaces, then onto the steeper gully slopes. Many of these slopes are already partially wooded, and some enrichment planting is envisaged, although encouraged regeneration will be the predominant mode of reforestation. These bushy slopes will add a further sponge for nitrogen and other chemicals – between the point of application and the ephemeral streams of the catchments. Species to be added to the mix could include totara, ngaio, akeake, karamu, kohuhu, houhere, broadleaf, and five-finger on upper/steeper/sunnier slopes; and matai, shining karamu, tarata, manatu, lancewood, kaikomako, titoki, rohutu, etc (Appendix C) on lower/gentler/shadier slopes.

It is anticipated that new seepage zones will form as water finds its own paths of least resistance. These would need to be vegetated in a different suite of species – namely harakeke, toetoe, ti kouka, miki (*Coprosma propinqua*, *C. dumosa*, *C. rigida*), manuka, kohuhu, and after 3-5 years or around the borders, kahikatea and pokaka.

Long term it is proposed that totara and matai may provide, in designated areas (Figure 6-1), the basis for a continuous canopy cultural harvest resource that will also lock up nutrients and N that will then be taken off site (a very long rotation 'cut and carry' system) with next generation replacement trees then accumulating biomass and nutrients in rotational time frames of centuries, while others across the wider catchment are left to live out their entire existence of a millennium or so. This will contribute to the overall ongoing removal of surplus nutrients and carbon accumulation in perpetuity. However, this idea is not yet currently adopted.

Finally, it will be essential that the whole project is operated on an 'adaptive management' principle, requiring frequent inspection in the first few years, then less frequently as the system settles, and establishing consistent and systematic monitoring protocols. These could include initial annual photographic records from points that will retain panoramic views, record of plant mortality, height, canopy closure, grass density, tree flowering/fruiting, seedling establishment, and pest plant/animal presence. According to the outcomes or results, replacement planting, weeding, pest control and other managements would be adjusted. Importantly, the data from this monitoring should be stored in a secure (carefully annotated) format and location to ensure repeatability and longitudinal trend analysis.

7 Recommendations

The following actions, in approximate priority and chronological order, are required to achieve the goals of ATWIS.

- Begin and maintain an eradication programme on the invasive weed plants and pest animals identified in Appendix A (red species).
- In the areas to be irrigated with treated wastewater from the ATWIS, first heavily graze with sheep to knock the grass back to a short turf in the late summer/early autumn before planting, then remove all stock.
- Introduce kanuka (and 5% manuka) seedlings, in mid-autumn, at 1.2 m spacing, along contoured rows 2 m apart. These may be supplemented with a limited range of other browse-tolerant species, with suitable protection against sheep, at 50-100 m intervals (see list). Dripper lines will be established between plant rows.
- Leave ungrazed for 6 months, carry out any interim weed/grass management, then reintroduce <u>light</u> sheep grazing. It is proposed that installed dripper lines be flushed periodically with fresh water, in advance of the full treated wastewater reticulation, to test the system but also to alleviate any exceptional dry periods.
- An additional option is to establish 25x25m, fenced cluster plantings at 200 m intervals and populate with ca. 250 seedlings of houhere, ti kouka, kohuhu, tarata, manatu, karamu, shining karamu, makomako, broadleaf, rohutu, putaputaweta, titoki, mapau, kaikomako, horoeka, totara, matai (in that approximate order of abundance).
- Begin enrichment under-planting other stock-free sites on gully slopes that will reconnect remnant bush areas – the above plus kowhai, rohutu, 5-finger, mikimiki (*Coprosma propinqua), C. linariifolia, C. rhamnoides, C. rigida*, mahoe, ngaio, akiraho, koromiko, akeake, allowing/encouraging/facilitating natural regeneration of indigenous species including poroporo.
- In addition, niches may be found for rarer species such as *Pittosporum obcordatum*, kawakawa, and *Olearia fimbriata*.
- In gullies and shaded foot slopes, use a strong representation of drought-sensitive species such as those highlighted above together with *Coprosma areolata*, *C. rotundifolia*, kahikatea, pokaka, turepo, miro and possibly rimu, beech and tree ferns.
- Ferns and other understorey or ground flora will establish themselves over time and thrive unassisted, provided browsing mammals are excluded. There are ample seed/spore sources all around.
- Plantations – slowly thin and encourage replacement of exotics with regenerating native species. Where these are regarded as heritage groves, they may be left to fulfil their natural longevity, but it would be recommended that recruitment is prevented and succession to indigenous forest allowed.
- Enhance Wetlands and seepages with harakeke, toetoe, *Carex secta*, Carex virgata, *Juncus sarophorus* (other rushes and sedges), manuka, mikimiki, ti kouka and taller wet forest species on the fringes – notably kahikatea and pokaka (Appendix B).
- Establish informative trail(s) and interpretation panels sensitive to and descriptive of the natural and cultural history of the site and of the hydrological processes being employed.
- Set up a baseline for an on-going monitoring regime to compare a representative sample of pre-treatment (pasture and wetland/seepage), control (untreated secondary natural woodland), with irrigated woodland and planted forest. In addition to water assessment, this might include plant, soil, wildlife (invertebrates, lizards, and birds) and microbial/fungal components of the ecosystem. DNA profiling of soils and water may be a desired approach. Information gained will provide the basis for adaptive management and inform future such ventures. Photo points should be set up at strategic locations to maintain an ongoing visual records of changes over time, and other recorded data must be archived and annotated in a secure and accessible database. Systematic inspection/assessment of the sites shall be carried out frequently in the first year (2 monthly), then according to status and performance this can be reduced to 3 monthly and further in subsequent years. Reporting of results should be available and scrutinised by independent parties on an annual basis.

- These observations and assessments will inform management adjustments.
- In consultation with mana whenua, an area designated for future cultural harvest on a steady state forest basis, may be managed on lower slopes of the Robinsons Bay Valley site; similarly interest in Pa Harakeke shall be gauged.
- In general, engagement with the local community to monitor, plant, maintain and manage pests will provide a sense of ownership of the project.

8 Conclusion

A full site walkover of all three ATWIS sites (together with Takamātua) was completed. The key findings with respect to the effects of the proposed ATWIS on terrestrial ecosystems is that the intended irrigated sites currently contain negligible indigenous habitat, and any individual native shrubs, trees or tussocks are largely non-functional in their present isolated state.

From these observations and interpretation, it can be stated unequivocally that the proposed irrigation scheme will have no detrimental ecological impact on existing natural/terrestrial or wetland remnant ecosystems. This is because the gentle slopes to be irrigated and revegetated with indigenous trees are currently almost exclusively dominated by exotic grasses and associated forbs and retain no continuous history from the primordial vegetation-soil system. Even natural seepages are dominated by exotic rushes apart from one outside the irrigation zone and are derived from a former forest ecosystem. The effect on the contained waterways has been modelled and shows the proposed scheme and its nutrient budget to be largely neutral compared to existing conditions, management and dynamics.

On the contrary, the additional native vegetation and eventually ‘noble’ podocarp trees will sequester carbon, N, and some P, that can in designated areas be part of a long rotation cultural harvest and conservation/biodiversity product. It is accepted that the successional trajectory will be different under the ATWIS compared to natural soil/vegetation development, but there is nothing lost from the existing transformed environment, and indeed, there will be benefits to the wider landscape and its ecological integrity (Meurk & Hall 2006). Provision of appropriate and evolving information will ensure that the unfolding narrative of the site can be told and that the landscape will be legible from a natural and cultural heritage perspective.

The result of the proposed planting, irrigation, and pest management will be a substantial net gain in biodiversity, regenerative processes, and other values for the Akaroa Harbour Basin. Among the multiple benefits will be the prime one of protecting the water quality in the harbour. Biodiversity gains will be in terms of indigenous forest and wetland, and associated wildlife, along with amenity, cultural sensitivity, and potential for sustainable harvest.

Adverse effects are assessed to be minor to negligible with some alteration of hydrological balance of soils and therefore species capability and assembly on already modified hill slopes compared to some theoretical original state in a climate that no longer exists.

The direct application of treated wastewater and intended revegetation (of early successional forest species) will directly affect mostly exotic pasture on gentle slopes. This will provide a new ecosystem compatible with indigenous microbiota and micro- to macro-wildlife and enhance indigenous landscape connectivity.

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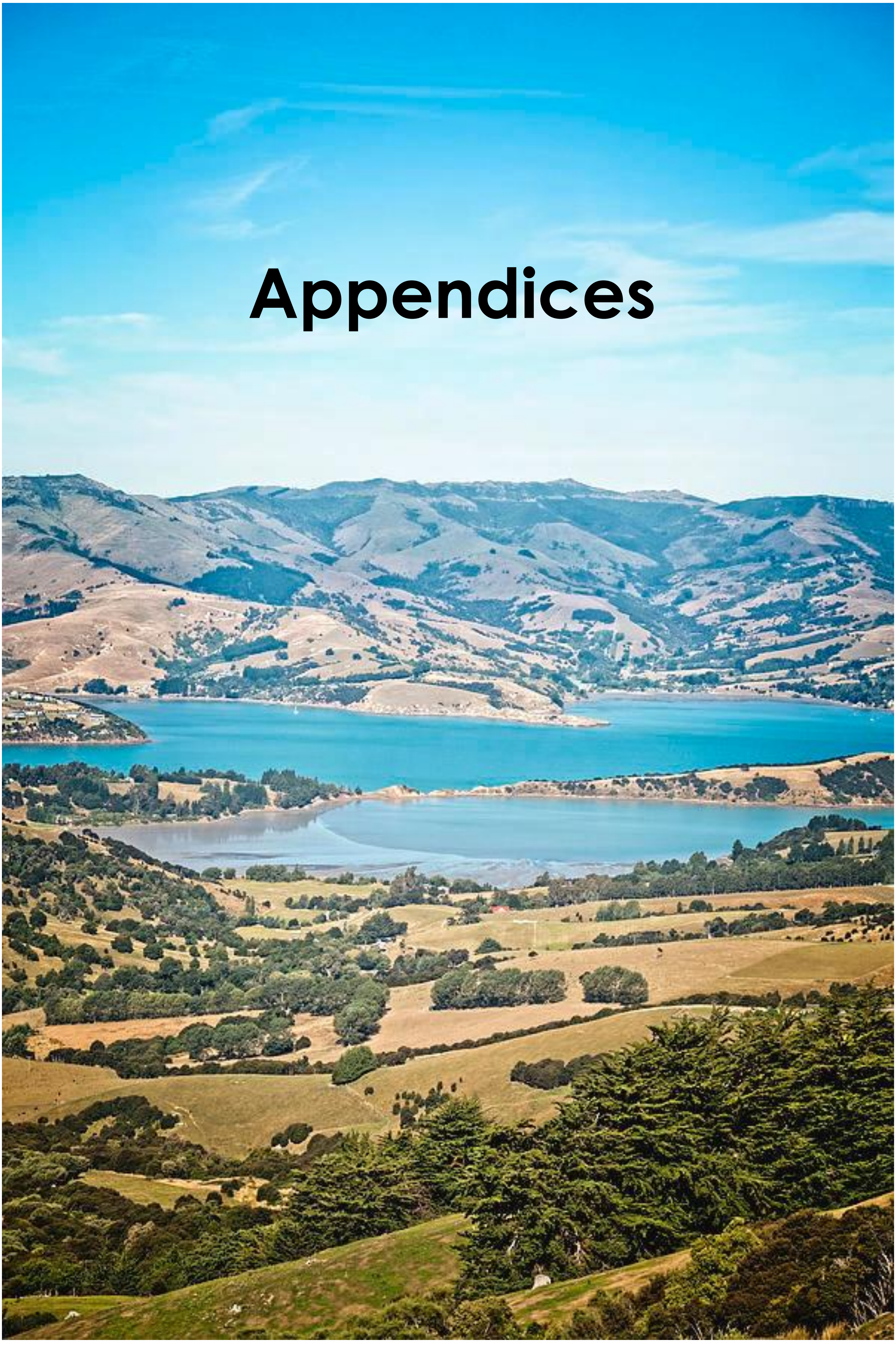
Appendices



Appendix A Species lists for each of WW Treatment Areas

As in legend at base of table, green highlighted species are indigenous, * indicates exotic/adventive species, half red highlighted species are weedy plants that should be contained and not propagated, whereas full red highlighted species are invasive exotics that require urgent control. Species from 'wider area', and especially birds and invertebrates are based on iNaturalist.NZ data.

		Robinsons Bay																								Hammond Pt		Takamatua			Akaroa/Takamatua					Wider
Science Name	Common Name	Eastern Boundary						Central Gully		Lower V.	Western Boundary (Low-Mid 3-4)					Plantatio	Sawmill Rd			SouthWest Upland 5														planted			Area
		Roadsid	Gully	Ridge	Wetland	outcrop	Pasture	east edg	seepage	11 & 12	Gully Wo	Pasture	Seepage	Seepage	W Fence	oak	Top Rd	Wooded	Wetland	Pasture	Scattere	Seepage	Seepage	Bush 7	Rock	Seepage	Pasture	Slope bo	Crop	Fenceline	Treeland	Pasture	Digester	Roadside	Akaroa border		
Acacia melanoxylon	blackwood*																																				x
Acer pseudoplatanus	sycamore*																													x							
Achillea millefolium	yarrow*			x								x					x			x										x			x	x			
Aesculus ?hippocastrum	horse chestnut*									x																											
Agrostis capillaris	browntop*									x									x								x										
Agrostis stolonifera	creeping bent*																		x																		
Alectryon excelsus	titoki																																				x
Alnus sp	alder*									x																											
Alopecurus geniculatus	foxtail*								x										x																		
Anthoxanthum odoratum	sweet vernal*									x																								x			
Anthriscus sylvestris	umbelliferae*							x																													
Asplenium flabellifolium	necklace fern	x									x																										
Asplenium gracillimum	graceful spleenwort	x																																			
Bellis perennis	common daisy*																		x								x					x					
Brachyglottis lagopus	nz daisy																																				x
Bromus catharticus	prairie grass*																													x			x				
Callitriche stagnalis	starwort*																						x														
Calystegia sylvestris	convolvulus*																													x			x				
Calystegia tuguriorum	NZ bindweed	x																			x									x							
Camellia japonica	camellia*																	x																			
Capsella bursa-pastoris	shepherd's purse*																	x		x																	
Cardamine hirsuta	bitter cress*			x													x													x		x	x			
Carex virgata	pukio									x																											
Cedronella	balm of Gillead*																																				x
Cerastium fontanum	mouse-ear chickweed*																x										x										
Cerastium glomeratum	annual chickweed*												x																								
Chamaecytisus prolifer	tree lucerne*	x								x																				x				x	x		
Cirsium arvense	Californian thistle*			x							x									x													x	x			
Cirsium vulgare	spear thistle*			x						x		x								x							x						x				
Clematis paniculata	puawhananga																																				
Clematis vitalba	old mans beard*																													x							
Conium maculatum	hemlock*																													x							
Coprosma areolata	veined coprosma	x														x																					
Coprosma crassifolia	thick-leaved mikimiki	x						x		x	x					x		s			x		edge	?													
Coprosma propinqua	mikimiki							x		x					x	x					x																
Coprosma propinqua x robusta		x																																			
Coprosma repens	taupata																												x								
Coprosma rhamnoides	twiggy coprosma	x									x					x																					
Coprosma robusta	karamu	x								x																								P	x		
Coprosma rotundifolia	round-leaved coprosma	x						x																													
Cordyline australis	ti kouka/cabbage tree									x																				x							
Crassula sieberiana	NZ stone crop																								x												
Crepis capillaris	hawkbit*											x											x										x				
Crocosmia x crosmiiflora	Montbretia*									x																											
Cupressus macrocarpa	Monterey cypress*														x	x		x																			
Cynosurus cristatus	crested dogstail*											x								x							x										
Dacrycarpus dacrydioides	kahikatea																												x	x							
Dactylis glomeratus	cocksfoot*	x		x	x					x		x	x	x			x		x	x		x	x			x				x			x	x			
Dianella nigra	turutu																																				x
Digitalis purpureus	foxglove*										x																			x							
Echium vulgare	viper's blugoss*					x																															
Elymus rectisetus	Australian wheatgrass*?					x																															
Erodium moschatum	storksbill*																	x																			
Eucalyptus sp.	gum*														x			x																	x		
Euphorbia peplus	milkweed*																x													x							
Festuca rubra	red fescue*					x																															
Foeniculum vulgare	fennel*									x																							x				
Fuchsia excorticata	tree fuchsia	x																																			
Galium aparine	cleavers*	x				x					x																			x							
Genista monspessulana	French broom*																																x				
Geranium molle	soft geranium*			x				x									x						x														
Geranium retrorsum	nz geranium					x																			x												
Gnaphalium audax	cudweed					x																															
Gunnera tinctoria	giant gunnera*									x																											
Hedera helix	ivy*									x																											
Hieracium pilosella	mouse-ear hawkweed*					x																															
Hoheria angustifolia	houhere	x								x											x			x				x						P			
Hoheria populnea	NI houhere*																													x							
Holcus lanatus	Yorkshire fog*				x									x				x				x									x					
Hydrocotyle heteromeria	pennywort										x																										
Hypochoeris radicata	catsear*			x								x					x			x							x							x			
Hypolepis ambigua	pigfern	x																																			
Ileostylis micranthus	mistletoe									x		*																									
Ipheion uniflorum	spring star flower*																																				
Juncus articulatus	jointed rush*																						x														

Science Name	Common Name	Robinsons Bay Eastern Boundary Roadsid	Gully	Ridge	Wetland	outcrop	Pasture	Central Gully east edg	seepage	Lower V 11 & 12	Western Boundary (Low-Mid 3-4) Gully Wc	Pasture	Seepage	Seepage	W Fence	Plantati oak	Sawmill Rd Top Rd	Wooded	Wetland	SouthWest Upland 5 Pasture	Scattere	Seepage	Seepage	Bush 7	Rock	Seepage	Hammond Pt Pasture	Takamatua Slope bo	Crop	Fencelin	Treeland	Akaroa/Takamatua Pasture	Digester	planted Roadside	Akaroa border		Wider Area
Juncus distegus	wiwi								x																		x										
Juncus edgariae	wiwi				x					x	x		x	x					x			x	x			x											
Juncus pallidus	wiwi																																				x
Juncus sarophorus	wiwi																						x														
Kunzea robusta	kanuka	x		x				x		x	x										x							x							x		
Lamium purpureum	red dead nettle*																													x							
Lolium perenne	perennial ryegrass*																			x		x					x					x	x				
Lophomyrtus obcordata	rohutu																																				x
Malus domestica	apple*	x																																			
Malva sylvatica	mallow*																													x							
Medicago sativa	lucerne*																												x								
Melicytus ramiflorus	mahoe	x						x		x	x							s			x			x						x					x		
Mimulus guttatus	monkey musk*																						x														
Muehlenbeckia australis	pohuehue	x		x				x		x	x				x						x		x					x							x		
Muehlenbeckia complexa	scrambling pohuehue			x						x	x	x	x			x					x																
Myoporum laetum	ngaio	x									s				x	x		s						x						x				P	x		
Myrsine australis	red mapau																																				
Nasturtium officinale?	watercress*																						x														
Olearia fimbriata	small-leaved shrub daisy																																				x
Olearia ilicifolia	hakeke																																				x
Olearia paniculata	akirahou																																	P			
Parsonsia heterophylla	kaihua																																				x
Pastinaca sativa	wild parsnip*																																				x
Pellaea rotundifolia	button fern	x																																			
Pennantia corymbosa	kaikomako	x						x																													
Phormium tenax	harakeke									x				P																				P			
Pinus radiata	Monterey pine*																																		x		
Piper excelsum	kawakawa	x																																			
Pittosporum eugenioides	tarata/lemonwood	x						x																x										P			
Pittosporum tenuifolium	kohuhu/black matipo	x								x																				x				P			
Plagianthus regius	manatu/ribbonwood									x											x													P			
Plantago lanceolatum	narrow-leaved plantain*			x						x		x					x			x			x							x		x	x				
Plantago major	broadleaved plantain*				x																						x					x					
Pneumatopteris pennigera	gully fern																													x							
Poa annua	annual meadowgrass*																x	x																			
Podocarpus totara	totara											stumps									stumps														x		
Polystichum oculatum	shield fern	x									x																										
Polystichum vestitum	prickly shield fern																																				x
Prunella vulgaris	selfheal*											x																									
Prunus sp	plum*									x				x																							
Pseudopanax arboreus	whauwhaupaku/5-finger	x																						x										P			
Pseudopanax crassifolius	horoeka/lancewood																							x													
Pteridium esculentum	rarahu/bracken	x																																			
Quercus robur	oak*															s																					
Ranunculus parviflorus	small-flowered buttercup*				x												x																				
Ranunculus repens	creeping buttercup*				x					x			x	x					x				x							x			x				
Ranunculus sceleratus	celery-leaved buttercup*																						x														
Ripogonum scandens	supplejack		x																																		
Rosa rubiginosa	briar rose*					x				x											x																
Rubus cissoides	bush lawyer							x																													
Rubus fruticosus agg.	blackberry*							x																						x							
Rubus schmidelioides	narrow-leaved lawyer	x																																			
Rubus squarrosus	leafless lawyer																																				
Rumex acetosella	sheep's sorrel*											x																									
Rumex crispus	dock*				x									x																							
Rumex obtusifolius	broadleaved dock*				x								x	x			x		x			x					x			x			x	x			
Rytidosperma sp	danthonia					x																			x												
Salix cinerea	grey willow*									x																											
Salix fragilis	crack willow*									x								x												x							
Sambucus nigra	elderberry*										x					x														x							
Senecio minimus	NZ groundsel																						x														
Senecio quadridentatus	NZ groundsel			x																																	
Silybum marianum	variegated thistle*			x							x	x								x																	
Sisymbrium officinale	hedge mustard*	x									x	x																		x			x				
Solanum chenopodioides	nightshade*	x																												x							
Solanum laciniatum	poroporo	x																												x							
Sonchus oleraceus	sow thistle*	x		x																					x								x				
Sophora microphylla	kowhai	x		x				x		x	x													x						x				P			
Stellaria media	chickweed*	x						x			x						x										x			x							
Taraxacum officinalis	dandelion*				x						x	x	x						x														x		x		
Tecomaria capensis	Cape honeysuckle*																																				x
Trifoliun pratense	red clover*																																	x			
Trifolium repens	white clover*				x							x		x						x		x	x				x					x	x	x			
Ulex europaeus	gorse*																																x				
Urtica ferox	ongaonga	x						x			x					x								x						x							
Urtica urens	nettle*										x							x																			
Veronica persica	creeping veronica*																																	x			
Veronica salicifolia	koromiko																																	P			
Vicia sativa	vetch*			x													x						x														
Vinca major	periwinkle*									x																											

		Robinsons Bay																								Hammond Pt		Takamatua			Akaroa/Takamatua					Wider
Science Name	Common Name	Eastern Boundary						Central Gully		Lower V.	Western Boundary (Low-Mid 3-4)					Plantatio	Sawmill Rd			SouthWest Upland 5														planted			Area
		Roadsid	Gully	Ridge	Wetland	outcrop	Pasture	east edg	seepage	11 & 12	Gully Wo	Pasture	Seepage	Seepage	W Fence	oak	Top Rd	Wooded	Wetland	Pasture	Scattere	Seepage	Seepage	Bush 7	Rock	Seepage	Pasture	Slope bo	Crop	Fenceline	Treeland	Pasture	Digester	Roadside	Akaroa border		
65 Indigenous spp																																					
154 spp total of which 24 are invasive exotics and 13 are priority for eradication																																					
Cryptogams																																					
Ramalina celastri	lichen																																				
Teloschistes velifer	lichen																																				
Tortula muralis	moss																																				
Fauna/Wildlife																																					
Local/taonga name	**English name**																																				
blackbird	blackbird	x																												x							
chaffinch	chaffinch											x																									
greenfinch	greenfinch											x																									
kahu	Australasian Harrier											x																									
kereru	NZ wood pigeon																	x																			
korimako	bellbird	x									x							x												x					x		
kotare	NZ kingfisher												x																								
mallard	mallard																													x							
piwakawaka	fantail		x																																		
pukeko	swamp hen									x																			x								
putakitaki	paradise shelduck			x																																	
riroriro	grey warbler	x									x																										
spur-winged plover	lapwing											x																	x								
yellow-hammer	yellow-hammer																			x																	
additional from iNaturalist																																					
Californian quail																																					x
dunnock																																					x
goldfinch																																					x
grey duck x mallard																																					x
house sparrow																																					x
kelp gull																													x								x
little pied shag																															x						x
magpie																																					x
mohoua																																					x
NZ pied shag																																					x
pied stilt																																					x
redpoll																																					x
rifleman																																					x
shining cuckoo																																					x
silvereye																															x						x
South Island pied oyster catcher																																					x
starling																																					x
tui																																					x
white-faced heron																																					x
28 birds																																					
red admiral butterfly								x																													
+ 32 invertebrates																																					
NZ skink																				x																	
cattle					x		x		x	x												x															
goat																																					
hare										x																											
rabbit										x																											
sheep							x													x							x										
												* on tree lucerne hedge																									
*																																					
*																																					
*																																					

Appendix B Detention Pond and Edge planting options for Old Coach Road Site

Including recommended species for subsurface wetland (highlighted blue in Appendix C)

Akaroa Wastewater Wetland Treatment
Initially Compiled by Kristy Harrison (Stantec), adapted for this report by Colin Meurk
12/09/21
The suggested list of plants is based on whether the wetland or border is wet or dry most of the time.
It is based on an anticipated very low incidence of inundation, i.e., <1 in 5 years.
Accordingly, some drought-tolerant species are selected.
For an area of around 3,200m^2, around 9,000 plants are needed at 0.6m spacing (plus additional for the edges), which should provide rapid cover and reduced maintenance.

Considerations include:
Site location
Growing conditions
Preference for plants for rongoā Māori and other traditional uses (*)
Low stature (no shrubs or trees in the pond itself) due to issues regarding root penetration
Availability in nurseries
Ease of maintenance – although this is a relative term!

OPTION 1: Detention basin
Dry detention basin with natural clay liner (preferable) which takes flow c. 1 in every 5 years or less.
Dry is a relative term here. The rainfall is 650 mm (35 mm more than chch). A basin is likely to be damper than surrounding terrain, given that the (Geotech) basin liner will be impervious. But that will therefore be a root barrier and so soil moisture availability will be affected by depth of the soil above that layer. The preliminary list is as follows.
Austroderia richardii, toetoe*
Phormium tenax, harakeke
Juncus edgariae, wiwi/hard rush
Juncus sarophorus, blue rush
Carex virgata, tussock sedge/pukio
Cyperus ustulatus, umbrella sedge
Coprosma propinqua, mikimiki (only on edge where not affected by Geotech root barrier)
Leptospermum scoparium, manuka (only on edge where not affected by Geotech root barrier)

OPTION 2: Subsurface wetland
Engineered substrate with PVC liner or similar, kept constantly wet by subsurface flow.
This is likely to be the most costly option in terms of construction, operation and maintenance.
Austroderia richardii, toetoe
Carex geminata, rautahi/cutty grass (a filler between taller species)
Carex secta, pukio
Cyperus ustulatus, umbrella sedge
Phormium tenax, harakeke/NZ flax

OPTION 3: Pā Harakeke
A potential site where specific varieties of harakeke/NZ flax are propagated for weaving if further negotiations demonstrate a will and wish from the weaver community for this – with the anticipated higher level (iwi) maintenance.
It would require watering, so a partial alternative to Option 2.
Suggested plants:
Phormium tenax (cultivars), harakeke/NZ flax
There are 50 varieties at the Rene Orchiston Collection in Lincoln.
Some of these varieties could be selected by local weavers and planted.

Edge Planting for all of above:
Coprosma lucida, shining karamu
Coprosma propinqua, mikimiki
Coprosma rigida, mikimiki
Coprosma robusta, karamu
Cordyline australis, ti kouka
Dacrycarpus dacrydioides, kahikatea (later enrichment planting)
Elaeocarpus hookerianus, pokaka
Hebe salicifolia, koromiko
Hoheria angustifolia, houhere
Leptospermum scoparium, manuka

Lophomyrtus obcordata, rohutu
Pennantia corymbosa, kaikomako
Pittosporum tenuifolium, kohuhu
Plagianthus regius, manatu
Prumnopitys taxifolia, matai (later enrichment planting)
Pseudopanax crassifolius, horoeka
Streblus heterophyllus, turepo

Higher, well-drained ground:
Aristotelia serrata, makomako/wineberry
Coprosma lucida, shining karamu
Coprosma robusta, karamu
Cordyline australis, ti kouka
Dodonaea viscosa, akeake
Griselinia littoralis, broadleaf
Hoheria angustifolia, houhere
Kunzea robusta, kanuka
Olearia paniculata, akiraho
Pittosporum eugenioides, tarata/lemonwood
Pittosporum tenuifolium, kohuhu
Plagianthus regius, manatu
Podocarpus totara, totara (later enrichment planting)
Pseudopanax crassifolius, horoeka
Sophora microphylla, kowhai

Appendix C Species proposed for Planting and Management

In the following table, green species are indigenous and expected to naturally colonise as the canopy closes and browsing pressure is reduced; orange species are recommended for active planting initially or later; blue species are specifically those for ponds and seepages with some zonal separation indicated; and red species those previously designated as invasive weeds to be managed. Species are indicated for the primary irrigated lands, for the pond areas, and for enrichment of plantations.

Planting Scheme Notes for Waste-Water Treatment in Akaroa – Water Delivery Logistics and Uptake

Colin D Meurk

24th March 2022

Preamble
Re planting: the first priority will be fast growth and establishment of canopy cover to shade grass/weeds as quickly as possible. These trees would be conventionally planted at 1.5 m spacings. The second priority is the long-term species (podocarps) that will gradually take up the nutrients and carbon, and in long term would need to be harvested and stored in some carbon sink (semi-permanent buildings or construction). Such trees (here it will be primarily totara, matai but possibly rimu) might be interplanted among the primary/nursery species in 2nd to 3rd year at approximately 5-10 m spacing from others of their type (including broadleaf/Griselinia). They would then be trimmed/limbed in succeeding years (bearing in mind that planting after an initial early canopy is established will force trees up rather than out) to provide merchantable logs in the 200-500 year range. These trees can potentially live for 1000 years. The detail of this will need to be modelled – in terms of sequestration potential of given trees and given densities with the anticipated inputs (of water and nutrients) and the target outflow nutrient concentrations.

Wetland treatment basins may be needed, top and bottom of catchments, to provide a more thorough removal of nutrients before surplus water enters streams. These basins will also have to be rejuvenated from time to time (say raupo harvested every 10-15 years). The species lists attached do not cover this option.

Draft Species Plan

The attached spreadsheet (Appendix A) is the total species lists from the field survey, and from the associated iNaturalist NZ database.

Appendix C is the planting and weed management plan, as per the colour-legend at bottom of spreadsheet.

There are 24 species designated as priority for weed control

There are 16 native species regarded as most suitable for first stage planting (based on a generalised expectation of ambient soil moisture and nutrient supply) – they are species desirous of continual soil moisture, are fast growing, hardy, and half of them are broadleaved and so will more quickly achieve canopy closure – within 3 to 5 years at 1.5 m spacing. The problem with relying just on say kanuka and ti kouka is that they do not form a dense canopy until at least 10 years or more old. There is also a finite greater risk of fire with a monoculture of kanuka. More generally, there is decreased risk of disease or other pest attack with mixed species base as opposed to a monoculture.

44 additional indigenous species will either naturally colonise and regenerate once a canopy is partially formed but may also be part of an enrichment programme. In particular, and critically (as outlined above), totara, matai, kahikatea, pokaka, kaikomako, titoki, horoeka, putaputaweta and broadleaf, should be inserted into the plantings, in appropriate locations, at about years 2 to 3.

There are 9 (blue) species that are designated for dry ponds, seepages etc. It is not clear yet, if these will be required. And a different/additional set will be required for detention/filtration basins if these are deemed necessary for functioning of system. This is spelled out in some more detail in Appendix B.

Orange highlighted species are the priority planting species for well-drained sites – both irrigated and not, and for under canopy planting in exotic forest

			Wet Ground/Seepages/Ponding*			Irrigated Free-draining Ground#				Gully/Non-irrigated**			Understorey of plantations - Irrigated***						
Science Name	Common Name		Centre Fi	Edge/Bank		Stage 1	Stage 2	Stage 3		Sheltered	Exposed		Stage 1	Self-Regenerating			Riparian shaded		
Observed Species										Moist	Dry								
Alectryon excelsus	titoki							x		2			1	x					
Aristotelia serrata	makomako	HDW		U			x			x			1	x					
Asplenium gracillimum	graceful spleenwort													x					
Austroderia richardii	toetoe	HDW		L															
Carpodetus serratus	putaputaweta	HDW		U				x		2			1				x		
Carex secta	pukio	HDW	x																
Carex virgata	pukio		x														x		
Clematis paniculata	puawhananga													x					
Coprosma areolata	veined coprosma			U						2			1						
Coprosma crassifolia	thick-leaved mikimiki										x								
Coprosma dumosa	mikimiki	HDW		L															
Coprosma linariifolia	yellow-wood	HDW								2			1						
Coprosma lucida	shining karamu	HDW		U			x			x				x					
Coprosma propinqua	mikimiki			L							x						x		
Coprosma rhamnoides	twiggy coprosma							x		2			1						
Coprosma rigida	miki	HDW		U		x							1	x			x		
Coprosma robusta	karamu			U		x				x				x			x		
Coprosma rotundifolia	round-leaved coprosma			U						2			1						
Coprosma rubra	red miki	HDW								2			2						
Coprosma wallii	miki	HDW									x								
Cordyline australis	ti kouka/cabbage tree			L		x					x			x			x		
Cyperus ustulatus	umbrella tussock sedge		x																
Dacrycarpus dacrydioides	kahikatea			U						2							x		
Dodonaea viscosa	akeake					x													
Elaeocarpus hookerianus	pokaka			U						x							x		
Fuchsia excorticata	tree fuchsia									2				x			x		
Griselinia littoralis	broadleaf	HDW					x				x			x					
Hoheria angustifolia	houhere			U		x				x	x			x					
Hypolepis ambigua	pigfern													x					
Ileostylis micranthus	mistletoe													x					
Juncus edgariae	wiwi		x																
Juncua pallidus	wiwi		x																
Juncus sarophorus	wiwi		x																
Kunzea robusta	kanuka					1					x								
Leptospermum scopariur	manuka			L		2													
Lophomyrtus obcordata	rohutu			U				x		2			2						
Melicytus ramiflorus	mahoe							x		2				x					
Muehlenbeckia complex	scrambling pohuehue										x								
Myoporum laetum	ngaio					x					x			x					
Myrsine australis	red mapau			U				x		x				x					
Myrsine divaricata	weeping mapau	HDW		L													x		
Olearia paniculata	akirahou										x								
Parsonsia heterophylla	kaihua													x					

			Wet Ground/Seepages/Ponding*			Irrigated Free-draining Ground#				Gully/Non-irrigated**			Understorey of plantations - Irrigated***						
Science Name	Common Name		Centre Fil	Edge/Bank		Stage 1	Stage 2	Stage 3		Sheltered	Exposed		Stage 1	Self-Regenerating			Riparian shaded		
Pennantia corymbosa	kaikomako			U				x		x			2				x		
Phormium tenax	harakeke		x	L		x													
Piper excelsum	kawakawa									2				x					
Pittosporum eugenioides	tarata/lemonwood					x				x	x			x					
Pittosporum tenuifolium	kohuhu/black matipo			U		x				x	x			x			x		
Plagianthus regius	manatu/ribbonwood			U		x				x	x						x		
Pneumatopteris pennige	gully fern													x			x		
Podocarpus totara	totara						x				x		1	x					
Polystichum oculatum	shield fern																		
Polystichum vestitum	prickly shield fern													x			x		
Prumnipitys taxifolia	matai							x		2			1						
Pseudopanax arboreus	whauwhaupaku/5-finger										x			x					
Pseudopanax crassifoliu	horoeka/lancewood			U			x			2				x					
Raukaua edgerleyi	edgers lancewood	HDW						x		2			2						
Ripogonum scandens	supplejack													x					
Rubus cissoides	bush lawyer							x						x					
Rubus schmidelioides	narrow-leaved lawyer													x					
Rubus squarrosus	leafless lawyer										x								
Solanum laciniatum	poroporo													encourage this to naturally regenerate					
Streblus heterophyllus	turepo			U				x					2				x		
Sophora microphylla	kowhai						x				x						x		
Urtica ferox	ongaonga													x					
Veronica salicifolia	koromiko			U													x		
additional species from Hugh Wilson 2019		HDW																	
64 Indigenous spp																			
Invasive Exotic Species																			
Acer pseudoplatanus	sycamore*																		
Aesculus hippocastanum	horse chestnut*																		
Alnus sp	alder*																		
Clematis vitalba	old mans beard*																		
Crocosomia x crosmiiflor	Montbretia*																		
Gunnera tinctoria	giant gunnera*																		
Hedera helix	ivy*																		
Hoheria populnea	NI houhere*																		
Pinus radiata	Monterey pine*																		
Rubus fruticosus agg.	blackberry*																		
Salix cinerea	grey willow																		
Sambucus nigra	elderberry*																		

45 species

20 species excluding understory planting

12 species

7 species

*For OldCoachRd

with zone L for high water edge, U upper bank/drained

#main WWT reveg exercise

**largely self-regenerating in sheltered gullies

***Enrichment as required with priority ranking

x indicates species suitable for planting,

1 & 2 provides additional precision for priority or later planting in the situations indicated

Appendix D Notes from CCC ranger Di Carter regarding sheep-kanuka revegetation system.

“Density – I have tried some at 1.5m spacing and 3m spacing (both variable some closer, some broader)
Stocking rate – couldn’t say exactly, but reasonably light

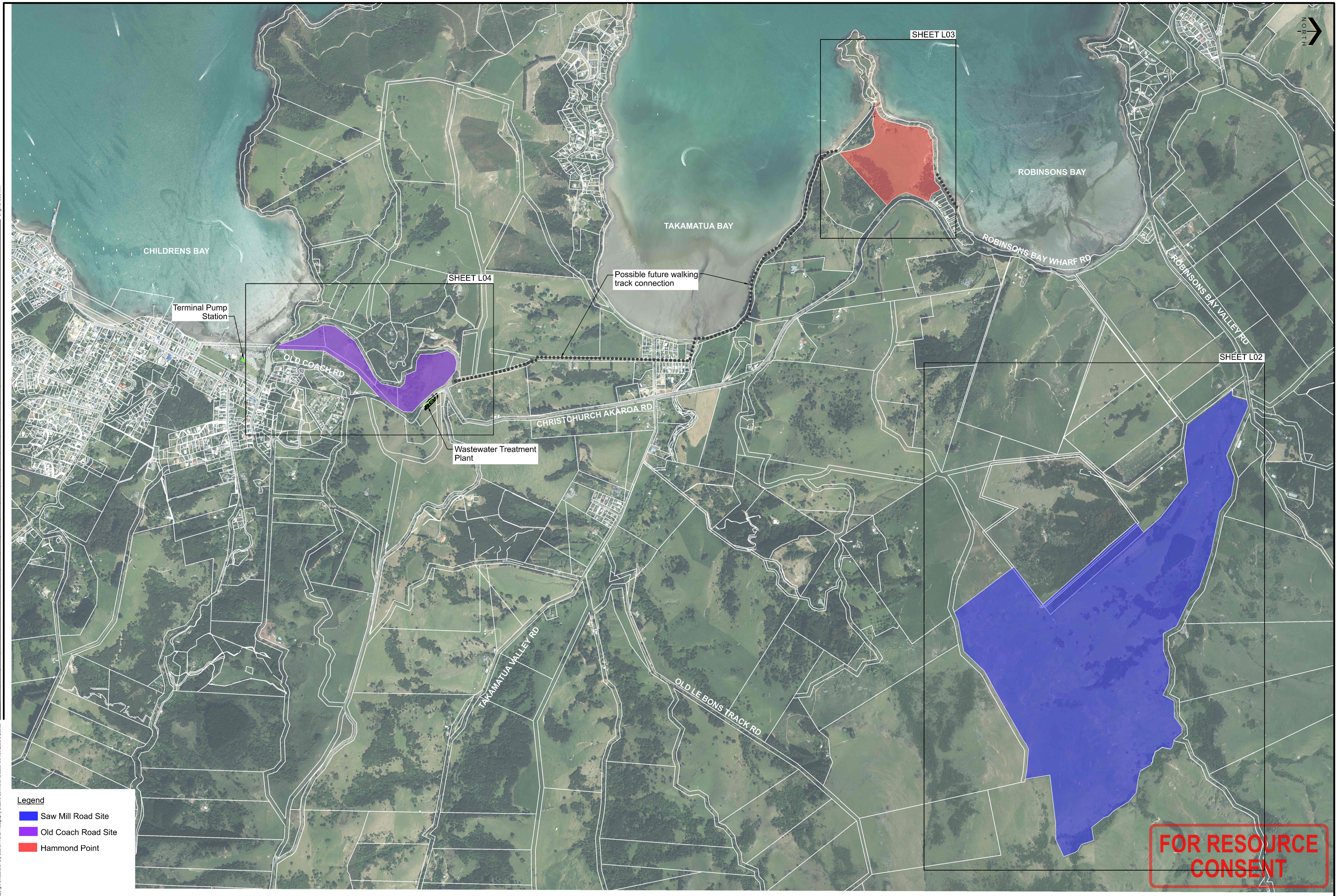
Timing of stocking – if plants are left for 6 months before stocking they will be fine. Stock may nibble on them briefly after this, but not for long.

Growth rates – depends on site (soils, moisture, and aspect) – generally 1.7m - 2m in height after 15 years

Estimated time for canopy closure – 12 – 15 years when planted at 1.5m density [note this is without irrigation]

Scale insect (and leaf roller attack) – no signs yet. Fingers-crossed it doesn’t arrive here!”

Appendix C CCC Concept Landscape Plans



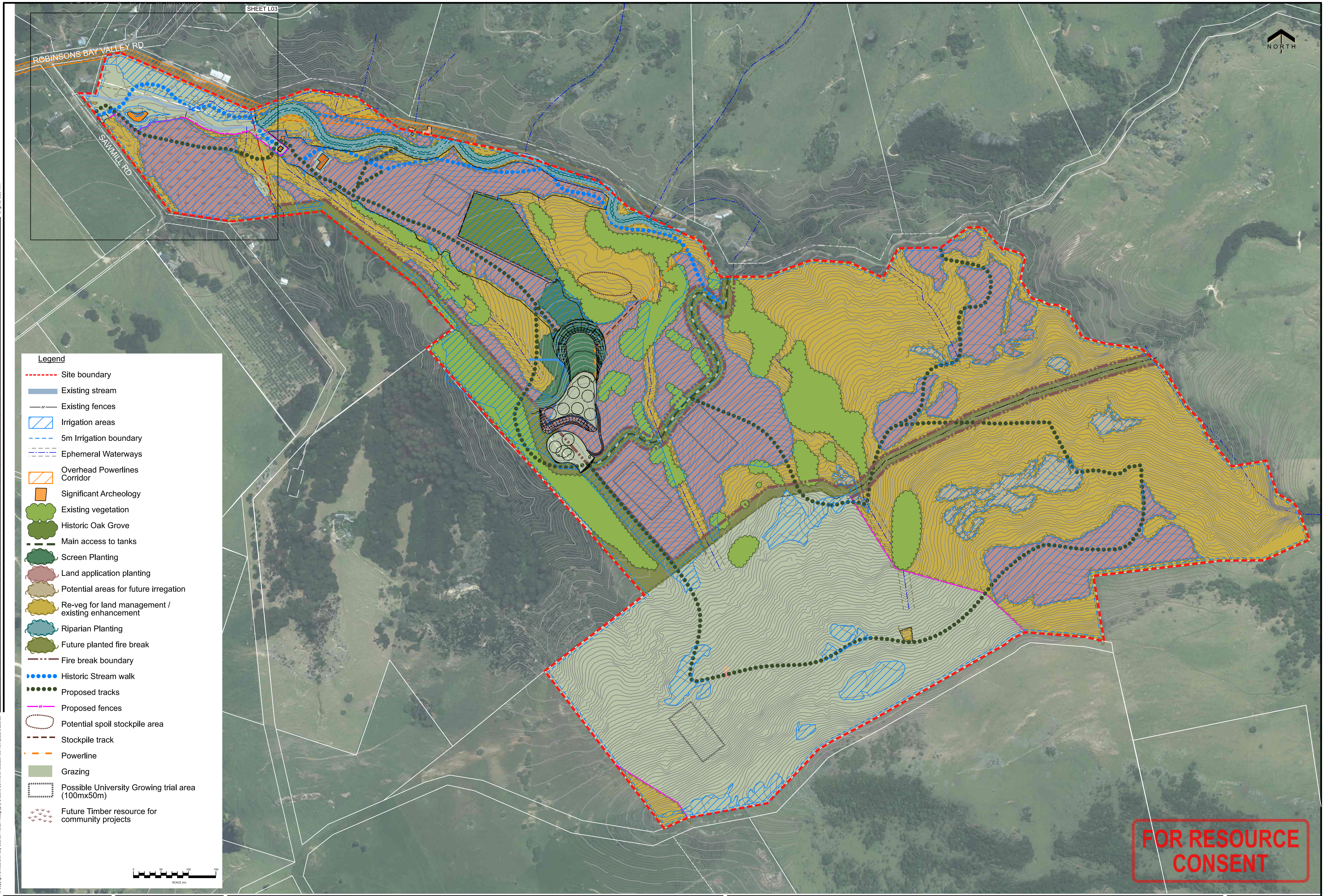
Christchurch City Council

AKAROA WASTEWATER SCHEME

OVERALL SITE LOCATIONS

SHEET L01

Original Plan Size: A1
ISSUE.1 12/2021
LP392501 CJ



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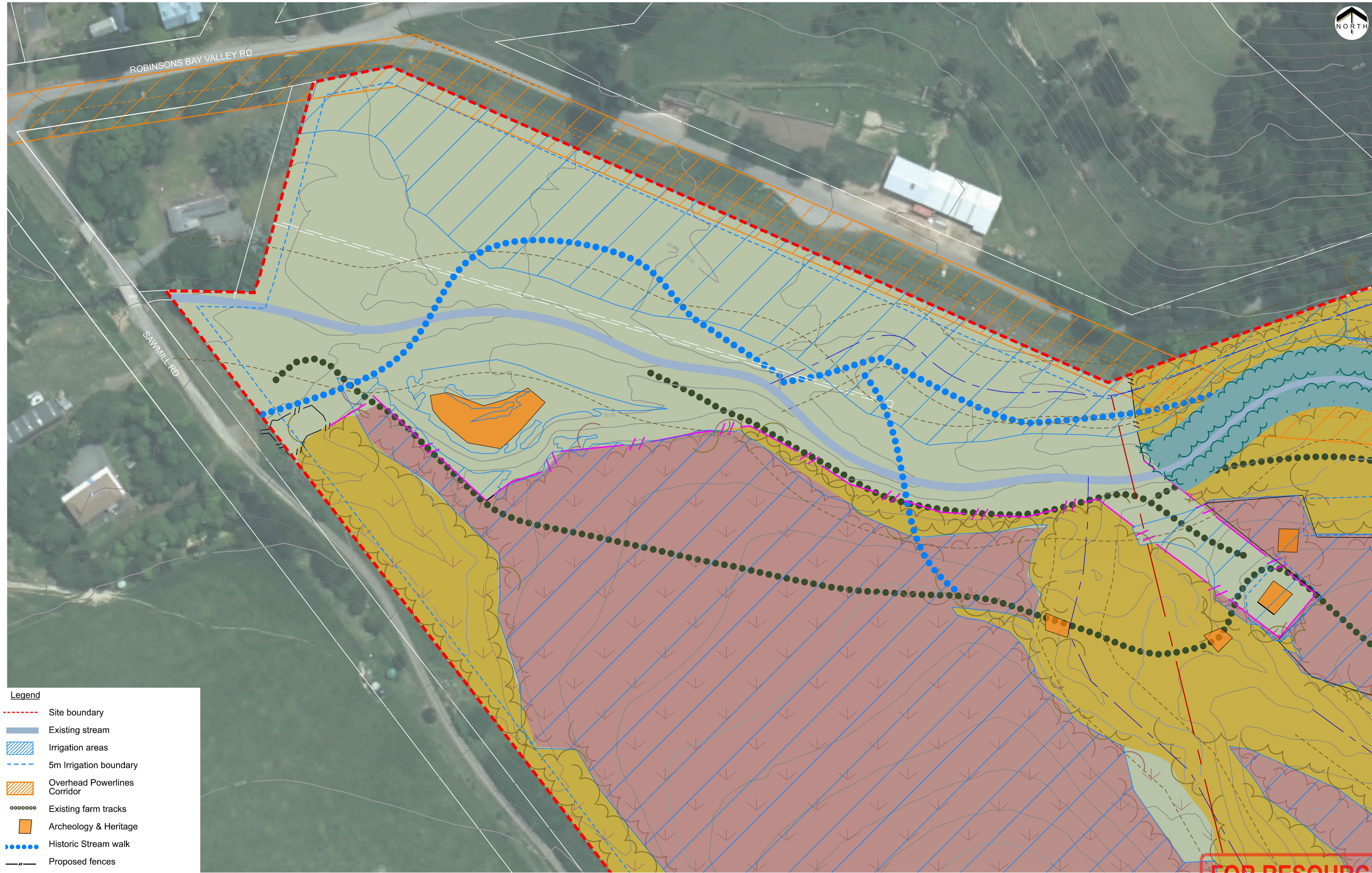
AKAROA WASTEWATER SCHEME

PLAN

SHEET L02

Original Plan Size: A1
ISSUE.1 12/2021
LP392501 CJ



Legend

- Site boundary
- Existing stream
- Irrigation areas
- 5m Irrigation boundary
- Overhead Powerlines Corridor
- Existing farm tracks
- Archeology & Heritage
- Historic Stream walk
- Proposed fences
- Land application planting
- Future timber resource for community projects

SCALE (m)

FOR RESOURCE CONSENT

Christchurch City Council	AKAROA WASTEWATER SCHEME	HERITAGE AREAS SHEET L03	Original Plan Size: A1 ISSUE.1 12/2021 LP392501 CJ

Christchurch City Council

AKAROA WASTE SCHEME

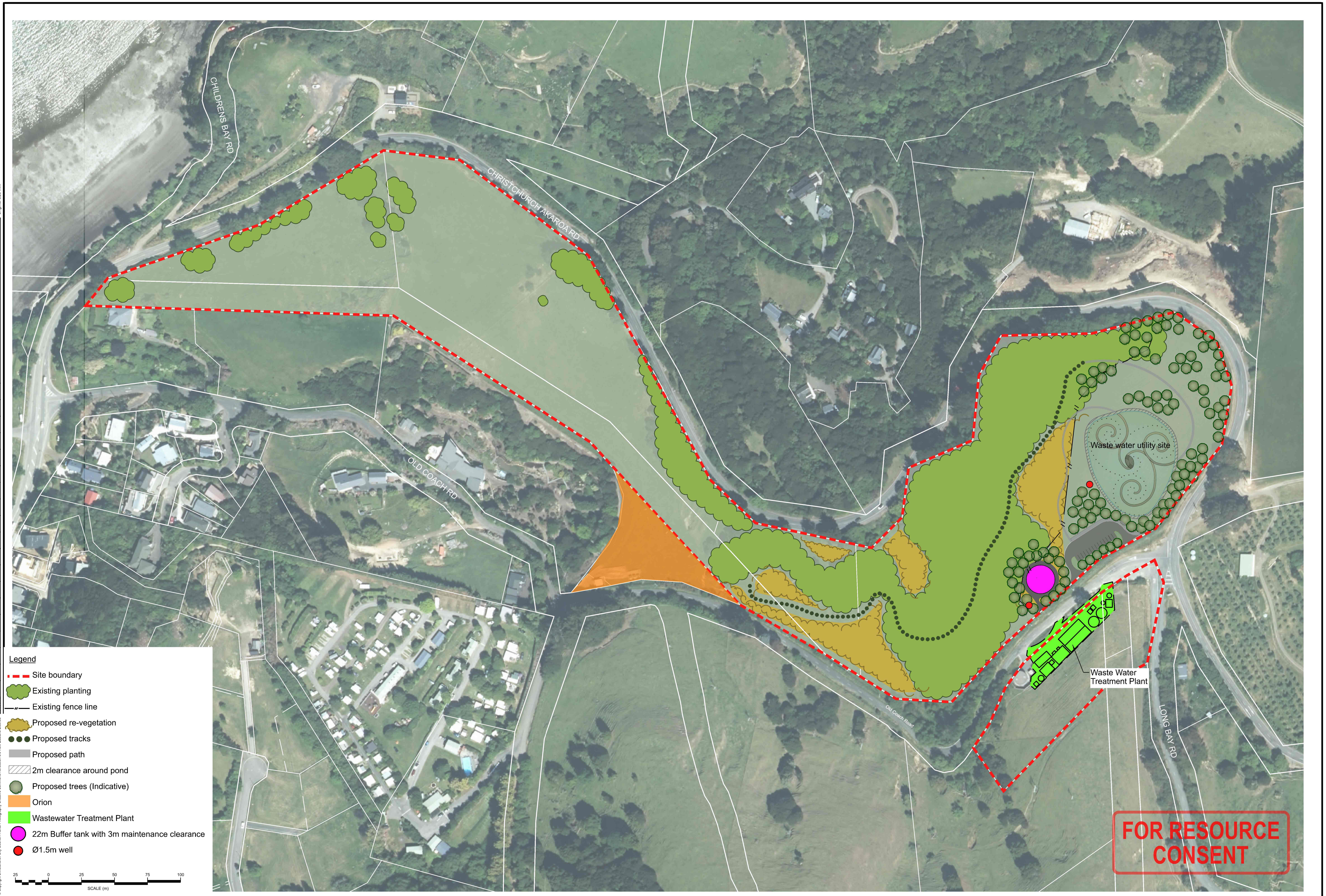
HAMMOND POINT

SHEET L04

Original Plan Size: A1

ISSUE.1 21/12/2021

LP392501 CJ



Christchurch City Council

AKAROA WASTEWATER SCHEME

OLD COACH ROAD PLAN

SHEET L04

Original Plan Size: A1
ISSUE.1 12/2021
LP392501 CJ

Appendix D Drawings

SITE OVERVIEW PLAN

SCALE 1 : 2000

50 0 50 100m

SCALE 1:2000

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE
B	ISSUED FOR INFORMATION ONLY	SW	24.02.22
A	ISSUED FOR INFORMATION ONLY	SW	20.11.21

Christchurch City Council

			NAME	SIGNED	DATE
DATUM	C.D.D.				
BENCH MK.	NZTM	DESIGNED	Steven Woods		10.21
RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C150.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED

FOR TENDER

DATE	SIGNED

FOR CONSTRUCTION

DATE	SIGNED

CONSULTANT

Stantec

CONSULTANT PROJECT REF. 310103534

CONSULTANT FILE REF. 310103534-01-001-C150

PROJECT TITLE

AKAROA TREATED WASTEWATER

IRRIGATION SCHEME

DRAWING TITLE

SITE OVERVIEW PLAN OPTION 5

CONTRACT NUMBER

CAD DRAWING FILE REF. 310103534-01-001

ORIGINAL SHEET SIZE A1

SCALES 1 : 2000

TSD PROJECT FILE NUMBER

SHEET C150 OF

TANK PLATFORM AND ACCESS ROADS PLAN
1:500

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.	Mt PLNT GD2000	DESIGNED	Steve Woods		10.21
RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C151.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

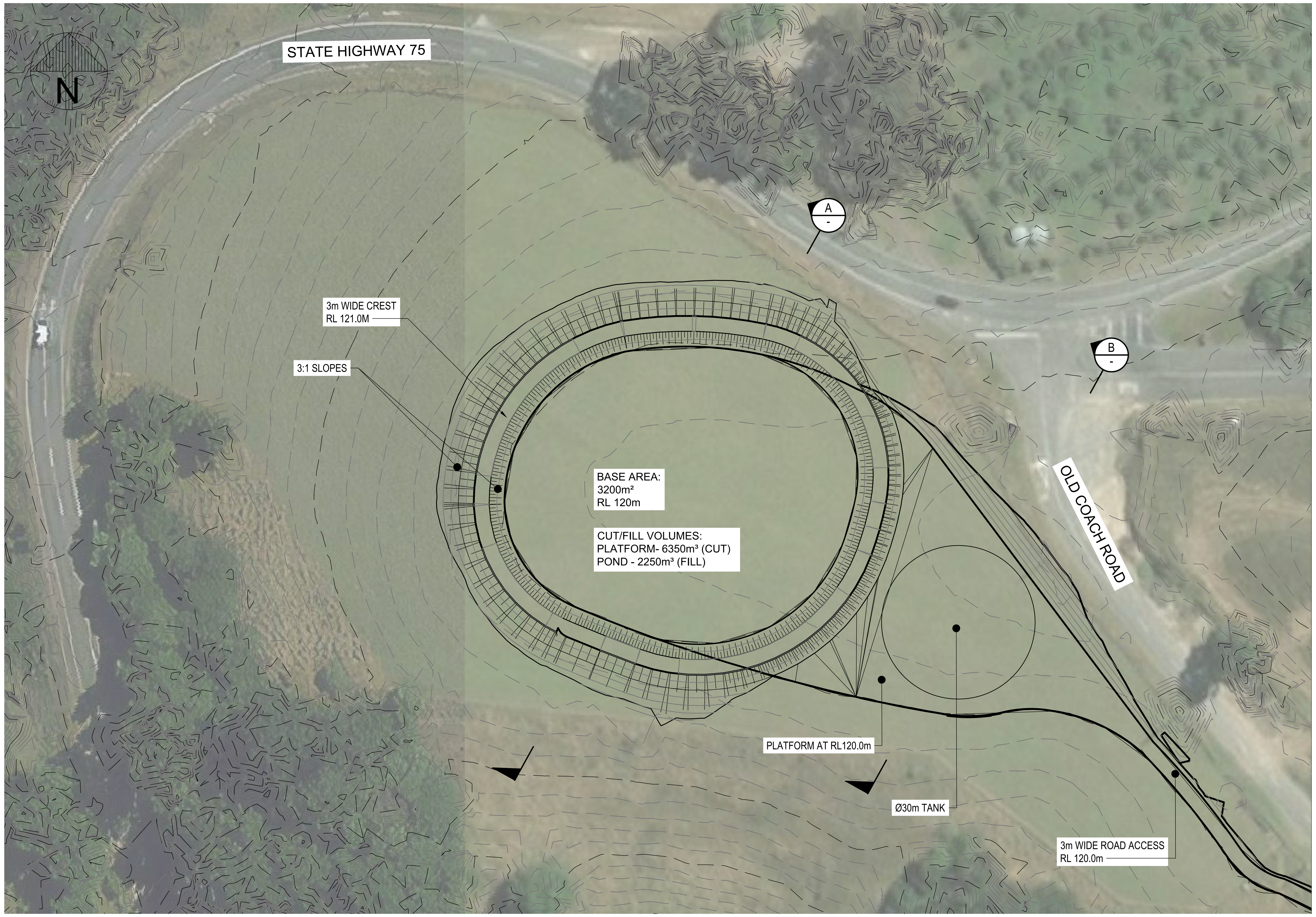
APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C151

PROJECT TITLE
AKAROA TREATED WASTEWATER
IRRIGATION SCHEME

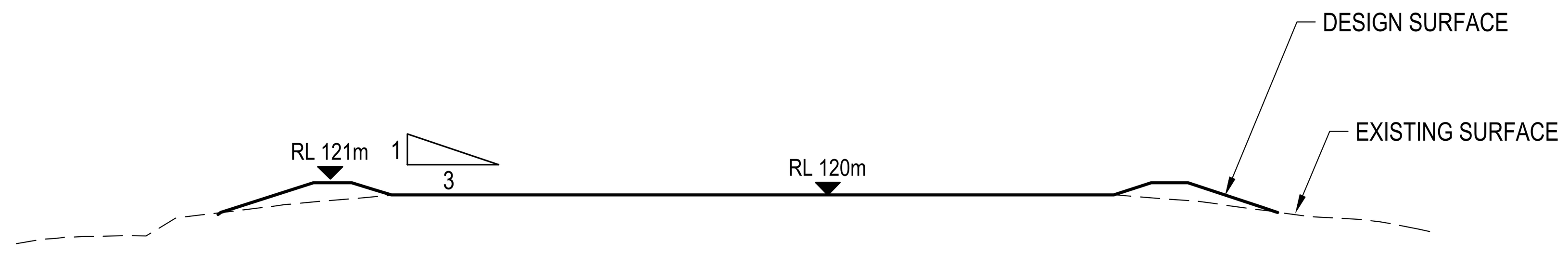
DRAWING TITLE
OPTION 5 - PLATFORMS, CUT DISPOSAL & ACCESS ROADS

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
ORIGINAL SHEET SIZE A1
SCALES
SHEET C151 OF

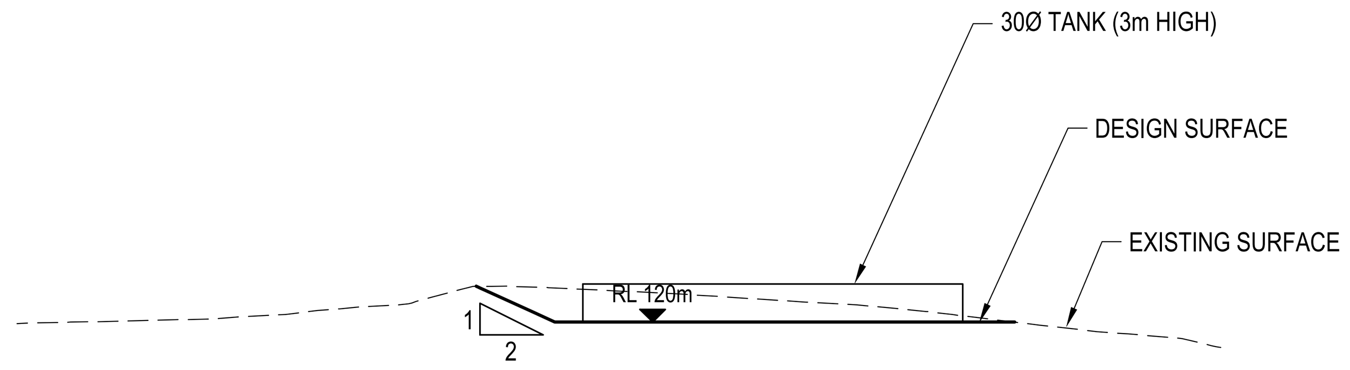


PLAN
1:500

10 0 10 20m
SCALE 1:500



SECTION A
SCALE 1 : 500



SECTION B
SCALE 1 : 500

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.		DESIGNED	Steven Woods		08/21
RL		DES. REVIEW			
SURVEY		DRAWN	Tom Frowein		08/21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-SK10.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-SK10

PROJECT TITLE
AKAROA RECLAIMED WATER & REUSE SCHEME

DRAWING TITLE
WETLAND CONCEPT SITE PLAN

CONTRACT NUMBER
ORIGINAL SHEET SIZE: A1
SCALES: AS SHOWN
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
SHEET: SK10 OF

WATER STORAGE TANKS & PIPELINE ROUTE - OVERVIEW PLAN

SCALE 1 : 7500

LEGEND :

RIVER / STREAM

WWTP DISCHARGE PIPELINE

PURPLE PIPE SCHEME

EXISTING COUNCIL WASTEWATER

EXISTING COUNCIL STORMWATER

EXISTING COUNCIL POTABLE WATER

NOTES:

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Christchurch City Council

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AKAROA TREATED WASTEWATER
IRRIGATION SCHEME

DRAWING TITLE
WATER STORAGE TANKS & PIPELINE ROUTE OVERVIEW PLAN

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
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ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
SHEET C200 OF

Appendix E Wetland Species List

Scientific Name	Common Name	Threat Status	Amount	No.	BP Endemic	Mahinga kai
SUBSURFACE WETLAND (3,200m2) - assumes 600mm gravel with plants planted into planting mix						
Austroderia richardii	Toetoe	Not Threatened	●	320	×	✓
Carex geminata	Rautahi	Not Threatened	●	320	×	×
Carex virgata	Swamp sedge	Not Threatened	●	320	×	×
Carex secta	Pukio	Not Threatened	●	320	×	×
Coprosma dumosa	-	Not Threatened	●	320	×	×
Coprosma propinqua	Mikimiki	Not Threatened	●	320	×	✓
Coprosma rigida	Stiff karamu	Not Threatened	●	320	×	×
Juncus edgariae	Hard rush	Not Threatened	●	320	×	×
Phormium tenax	Harakeke, flax	Not Threatened	●	320	×	✓
Plagianthus divaricatus	Saltmarsh ribbonwoc	Not Threatened	●	320	×	✓
				3200		
DRY DETENTION POND (3,200m2) - assumes 30mm soil/planting mix over 300mm gravel						
Austroderia richardii	Toetoe	Not Threatened	●	400	×	✓
Carex geminata	Rautahi	Not Threatened	●	400	×	×
Carex virgata	Purei	Not Threatened	●	400	×	×
Carex secta	Pukio	Not Threatened	●	400	×	×
Coprosma propinqua	Mikimiki	Not Threatened	●	400	×	✓
Coprosma rigida	Stiff karamu	Not Threatened	●	400	×	×
Muehlenbeckia complexa	Pohuehue	Not Threatened	●	400	×	✓
Phormium tenax	Harakeke, flax	Not Threatened	●	400	×	✓
				3200		
DRY SLOPES OF POND (4,000m2)						
Carmichaelia australis	Native broom	Not Threatened	●	400	×	×
Coprosma crassifolia	Mikimiki	Not Threatened	●	400	×	×
Coprosma virescens	Mikimiki	At Risk Declining	●	400	×	×
Corokia cotoneaster	Korokio	Not Threatened	●	400	×	×
Hebe salicifolia	Koromiko	Not Threatened	●	400	×	✓
Lophomyrtus obcordata	Rohutu	Threatened Nationally Critical	●	400	×	×
Olearia avicenniaefolia	Mountain akeake	Not Threatened	●	400	×	×
Ozothamnus leptophyllus	Tauhinu	Not Threatened	●	400	×	×
Pteridium esculentum	Bracken	Not Threatened	●	400	×	✓
Poa cita	Silver tussock	Not Threatened	●	400	×	✓
				4000		

Appendix F PDP Irrigation Model Results

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solutions for your environment

27 January 2022

Logan Thomson
Associate – Civil Engineer, Water
Beca
PO Box 13960
CHRISTCHURCH 8141

Dear Logan

AKAROA RECYCLED WATER SCHEME - IRRIGATION MODEL RESULTS FOR RECYCLED WATER DISPOSAL AT ROBINSONS BAY WITH SUPPLEMENTARY WETLAND

1.0 Introduction

Christchurch City Council (CCC) is investigating options to irrigate recycled water from a proposed wastewater treatment plant (WWTP) servicing the Akaroa township. Pattle Delamore Partners Ltd (PDP) have been engaged by Beca Ltd to prepare a soil moisture balance (SMB) assessment to quantify the volume of recycled water storage required as part of the irrigation scheme.

Irrigation of recycled water to 40 ha of trees planted at the head of bays sites: Robinsons Bay, Hammond Point, and Takamatua has been modelled. PDP has previously modelled various irrigation to land scenarios at these sites. This letter has been prepared to present the recycled water storage requirements of the irrigation scheme using an updated long-term wastewater flow series derived from the Beca network drainage model (NDM).

2.0 Model Method and Inputs

2.1 Wastewater Flow Estimate

2.1.1 Dry Weather Flow

Beca has developed a NDM for the Akaroa township. The NDM estimates wastewater flows generated within the catchment servicing the WWTP from 19 Dec 2008 to 29 Feb 2020 accounting for future population growth. The NDM outputs the wastewater flow broken down into the following constituents: Baseflow, composed of the water treatment plant retentate flow and ground water derived inflow and infiltration (GWDII); rainfall derived inflow and infiltration (RDII); and population flow. The rainfall used for the NDM is from the Akaroa EWS rainfall gauge located near Stanley Park, Akaroa.

The SMB uses the longest period of data available to best capture the wide range of climate trends. This provides a better representation of wet and dry years the system will encounter and helps reduce bias from a smaller dataset. The long-term flow series for the Akaroa WWTP has been developed from 1 January 1972 to 30 April 2021 using Virtual Climate Station Network (VCSN) data.

The NDM is the foundation for developing the long-term flow series. The dry weather flow (all wastewater flow components except for RDII) have been taken directly from the NDM. Table 1 shows the components of the dry weather flow.

Table 1: Dry Weather Flow	
Parameter	Flow (m^3/day)
Baseflow	285
Peak Population (Jan)	894
Summer Population (Dec, Feb)	506
Population (Mar – Nov)	236

It is noted that while the base flow has been assumed to be a constant daily rate, based on the long term NDM results, the retentate and GWII vary monthly. Table 2 shows the components of the baseflow broken down monthly. The retentate has been modelled as the monthly average flow recorded at the L'Aube Hill water treatment plant, as supplied by CCC from SCADA records. The GWII was estimated as the base flow constant minus the retentate flow for each month. This separation of the baseflow has been provided as I&I reduction scenarios differ in proportions for the two components.

Table 2: Base Flow		
Parameter	Retentate Flow (m^3/day)	GWII (m^3/day)
January	116	169
February	121	164
March	127	158
April	109	177
May	97	188
June	83	202
July	92	193
August	88	197
September	99	186
October	104	181
November	118	167
December	118	168

2.1.2 Wet Weather Flow

The RDII in the NDM is estimated using the Akaroa EWS rainfall station. The Akaroa EWS has data available from mid-December 2008 to the present day. Given this relatively short period, rainfall from the NIWA Virtual Climate Station Network (VCSN) 20249 was selected to estimate RDII in the long-term flow series. The VCSN stations are generated on a 5 km grid and provide estimates of daily rainfall based on the spatial interpolation of actual data observations made at climate stations located around the country. VCSN 20249 is located approximately 4 km north of the Akaroa township and provides rainfall from 1 January 1972 to 30 April 2021. A comparison between VCSN 20249 and Akaroa EWS indicates that on average there is a difference in annual rainfall totals of approximately 4%. The timing of measured rainfall events is similar for the two-rainfall series, providing confidence in using the VCSN 20249 dataset to estimate RDII.

A relationship between the NDM RDII (generated from the Akaroa EWS) and VCSN 20249 rainfall over the period December 2008 to February 2020 has been developed. Figure 1 shows the RDII response in the wastewater network corresponding to rainfall events. A rainfall event is considered independent if there have been two or more consecutive no rainfall days prior to the start. The RDII is summed on a rainfall event basis.

A manual trendline has been selected to estimate the relationship between RDII and a rainfall event. The manual trendline is tailored to fit the larger rainfall events (> 100 mm rainfall events). It is noted that, although non-linear trendlines may provide a better overall fit to the data, the purpose of the long-term flow series is to provide an estimate of the peak recycled water storage volume required over the long-term modelling period. Therefore, the trendline is chosen to favour larger rainfall (resulting in larger RDII) events.

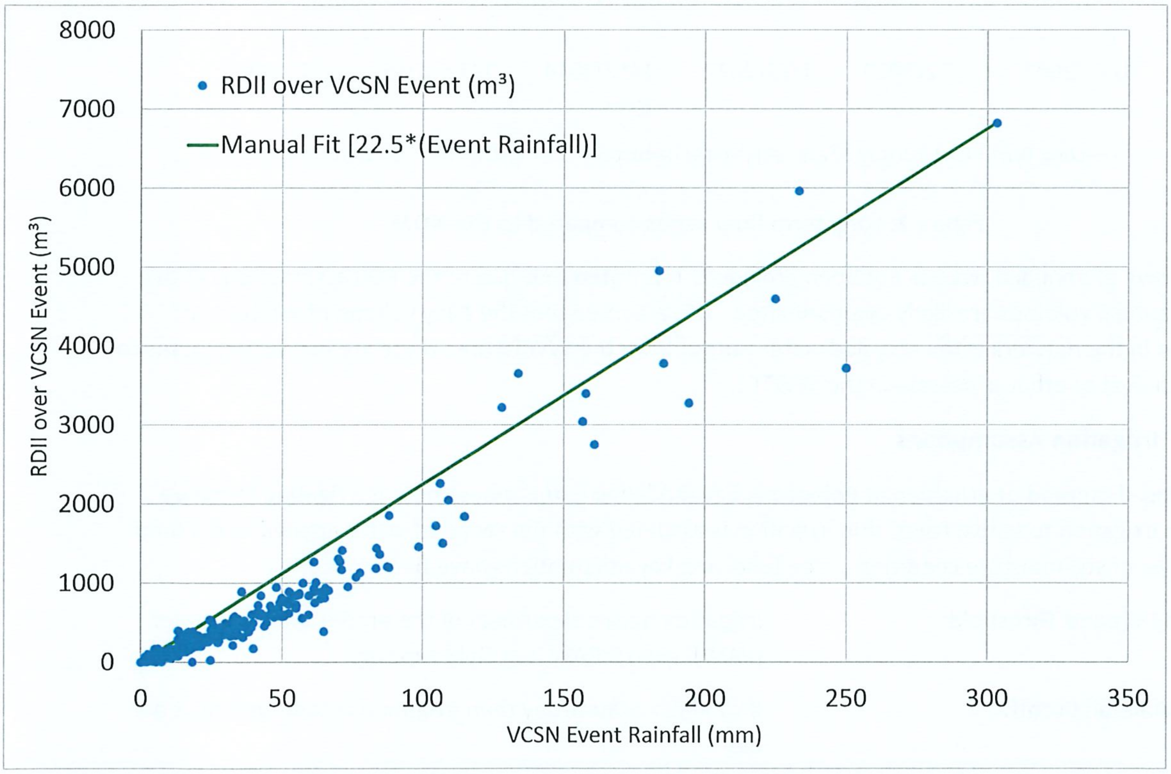

Figure 1: Relationship between VCSN Rainfall Events and the RDII response from the Beca NDM.

The relationship was then applied to rainfall events from the VCSN 20249 rainfall series from January 1972 to April 2021. This produced the RDII component of the long-term wastewater flow series. The long-term flow series is compared to the NDM in Figure 2. In general, the long-term flow series overestimates the wastewater flows. There are a few events in the NDM which are underestimated in the long-term flow series, these are indicated by the points above the trendline in Figure 1. Overall, the long-term flow series is considered appropriate for the purpose of the model. The under-estimated events are not influential in determining the peak recycled water storage requirements.

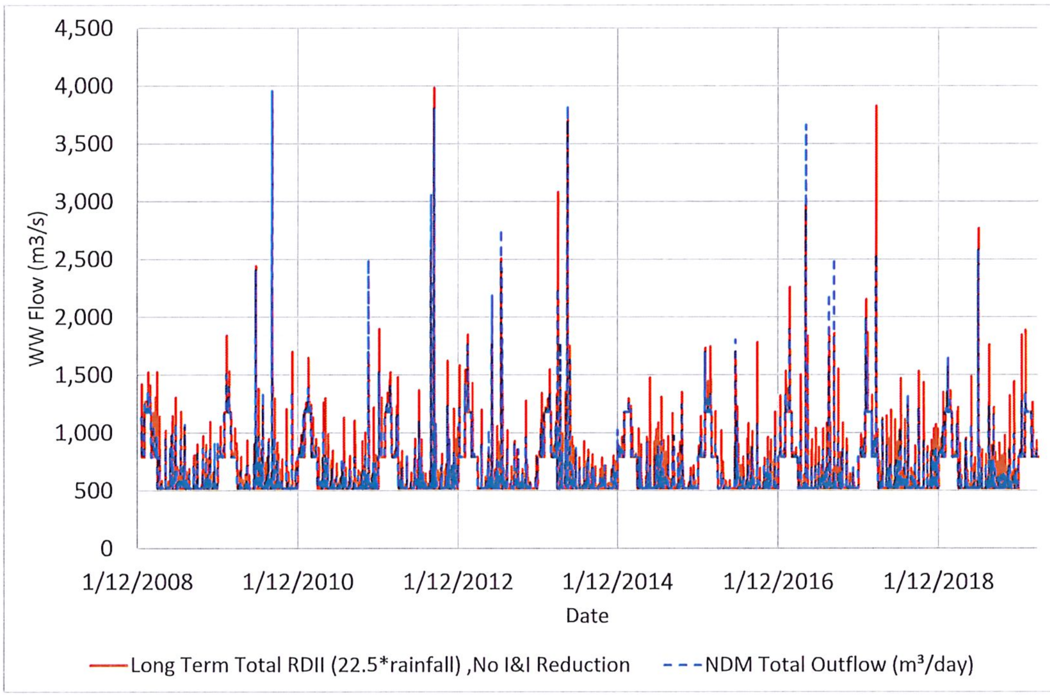

Figure 2: Long term flow series compared to the NDM

A breakdown of annual flows has not been provided. It is noted that due to the RDII assumptions above, RDII and annual volumes are likely overestimated. It is assumed that the daily volume of wastewater generated in the network is the recycled water output from the WWTP (i.e., there are no volume losses to sludge removal or other processes in the WWTP).

2.2 Irrigation Assumptions

The proposed method of irrigation at Robinsons Bay modelled in this assessment is irrigation to native trees. For irrigation to native trees, drip irrigation is assumed with the recycled water applied to the land irrespective of soil moisture conditions. The following key assumptions have been made:

Irrigation Demand Threshold:	Irrigation occurs regardless of the profile available water (PAW), even if PAW is at field capacity
Extreme Rainfall Cutoff:	If rainfall > 50mm/day then irrigation ceases until next dry day
Irrigation Season:	All year round
Irrigation Efficiency:	100% efficiency
Rainfall:	NIWA VCSN 20249 and Akaroa EWS
Maximum Irrigation Application (mm/day):	Dec–Feb: 2.75, Mar–May: 2.15, Sep–Nov: 2.15, Jun–Aug: 1.5

The maximum irrigation application per day is less than the Long-Term Acceptance Rate of the soils and is selected to avoid surface ponding when the PAW is at field capacity.

The rainfall described for the SMB is a composite of VCSN 20249 and Akaroa EWS. This is due to a more representative rainfall over the irrigation area being required. For the RDII estimation, the relationship between the VCSN and RDII (modelled using the Akaroa EWS) was used to estimate RDII over the long-term rainfall record. As the relationship was based on a representative RDII, it is appropriate for its purpose.

2.3 Wetland Operation Rules

The effect that a constructed wetland has on recycled water storage requirements was investigated by extending the soil moisture balance model previously created by PDP. This model is described in the PDP letter to Beca "Irrigation Model Results for Akaroa Treated Wastewater Land Disposal at Robinsons Bay" dated 9 May 2017.

A sub-surface wetland is proposed, which will be filled with granular media and planted with wetland species. A minimum water level will be required in the wetland to maintain plant growth and a freeboard will extend the potential depth of the wetland above the surface of the media. The model diverts any required recycled water from the WWTP to the wetland each day to replace evapotranspiration losses and maintain the minimum water level for plant health. It was agreed with CCC and Beca that the surface area for the wetland would be 3,800 m^2.

When the recycled water storage is 100% full, excess water will be diverted to the wetland. These flows comprise both recycled water and any rainfall over the storage. If the volume within the wetland exceeds the maximum level, there is a controlled outflow to the harbour.

The controlled wetland discharge to the harbour has been set at a constant rate of 2 L/s until the wetland freeboard is exceeded. If the wetland freeboard is exceeded, the volume of water above the freeboard will overflow to the harbour at an unrestricted rate.

Wetland Model Summary

Wetland Surface Area:	3,800 m^2
Wetland Media Depth:	0.6 m
Wetland Total Depth (including freeboard):	1.0 m
Wetland Media Porosity:	30%
Wetland Minimum Level:	300 mm
Wetland (Controlled) Outlet Flow:	2 L/s

The above parameters result in a total volume of water in the wetland (including freeboard) of 2,204 m^3.

2.4 Model Schematic

Figure 3 shows the schematic of the overall irrigation scheme. Figure 4 below shows a graphical representation of the extended irrigation model. The irrigation model currently assumes the flows generated at the Akaroa township are irrigated to land. All flows are buffered in a single pond. In practice, these flows would enter multiple ponds through the system as illustrated in Figure 3. The final volumes of the in-line storage are dependant on the final design of the WWTP treatment capacity (expected to be limited to 1,200 m^3/day to 1,900 m^3/day.

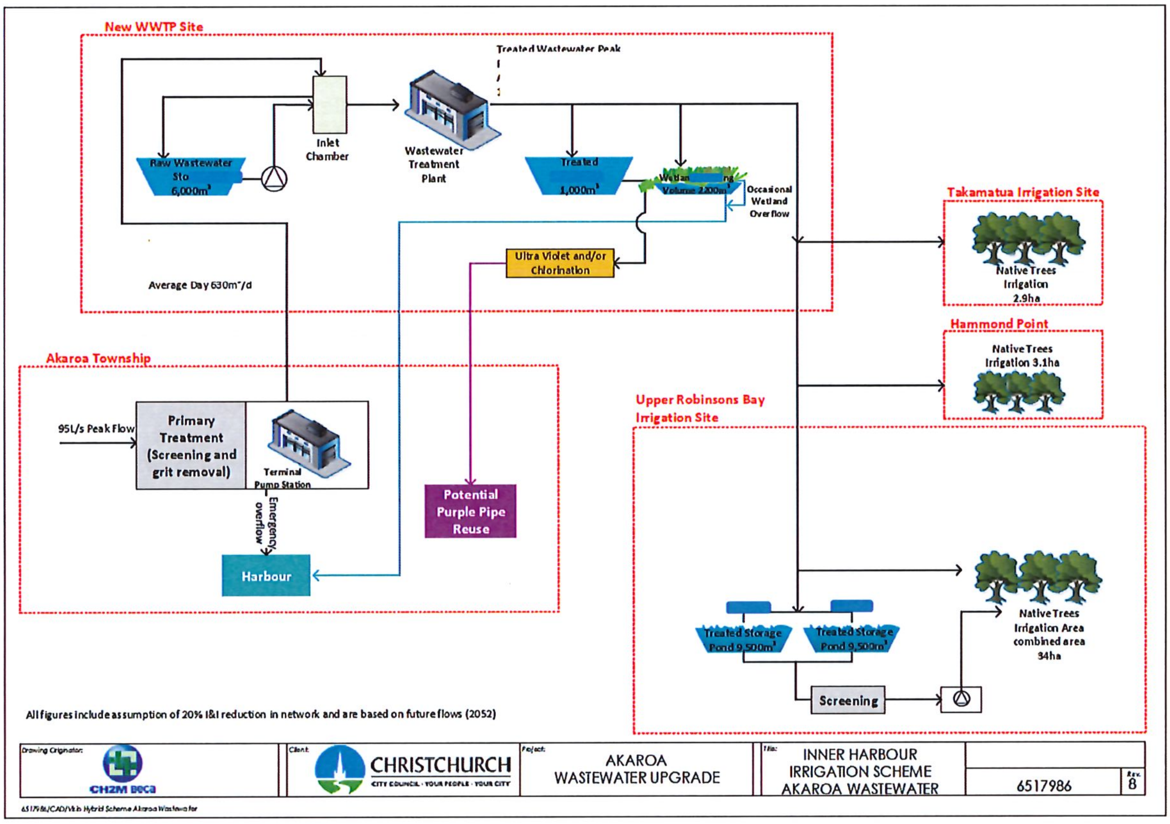

Figure 3: Schematic of Inner Bays Irrigation and Reuse Scheme (Provided by Beca)

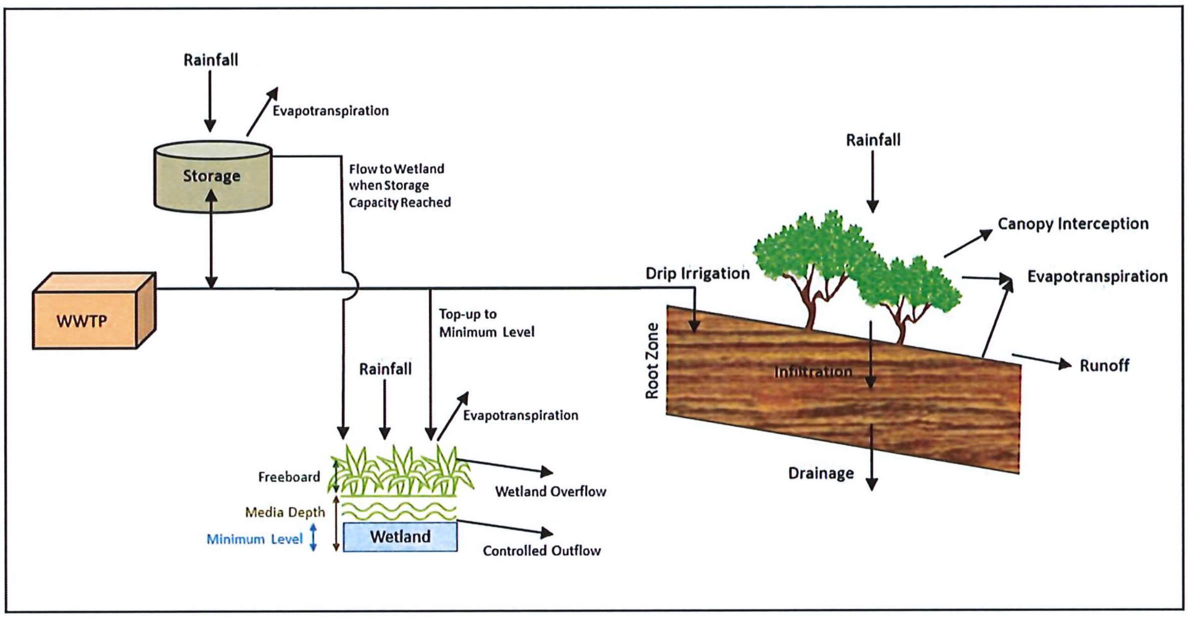

Figure 4: Schematic showing the soil moisture balance

3.0 Updated Model Results

3.1 Model Inputs

Five scenarios are evaluated in this letter.

1. Updated wastewater flow series
2. Scenario 1 with a 3,562 m^3/day flow cap. This value corresponds to the volume from the network during a 24-hour, 1 in 10 year average recurrence interval storm. Flows exceeding this cap overflow into the harbour prior to the WWTP.
3. Scenario 2 with additional 20% reduction in GWII and RDII was assumed and a 75% reduction in retentate flows.
4. Scenario 3 with a maximum storage pond at 12,000 m^3 and storage pond surface area at 6,000 m^2
5. Scenario 4 with the storage pond covered (surface area 0 m^2). This removes added volume from rainfall on the storage pond itself.

For the first three scenarios, the storage surface area was kept constant at 10,000 m^2 for the purposes of calculating rainfall accumulation over the storage pond. The effect on storage volumes with the changing of parameters could, therefore, be assessed. The storage volume was 'limitless' so no overflows would occur.

Scenarios 2, 3, 4 and 5 assessed the effects of a flow cap through the wastewater network prior to the WWTP. Flows exceeding 3,562 m^3/day are assumed to overflow out of the network and bypass the WWTP and irrigation systems. After the WWTP, flow is either directed to 'top up' the wetland, irrigated to land, or diverted to the recycled water storage pond.

For scenarios 3, 4 and 5, a 20% reduction in GWII and RDII was assumed and a 75% reduction in retentate flows as instructed by CCC. The discharge location of the retentate flows can be controlled, reducing the volume required to be sent to the WWTP. Therefore, a greater reduction in flows from this source can be applied.

Scenario 5 assumes that the storage pond is covered. This removes the accumulation of rainfall within the storage pond footprint.

3.2 Model Results

Table 3 shows the peak storage required for native tree irrigation of the Inner Harbour Irrigation Scheme (previously referred to as Robinsons Bay) for each of the scenarios outlined above.

Table 3: Model Results for Irrigation to Native Trees – Inner Harbour Irrigation Scheme

Scenario	Peak Storage	Storage Overflow to Wetland
1	26,900	-
2	26,900	-
3	15,900	-
4	12,000	1,750
5	11,250	-

Table 3 shows that a modelled 12,000 m^3 with a surface area of 6,000 m^2 will provide storage with a limited recycled water overflow into the wetland. The model shows one overflow event where the storage volume is exceeded and recycled water overflows into the wetland. The recycled water is discharged from the wetland to the harbour via the controlled 2 L/s discharge discussed in section 2.3. There are no uncontrolled recycled water overflows from the wetland to the harbour in the model as the wetland freeboard is not exceeded.

Figure 5 shows the build-up of peak storage in scenario 4. While a single rainfall event ultimately causes the exceedance of storage volume, preceding events contribute to partially filling the pond. It is the total volume from these events over the period which contribute to the storage overflow. This is explaining why scenario 2 shows no change in the peak storage required even when the daily flow is capped. A daily flow cap does not substantially reduce the volume of flow over the event duration. Scenarios 3 and 4 include reductions in the I&I and retentate components of the flow. These target the volumes of wastewater flow through the WWTP, and hence, show a major reduction in the storage requirements. Overall, scenario 4 provides sufficient storage where over the 49-year period modelled, only one exceedance of the recycled water storage pond was predicted.

With a covered storage pond, the peak storage needed reduces to 11,250 m^3. Figure 6 shows the build-up of peak storage in scenario 5. The historic rainfall data used in the model has a 212 mm and 232 mm rainfall event in the month preceding the peak storage. During these events, there is no irrigation due to the rainfall cut off. This results in a reduced storage requirement when the storage pond is covered, as illustrated in the difference between scenario 3 and 5 (both have no overflows). With allowance for overflow events from the storage pond to the wetland, further reductions in storage requirements can be achieved.

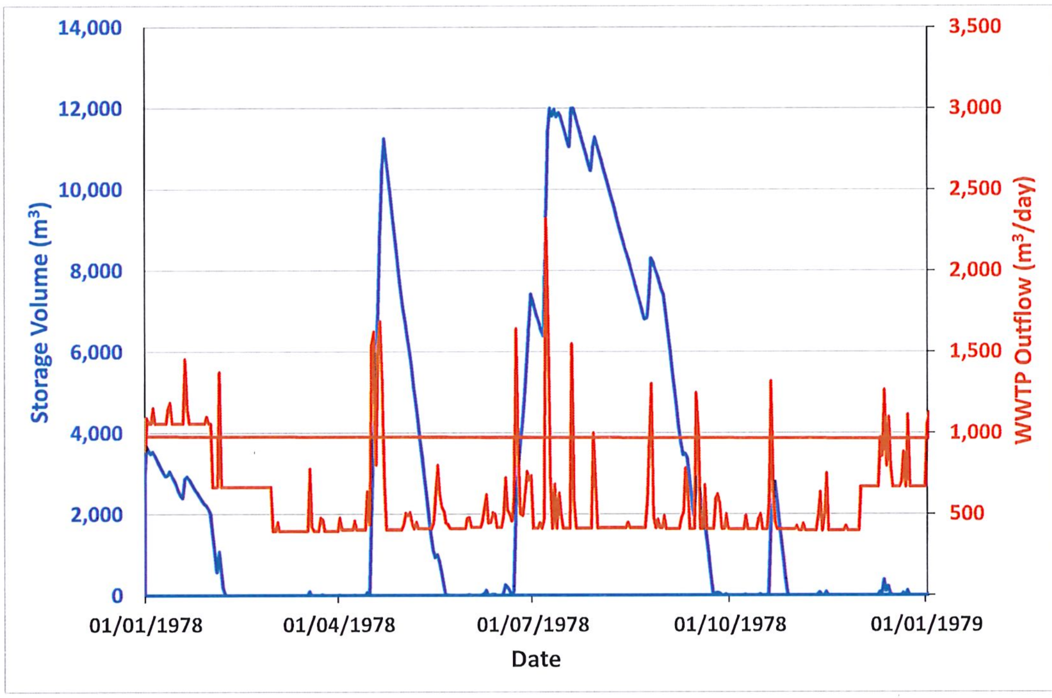

Figure 5: Build-up of storage during overflow period

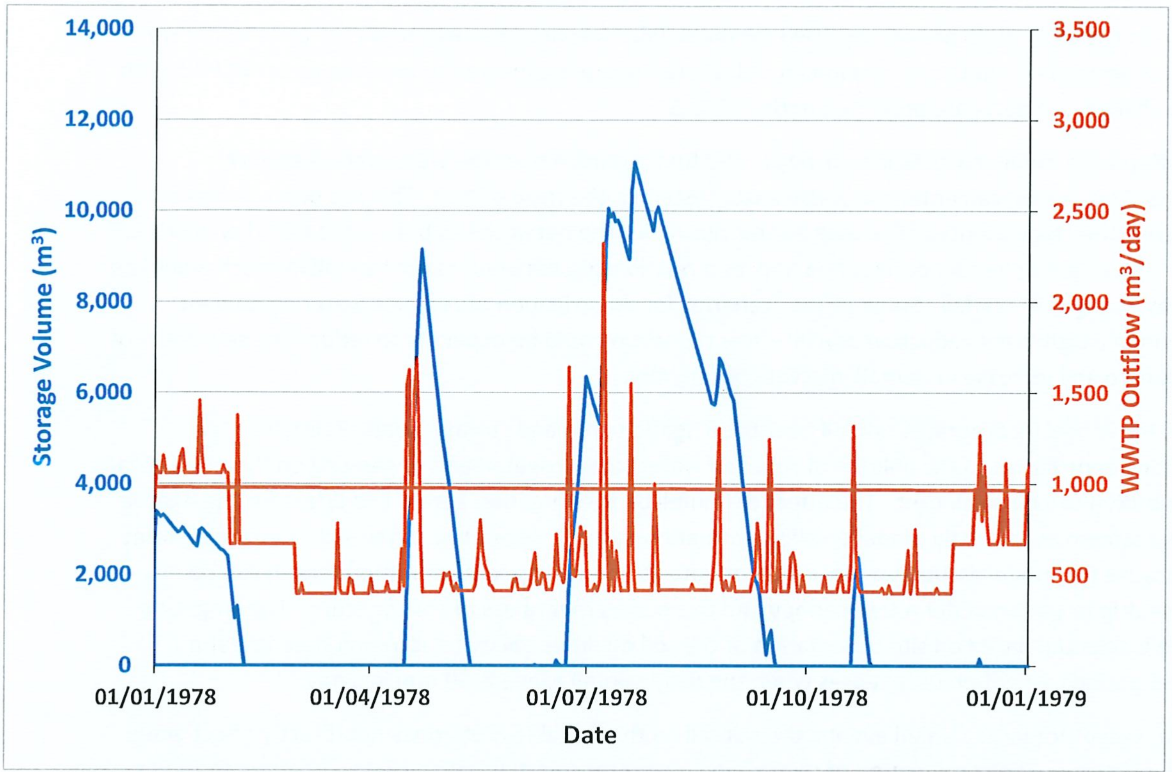

Figure 6: Build-up of storage during peak period with a covered storage pond

4.0 Potential Effects of Climate Change

This section discusses the potential effect of climate change to the model in a qualitative manner. The land disposal system needs to operate as designed from its startup (presumably with current weather patterns) and with the effect of any future changes to the climate of Banks Peninsula. Consequently, only effects of climate change that require an increase to the storage and irrigation areas in the future are relevant.

The effects of climate change on the Akaroa scheme are assessed based on the National Institute of Water & Atmospheric Research report "Climate Change Projections for the Canterbury Region" (NIWA, 2020). The NIWA report assesses the Representative Concentrations Pathways (RCPs) 4.5 and 8.5 scenarios. The NIWA report considers the effects of climate change at the years 2040 and 2090. RCP4.5 is considered to be a 'stabilisation' scenario where greenhouse gas concentrations and therefore, radiative forces, stabilise by 2100. The RCP8.5 is the 'business as usual' scenario and predicts very high greenhouse gas concentrations.

It should be noted that the NIWA report presents changes to the average rainfall and evapotranspiration (among other climate parameters) and the report itself is based on averaging the results of six different climate models. Consequently, some variation both between the climate model projections and variation from the averages can be expected.

The soil moisture balance model developed for the Akaroa scheme uses both rainfall and potential evaporation to calculate the irrigation requirements.

4.1 Rainfall

The impacts of rainfall on the Banks Peninsula vary depending on the RCP scenario and projected timeframe. For RCP 4.5, by the year 2040, the annual mean rainfall is expected to increase by up to 5%

compared to the 1986-2005 period. By 2090 for the RCP8.5 scenario, there is predicted to be either no change or a decrease of up to 5%. Seasonally, winter rainfalls are expected to increase under RCP4.5 with either no change or a decrease predicted under RCP8.5.

Rainfall affects the model outputs in two ways. The first is rainfall over the wastewater network catchment. This rainfall can enter the wastewater system in the form of RDII. This has been assessed by Beca in sizing the components of the wastewater network. The network has been sized based on a RCP8.5 scenario. The irrigation model derives and applies a relationship between rainfall and RDII which would be affected by changes to rainfall. Some of the scenarios for the irrigation of recycled water contain an assumption of a significant reduction of RDII – this reduction could be expected to reduce the sensitivity of the network to any increase in rainfall intensity or quantity.

Secondly, the model incorporates rainfall over the irrigation area and storage pond. Rainfall on the storage pond contributes to the volume of recycled water to be irrigated and depending on the pond area, the contribution can be significant. The effect of rainfall on the irrigation area is less direct for the Akaroa model: the system as currently modelled allows irrigation to occur regardless of the soil moisture content. This is because the model assumes a low irrigation rate (1mm/d in the critical winter period) can be applied via drip irrigation under a tree canopy and this occurs regardless of soil moisture. This irrigation rate value is selected based on site observation of the soil qualities ability to accommodate irrigation during wet periods. Irrigation only ceases when the daily rainfall exceeds 50 mm in a day.

Therefore, except for large rainfall events, the rainfall on the irrigable areas does not directly affect when irrigation will occur. The combination of rainfall and evapotranspiration, does, however, affect the soil's ability to accommodate the water. This is accommodated in the model by using a conservative maximum irrigation application depth which varies with the season.

4.2 Potential Evapotranspiration

The annual potential evapotranspiration deficit accumulation is projected to increase for both RCP 4.5 and RCP 8.5 scenarios. For the Akaroa wastewater scheme, this would likely increase the ability to irrigate a larger amount volume, on an annual basis. Using the current climate data for evapotranspiration builds a level of conservatism with respect to the long-term operation of the scheme.

The NIWA report provides projections of the change to soil moisture deficit which is based on a combination of factors including rainfall and evapotranspiration. The NIWA report predicts no change to the number of days of soil moisture deficit during the winter period for either RCP 4.5 or RCP8.5 scenarios. For the other seasons, a small increase in days with a soil moisture deficit is predicted. The sizing of the storage volume and land area for the Akaroa scheme is driven by the ability to dispose of the recycled water during the winter months and so in this regard, the use of existing climate data in the Akaroa model has a neutral effect with respect to climate change.

4.3 Summary

The Akaroa irrigation model has been designed to size the land irrigation area and storage volume to avoid discharges from the designed system. It is periods of wet weather (typically during winter) that dictate the sizing of the irrigation area and storage volume needed to avoid discharges of recycled water to the environment.

The NIWA projection for climate change in the Canterbury region, and specifically for Banks Peninsula, indicate that winter rainfall is variable depending on the RCP scenario considered, and the time frame. The effects range from either a small increase in annual mean rainfall (5% increase for RCP4.5 in 2040) to no change or a small decrease in average annual rainfall for the more pessimistic RCP8.5 scenario at the year 2090. The model uses a conservative (low) irrigation application rate in winter, which climate influences are not expected to reduce. The current model is based on irrigation regardless of PAW, which allows for certainty in the volume of recycled water being discharged. Rainfall on the recycled water storage pond may result in reduced capacity following short, intense storms. Options for covering the storage pond may provide increased utilisation of the storage capacity for recycled water.

For potential evapotranspiration and overall soil moisture deficit, the NIWA projections indicate that climate change will increase the ability to dispose of recycled water to land in the Akaroa area on an average annual basis.

It should be noted that the current modelling of sizing of storage and disposal area tends to be driven by periods of prolonged wet weather rather than individual extreme weather events. Information on the changes to extreme cases is limited and specifically noted as a limitation in the NIWA report and so remains an area of uncertainty.

It should also be noted that while the system needs to be sized to cater for future climate, it must also be suited to the existing climate to operate within the early years of its construction. On balance we believe the sensitivity of the model to climate change is neutral or balanced out

5.0 Conclusion

PDP has run four scenarios to estimate the peak storage of recycled water from the proposed Akaroa WWTP. The irrigation will occur to 40 ha of trees planted at the head of bays sites on the Banks Peninsula. This letter was prepared to update peak storage model results based on new wastewater flows, estimated from the Beca NDM. The results of the modelling indicate that with 20% I&I reduction and 75% retentate reduction (as instructed by CCC) a 12,000 m^3 storage pond with a surface area of 6,000 m^2 will result in one storage overflow event over the 49-year modelling period. If the reductions assumed are not realised there is a risk that more storage may be needed and/or more an overflows may occur.

Covering the storage pond results in a reduction in storage volume over the modelled period. It is estimated that 11,250 m^3 of storage will provide sufficient storage with no overflows shown over the 49 years of modelled data.

The sensitivity to climate change has been qualitatively assessed using projections published by NIWA. The projected effects of climate change indicate the annual rainfall over the network and irrigation catchments are expected to be similar or increase by up to 5% depending on the RCP4.5 climate change scenario. Overall, it is anticipated that the intensity of large rainfall events will increase while the duration of events will decrease. While this has an influence on the design of the wastewater network, the effects of climate change are not expected to greatly impact the disposal of recycled water for the Akaroa wastewater scheme. The historical long-term rainfall is expected to provide a reasonable estimate of storage requirements accounting for potential climate effects.

6.0 Limitations

- This model has been prepared for the purpose of estimating the peak treated recycled water storage requirements for the Akaroa wastewater disposal scheme. The assumptions surrounding the development of the long-term flow record reflect this purpose and may not be suitable for assessments of the typical operating conditions

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of wastewater flows provided by Beca and Christchurch City Council and the analysis of future flows carried out by Beca. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Beca for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED

Prepared by	Reviewed and Approved by
Neeraj Pratap	**Murray Kerr**
Environmental Engineer	Technical Director – Water Infrastructure

Appendix G Technical Memo – Contaminant Fates

Stantec **Memo**

To:	Janan Dunning Christchurch	From:	Charles Mellish Hamilton
Project/File:	Akaroa Domestic Wastewater Contaminants – Akaroa Treated Wastewater Irrigation Scheme	Date:	October 2022

Reference: 310103534

1 Background

1.1 Scheme Description

The Christchurch City Council's proposed Akaroa Treated Wastewater Irrigation Scheme (the scheme) will consist of a terminal Pump Station conveying raw domestic wastewater from Akaroa to a new Wastewater Treatment Plant (WWTP) on Old Coach Road. Treatment is understood to include a nutrient removal activated sludge process with clarification and possibly filtration. Treated wastewater is proposed to be applied to two irrigation areas (at Robinsons Bay and Hammond Point) via surface drip irrigation, with a small portion irrigated to Jubilee Park in Akaroa using Subsurface Drip Irrigation (SDI) via a 'purple pipe' scheme.

This memo discusses contaminants typically found in New Zealand domestic wastewater (including metals, pharmaceuticals, emerging contaminants, herbicides, and pesticides etc.) and their fate when irrigated to land. The particular interest in this case is whether those contaminants are likely to enter ground and / or surface water. The scheme design must therefore consider:

- effects on receiving water, including nearby streams
- problematic contaminant accumulation in the soils of the irrigated areas

1.2 Assessment of Effects

Potential effects of the proposed scheme are summarised in 'Akaroa Wastewater Summary of Land Disposal and Reuse Investigations', Section 5.7.2.3, Preliminary Assessment of Effects[1], Beca July 2020, Page 67. The report states that "in terms of other potential effects, 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."

Investigation into Persistent Organic Pollutants (POPs) was not described in the report but will be discussed in this memo amongst other contaminants to provide advice on risk mitigation if the impacts of contamination are observed after irrigation commences.

[1] Akaroa Wastewater Summary of Land Disposal and Reuse Investigations, Beca

2 Contaminant Guidelines

2.1 General

The assessment of persistent organic contaminants is made against several guidelines, however as there is limited analytical data available in NZ, the NZ Biosolids Guidelines for metals and organics limits are used to provide a reference against which treated wastewater quality is compared. The sections below discuss the guidelines considered as relevant to this assessment.

2.2 Environment Canterbury's Land and Water Regional Plan

2.2.1 ANZECC TABLE 3.4.1[2] TRIGGER VALUES FOR SELECTED TOXICANTS

Constituents from Table S5B of the Canterbury Land and Water Regional Plan are referenced from ANZECC[3] guidelines for 99th, 95th and 90th percentile limits in Table 3.4.1 respectively. These are limits for marine and river recreational use and do not relate to persistent organic pollutants in soils. However, acidification of contaminated soils is the mechanism for release of metals held in soils when pH declines below 4.5. Treated wastewater is stable, typically ranging from pH 6 - 8 and is not expected to influence soil alkalinity but can influence salinity adversely depending on the mode and rate of application.

2.3 Persistent Organic Pollutants

The pathway for POPs in irrigation water to enter receiving surface waters is either through direct runoff because of over irrigation (waterlogged soils) and or through seepage. Another pathway is through acidification of soils, through application of irrigation water, which mobilises the contaminants held in soils. This is true for metal contaminants but not valid POPs. Percolation of POPs to groundwater is generally considered to be low in the scientific community. Mobility of POPs through soils is more due to solvents being present. It is more likely that washout of POP laden soils due to waterlogging and or heavy rain events will be the main pathway for POPs entering receiving waters.

2.4 New Zealand Biosolids Guidelines 2003[4]

The NZ biosolids guidelines stipulates the soil limit or ceiling concentrations for biosolids application to land. The guideline's limits aim to safeguard the life-supporting capacity of soils, promote the responsible use of biosolids and protect public health and the environment. The guidelines promote best practice to minimise the risks of applying biosolids to land. The irrigation of treated wastewater is not defined by biosolids limits, but the limits provide a reference point for the soil ceiling limits exposed to the application of metals.

Table 1 is an excerpt from the NZ Biosolids Guidelines.

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[2] Table S5B: Schedule and Table references from the LWRP regarding River Water Quality
[3] Australian and New Zealand Environment and Conservation Council
[4] Guidelines for the Safe Application of Biosolids to Land in New Zealand 2003, Table 4.2: Soil limits and biosolids classification by contaminant levels

Table 1: NZ Biosolids Guidelines: Heavy Metals Soil Limit

Metals	Soil limit or ceiling concentrations (mg/kg dry weight)	Biosolids limits Grade a max. concentration (mg/kg)	Biosolids limits Grade b max. concentration (mg/kg)
Arsenic (As)	20	20	30
Cadmium (Cd)	1	1	10
Chromium (Cr)	600	600	1500
Copper (Cu)	100	100	1250
Lead (Pb)	300	300	300
Mercury (Hg)	1	1	7.5
Nickle (Ni)	60	60	135
Zinc (Zn)	300	300	1500

3 Contaminant Assessment

3.1 Irrigation Area Soils

Aqualinc[5] undertook preliminary investigations of the irrigation areas and compiled a report for Christchurch City Council where soil types are documented. The soil types referred to in Aqualinc's report have 9% sand, 71.5% silt and 19.5% clay fractions. The available water profile zone varies between 150 mm and 600 mm. Sufficient depth is available within which adsorption of heavy metals will become bound to the clay and silt fraction. The sand fraction is low, indicating that adequate capacity is available within the soils to limit the migration of metals into the receiving water environment.

3.2 Metals

Treated wastewater metal contaminant sampling from the current Akaroa wastewater treatment plant by Christchurch City Council[6] has been completed for total lead, copper, chromium, cadmium, and zinc. Copper and zinc are the only two metals shown to be prevalent in the treated wastewater samples in concentrations that exceed the RCEP Standard[7] for metals in coastal water. This is a trend seen in

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[5] Draft Report: Akaroa Treated Wastewater Irrigation Scheme, Aqualinc, September 2022
[6] Akaroa wastewater network sampling period was from 11 December 2013 up to 7 February 2014
[7] Regional Coastal Environment Plan for the Canterbury Region (RCEP; ECan 2005)

towns across New Zealand, where these two metals leach from drinking water networks and are measured in treated wastewater.

The minimum RCEP water quality standard for copper concentrations set out in RCEP Schedule 4 for Class Coastal SG Water (i.e., Akaroa Harbour) after reasonable mixing is 0.005mg/L. The concentrations in Akaroa's treated wastewater prior to coastal discharge were observed ranging between 0.015 and 0.030mg/L. The minimum RCEP water quality standard for Zinc after reasonable mixing is 0.05mg/L with 50% of the treated wastewater observations ranging between 0.05 and 0.10 mg/L respectively prior to discharge. Irrigating at these concentrations, treated wastewater would likely meet the RCEP standards after mixing if applied directly to coastal water[8]. The impact of treated wastewater applied to land, therefore, would have either a very low or indiscernible impact in receiving stream water, and undetectable in coastal water.

Akaroa’s network may well have exposure to low alkalinity corrosion of metal fittings that results in the propensity for metals to leach into wastewater as shown by Council’s treated wastewater sampling data.

3.2.1 LEACHING OF METALS MECHANISM

Sediments attract adsorbed metal contaminants, introduced by irrigating treated wastewater. The contaminants are predominately attached to the smaller (<120µm) particle size sediments. These contaminants – particularly metals - are tightly bound within the sediment particles. There is a low risk of mobilisation of metals in solution as fine fractions of soils generally enhance adsorption of metals.

Changes in the oxidation state of previously anoxic sediments can lead to lower pH (that depends on things like sulphate content of the sediment, etc.) and thus to mobilisation of metal contaminants. A paper that researched the element release during oxidation[9] noted that porewater pH was the most important factor explaining heavy metal release during oxidation. Samples with fine fractions (silts and clays) mostly displayed a higher acid neutralizing capacity, which results in a limited release of heavy metals compared to sands. Loess (the dominant soil type across all three irrigation areas) has fine fractions that adsorb metals and act as a layer that traps contaminants.

The risk of mobilisation of metals into the soluble fraction is realised when pH is below 4.5. The risk of metal mobilisation from the scheme is low as the soils across the proposed irrigation areas have pH values of 5.6 – 5.7 (Table 3[10]). Treated wastewater has alkalinity above 100mg $CaCO_3$/L with pH varying between 6 to 8. Recent samples showed soil pH values were acidic implying that treated wastewater will not impact soil pH adversely. Long term impacts will be monitored to manage risk of further acidification of soils.

Table 2: pH of soils in proposed irrigation area (sampled on 2021/11/10)

Soil Sample Location	pH
Akaroa Soil	5.6
Takamātua Soil	5.7
Hammond Point Soil	5.7

[8] Aqualinc reports that the dilution ratio of stream to wastewater flow is about 90% of the WW flow
[9] V. Cappuyns and R. Swennen, entitled “Evolution of element release during oxidation and its relevance towards the management of contaminated sediments”
[10] Data received via email correspondence from Helen Rutter, Aqualinc -soil sampling pH data.

Robinsons Valley Soil	5.6

3.3 Phosphorus

Phosphorus is introduced in solution and becomes complexed with other elements in the soil, which results in a low leaching potential. Low application rates will ensure that there is no excess phosphorus in the soils. The grading of the soils provides low leaching risk as less than 10% of the soil is sandy, with predominantly fine silts and clays binding phosphorus onto fine soil particles.

Robinson[11] observed that the fate of irrigated treated wastewater soil P loading was 55kg P/ha/year on native vegetation at Duvauchelle, which contains an average of 11mgP/kg. Current treated wastewater P concentrations are less than 4mgP/L. Robinson postulated that "most of this P is lost in the top 300mm will be retained by the subsoil".

Over 50 years, accumulation of NZ-native plant material results in P accumulation in the system. Akaroa's proposed treatment process has flexibility to control soluble P in the effluent using biological P uptake. Alum dosing may be considered to reduce phosphorus to minimal levels if warranted by environmental triggers.

3.4 Contaminants

3.4.1 CONTAMINANTS OF EMERGING CONCERN AND PERSISTENT ORGANIC POLLUTANTS

Persistent Organic Pollutants (POPs) are managed in New Zealand using the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2011 which replaced the WaterNZ Guidelines 2003. Contaminants of Emerging Concern (CEC) are not regulated currently but as global understanding improves, local regulators will respond to reduce contaminants in treated wastewater. Organisations such as the USEPA provided an advisory for PFAS[12] in June 2022 and provided a timeline for final PFAS regulation will occur in 2023.

In the absence of readily available data on the prevalence of Persistent Organic Pollutants POPs in New Zealand soils, some European studies were reviewed. The distribution of persistent organic pollutants was studied in temperate forests and semi-rural soil environments across Europe and published in the Journal of Forestry Research[13]. The results show that soil organic carbon storage acts as a potential POP sink in surface soils. Subsoils did not appear to have higher concentrations. The study concluded that forest soils can act as a potential sink for POPs.

This indicates that irrigation of soils with comparative similar carbon storage will result in POPs accumulating in the soils and therefore not released to receiving waters if the soils are not disturbed.

[11] Phosphorus in Treated Municipal Wastewater irrigated onto NZ-native vegetation, June 2019

[12] PFAS per- and polyfluoroalkyl substances

[13] Maqsood, S., Murugan, R. Distribution of persistent organic pollutants in aggregate fractions of a temperate forest and semi-rural soil. J. For. Res. 28, 953–961 (2017). https://doi.org/10.1007/s11676-017-0380-0

In the absence of management guidelines or regulations on NZ limits or standards, long-term monitoring is required to observe the response of the receiving environment to irrigation of treated wastewater.

4 Conclusions

Soil contamination limits are provided to document the maximum allowable concentration when considering contaminant concentrations in soils. NZ Biosolids guidelines are referenced against which future sampling analytical results can be reported. NZ Biosolids guidelines also confirm a low risk of phosphorus leaching from soils ensuring receiving waters are not exposed to nutrients that would promote eutrophication.

The alkalinity of treated wastewater is stable and is not expected to adversely affect receiving soils. Stable soil alkalinity keeps contaminants bound in the soil matrix to avoid leaching into receiving waters.

The risk to receiving waters (e.g., Robinsons Bay Stream) from heavy metals, and emerging contaminants from irrigating treated wastewater to the proposed irrigation areas is low. It is expected that contaminants from treated wastewater of domestic origin irrigated to native trees will be retained in the site soils. Through good irrigation practices and management, it is not expected that contaminants will accumulate to a degree that would cause adverse effects on soil structure or quality across the irrigation areas.

Overall, the risk of the contaminants considered above entering ground or surface water is assessed as low, be that organic and inorganic chemical, or phosphorus, based on readily available data. Monitoring long term impact of contaminants leaching from soils is required to instigate mitigation measures if required.

5 Recommendations

Analytical data must be collected through a sampling regime following commencement of treated wastewater irrigation to monitor the effect on receiving soils and enable any adverse effects to be managed and mitigated. Sampling of treated wastewater to record contaminants of concern will enable mitigation measures (if any) to be identified and implemented. If contaminants of concern that exceed guideline values are present in treated wastewater, advanced oxidation processes may be deployed in the treatment process, to break down the chemicals. Processes such as ozonation are used for this purpose and if needed can be added to the treatment process retrospectively.

The following operational monitoring and testing to provide baseline treated wastewater concentrations and monitor contaminant loads in irrigated soils is recommended:

- Treated wastewater nutrients (nitrogen and phosphorus) and contaminants
- Treated wastewater organic compounds
- Soil testing of Barry's Bay soils is proposed by Aqualinc for irrigation areas to confirm site-specific soil attributes and confirm contaminant fate as final design of the irrigation system, flow rate, require further soil tests be completed to determine specific soil properties.

- Ongoing sampling of soils is proposed for irrigation areas to monitor long term trends of adsorbed contaminants and phosphorus, soil structure and quality.

Stantec New Zealand

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Appendix H Freshwater Ecology Report

Akaroa Treated Wastewater Irrigation Scheme (ATWIS): Assessment of Environmental Effects on Freshwater Ecology

EOS Ecology Report No. STA03-21004-01 | December 2022

Prepared for Stantec

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RECOMMENDED CITATION: Dewson, Z. 2022. Akaroa Treated Wastewater Irrigation Scheme (ATWIS): Assessment of Environmental Effects on Freshwater Ecology. EOS Ecology Report No. STA03-21004-01. 59 p.

EXECUTIVE SUMMARY

The Christchurch City Council (CCC) is applying for resource consent to apply treated wastewater to land by irrigation within the Akaroa Inner Bays (Robinsons Bay Valley, Hammond Point, and Jubilee Park (Akaroa)). The scheme, which is known as the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), will use highly treated wastewater from a new treatment plant at Old Coach Road (Childrens Bay) to irrigate native trees on land at Robinsons Bay Valley and Hammond Point, as well as the irrigation of grass at Jubilee Park, rather than discharging Akaroa's treated wastewater to Akaroa Harbour as currently occurs. The Takamātua Stream catchment was also considered as a possible irrigation area at the outset of the project, but was subsequently removed when the irrigation capacity of Hammond Point and Robinsons Bay Valley was found to be sufficient.

EOS Ecology has been commissioned by Stantec to prepare an assessment of environmental effects (AEE) of the ATWIS on the freshwater ecology of the area. Our assessment begins by presenting the results of baseline surveys which outline the state of the existing environment (water quality and freshwater ecology) in areas where the scheme may impact on surface waterways, then follows on to an AEE on the freshwater receiving environments relevant to the proposed ATWIS.

We initially identified Robinsons Bay Stream, Takamātua Stream, Childrens Bay Creek, and Grehan Stream as the permanent waterways that could be affected by the scheme as receiving environments. Although the Takamātua Stream catchment is now no longer part of ATWIS, the monitoring information for this waterway is included as part of this report to provide further context and information that may be relevant to future studies. Existing fish, invertebrate and instream habitat survey data was available for Robinsons Bay Stream and Takamātua Stream and therefore no additional ecological surveys were completed at sites on these waterways. Three additional sites were surveyed for ecological values (habitat, macroinvertebrates, and fish) as part of the current project, including one site on Childrens Bay Creek and two sites on Grehan Stream (true left and true right branches). Environmental DNA (eDNA) sampling was also undertaken at nine sites, to provide a consistent overview of fish presence/absence for all streams that may interact with ATWIS. We found that freshwater ecological values were moderate to high for all the stream sites considered. This reflected the fact that the fish values were moderate to high for all sites, with several species with 'at risk' threat classifications being recorded in Robinsons Bay Stream, Takamātua Stream, and Grehan Stream (kōaro, īnanga, giant bully, and bluegill bully), while longfin eel ('at risk – declining') were found in all surveyed catchments and Takamātua Stream also supported torrentfish ('at risk – declining') and lamprey ('threatened – nationally vulnerable').

Aquatic invertebrate values were relatively low for all sites except those in Robinsons Bay Stream. Robinsons Bay Stream supported four regionally endemic species, with *Neocurupira chiltoni*, *Costachorema peninsulae*, *Nesameletus vulcanus*, and *Zelandobius wardi* found at the most upstream site in this stream. Only *Neocurupira chiltoni* was found at the mid catchment site on Robinsons Bay Stream, while *Zelandobius wardi* was found in Takamātua Stream and the true left branch of Grehan Stream. Two of the regionally endemic macroinvertebrate species found in Robinsons Bay Stream have a threat classification of 'threatened – nationally endangered' (the mayfly *Nesameletus vulcanus* and the stonefly *Zelandobius wardi*), while one is 'threatened – nationally vulnerable' (the caddisfly *Costachorema peninsulae),* and another is 'at risk – naturally uncommon' (the regionally endemic net-wing midge *Neocurupira chiltoni*). Takamātua Stream and the true left branch of Grehan Stream also supported the 'threatened – nationally endangered' stonefly (*Zelandobius wardi*).

To establish the baseline water quality of potential receiving environments, a water quality sampling programme was initiated during August 2021, with 12 monthly sampling rounds completed for six sampling locations by July 2022. Sampling sites included Robinsons Bay Stream (1 site), Takamātua Stream (1 site), Childrens Bay Creek (2 sites), and Grehan Stream (2 sites). Water quality analysis for each site included a range of physicochemical measures, nutrients, heavy metals, and faecal indicator bacteria. Water quality was found to be variable across the 12 monthly rounds of sampling for all sites, but while some physical and chemical water quality stressors such as electrical conductivity, phosphorus, and pH regularly exceeded default guideline values, measures of nitrate, ammonia, heavy metals, and dissolved oxygen were typically within the relevant guidelines at most sampling sites.

As part of the AEE, we identified the potential construction and operational effects of the ATWIS. The construction effects of the ATWIS relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including the stream crossings required for the associated pipeline. Potential effects include the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and concrete related contaminants) and freshwater habitat disturbance (e.g., machinery working in and around waterways during construction of pipeline and access roads, stream bed disturbance for pipeline stream crossings).

The operational effects relate to the ongoing effects of the proposed ATWIS once it is complete and operating. The main potential effect of irrigating treated wastewater to land is the discharge of contaminants from the irrigation areas to surface water (via surface runoff or groundwater). The main effects of this are expected to be a small increase in stream flow, as well as an increase in the concentration of nitrate nitrogen in the streams within the irrigated catchment (Robinsons Bay) once irrigation is underway. Based on investigations and modelling of the water and nitrogen balance for Robinsons Bay Stream catchment, the CCC's preferred irrigation scenario will result in mean stream flow that is 7 L/s (2%) higher than existing and a stream nitrate concentration for Robinsons Bay Stream that is 190% greater than the existing median nitrate concentration (McIndoe *et al*., 2022). However, the estimated post irrigation nitrate concentration for the stream would still be within the typical range of variation for nitrate concentrations in Robinsons Bay Stream, based on the 12 months of water quality monitoring data.

Effects management will be an important part of the ATWIS and has been a consideration throughout the planning of this project. The mitigations required for the construction phase of the ATWIS will be detailed in a Construction Environmental Management Plan (CEMP) that will adopt the methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury. As for the operational stage, the preferred irrigation scenario proposed by CCC includes the planting of native trees both within the irrigation area as well as for infill and riparian planting, along with destocking of the planted areas to offset the nutrients introduced to the catchment by the treated wastewater. Additional mitigation options are available for the operational phase if monitoring indicates that that this is necessary.

With proper implementation of the described effects management approaches during construction, and with implementation of the CCC's 'preferred' irrigation scenario and subsequent modelled/predicted nutrient outputs to stream flow, it is expected that the potential adverse effects of the ATWIS should be able to be reduced to an overall 'less than minor' effect. Monitoring of the freshwater receiving environments is recommended so that scheme operators and consent authorities will become aware of any unanticipated effects in a timely manner. Several adaptive management approaches are suggested to attend to any unanticipated effects.

1 INTRODUCTION

The Christchurch City Council (CCC) has resource consent to build a new wastewater treatment plant in Akaroa to replace the existing wastewater treatment plant at Takapūneke Reserve. The new wastewater treatment plant will be located on Old Coach Road, Childrens Bay, Akaroa (Figure 1). In December 2020, the Council resolved that the highly treated wastewater from the new treatment plant would be discharged to land, rather than to the Akaroa Harbour as currently occurs. The Council also decided that the treated wastewater would be irrigated to land within the Akaroa Inner Bays (Robinsons Bay, Hammond Point, and Takamātua), and that there would be additional investigations around the feasibility of irrigating public spaces within Akaroa and the non-potable reuse of treated wastewater within Akaroa. Following a period of further design and investigation, the proposed scheme now includes a surface drip irrigation system to irrigate native trees with the treated wastewater at Robinsons Bay Valley and Hammond Point, as well as subsurface drip irrigation of Jubilee Park in Akaroa during dry periods.

To achieve the CCC's vision for Akaroa's new wastewater reuse scheme, Stantec are leading a project to undertake the detailed scheme design and consenting for the proposed Akaroa Treated Wastewater Irrigation Scheme (ATWIS). EOS Ecology was commissioned by Stantec to undertake ecological assessments and water quality sampling to support the preparation of an assessment of environmental effects (AEE) for ATWIS. This work has included technical assessments of water quality and freshwater ecology (this report), as well as estuary ecology (Burns & Hempston, 2022).

This report describes the state of the existing environment (water quality and freshwater ecology) in areas where the scheme may impact on surface waterways, including where pipelines cross waterways, and where irrigation areas are near waterways. The report also includes an assessment of the likely effects of construction and operational stages of the project on the freshwater ecology of these areas. Baseline information about estuary ecology and an assessment of the likely effects of the ATWIS on estuary ecology are presented in a related report (Burns & Hempston, 2022). Both the freshwater and estuary ecology assessments are based on the most up to date scheme design details for ATWIS, as provided by Stantec at the time of writing this assessment.

Figure 1 *…figure over page…* **Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), including key geographical landmarks, the proposed locations of the irrigation areas in Robinsons Bay Valley, Hammond Point, and Jubilee Park (Akaroa), and the proposed pipeline route.**

Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS)

WASTEWATER PIPELINE

- Two pipelines (raw wastewater uphill, treated wastewater downhill)
- WWTP discharge pipeline (treated wastewater)
- Pipeline stream crossings
- Irrigation areas
- Existing outfall pipe
- Waterways

0 200 400 800 Meters

N

Layer source: pipeline, WWTP, outfall, irrigation areas: CCC; pipeline stream crossings: EOS Ecology from site visits; waterways: modified by EOS Ecology from site visits, original layers by LINZ & CCC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2 METHODS

All waterways that might be affected by aspects of the proposed ATWIS were identified[1]. As this work was completed prior to the completion of detailed scheme design, the range of waterways identified was initially broad, including Robinsons Bay Stream (also known as Lavericks Drain), Takamātua Stream, Childrens Bay Creek, and Grehan Stream (Figure 2). We completed a literature search to gather existing ecological and water quality information for these freshwater environments and worked through a gaps analysis to identify areas where additional survey and sampling work was required.

2.1 Ecological Surveys

Existing fish, invertebrate and instream habitat survey data was available for Robinsons Bay Stream (EOS Ecology, 2013; Instream, 2020) and Takamātua Stream (Instream, 2020) (Figure 2). Three sites were surveyed for instream habitat, macroinvertebrates and fish as part of the current project, including one site on Childrens Bay Creek and two sites on Grehan Stream (true left and true right branches), as shown in Figure 2. Although the Takamātua Stream catchment is now no longer part of ATWIS, monitoring information has been collected for this waterway because it was initially considered as a possible irrigation area. Ecological and water quality survey data for Takamātua Stream has been included in this report to provide further context and information that may be relevant to future studies. Nine sites in total were sampled for environmental DNA (eDNA), with some of these locations overlapping with the physical ecology survey sites (Figure 2). In addition to ecological surveys, site walkovers were completed for all waterways that the proposed wastewater pipeline would cross, to assess flow permanence at these locations.

2.1.1 Habitat

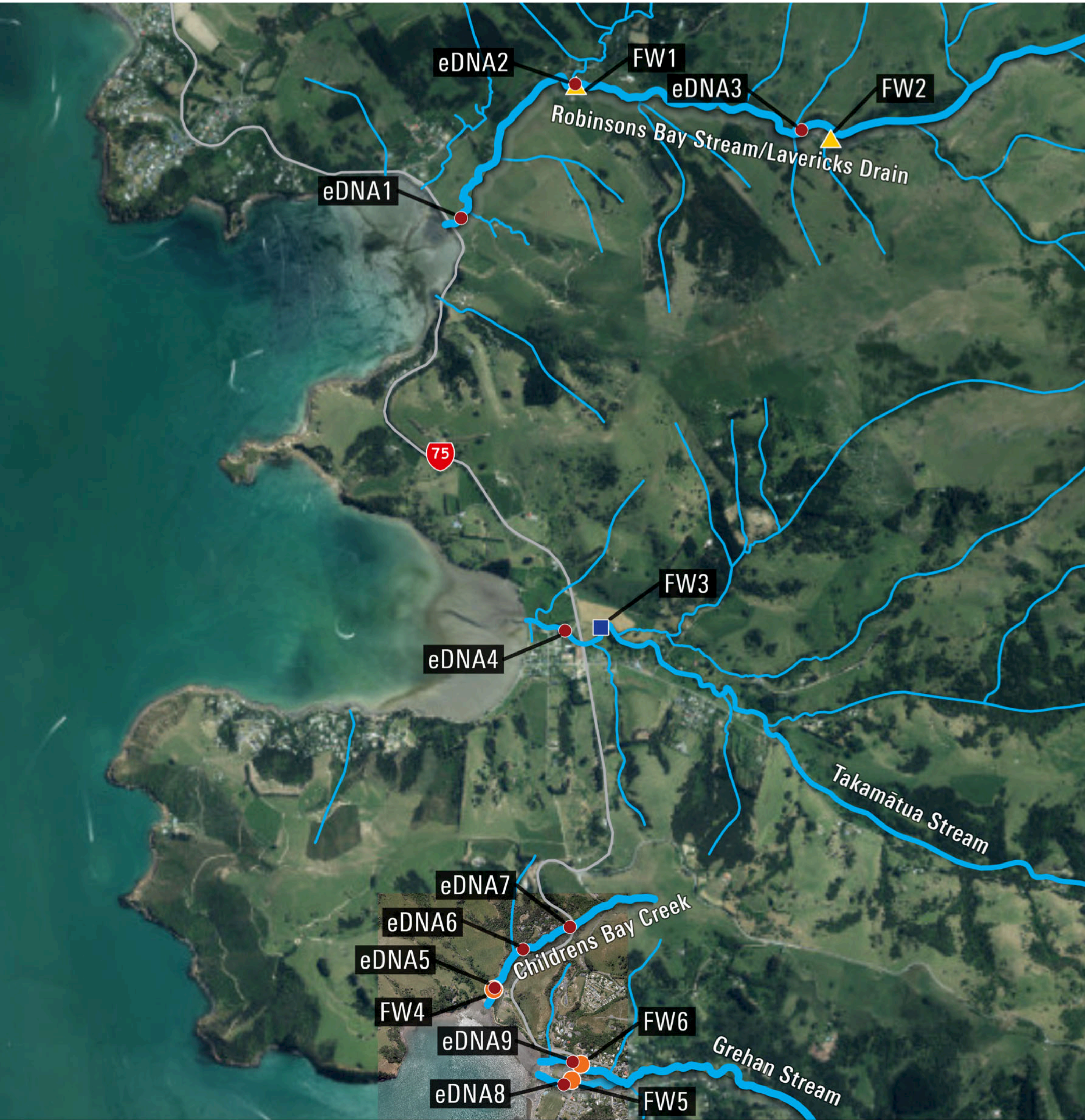
Instream and riparian habitat characteristics were recorded from within a 50 m reach at each survey site. Free-water depth, macrophyte depth, sediment depth, and channel width were recorded for three transects at each site (using five points across each transect). On a site-wide basis, substrate composition, macrophyte cover and composition, riparian vegetation type, available fish cover (substrate; macrophytes/algae; debris; overhanging vegetation; undercut banks; overhead shade), and the percentage of each mesohabitat type (riffle; run; pool) were visually estimated. The P1 habitat assessment protocol of Harding *et al.* (2009) was also completed for each site.

2.1.2 Macroinvertebrates

A single composite kicknet sample was used to collect macroinvertebrates from each site. The sample was made up of a composite of six individual kicknets, in alignment with the 0.6m^2 minimum sample size prescribed under the new NEMS Macroinvertebrate guidelines (Ministry for the Environment, 2022), and covering all microhabitats present (e.g., where present, macrophytes, woody debris, stony substrate). Each composite invertebrate sample was preserved in 70% isopropyl alcohol and taken to the laboratory for identification following the NEMS Full Count with Subsampling Option method, which supercedes the equivalent Stark *et al*. (2001) protocols.

Figure 2 *…figure over page…* Map showing site locations of freshwater ecology survey sites on Childrens Bay Creek and the two branches of Grehan Stream. Also shown are the locations of existing ecological surveys on Robinsons Bay Stream/Lavericks Drain and Takamātua Stream.

[1] At the time of the ecological surveys, the design of the proposed scheme included an irrigation area in Robinsons Bay Stream catchment, Takamātua Stream catchment, and a wetland discharge to Childrens Bay Creek. However, at the time of writing this report the scheme design had been finalised as having an irrigation area in Robinsons Bay Stream catchment and Hammond Point, and no wetland discharge to Childrens Bay Creek.



Freshwater Ecology Survey Sites

- eDNA fish survey sites
- Freshwater ecology sites

HISTORIC FRESHWATER ECOLOGY SITES

- EOS Ecology, 2013
- Instream, 2020
- Waterways
- Roads

0 250 500 1,000 Meters

N

Layer source: eDNA & freshwater ecology sites determined by EOS Ecology in 2021, Historic sites, EOS Ecology & Instream, Waterways: Modified by EOS Ecology from site visits, original layers by LINZ & CCC; Highways: LINZ.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2.1.3 Fish Surveys

Fish were sampled within the three ecological survey sites using electrofishing. This method is described below:

» Electrofishing is a method of fishing that passes an electric current through the water that serves to temporarily 'stun' fish, allowing for their capture in dip nets or handheld stop nets. Spot electrofishing over the length of the survey sites was undertaken to ensure that all habitat types were fished where conditions were suitable for electrofishing.

Electrofishing was used at one site on Childrens Bay Creek and two sites on Grehan Stream during December 2021. Electrofishing was carried out within a 50 m reach at each survey site. All captured fish were retained in buckets (with air bubblers), identified, measured, and counted before being returned to the reach from which they were captured. Where parts of the reach were not amenable to electrofishing (e.g., water too shallow or vegetation impenetrable), spot fishing at suitable locations was undertaken rather than fishing entire reaches.

A search of the New Zealand Freshwater Fish Database (NZFFD; Crow, 2017) was also conducted to find any available past records of fish in within the Robinsons Bay, Takamātua Bay, Childrens Bay, and Grehan Stream catchments.

2.1.4 Environmental DNA (eDNA)

To supplement the existing ecological information and the more traditional fish and invertebrate surveys that were completed as part of the current project, a wider eDNA sampling programme was undertaken during September 2021. This method is described below:

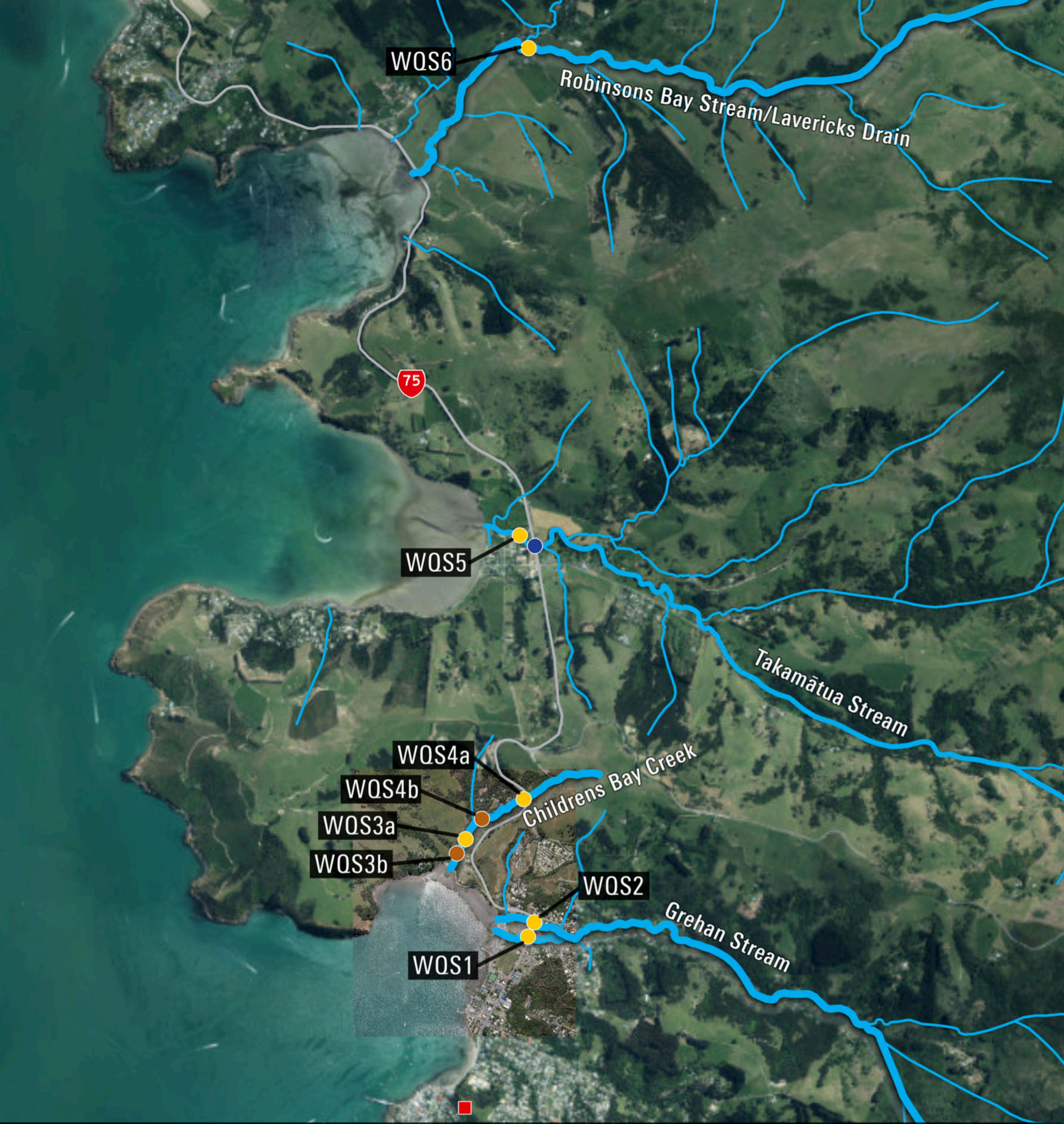
» eDNA is a method that measures the presence of fish, macroinvertebrates, and other organisms by detecting traces of genetic material that they leave in the environment. Replicate water samples are filtered on site and returned to the eDNA laboratory for processing.

Collection of eDNA samples was undertaken at nine sites during September 2021, primarily to provide a consistent overview of fish presence for all streams that may interact with ATWIS, but also to gain information on the presence of regionally endemic macroinvertebrates (Figure 2). Six replicate eDNA samples were collected at each site, using filters supplied by the testing laboratory and preserved prior to transport to Wilderlab NZ Ltd, Wellington, for analysis. For each sample, the laboratory completed a multi-species analysis by metabarcoding for fish, insects, birds, and mammals.

2.1.5 Water Quality

Water quality sampling was completed monthly over a period of one year, at six sites (Figure 3). Water temperature, pH, and specific conductivity (µS/cm) were measured *in situ* at each site using a Eutech PCSTestr 35 handheld meter which was calibrated according to manufacturer's instructions at the start of the sampling day. Dissolved oxygen (DO) was measured using a calibrated YSI ProODO handheld meter. Water samples were collected from the centre of the wetted channel, using sample containers supplied by the testing laboratory and were stored on ice in chilly bins for transport to Hill Laboratories, Christchurch, for testing. The parameters tested for by the laboratory were pH, total hardness, electrical conductivity (EC), total suspended solids (TSS), total and dissolved cadmium (Cd), total and dissolved chromium (Cr), total and dissolved copper (Cu), total and dissolved lead (Pb), total and dissolved zinc (Zn), total nitrogen (TN), total ammoniacal nitrogen (NH_4-N), nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), total kjeldahl nitrogen (TKN), dissolved reactive phosphorus (DRP), total phosphorus (TP), total biochemical oxygen demand (BOD), and *Escherichia coli*.

Figure 3 *…figure over page…* Map showing site locations of water quality sampling sites on Robinsons Bay Stream/Lavericks Drain, Takamātua Stream, Childrens Bay Creek, and the two branches of Grehan Stream. The primary sites are those that were selected as the initial sampling locations, while secondary backup sites were identified for Childrens Bay Creek in case of stream drying. Also shown are the locations of an Environment Canterbury long term water quality monitoring site at Takamātua, and the Akaroa Electronic Weather Station operated by NIWA.



Water Quality Sampling Sites

Waterways
Roads
Akaroa Electronic Weather Station (NIWA)

WATER QUALITY SAMPLING SITES
Primary
Secondary
Environment Canterbury

Layer source: Water quality sampling sites: ECan & determined by EOS Ecology. 2021, Weather Station: NIWA, Waterways: Modified by EOS Ecology from site visits, original layers by LINZ & CCC; Highways: LINZ.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2.2 Data Analysis

Raw macroinvertebrate data from the three survey sites and the existing data from previous survey work in the area was summarised by taxa richness, total abundance, and abundance of the five most common taxa. Invertebrate community metrics calculated were the number of Ephemeroptera-Plecoptera-Trichoptera taxa (EPT taxa richness), %EPT abundance, the Macroinvertebrate Community Index (MCI and QMCI), and the average score per metric (ASPM). The points below provide brief clarification of these metrics.

» Taxa richness is the number of different taxonomic groups identified in each sample. In this case, taxa refers to the lowest level of classification that was obtained during the study. Taxa richness is a useful community metric related to habitat diversity, with sites with more diverse habitats often having greater richness. However, there are numerous aquatic invertebrate taxa that prefer or tolerate degraded instream conditions such that taxa richness on its own should not be used to infer stream health.

» Total abundance refers to the number of macroinvertebrates collected from the sampled area; in this case it is the number of individuals collected in each composite kicknet sample.

» EPT refers to three Orders of invertebrates that are generally regarded as 'cleanwater' taxa. These Orders are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies): forming the acronym EPT. These taxa are relatively intolerant of organic enrichment or other pollutants and habitat degradation. The exceptions to this are the hydroptilid caddisflies (e.g., Trichoptera: Hydroptilidae: *Oxyethira, Paroxyethira*), which we have excluded from some EPT metrics because they are algal piercers and often found in high numbers in nutrient enriched waters with high algal content. In general, the disappearance and reappearance of EPT taxa can also provide evidence of whether a site is impacted or recovering from a disturbance. EPT taxa are generally more diverse in non-impacted stream systems, although there is a small set of EPT taxa that can persist in degraded waterways.

» Macroinvertebrate Community Index (MCI): In the mid-1980s the MCI was developed as an index of community integrity for use in stony riffles in New Zealand streams and rivers and can be used to determine the level of organic enrichment for these types of streams (Stark, 1985). Although developed to assess nutrient enrichment, the MCI will respond to any disturbance that alters macroinvertebrate community composition (Boothroyd & Stark, 2000), and as such is used widely to evaluate the general health of waterways in New Zealand. The MCI is calculated as an overall score for each sample, which is based on pollution-tolerance values for each invertebrate taxon found in that sample. The pollution tolerance values range from 1 (very pollution tolerant) to 10 (pollution-sensitive). MCI is calculated using presence/absence data only, but a quantitative version has been developed that incorporates abundance data and so gives a more accurate result by differentiating rare taxa from abundant taxa. This is known as the quantitative macroinvertebrate community index (QMCI). MCI and QMCI are attributes included in the NPS-FM (2020), with a "national bottom line" of 4.5 for QMCI and 90 for MCI. The NPS-FM (2020) uses the following bands and descriptions:

  – QMCI ≥6.5; MCI ≥130; A band; "Macroinvertebrate community, indicative of pristine conditions with almost no organic pollution or nutrient enrichment."

  – QMCI ≥5.5 and <6.5; MCI ≥110 and <130; B band; "Macroinvertebrate community indicative of mild organic pollution or nutrient enrichment. Largely composed of taxa sensitive to organic pollution/nutrient enrichment."

  – QMCI ≥4.5 and <5.5; MCI ≥90 and <110; C band; "Macroinvertebrate community indicative of moderate organic pollution or nutrient enrichment. There is a mix of taxa sensitive and insensitive to organic pollution/nutrient enrichment."

- QMCI <4.5; MCI <90; D band; "Macroinvertebrate community indicative of severe organic pollution or nutrient enrichment. Communities are largely composed of taxa insensitive to inorganic pollution/nutrient enrichment."

» Average Score Per Metric (ASPM): The ASPM is an aggregated metric developed by Collier (2008) that generates a score between 0 and 1 based on averaging normalised values of %EPT-abundance, EPT-richness, and MCI. This metric is an attribute included in the National Policy Statement for Freshwater Management (NPS-FM) (2020) with a score of 0.3 being the "national bottom line" and the following bands and descriptions:

- ≥0.6, A band, "Macroinvertebrate communities have high ecological integrity, similar to that expected in reference conditions."
- <0.6 and ≥0.4, B band, "Macroinvertebrate communities have mild-to-moderate loss of ecological integrity."
- <0.4 and ≥0.3, C band, "Macroinvertebrate communities have moderate-to-severe loss of ecological integrity."
- <0.3, D band, "Macroinvertebrate communities have severe loss of ecological integrity."

Fish data was summarised as presence/absence for each fish survey (including data from the three electrofished sites and the existing data from previous survey work in the area) or eDNA sampling location. The focus of these fish surveys was to determine the species present rather than densities, thus calculation of catch per unit effort (CPUE) was not necessary.

Water quality data collected over the 12 sampling occasions was summarised by minimum, maximum, and median values for each water quality parameter. Although water quality data was also collected from these catchments by McIndoe *et al.* (2022), there was little overlap in the sites, timing, and parameters measured, so that data has not been included as part of this analysis. Median values were compared to default guideline values (DGV) for toxicants according to the Australian & New Zealand guidelines for fresh & marine water quality (ANZG, 2018). The Cool Wet Low-elevation climate class from the River Environment Classification (REC) was used to determine the relevant DGVs for these streams, since it was the dominant REC climate class within Robinsons Bay Stream, Takamātua Stream, and Grehan Stream[2]. Where appropriate, the DGV was adjusted for site-specific hardness using the algorithms presented in Warne *et al.* (2018). In accordance with the recommendations of Warne *et al.* (2018), copper was not modified for water hardness, but cadmium, chromium, nickel, zinc, and lead were. The receiving water standards in the Canterbury Land and Water Regional Plan have also been used for comparison where no other relevant guidelines exist for parameters.

[2] River Environment Classification (REC) for the relevant streams was determined using the NZ River Maps website https://shiny.niwa.co.nz/nzrivermaps/

3 STATE OF THE EXISTING ENVIRONMENT

3.1 Habitat

3.1.1 Robinsons Bay Stream

Robinsons Bay Stream (also known as Lavericks Drain), drains a rural catchment and enters Robinsons Bay at the northeastern end of Akaroa Harbour. The Robinsons Bay Stream catchment extends from an elevation of 747 m asl and covers an area of approximately 1,383 ha, with land cover dominated by high producing exotic grassland (Canterbury Maps, 2022). The stream has permanent flow, at least in its mid to lower reaches, and is runoff-fed by many small tributaries, many of which may be intermittent or ephemeral. The major tributary of Robinsons Bay Stream is Okains Peak Drain, which drains the northern most slopes of the Robinsons Bay Stream catchment. Recent flow gauging of Robinsons Bay Stream (September 2021 to February 2022) has indicated that the stream discharges an average of 156 L/s at a gauging site just upstream of the Okains Peak Drain confluence at Sawmill Road (McIndoe *et al.*, 2022).

Habitat characteristics were measured at two sites on Robinsons Bay Stream, during macroinvertebrate and fish survey work in February 2013 (EOS Ecology, 2013). At that time the mean wetted width of the stream was between 2.5 and 3 m, with riffle, run and pool flow types present at both survey sites (Table 1; Figure 4). Substrate was typically dominated by boulder sized material, with large cobbles also present. While periphyton was abundant, macrophytes were limited to the margins of the stream.

3.1.2 Takamātua Stream

Takamātua Stream drains a predominantly rural catchment with an area of approximately 1,275 ha (Canterbury Maps, 2022). There is a small residential settlement by the coast, where the stream flows into Takamātua Bay, at the northeastern end of Akaroa Harbour. The mainstem of Takamātua Stream drains the southernmost valley of the catchment, while several tributary branches drain the valleys in the northern part of the catchment. Recent flow gauging of Takamātua Stream (September 2021 to February 2022) has indicated that the stream discharges an average of 262 L/s at SH75 (McIndoe *et al.*, 2022).

Habitat characteristics were measured for Takamātua Stream at SH75, during macroinvertebrate and fish survey work in February 2020 (Instream, 2020). At that time the mean wetted width of the stream was 1.2 m, with riffle, run and pool flow types present at the survey site (Table 1; Figure 4). The substrate was dominated by large and small cobble sized material, with boulders, pebbles, gravel, and sand/silt also present. Periphyton was abundant at this site, although there were no filamentous algae or macrophytes recorded.

3.1.3 Childrens Bay Creek

Childrens Bay Creek drains into the northern part of Childrens Bay, with two small intermittent/ephemeral branches joining to form the lower mainstem of the waterway. The lower stream flows through CCC reserve land, while the upper part of the catchment includes large areas of high producing exotic grassland, native and exotic vegetation, and residential properties.

Habitat characteristics were measured at a site on lower Childrens Bay Creek, during macroinvertebrate and fish survey work in December 2021. The mean wetted width of the stream was 0.9 m, with riffle, run and pool flow types present at the survey site (Table 1, Figure 4). The substrate was dominated by sand/silt sized material, with smaller proportions of gravel, pebbles, small and large cobbles also present. There were no visible algae or macrophytes at this site during the survey.

3.1.4 Grehan Stream

The Grehan Stream catchment covers an area of approximately 504 ha, with land cover dominated by high producing exotic grassland (Canterbury Maps, 2022), although there are also substantial areas of native vegetation in the upper catchment. In its lower reaches the stream flows through the Akaroa township and divides into two branches before discharging to the eastern side of Childrens Bay. Recent flow gauging of Grehan Stream (September 2021 to February 2022) has indicated that the true left branch discharges an average of 37 L/s near the coast (McIndoe *et al*., 2022).

Habitat characteristics were measured at two sites on Grehan Stream, including the true left and true right branches of the stream within Akaroa township, during macroinvertebrate and fish survey work in December 2021. The mean wetted width of the stream was 1.7 m for the true left branch and 1.8 m for the true right branch. Both branches had riffle and run flow-types present, but no pool habitat observed (Table 1, Figure 4). The substrate of both branches was dominated by large and small cobbles, with smaller proportions of pebbles, cobbles, boulders, gravel, and sand/silt sized material also present. Both branches had abundant periphyton, including filamentous algae. Macrophytes were also present (Table 1).

Mid reaches of Robinsons Bay Stream (FW1), at the downstream end of the survey section, looking upstream (February 2013).

Upper reaches of Robinsons Bay Stream (FW2), at the upstream end of the survey reach, looking downstream (February 2013).

Takamātua Stream (FW3), around 150 m upstream of SH75, looking upstream (image by Instream Consulting Limited).

Lower Childrens Bay Creek (FW4).

True left branch of Grehan Stream (FW5).

True right branch of Grehan Stream (FW6).

Figure 4 Site photos of the six ecological survey sites across Robinsons Bay, Takamātua, Childrens Bay and Grehan catchments. These sites were surveyed for habitat, macroinvertebrates, and fish. Photos taken by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during survey in February 2020 (Takamātua Stream).

Table 1 Measured habitat parameters for the six ecological survey sites across Robinsons Bay, Takamātua, Childrens Bay, and Grehan catchments.

Parameter	Robinsons Bay Stream		Takamātua Stream	Childrens Bay Creek	Grehan Stream	
	Site FW1: Mid Catchment	Site FW2: Upper Catchment	Site FW3: at SH75	Site FW4: Lower Stream	Site FW5: True Left	Site FW6: True Right
Sampling date	February 2013	February 2013	February 2020	December 2021	December 2021	December 2021
Mean wetted width (m)	3	2.5	1.2	0.9	1.7	1.8
Mean water depth (m)	0.2	0.25	Not recorded	0.16	0.03	0.21
Mean sediment depth (m)	Not recorded	Not recorded	0	0.04	0	0.01
Mean fine sediment cover (%)	Not recorded	Not recorded	25	54	5	1
Mesohabitat lengths (riffle:run:pool %)	20:20:60	40:30:30	15:30:25	40:35:25	30:70:0	50:50:0
Site algal cover (%)	Periphyton abundant	Periphyton abundant	Periphyton abundant	No visible algae	Periphyton abundant, filamentous algae present	Periphyton abundant, filamentous algae present
Site macrophyte cover (%)	Only at margins	Only at margins	0	0	35	25
Macrophyte species	Not recorded	Not recorded	None	None	*Mimulus guttatus* (monkey musk); *Ranunculus trichophyllus*; *Rorippa* (watercress)	*Mimulus guttatus* (monkey musk); *Rorippa* (watercress)
Overall site substrate composition (%)	Boulder: 60 Large cobble: 40 Small cobble: 0 Pebble: 0 Gravel: 0 Sand/Silt: 0	Boulder: 65 Large cobble: 30 Small cobble: 0 Pebble: 0 Gravel: 0 Sand/Silt: 5	Boulder: 10 Large cobble: 25 Small cobble: 25 Pebble:20 Gravel: 5 Sand/Silt: 15	Boulder: 1 Large cobble: 5 Small cobble: 20 Pebble: 10 Gravel: 10 Sand/Silt: 54	Boulder: 5 Large cobble: 20 Small cobble: 35 Pebble: 20 Gravel: 10 Sand/Silt: 5 Manmade: 5	Boulder: 10 Large cobble: 50 Small cobble: 29 Pebble: 20 Gravel: 5 Sand/Silt: 1 Manmade: 5

3.2 Macroinvertebrates

A total of 65 invertebrate taxa were recorded in representative kicknet samples taken from freshwater ecology survey sites on Robinsons Bay Stream, Takamātua Stream, Childrens Bay Creek, and Grehan Stream (Figure 2). The most diverse groups were two-winged flies (Diptera) and caddisflies (Trichoptera) with 22 taxa each, followed by mayflies (Ephemeroptera: 6 taxa), molluscs (Mollusca: 3 taxa), crustaceans (Crustacea: 3 taxa), and beetles (Coleoptera: 2 taxa). Groups represented by one taxon included stoneflies (Plecoptera), worms (Oligochaeta), flatworms (Platyhelminthes), mites (Acari), nematodes (Nematoda), dobsonflies (Megaloptera), scorpionflies (Mecoptera), and springtails (Collembola).

Taxa richness and EPT taxa richness were both highest for sites in Robinsons Bay Stream, followed by Takamātua Stream, and Grehan Stream. Taxa richness and EPT taxa richness were lowest for the survey site on Childrens Bay Creek (Table 2). The freshwater snail *Potamopyrgus antipodarum* was among the five most abundant taxa for all survey sites, and the most abundant for three of the six survey sites, representing 58.8% and 68.9% of total abundance for the true left and true right branches of Grehan Stream respectively, and 25.3% of total abundance for the upstream site on Robinsons Bay Stream (Figure 5). The most abundant taxa for the mid catchment site on Robinsons Bay Stream was the cased caddisfly *Pycnocentrodes*, representing 40.6% of total abundance at that site. *Oxyethira,* a more pollution-tolerant cased caddisfly was dominant in the sample from Takamātua Stream, whereas a midge larvae (Tanypodinae) had the highest abundance for Childrens Bay Creek. The top five most abundant taxa for each site accounted for between 68 and 92% of total abundance (Figure 5).

Each of the three Orders of the cleanwater EPT taxa (Ephemeroptera, Plecoptera, Trichoptera) were represented at survey sites on Robinsons Bay Stream, but only Ephemeroptera and Trichoptera were recorded in Takamātua and Grehan streams. No EPT taxa were recorded for Childrens Bay Creek (Table 2). The highest percentage abundance of EPT taxa was recorded for Robinsons Bay Stream, followed by Takamātua Stream, and Grehan Stream. However, for Takamātua Stream, the dominance of the pollution-tolerant hydroptilid caddisfly *Oxyethira,* is largely responsible for the relatively high proportion of EPT at that site. While Mollusca had the highest relative abundance over all sites, this was largely as result of their dominance at Grehan Stream, with Trichoptera being the dominant group for Robinsons Bay Stream and Takamātua Stream, while Diptera dominated the macroinvertebrate community for Childrens Bay Creek (Figure 6).

These surveys indicate that except for Robinsons Bay Stream, the macroinvertebrate community in these streams was dominated by taxa that prefer or tolerate degraded habitat and/or water quality conditions (e.g., snails, ostracods, amphipods, worms). This is reflected in the MCI, QMCI, and ASPM values calculated for each site, with values that fall within NPS-FM 2020 attribute bands B and C for Robinsons Bay Stream, attribute band C or D for Grehan Stream, and attribute band D for Takamātua Stream and Childrens Bay Creek (Figure 7; Figure 8). Attribute band D falls below the national bottom line in the NPS-FM 2020 and represents macroinvertebrate communities that have a severe loss of ecological integrity.

Environmental DNA (eDNA) results for nine sites recorded the most invertebrate species present for sites at Grehan Stream (average of 32 to 37 species), followed by Robinsons Bay Stream (25 to 27 species), Takamātua Stream (24 species), and Childrens Bay Creek (4 to 17 species) (Table 3).

Several macroinvertebrate taxa that are regionally endemic to Banks Peninsula were found in the surveyed catchments. Robinsons Bay Stream supported four regionally endemic species, with *Neocurupira chiltoni*, *Costachorema peninsulae*, *Nesameletus vulcanus*, and *Zelandobius wardi* found at the most upstream site in this stream (Table 2; Table 3). Only *Neocurupira chiltoni* was found at the mid catchment site on Robinsons Bay Stream, while *Zelandobius wardi* was found in Takamātua Stream and the true left branch of Grehan Stream.

Of the macroinvertebrate taxa present at these sites and listed in the New Zealand Threat Classification System (NZTCS), most were listed as 'not threatened' (Table 2; Table 3). However, Robinsons Bay Stream (most upstream site) supported two 'threatened – nationally endangered' species (the mayfly *Nesameletus vulcanus* and the stonefly *Zelandobius wardi*), as well as one 'threatened – nationally vulnerable' species (the caddisfly *Costachorema peninsulae),* and one 'at risk – naturally uncommon' species (the regionally endemic net-wing midge *Neocurupira chiltoni*). Takamātua Stream and the true left branch of Grehan Stream also supported the 'threatened – nationally endangered' stonefly (*Zelandobius wardi;* Table 3).

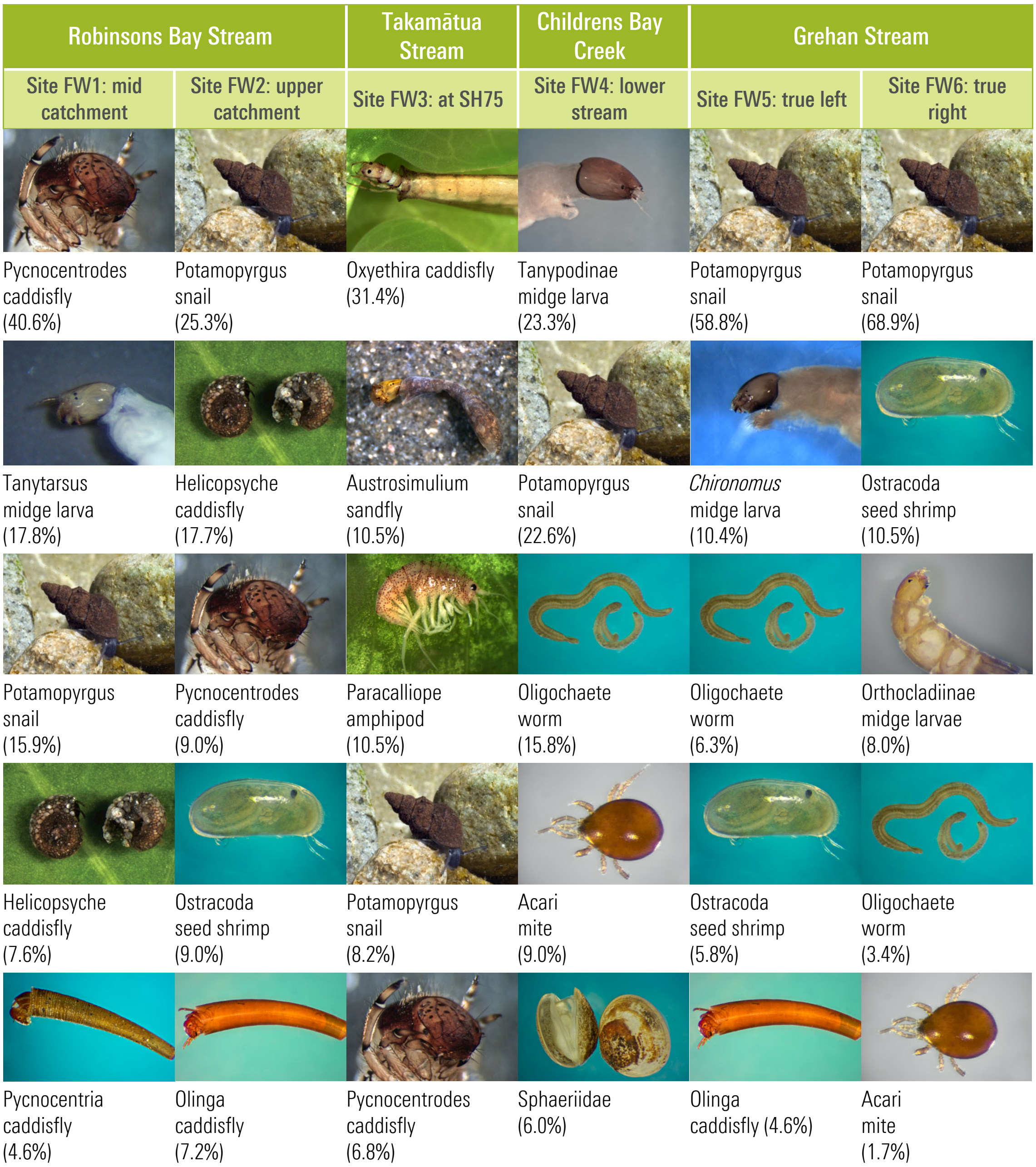


Figure 5 Images of the most abundant aquatic macroinvertebrates overall for each stream. Percentage abundance for each survey location is provided in brackets. Data based on a composite invertebrate kicknet sample collected by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream). All photos are by EOS Ecology.

Table 2 **Macroinvertebrate community metrics for the six ecological survey sites, based on a composite invertebrate kicknet sample collected by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream). The hard bottom (HB) MCI/QMCI was the relevant metric considering the substrate type for these streams. The NPS-FM 2020 attribute bands are shown in parentheses.**

Metric		Robinsons Bay Stream		Takamātua Stream	Childrens Bay Creek	Grehan Stream	
		Site FW1: Mid Catchment	Site FW2: Upper Catchment	Site FW3: at SH75	Site FW4: Lower Stream	Site FW5: True Left	Site FW6: True Right
Taxa Richness		33	34	25	16	22	21
EPT Taxa Richness		16	17	10	0	6	7
EPT Taxa Richness (excl. Hydroptilidae)		15	17	8	0	5	6
%EPT		62.54	55.20	47.27	0.00	8.08	1.10
%EPT (excl. Hydroptilidae)		62.52	55.20	14.55	0.00	6.00	1.05
MCI-HB		102.4 (Band C)	119.4 (Band B)	86.0 (Band D)	68.8 (Band D)	86.4 (Band D)	97.1 (Band C)
QMCI-HB		5.06 (Band C)	6.11 (Band B)	3.38 (Band D)	3.71 (Band D)	3.64 (Band D)	3.70 (Band D)
ASPM		0.55 (Band B)	0.58 (Band B)	0.28 (Band D)	0.11 (Band D)	0.22 (Band D)	0.23 (Band D)
Regionally endemic species present		*Neocurupira chiltoni*	*Neocurupira chiltoni, Costachorema peninsulae, Nesameletus vulcanus*	None	None	None	None
Conservation status of freshwater invertebrates (for those that are classified)	Threatened – Nationally Endangered	-	1 species: *Nesameletus vulcanus*	-	-	-	-
	Threatened – Nationally Vulnerable	-	1 species: *Costachorema peninsulae*	-	-	-	-
	At risk – Naturally Uncommon	1 species: *Neocurupira chiltoni*	1 species: *Neocurupira chiltoni*	-	-		
	Not Threatened	14 species	11 species	7 species	1 species	5 species	6 species

Table 3 Summary of the number of macroinvertebrate species present at eDNA survey sites, from six replicate eDNA samples collected at each site by EOS Ecology in September 2021. A summary of conservation status (according to Grainger *et al*., 2018) is provided where available. Means have been calculated using the six replicate samples collected from each site, using the species level identification provided by the eDNA laboratory (Wilderlab NZ Ltd).

Metric		Robinsons Bay Stream			Takamātua Stream	Childrens Bay Creek			Grehan Stream	
		Site eDNA1: Lower	Site eDNA2: Middle	Site eDNA3: Upper	Site eDNA4: Lower	Site FW4: Lower Stream	Site eDNA6: Middle	Site eDNA7: Upper	Site eDNA8: True Left	Site eDNA9: True Right
Mean number of species present		25	27	26	24	17	14	4	37	32
Mean number of EPT species present		5	6	9	5	2	2	0	9	8
Regionally endemic species present				*Zelandobius wardi*	*Zelandobius wardi*				*Zelandobius wardi*	
Conservation status of freshwater invertebrates (for those that are classified)	Threatened – Nationally Endangered			1 species: *Zelandobius wardi*	1 species: *Zelandobius wardi*				1 species: *Zelandobius wardi*	
	Data Deficient (insufficient data to assess status)	1 species: *Austropeplea tomentosa*								
	Not Threatened	11 species	12 species	15 species	13 species	6 species	4 species		16 species	14 species

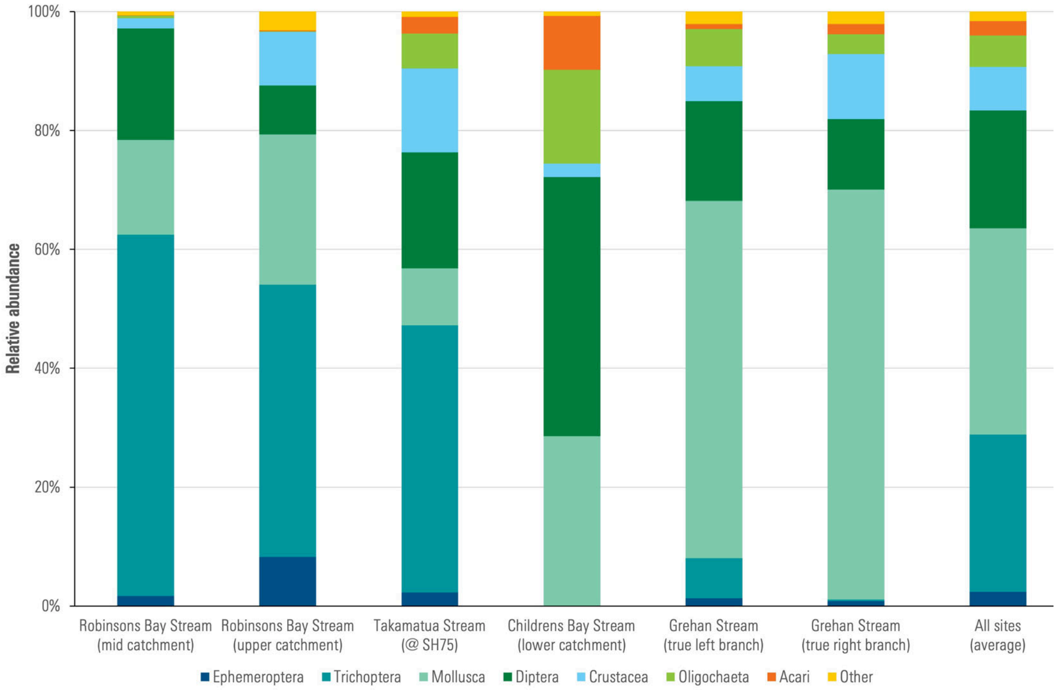


Figure 6 Graph of the relative abundance of different macroinvertebrate groups in samples collected from each of the six ecological survey sites. Data based on a composite invertebrate kicknet sample collected by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream).

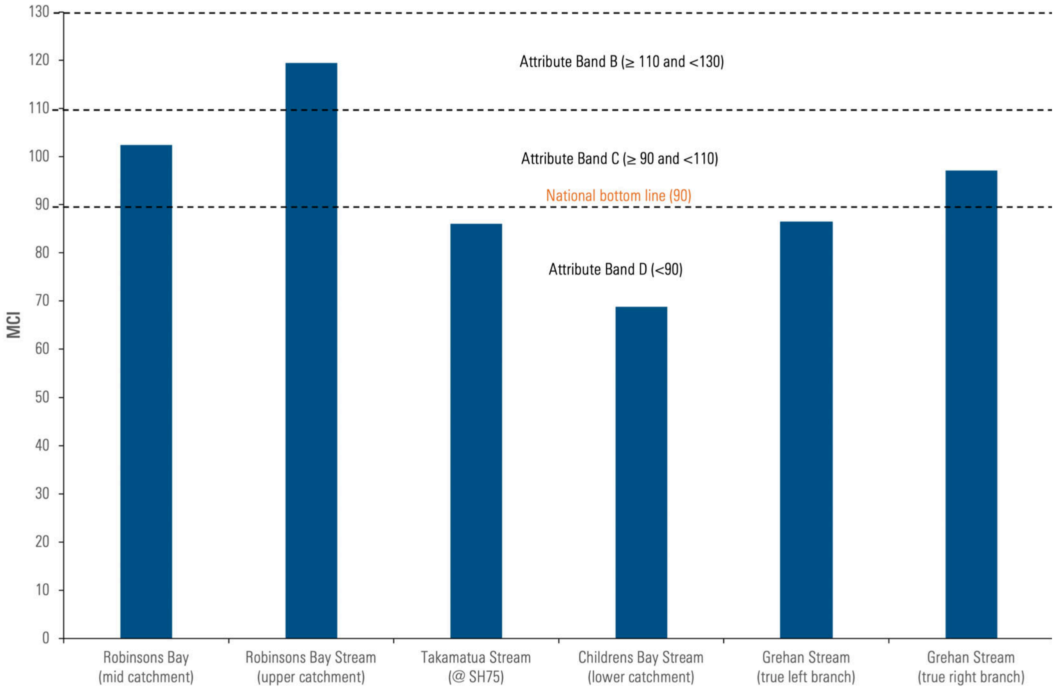


Figure 7 Graph of the Macroinvertebrate Community Index (MCI) values calculated for each of the six ecological survey sites. Data based on a composite invertebrate kicknet sample collected by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream). NPS-FM (2020) attribute bands and the national bottom line are also indicated on the graph.

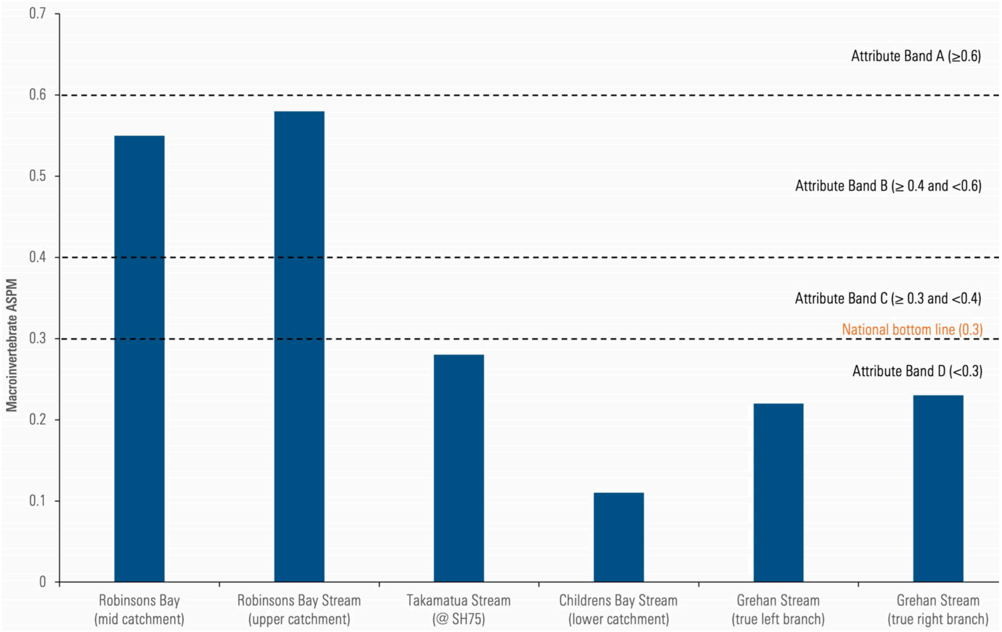


Figure 8 Graph of the Macroinvertebrate Average Score Per Metric (ASPM) values calculated for each of the six ecological survey sites. Data based on a composite invertebrate kicknet sample collected by EOS Ecology during surveys in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream). NPS-FM (2020) attribute bands and the national bottom line for this metric are also indicated on the graph.

3.3 Fish

A total of 12 species of fish have been recorded from surveyed streams within the Akaroa Inner Bays catchment, including ecological surveys and eDNA sampling as part of this investigation, as well as previous records included in the New Zealand Freshwater Fish Database (NZFFD) (Table 4; Figure 9). All these species are native or endemic, five have an 'at risk – declining' conservation status (longfin eel, kōaro, īnanga, bluegill bully, and torrentfish), one has an 'at risk – naturally uncommon' conservation status (giant bully), and one has a 'threatened – nationally vulnerable' conservation status (lamprey), according to the threat classification of Dunn *et al.* (2018).

The number of fish species recorded for each site ranged from zero (at the middle site on Childrens Bay Creek), to eleven species for the Takamātua Stream site (Table 4). The lower catchment sites on Robinsons Bay Stream and Childrens Bay Creek had greater fish diversity compared to sites further upstream on these waterways, which is a typical pattern for fish diversity in New Zealand waterways, where many native species are migratory. While fish passage was not considered as part of the current surveys, there are two culverts on Childrens Bay Creek that are expected to act as major barriers to fish passage (Figure 10), and the detection of shortfin eel DNA at the upper site on this stream was unexpected.

Most fish species were detected by both traditional survey methods and eDNA sampling, although lamprey was only detected by eDNA sampling (Table 4). Even so, many species were detected at a wider range of locations because of the use of eDNA sampling techniques (Table 4). Shortfin eel, longfin eel, and redfin bully were the most frequently encountered fish species, being found in each of the four catchments. Lamprey and torrentfish were the least common, recorded only from the site on Takamātua Stream. Past fish records from the NZFFD are sparse in this area but record the presence of kōaro and īnanga in lower Robinsons Bay Stream (Table 4).

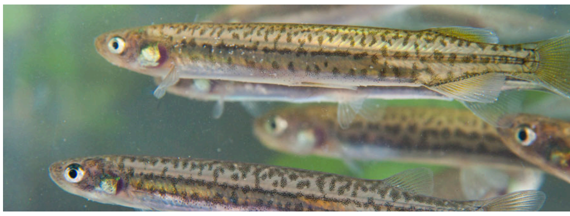
Īnanga have been recorded for Robinsons Bay Stream, Takamātua Stream, and Grehan Stream. The lower reaches of these streams may also provide important īnanga spawning habitat. Takamātua Stream is a known īnanga spawning stream, specifically with the reach between SH75 and the coast (Orchard, 2018). Grehan Stream has been the location of an īnanga spawning habitat restoration project during 2018, and the lower reaches of Robinsons Bay Stream are listed as īnanga spawning habitat in the Canterbury Land and Water Regional Plan.

Shortfin eel / *Anguilla australis*
(Not threatened)

Longfin eel / *Anguilla dieffenbachia*
(At risk - declining)

Kōaro / *Galaxias brevipinnis*
(At risk - declining)

Banded kōkopu / *Galaxias fasciatus*
(Not threatened)



Īnanga / *Galaxias maculatus*
(At risk -declining)

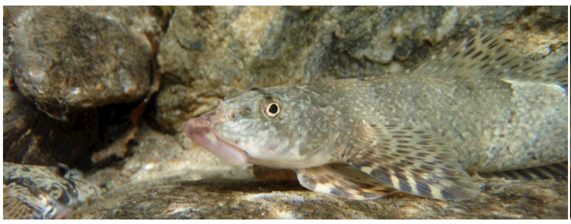
Giant bully / *Gobiomorphus gobioides*
(At risk - naturally uncommon)

Common bully / *Gobiomorphus cotidianus*
(Not threatened)

Redfin bully / *Gobiomorphus huttoni*
(Not threatened)

Bluegill bully / *Gobiomorphus hubbsi*
(At risk – declining)

Lamprey / piharau / *Geotria australis*
(Threatened – nationally vulnerable)



Torrentfish / panoko / *Cheimarrichthys fosteri*
(At risk – declining)

Black flounder / pātiki mohoao / *Rhombosolea retiarii*
(Not threatened)

Figure 9 Images of the 12 fish species recorded during EOS Ecology ecological surveys and eDNA sampling in the Akaroa Inner Bays catchments between August and December 2021. The conservation status from Dunn *et al.* (2018) is shown in parenthesis.

Table 4 Freshwater fish species present at survey sites for both eDNA samples collected in September 2021 (indicated by a green tick ✓) and electrofishing surveys undertaken by EOS Ecology in February 2013 (Robinsons Bay) and December 2021 (Childrens Bay & Grehan Stream), and by Instream Consulting Limited during February 2020 (Takamātua Stream) (orange tick ✓). Additional records for these locations in the New Zealand Freshwater Fish Database (NZFFD) are denoted by a blue tick (✓). The conservation status (according to Dunn *et al*., 2018) is also given in parenthesis in the first column. Note that the Robinsons Bay eDNA middle site approximately corresponds with the lower ecological survey site reported by Instream, 2020.

Species	Robinsons Bay Stream			Takamātua Stream	Childrens Bay Creek			Grehan Stream	
	Site eDNA1: Lower	Site eDNA2: Middle	Site eDNA3: Upper	Site eDNA4: Lower	Site eDNA5: Lower	Site eDNA6: Middle	Site eDNA6: Upper	Site eDNA8: True left	Site eDNA9: True right
Shortfin eel *Anguilla australis* (Not threatened)	✓ (green)	✓ (orange)	✓ (green) ✓ (orange)	✓ (green)	✓ (green) ✓ (orange)		✓ (green)	✓ (green) ✓ (orange)	✓ (green) ✓ (orange)
Longfin eel *Anguilla dieffenbachia* (At risk – declining)	✓ (green)	✓ (green) ✓ (orange)	✓ (green) ✓ (orange)	✓ (green) ✓ (orange)	✓ (green)			✓ (green) ✓ (orange)	✓ (green) ✓ (orange)
Kōaro *Galaxias brevipinnis* (At risk – declining)	✓ (blue)		✓ (green)	✓ (green)				✓ (green)	✓ (green)
Banded kōkopu *Galaxias fasciatus* (Not threatened)					✓ (green) ✓ (orange)			✓ (green)	✓ (green)
Īnanga *Galaxias maculatus* (At risk – declining)	✓ (green) ✓ (blue)	✓ (orange)		✓ (green)				✓ (green) ✓ (orange)	✓ (green) ✓ (orange)
Giant bully *Gobiomorphus gobioides* (At risk – naturally uncommon)	✓ (green)			✓ (green)				✓ (green) ✓ (orange)	✓ (green) ✓ (orange)
Common bully *Gobiomorphus cotidianus* (Not threatened)	✓ (green)			✓ (green)				✓ (green)	✓ (green) ✓ (orange)
Redfin bully *Gobiomorphus huttoni* (Not threatened)	✓ (green)	✓ (green)	✓ (green)	✓ (green) ✓ (orange)	✓ (green) ✓ (orange)			✓ (green)	✓ (green)
Bluegill bully *Gobiomorphus hubbsi* (At risk – declining)	✓ (green)	✓ (green) ✓ (orange)	✓ (green)	✓ (green) ✓ (orange)				✓ (green)	✓ (green) ✓ (orange)
Lamprey *Geotria australis* (Threatened – nationally vulnerable)				✓ (green)					
Torrentfish *Cheimarrichthys fosteri* (At risk – declining)				✓ (orange)					
Black flounder *Rhombosolea retiaria* (Not threatened)				✓ (green)					✓ (orange)
TOTAL	8	5	5	11	4	0	1	9	10

Looking downstream at a degraded metal ramp from the road culvert under SH75. The vertical drop is at least 2m.

Looking upstream at the culvert outlet pipe in the road to the Akaroa Cottages. There is a vertical drop of 0.65 m from the pipe outlet, and a second smaller vertical drop downstream of the concrete sill where the stream channel has eroded away (just out of the image).

Figure 10 Photographs of significant fish passage barriers within Childrens Bay Creek. Despite this, longfin eels were recorded in eDNA samples collected upstream of these impediments.

3.4 Water Quality

Twelve rounds of water quality sampling were undertaken at six sites to collect background water quality information for Robinsons Bay Stream, Takamātua Stream, Childrens Bay Creek, and Grehan Stream. Sampling was undertaken approximately monthly between August 2021 and July 2022, and included sampling during wet weather, dry weather, and within a short time of rainfall (Figure 11). There has been some substantial rainfall over this period, and the inclusion of wet weather sampling was intended to highlight the range of water quality conditions experienced by these streams, rather than to focus on dry weather conditions only. Median values have been calculated across all sampling rounds (n=12) and compared to ANZG (2018) default guideline values (DGV's) where these are available (Table 5; Table 6).

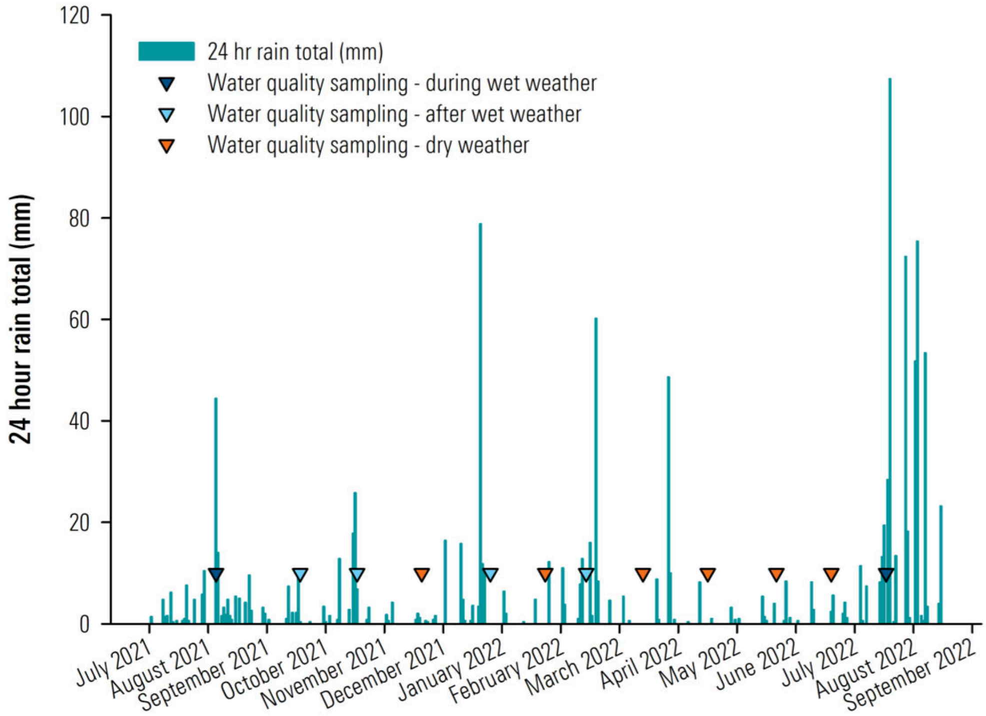


Figure 11 Graph of daily rainfall for Akaroa Electronic Weather Station (EWS; NIWA) between March 2021 and July 2022. The timing of the 12 monthly water quality sampling rounds is also shown. Wet weather sampling is defined as greater than 10 mm of rainfall within 24 hours on the day of sampling, after wet weather is greater than 10 mm of rainfall within 3 days of sampling, and dry weather sampling is less than 10 mm of rainfall within 7 days of sampling. Location of the EWS is provided in Figure 3.

3.4.1 Conductivity, pH, Total Suspended Solids, and Dissolved Oxygen

Over the 12 water quality sampling rounds, the median values of electrical conductivity (EC) exceeded the DGV for all six stream sites (Table 5). With measured values of EC ranging from 10.5 to 177.5 mS/m over all sites, the sampling has shown that this parameter regularly exceeds the relevant DGV (Table 5; Figure 12). While EC shows low variation over time for the Robinsons Bay Stream, Takamātua Stream, and Grehan Stream sampling locations, the two Childrens Bay Creek sampling sites show high variability over time (Figure 12).

All streams surveyed have median pH values between 7.8 and 8.25, with the median pH values for Robinsons Bay Stream and Childrens Bay Creek falling outside of the 20th and 80th percentile DGVs (Table 5). However, the range of pH values measured at each site all fall within the Canterbury LWRP Schedule 5 receiving water standards which state that pH shall be between 6.5 and 8.5.

Median total suspended solids (TSS) concentrations were below the laboratory detection limit of 3 g/m^3 for all sites except Childrens Bay Creek (downstream) (Table 5). However, with the DGV also being less than the laboratory detection limit, it is not possible to determine how many of the sites exceeded the DGV, except for Childrens Bay (downstream) site. The nature of the Childrens Bay (downstream) sampling site, with little flowing water and fine sediment substrate may have contributed to the higher TSS concentrations for this site. Total suspended solids concentrations were highly elevated at all sites during the first round of sampling, which was undertaken during wet weather (Figure 11), whereas samples collected after rainfall or during sustained dry weather generally reported low TSS concentrations at all sites.

Field measurements of dissolved oxygen saturation (DO) were recorded during water quality sample collection for each site. These results show that the median DO values for all sites fall within the suitable range of 80% to 105% (20th and 80th percentile DGVs) (Table 5).

3.4.2 Nutrients

Nitrate-nitrogen (Nitrate-N) concentrations were typically elevated for sampling rounds that occurred during and after wet weather, with lower concentrations recorded at all sites during extended dry weather periods (Table 5; Figure 11; Figure 13). The variety of weather conditions encountered during sampling has contributed to the highly variable Nitrate-N concentrations seen over the 12 sampling rounds completed for this study (Figure 13). Total nitrogen (TN) and dissolved inorganic nitrogen (DIN) concentrations follow a similar pattern, with higher concentrations being measured during and after wet weather, especially the initial wet weather sampling round, which has resulted in the wide ranges of concentration presented for these measurements in Table 5.

Over the 12 sampling rounds, the Takamātua Stream was the only sampling location where the median Nitrate-N value exceeded the DGV, with median Nitrate-N concentrations well below the DGV for all other sampling sites (Table 5). Median TN concentrations exceeded the DGV for both Takamātua and Childrens Bay (downstream) sampling sites, while median DIN exceeded the LWRP schedule 5 receiving water standards (Banks Peninsula) for Takamātua Stream, Childrens Bay (downstream), and both branches of Grehan Stream.

Total ammoniacal-nitrogen (total ammoniacal-N) concentrations were frequently recorded as below laboratory detection limits for most sites, with Childrens Bay Creek (downstream) being the only site where the median total ammoniacal-N concentration was above the detection limit (Table 5). Total ammoniacal-N concentrations were higher than usual for all sites during the initial wet weather sampling round.

Median dissolved reactive phosphorus (DRP) exceeded the LWRP schedule 5 receiving water standards for Banks Peninsula streams at all sites, while total phosphorus (TP) exceeded the DGV for all sites (Table 5). Concentrations of DRP were relatively consistent over time, although concentrations were elevated at all sites during the initial wet round of wet weather sampling (Figure 14).

3.4.3 Total Biochemical Oxygen Demand and *Escherichia coli*

Total biochemical oxygen demand (BOD) was recorded at below the laboratory detection limit of 2 gO_2/m^3 for all sites during all but the first sampling round (the wet weather round). Therefore, the median BOD for all sites is <2 gO_2/m^3 (Table 5). The highest BOD of 7 gO_2/m^3 was recorded for Takamātua Stream during the wet weather sampling round.

Median values of *E. coli* at all sampling sites are below the LWRP schedule 5 receiving water standard of 550 cfu/100 mL for Banks Peninsula streams, but all sites except Childrens Bay Creek (upstream) exceeded the Plan Change 7 (PC7) median value of ≤130 (Table 5). Extremely high *E. coli* values were recorded at all sites during the first sampling round (wet weather) in comparison to all subsequent sampling rounds (Figure 15). During this initial wet weather sampling round, values of up to 25,000 cfu/100mL were recorded, with this highest value being measured for Robinsons Bay Stream.

3.4.4 Heavy Metals

Total and dissolved copper concentrations were regularly measured as being below laboratory detection limits for all streams (Table 6). The median value for total copper only exceeded the DGV for Childrens Bay Creek (upstream and downstream sites), while median dissolved copper concentrations were below detection limits for all sites. As for other measured water quality parameters, the total and dissolved copper concentrations were highest during the initial round of wet weather sampling.

Median total lead concentrations were below hardness modified DGVs for all sites except Childrens Bay Creek (downstream), whereas median dissolved lead concentrations were below laboratory detection limits and hardness modified DGVs at all sites (Table 6). While all sites recorded total and dissolved lead concentrations below laboratory detection limits for many sampling rounds, the concentrations of dissolved lead were always below laboratory detection limits during the 12 sampling rounds at Robinsons Bay Stream and Takamātua Stream (Table 6).

Median total and dissolved zinc concentrations exceeded hardness modified DGVs for both sites on Childrens Bay Creek but were below the hardness modified DGVs for all other sites (Table 6). All sites recorded total and dissolved zinc concentrations below laboratory detection limits for at least one sampling round, while dissolved zinc was always below detection for Robinson Bay Stream.

Median values of total and dissolved cadmium were below hardness modified DGVs and laboratory detection limits for all sites (Table 6). Dissolved cadmium was below laboratory detection limits for all sampling rounds at all sites, while for total cadmium, the laboratory detection limit was only exceeded at three sites (Takamātua Stream and both sites on Childrens Bay Creek) during the first sampling round (wet weather) (Table 6).

Median values of total and dissolved chromium were below hardness modified DGVs and laboratory detection for all sites (Table 6). All sites recorded total and dissolved chromium concentrations below laboratory detection limits for most sampling rounds, with dissolved chromium being below laboratory detection limits for all sampling rounds at Robinsons Bay Stream, Takamātua Stream, and Grehan Stream (true right) (Table 6).

Table 5 **Median and range of values recorded for water quality parameters measured at the six water quality sites monthly between August 2021 and July 2022 (12 sampling rounds). ANZG (2018) default guideline values (DGVs) are shown where available, using the Cool-Wet-Low Elevation REC category, along with receiving water standards for Banks Peninsula from the Environment Canterbury Land and Water Regional Plan (LWRP Schedule 5 Table S5A), Plan Change 7 to the Canterbury Land and Water Regional Plan (PC7), and national bottom lines (NBL) from the National Policy Statement for Freshwater Management (NPS-FM, 2020). The bolded values are those that exceed the relevant guideline values.**

Parameter (Units)	Location	Guideline values	Median	Range
Electrical Conductivity (mS/m)	Robinsons Bay Stream (WQS6)	14.5 (80th DGV)	**19.9**	15.0–22.0
	Takamātua Stream (WQS5)		**17.5**	10.5–20.1
	Childrens Bay upstream (WQS4)		**75.8**	15.6–86.8
	Childrens Bay downstream (WQS3)		**102.8**	16.2–177.5
	Grehan true left (WQS1)		**17.1**	11.0–19.7
	Grehan true right (WQS2)		**17.0**	11.2–19.7
pH	Robinsons Bay Stream (WQS6)	7.8 (80th DGV) 7.23 (20th DGV) 6.5–8.5 (LWRP Schedule 5)	**7.90**	7.30–8.10
	Takamātua Stream (WQS5)		7.80	7.10–8.20
	Childrens Bay upstream (WQS4)		**8.25**	7.20–8.30
	Childrens Bay downstream (WQS3)		**7.90**	7.00–8.10
	Grehan true left (WQS1)		7.80	7.20–7.90
	Grehan true right (WQS2)		7.80	7.20–7.90
Total Suspended Solids (g/m^3)	Robinsons Bay Stream (WQS6)	1.8 (80th DGV)	<3	<3–710.0
	Takamātua Stream (WQS5)		<3	<3–710.0
	Childrens Bay upstream (WQS4)		<3	<3–210.0
	Childrens Bay downstream (WQS3)		**12.5**	<3–1080.0
	Grehan true left (WQS1)		<3	<3–230.0
	Grehan true right (WQS2)		<3	<3–220.0
Dissolved Oxygen (% saturation)	Robinsons Bay Stream (WQS6)	105 % (80th DGV) 80 % (20th DGV)	102.3	98.0–108.2
	Takamātua Stream (WQS5)		101.5	94.6–121.7
	Childrens Bay upstream (WQS4)		97.2	79.6–99.3
	Childrens Bay downstream (WQS3)		85.7	78.3–100.6
	Grehan true left (WQS1)		98.5	92.6–103.5
	Grehan true right (WQS2)		99.5	93.3–106.0
Dissolved Oxygen (g/m^3)	Robinsons Bay Stream (WQS6)	8.0 (PC7: 7-day mean minimum) 7.5 (PC7: 1-day minimum)	11.5	9.6–13.0
	Takamātua Stream (WQS5)		11.2	9.9–14.0
	Childrens Bay upstream (WQS4)		10.4	8.2–12.3
	Childrens Bay downstream (WQS3)		9.9	8.3–12.0
	Grehan true left (WQS1)		11.0	9.8–13.1
	Grehan true right (WQS2)		11.2	9.7–13.0
Nitrate-N (g/m^3)	Robinsons Bay Stream (WQS6)	0.170 (80th DGV) 2.4 (NBL for toxicity)	0.052	0.002–0.510
	Takamātua Stream (WQS5)		**0.305**	0.019–0.750
	Childrens Bay upstream (WQS4)		0.074	0.008–0.420
	Childrens Bay downstream (WQS3)		0.071	0.028–0.630
	Grehan true left (WQS1)		0.090	0.014–0.500
	Grehan true right (WQS2)		0.117	0.005–0.470
Total Nitrogen (g/m^3)	Robinsons Bay Stream (WQS6)	0.272 (80th DGV)	0.195	<0.110–4.300
	Takamātua Stream (WQS5)		**0.460**	0.150–4.200
	Childrens Bay upstream (WQS4)		0.230	0.150–2.600
	Childrens Bay downstream (WQS3)		**0.375**	0.220–3.200
	Grehan true left (WQS1)		0.205	<0.110–2.900
	Grehan true right (WQS2)		0.190	<0.110–2.900
Dissolved Inorganic Nitrogen (g/m^3)	Robinsons Bay Stream (WQS6)	0.09 (LWRP Schedule 5) 0.24 (A band from STAG 2019) 1.0 (NBL from STAG 2019)	0.058	0.008–0.554
	Takamātua Stream (WQS5)		**0.315**	0.024–0.799
	Childrens Bay upstream (WQS4)		0.081	0.014–0.490
	Childrens Bay downstream (WQS3)		**0.099**	0.043–0.674
	Grehan true left (WQS1)		**0.097**	0.020–0.512
	Grehan true right (WQS2)		**0.125**	0.011–0.481
Total Ammoniacal-N (g/m^3)	Robinsons Bay Stream (WQS6)	0.009 (80th DGV) 0.24 (NBL for toxicity)	<0.01	<0.01–0.044
	Takamātua Stream (WQS5)		<0.01	<0.01–0.039
	Childrens Bay upstream (WQS4)		<0.01	<0.01–0.060

Parameter (Units)	Location	Guideline values	Median	Range
	Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)		0.019 <0.01 <0.01	<0.01–0.044 <0.01–0.012 <0.01–0.015
Dissolved Reactive Phosphorus (g/m^3)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	0.025 (LWRP Schedule 5)	**0.039** **0.033** **0.036** **0.032** **0.032** **0.035**	0.025–0.045 0.020–0.072 0.028–0.220 0.008–0.105 0.019–0.066 0.019–0.063
Total Phosphorus (g/m^3)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	0.018 (80^{th} DGV)	**0.052** **0.050** **0.087** **0.077** **0.045** **0.051**	0.039–1.24 0.033–1.27 0.051–0.79 0.050–1.86 0.028–0.60 0.030–0.60
Total Biochemical Oxygen Demand ($g\ O_2/m^3$)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)		<2 <2 <2 <2 <2 <2	<2–6 <2–7 <2–5 <2–5 <2–4 <2–4
Escherichia coli (cfu / 100 mL)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	550 (LWRP Schedule 5) ≤130 (PC7: median value) 540 (NBL for primary contact sites)	**355** **355** 80 **265** **180** **180**	11–25,000 70–19,000 2–3,900 13–14,000 30–5,800 14–7,000

Table 6 **Median and range for total and dissolved metal concentrations tested at the six water quality sites monthly between August 2021 and July 2022 (12 sampling rounds). ANZG (2018) default guideline values (DGVs) are shown for the 99% level of protection, as required by the LWRP for Banks Peninsula streams and these have been modified for water hardness at each stream using the method of Warne *et al* (2018). *Note that copper DGVs have not been adjusted for water hardness, as per Warne *et al.* 2018. The grey shaded values are those that exceed the DGV.**

Parameter (Units)	Location	Hardness modified DGV (99% level of protection)	Median	Range
Total Copper (µg/L)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	1.0*	<0.53 <0.53 0.41 0.76 <0.53 <0.53	<0.53–10.20 <0.53–6.20 <0.53–8.40 <0.53–14.10 <0.53–5.20 <0.53–5.00
Dissolved Copper (µg/L)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	1.0*	<0.50 <0.50 <0.50 <0.50 <0.50 <0.50	<0.50–1.20 <0.50–1.10 <0.50–3.50 <0.50–2.00 <0.50–1.50 <0.50–1.50
Total Lead (µg/L)	Robinsons Bay Stream (WQS6) Takamātua Stream (WQS5) Childrens Bay upstream (WQS4) Childrens Bay downstream (WQS3) Grehan true left (WQS1) Grehan true right (WQS2)	0.68 0.84 0.14 0.14 0.83 0.83	<0.11 <0.11 <0.11 **0.19** <0.11 <0.11	<0.11–7.10 <0.11–4.50 <0.11–2.80 <0.11–12.70 <0.11–3.40 <0.11–3.30

Parameter (Units)	Location	Hardness modified DGV (99% level of protection)	Median	Range
Dissolved Lead (µg/L)	Robinsons Bay Stream (WQS6)	0.68	<0.10	all below detection
	Takamātua Stream (WQS5)	0.84	<0.10	all below detection
	Childrens Bay upstream (WQS4)	0.14	<0.10	<0.10–0.18
	Childrens Bay downstream (WQS3)	0.14	<0.10	<0.10–0.16
	Grehan true left (WQS1)	0.83	<0.10	<0.10–0.14
	Grehan true right (WQS2)	0.83	<0.10	<0.10–0.13
Total Zinc (µg/L)	Robinsons Bay Stream (WQS6)	1.85	<1.10	<1.10–45.0
	Takamātua Stream (WQS5)	2.13	1.15	<1.10–31.0
	Childrens Bay upstream (WQS4)	0.65	**1.35**	<1.10–40.0
	Childrens Bay downstream (WQS3)	0.65	**2.45**	<1.10–71.0
	Grehan true left (WQS1)	2.12	2.05	<1.10–29.0
	Grehan true right (WQS2)	2.12	1.15	<1.10–27.0
Dissolved Zinc (µg/L)	Robinsons Bay Stream (WQS6)	1.85	<1.00	all below detection
	Takamātua Stream (WQS5)	2.13	<1.00	<1.00–4.60
	Childrens Bay upstream (WQS4)	0.65	**1.25**	<1.00–8.10
	Childrens Bay downstream (WQS3)	0.65	**1.10**	<1.00–5.20
	Grehan true left (WQS1)	2.12	1.45	<1.00–5.30
	Grehan true right (WQS2)	2.12	<1.00	<1.00–3.10
Total Cadmium (µg/L)	Robinsons Bay Stream (WQS6)	0.05	<0.053	all below detection
	Takamātua Stream (WQS5)	0.05	<0.053	<0.053–0.062
	Childrens Bay upstream (WQS4)	0.02	<0.053	<0.053–0.135
	Childrens Bay downstream (WQS3)	0.02	<0.053	<0.053–0.074
	Grehan true left (WQS1)	0.05	<0.053	all below detection
	Grehan true right (WQS2)	0.05	<0.053	all below detection
Dissolved Cadmium (µg/L)	Robinsons Bay Stream (WQS6)	0.05	<0.05	all below detection
	Takamātua Stream (WQS5)	0.05	<0.05	all below detection
	Childrens Bay upstream (WQS4)	0.02	<0.05	all below detection
	Childrens Bay downstream (WQS3)	0.02	<0.05	all below detection
	Grehan true left (WQS1)	0.05	<0.05	all below detection
	Grehan true right (WQS2)	0.05	<0.05	all below detection
Total Chromium (µg/L)	Robinsons Bay Stream (WQS6)	2.57	<0.53	<0.53–8.50
	Takamātua Stream (WQS5)	2.94	<0.53	<0.53–4.50
	Childrens Bay upstream (WQS4)	0.93	<0.53	<0.53–3.70
	Childrens Bay downstream (WQS3)	0.93	<0.53	<0.53–14.40
	Grehan true left (WQS1)	2.92	<0.53	<0.53–3.3
	Grehan true right (WQS2)	2.92	<0.53	<0.53–3.3
Dissolved Chromium (µg/L)	Robinsons Bay Stream (WQS6)	2.57	<0.50	all below detection
	Takamātua Stream (WQS5)	2.94	<0.50	all below detection
	Childrens Bay upstream (WQS4)	0.93	<0.50	<0.50–0.90
	Childrens Bay downstream (WQS3)	0.93	<0.50	<0.50–0.70
	Grehan true left (WQS1)	2.92	<0.50	<0.50–0.50
	Grehan true right (WQS2)	2.92	<0.50	all below detection

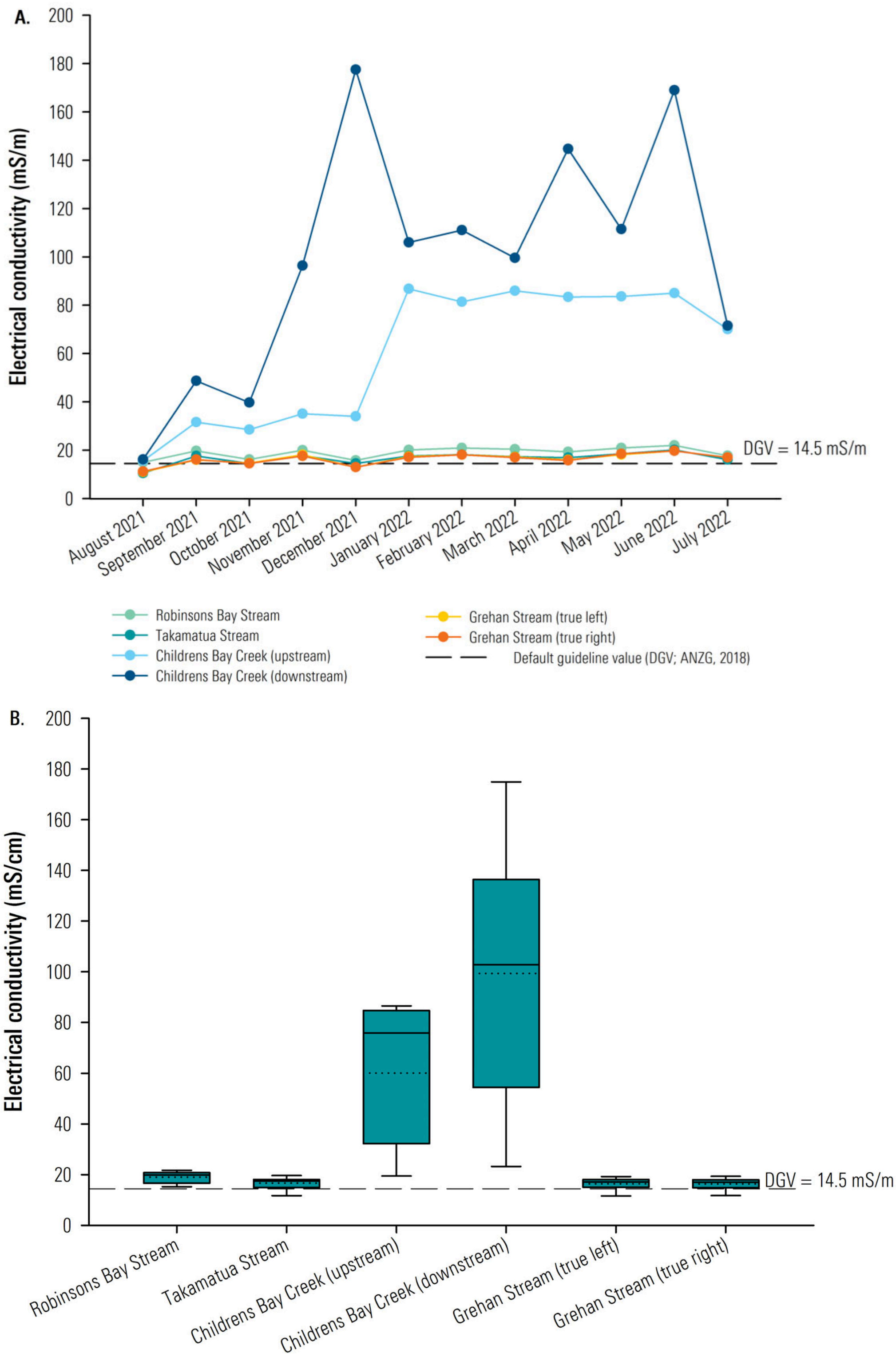


Figure 12 Line graph and box plot (median = solid line in box, mean = dotted line, upper and lower quartiles = extent of the box, max/min values = extent of the whiskers) of electrical conductivity for the six water quality sampling sites over 12 sampling rounds between August 2021 and July 2022. The ANZG (2018) default guideline value (DGV) for electrical conductivity is shown as the dashed line on each graph.

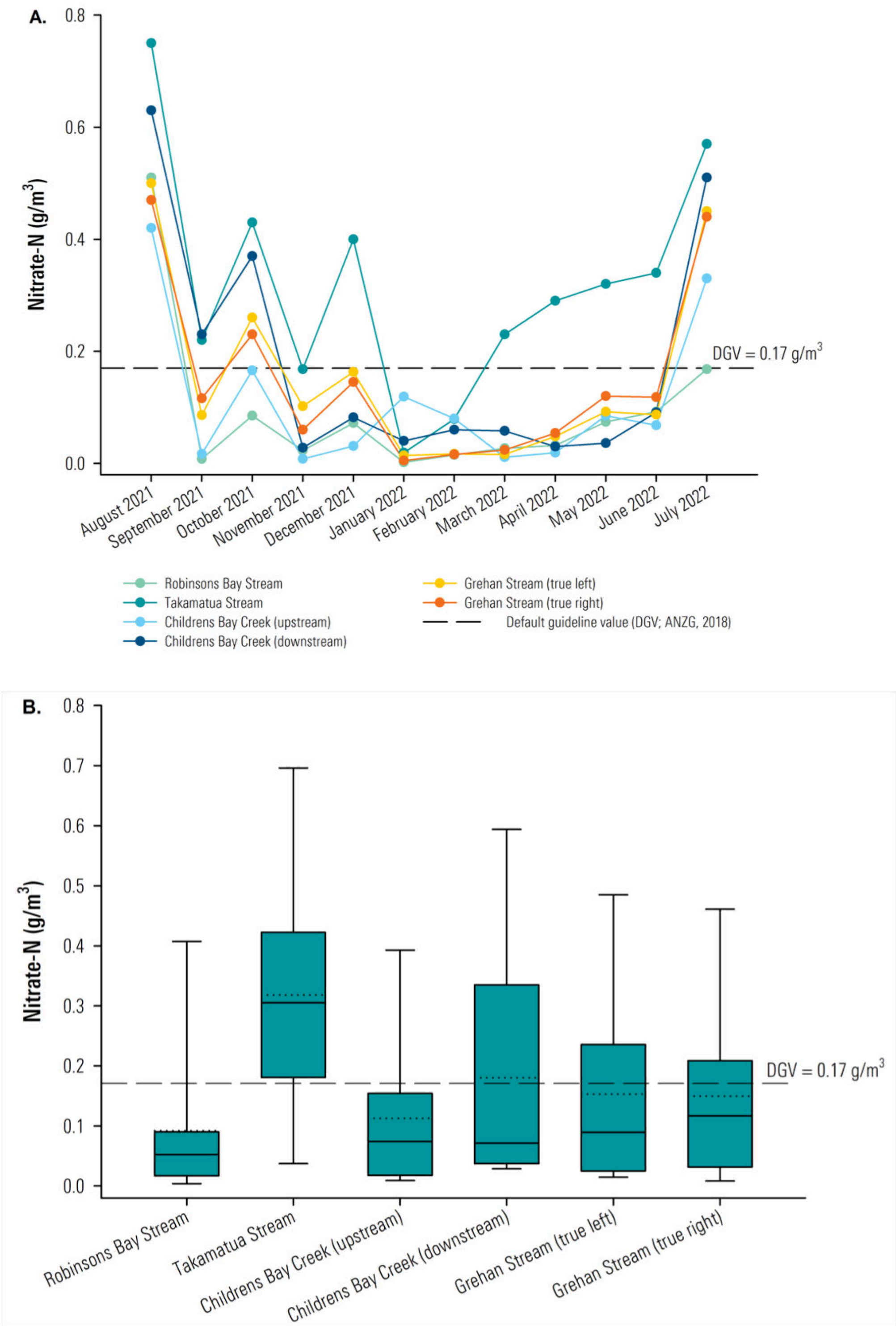
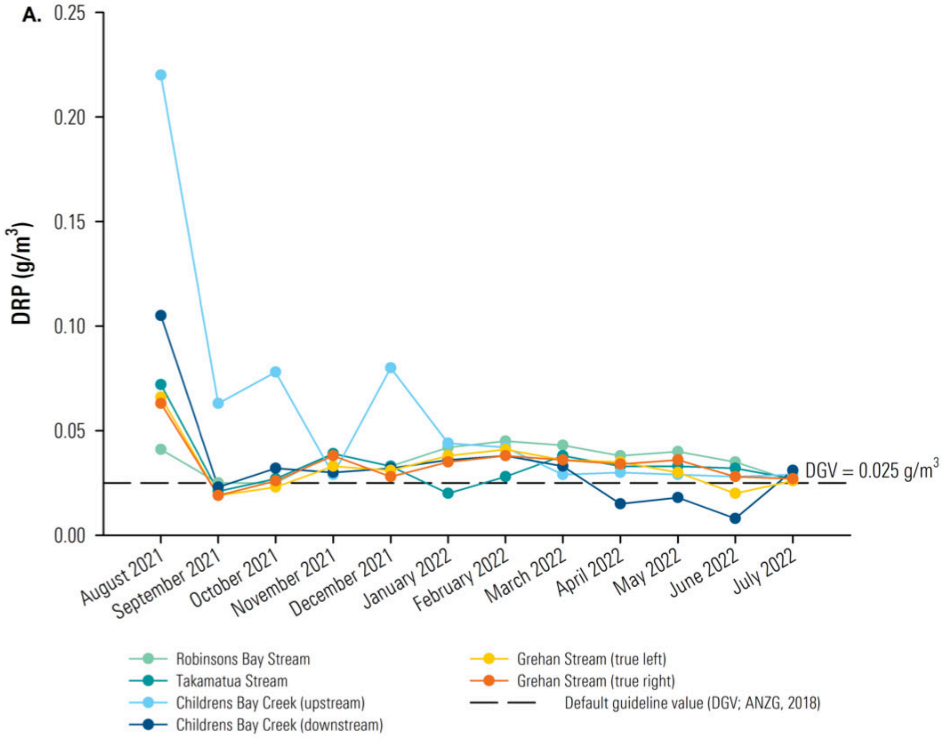


Figure 13 Line graph and box plot (median = solid line in box, mean = dotted line, upper and lower quartiles = extent of the box, max/min values = extent of the whiskers) of Nitrate-N for the six water quality sampling sites over 12 sampling rounds between August 2021 and July 2022. The ANZG (2018) default guideline value (DGV) for nitrate-N is shown as the dashed line on each graph.



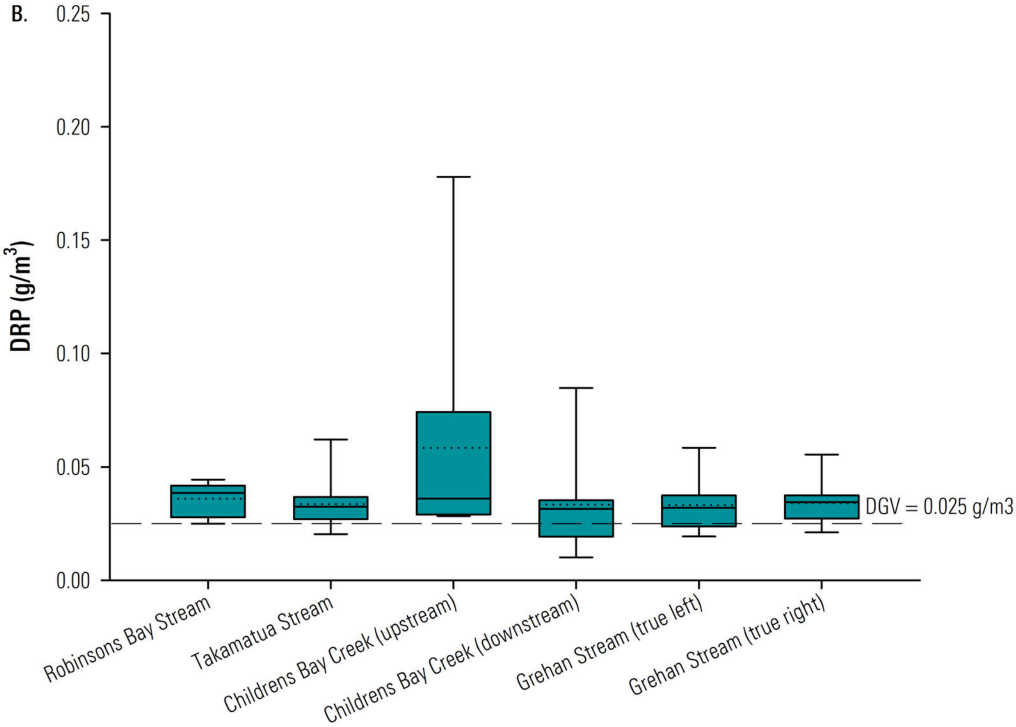
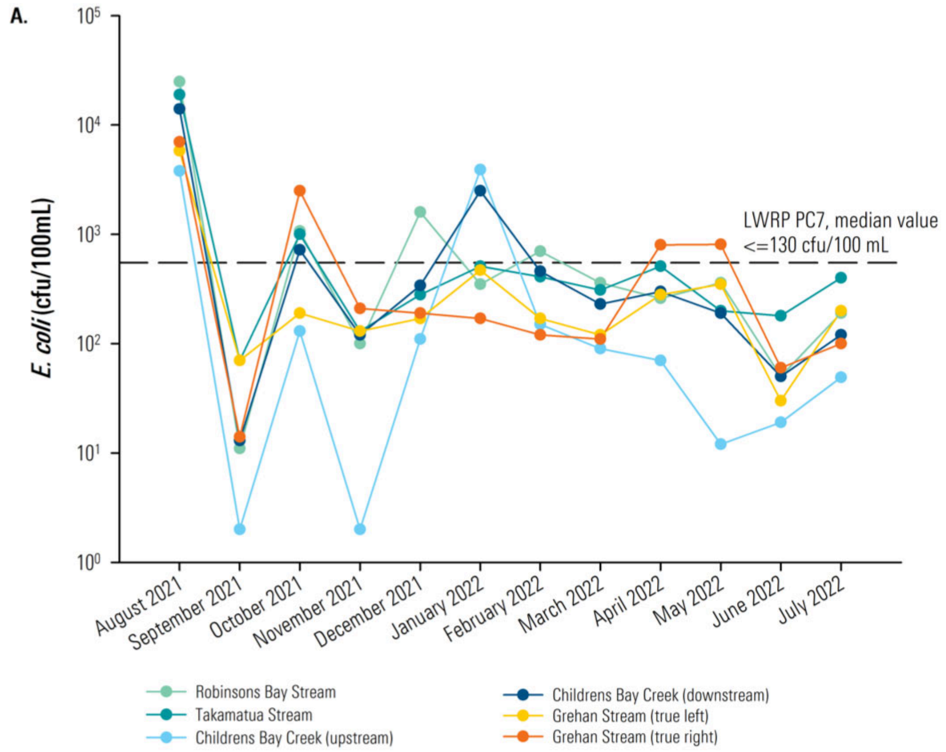


Figure 14 Line graph and box plot (median = solid line in box, mean = dotted line, upper and lower quartiles = extent of the box, max/min values = extent of the whiskers) of dissolved reactive phosphorus (DRP) for the six water quality sampling sites over 12 sampling rounds between August 2021 and July 2022. The ANZG (2018) default guideline value (DGV) for DRP is shown as the dashed line on each graph.



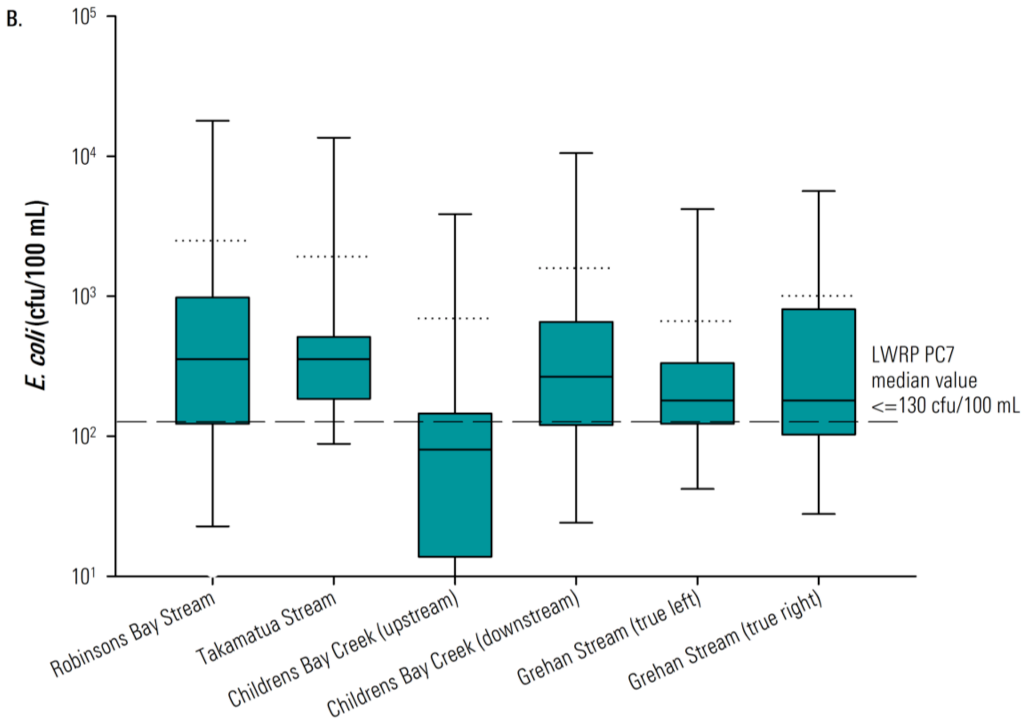


Figure 15 Line graph and box plot (median = solid line in box, mean = dotted line, upper and lower quartiles = extent of the box, max/min values = extent of the whiskers) of *E. coli* for the six water quality sampling sites over 12 sampling rounds between August 2021 and July 2022, shown with a log scale. The LWRP Plan Change 7 (PC7) freshwater outcome for *E. coli* for Banks Peninsula is shown as a dashed line on each graph.

3.5 Wetlands

Meurk (2022) identified several wetland areas or wet seepages within the Robinsons Bay catchment during site walkovers. However, most of these identified areas were outside of the irrigation areas and were typically of low quality, with only native rushes and exotic pasture species present and no indigenous wetland ground cover identified. McIndoe *et al.* (2022) also completed site walkovers to identify the most suitable and less suitable areas for irrigation on each site. As part of this process, they identified unmapped ephemeral streams, boggy areas, and springs and removed these from the potential irrigation area. As wetlands have been covered in these two reports, they were not included any further in our freshwater ecology report.

3.6 Ecological Values Assessment

Roper-Lindsey *et al.* (2018) provides guidance for the evaluation of ecological value or importance in terms of four "matters": representativeness, rarity/distinctiveness, diversity and pattern, and ecological context. However, these "matters" are more suited for application to terrestrial habitats (e.g., forests, vegetation assemblages, and wetlands that have distinct boundaries) rather than waterways; the condition and values of which are strongly influenced by the land use and catchment upstream of any survey site. Roper-Lindsey *et al.* (2018) states, "*Although a wide range of metrics and measures are used in the assessment of freshwaters there is no unifying set of attributes used to assign value or significance*." We have therefore adapted a method that uses a suite of widely accepted metrics (e.g., macroinvertebrate community indices, degree of channel modification, riparian vegetation condition) to determine ecological value and from that, to assign a value to a site following the five-point scale of Roper-Lindsey *et al.* (2018) of Very High, High, Moderate, Low, Negligible. These assessment categories and criteria are outlined in Appendix 9.1, whilst the characterisation of the surveyed sites to Roper-Lindsey *et al.* (2018) five-point scale is provided in Table 7.

On this basis, the different catchments within the project area score slightly differently. Robinsons Bay Stream scores a 'moderate-high' overall aquatic ecological value, because of its moderate to high habitat and invertebrate values, and moderate fish values. Takamātua Stream scores a 'high' overall aquatic ecological value, largely because of its high fish values and the presence of a threatened fish species. Childrens Bay Creek and Grehan Stream score a 'moderate' overall aquatic ecological value, with their low invertebrate values being balanced out by moderate to high fish values (Table 7).

Table 7 Freshwater ecological values site assessment for the Akaroa Treated Wastewater Irrigation Scheme (ATWIS). The five point 'values' scale (Very High, High, Moderate, Low, Negligible) of Roper-Lindsay *et al*. (2018) is based off the scoring of a number of characteristics. Further detail regarding the characteristics is provided Appendix 9.1.

Characteristics	Robinsons Bay Stream		Takamātua Stream	Childrens Bay Creek	Grehan Stream	
	Site FW1: mid catchment	Site FW2: upper catchment	Site FW3: at SH75	Site FW4: lower stream	Site FW5: true left	Site FW6: true right
Aquatic invertebrates (values score)	Moderate	High	Low	Low	Low	Low
Aquatic invertebrates: species dominance (% of most abundant taxa)	40.6% *Pycnocentrodes*	25.3% *Potamopyrgus*	31.4% *Oxyethira*	23.3% Tanypodinae	58.8% *Potamopyrgus*	68.9% *Potamopyrgus*
Aquatic invertebrates: MCI score NPS-FM (2020) band	102 (Band C)	119 (Band B)	86 (Band D)	69 (Band D)	86 (Band D)	97 (Band C)
Aquatic invertebrates: QMCI score/NPS-FM (2020) band	5.1 (Band C)	6.1 (Band B)	3.4 (Band D)	3.7 (Band D)	3.6 (Band D)	3.7 (Band D)
Aquatic invertebrates: ASPM score/NPS-FM (2020) band	0.55 (Band B)	0.58 (Band B)	0.28 (Band D)	0.11 (Band D)	0.22 (Band D)	0.23 (Band D)
Aquatic invertebrates: EPT richness (excl. Hydroptilidae)	15	17	8	0	5	6
Aquatic invertebrates: EPT % abundance (excl. Hydroptilidae)	62.52	55.20	14.55	0.00	6.00	1.05
Aquatic invertebrates: Number of "Threatened" species (nationally vulnerable/endangered/ critical (NV/NE/NC))	0	3	1	0	1	0
Aquatic invertebrates: Number of "At risk" species (AR)	1	1	0	0	0	0
Aquatic invertebrates: Number of regionally endemic species	1	4	1	0	1	0
Fish (values score)	Moderate	Moderate	High	Moderate	High	High
Fish: species diversity	5	5	11	4	9	10
Fish: Number of "Threatened" species (nationally vulnerable/ endangered/ critical (NV/NE/NC))	0	0	1	0	0	0
Fish: Number of "At risk" species (AR)	3	3	6	1	5	5
Habitat (values score)	Moderate	High	Moderate	Moderate	Low	Low
Flow periodicity	Permanent	Permanent	Permanent	Permanent	Permanent	Permanent
Riparian vegetation	grass dominant, native and exotic trees also present	native trees dominant	grass, shrubs, and deciduous exotic trees	grass dominant, native trees and shrubs also present	shrubs dominant, native trees and grass also present	grass dominant, native trees and shrubs also present

Characteristics	Robinsons Bay Stream		Takamātua Stream	Childrens Bay Creek	Grehan Stream	
	Site FW1: mid catchment	Site FW2: upper catchment	Site FW3: at SH75	Site FW4: lower stream	Site FW5: true left	Site FW6: true right
Channel morphology	weakly sinuous	weakly sinuous	strongly sinuous	weakly sinuous	modified	modified
Stream bank erosion	banks mostly stable	banks mostly stable	banks stable but with some undercutting	banks mostly stable but with some undercutting	banks stable	banks stable but with some undercutting
Stock access and catchment land use	sheep access both sites, minor damage, rural area	no stock access, rural area	no stock access, rural area	no stock access, within reserve area	no stock access, urban area	no stock access, urban area
Instream habitat types (descending order by %)	pool/riffle/run	riffle/run/pool	run/pool/riffle	riffle/run/pool	run/riffle	riffle/run
Fine sediment substrate (sand/silt %)	0	5	15	54	5	1
Overall Score	Moderate	High	High	Moderate	Moderate	Moderate

4 ASSESSMENT OF ENVIRONMENTAL EFFECTS

4.1 Overview of Proposed Scheme/Project Details

The Akaroa Treated Water Irrigation Scheme (ATWIS) is proposed as a replacement for the existing Akaroa Wastewater Treatment Plant which currently discharges treated wastewater to Akaroa Harbour. The existing wastewater network in Akaroa captures wastewater within the urban area by gravity, draining to three pump stations. These pump stations then pump wastewater to the wastewater treatment plant to the south of the Akaroa township. As part of the proposed ATWIS, there would be a new wastewater treatment plant (WWTP) located on Old Coach Road to the north of the town (already consented; Figure 16). As a result, the direction of flow between pump stations would be reversed and a new terminal pump station (TPS) would be built in the boat park at Childrens Bay (already consented), to pump wastewater up to the treatment plant sited at an elevation of 119 m asl. As part of the ATWIS, there would be a new pipeline constructed (~1.4 km length), to transport untreated wastewater from the TPS to the WWTP at Old Coach Road. The Christchurch City Council (CCC) owns the land for the new WWTP and TPS, and consents have already been granted for these aspects of the scheme.

To avoid the need for an oversized treatment plant to cope with peak flows, a covered wet weather raw wastewater tank is proposed at the Old Coach Road site (opposite the WWTP on Old Coach Road). The purpose of this storage facility is to hold untreated wastewater conveyed from the TPS that exceeds the treatment plant processing capacity, typically during daily peak flows or storm events. Wastewater would be pumped from the storage facility to the WWTP for treatment once capacity returns.

Treated wastewater from the WWTP would then be conveyed along a new gravity main to irrigate new areas of native trees in Robinsons Bay Valley and at Hammond Point, as well as to irrigate Jubilee Park in Akaroa during dry conditions. The new pipeline will be used to convey the treated wastewater from the WWTP to the irrigation areas, and as necessary to storage tanks that will be sited at the Robinsons Bay Valley site. The pipeline is approximately 5.5 km in length, and will cross six waterways, including Takamātua Stream and several tributaries of Robinsons Bay Stream. Treated wastewater would be irrigated to land directly, or temporarily stored in tanks at the Robinsons Bay Valley irrigation site if field capacity is reduced following heavy or prolonged rainfall, preventing irrigation. The ATWIS also provides potential for non-potable reuse of water for irrigating public parks in Akaroa. At this stage, the only area within Akaroa township that will be irrigated with reclaimed water is Jubilee Park, which is located adjacent to the true left branch of Grehan Stream.

A subsurface wetland is also proposed at the Old Coach Road site. The purpose of the subsurface wetland is to provide additional storage for treated wastewater if the storage capacity at Robinson Bay Valley is exceeded, or if emergency storage is needed for treated wastewater which would be necessary such as if the gravity main to the irrigation sites was damaged. The proposed subsurface wetland will be fully lined with impervious material and is not designed to overflow anywhere or have any discharge. The wetland will receive a continuous residual flow of treated wastewater to maintain the plants in good condition, with the volume of that flow regulated according to rainfall, evaporation, and evapotranspiration rates. The storage capacity of the wetland will be retained at as close to 100% as possible, with stormwater being decanted off as necessary and directed back through the WWTP.

The ATWIS is designed so that the only discharge will be of highly treated wastewater to land to the defined irrigation areas. As the treated wastewater will all be irrigated to land, there will be no direct discharge to surface or ground water, or to coastal water as part of this scheme. However, it is anticipated that a portion of the irrigated water will drain through the soils of the irrigation areas and ultimately enter surface waterways via groundwater (McIndoe *et al.*, 2022).

Figure 16 *…figure over page…* Overview of Features of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), including proposed irrigation areas, wastewater pipeline, pipeline stream crossings, and the wastewater treatment plant.

Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS)

WASTEWATER PIPELINE

- Two pipelines (raw wastewater uphill, treated wastewater downhill)
- WWTP discharge pipeline (treated wastewater)
- Pipeline stream crossings
- Irrigation areas
- Existing outfall pipe
- Waterways

Layer source: pipeline, WWTP, outfall, irrigation areas: CCC; pipeline stream crossings: EOS Ecology from site visits; waterways: modified by EOS Ecology from site visits, original layers by LINZ & CCC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

4.2 Determining the Magnitude of Effects

Determination of the magnitude of the potential effects that have been identified as part of this project has been undertaken using Table 8 of Roper-Lindsay *et al.* (2018), which is reproduced below (Table 8). Based on the ecological value of the site to be disturbed (Table 7) and the magnitude of potential effects (Table 8), the overall level of each potential effect has then been evaluated using the matrix approach described in Roper-Lindsay *et al.* (2018; Table 9).

Table 8 Criteria for describing magnitude of effect (taken from Table 8 of Roper-Lindsay *et al.* (2018)).

Magnitude	Description
Very high	» Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally change and may be lost from the site altogether, AND/OR » Loss of a very high proportion of the known population or range of the element/feature.
High	» Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed, AND/OR » Loss of a high proportion of the known population or range of the element/feature.
Moderate	» Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed, AND/OR » Loss of a moderate proportion of the known population or range of the element/feature.
Low	» Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns, AND/OR » Having a minor effect on the known population or range of the element/feature.
Negligible	» Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation, AND/OR » Having negligible effect on the known population or range of the element/feature.

Table 9 Matrix for determining the level of effects based on ecological value of site to be disturbed and magnitude of the effects of the proposed activity. Adapted from Table 10 of Roper-Lindsay *et al.* (2018).

		Ecological Value				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
Magnitude	**Very high**	Very high	Very high	High	Moderate	Low
	High	Very high	Very high	Moderate	Low	Very low
	Moderate	High	High	Moderate	Low	Very low
	Low	Moderate	Low	Low	Very low	Very low
	Negligible	Low	Very low	Very low	Very low	Very low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

The level of effect derived from Table 9 is then adapted into planning terminology/RMA context using the continuum below, obtained from the Quality Planning website (www.qualityplanning.org.nz), with the addition of a positive effects category.

» Positive effects – the overall effects will be positive.

» Nil effects – no effects at all.

» Less than minor adverse effects – adverse effects that are discernible day-to-day effects, but too small to adversely affect other persons.

» Minor adverse effects – adverse effects that are noticeable but will not cause any significant adverse impacts.

» More than minor adverse effects – adverse effects that are noticeable that may cause an adverse impact but could be potentially mitigated or remedied.

» Significant adverse effects that could be remedied or mitigated – an effect that is noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.

» Unacceptable adverse effects – extensive adverse effects that cannot be avoided, remedied, or mitigated.

4.3 Potential Effects

The potential effects of the planned programme on aquatic ecology can be split into two distinct portions:

» Construction effects: these relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including the stream crossings required for the associated pipeline. Potential effects are the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and concrete related contaminants) and habitat disturbance (e.g., machinery working in and around waterways during construction of pipeline and access roads, stream bed disturbance for pipeline stream crossings).

» Operational effects: these relate to the ongoing effects of the proposed ATWIS once it is complete and operating. The main potential effect of irrigating treated wastewater to land is the discharge of contaminants from the irrigation areas to surface water (via surface runoff or groundwater). Another potential effect is the overflow of untreated wastewater from any of the ATWIS facilities to surface waterways which could discharge contaminants to surface water receiving environments. However, it is our understanding that the scheme does not provide for any planned overflows and includes provision for emergency storage to reduce the risk of emergency overflows (Section 4.1), so that these potential effects would not be a part of normal operations.

4.3.1 Construction Effects

At the time of writing this report, the specific construction methodology had not been finalised for this project. From the information available, we have identified the following potential adverse effects during the construction phase:

» Freshwater habitat and fish migration disturbance – the adverse effects of disturbance to existing freshwater habitats and of the obstruction of the free passage of fish during the construction phase. These effects would be relevant to any stream crossings required during the formation of access tracks or if any instream works are required for the pipeline stream crossings. At this stage no temporary or permanent steam crossings are proposed for the construction of access tracks. No instream works are proposed for permanently flowing waterways (those labelled 1, 2, & 5 on Figure 16), as the construction methodology for these will involve directional drilling beneath the streams, rather than traditional trenching methods. Any trenching works in ephemeral or intermittent waterways (those labelled 3, 4, 6, 7, 8, 9, 10, & 11 on Figure 16) will be completed in dry conditions so that no habitat or fish migration disturbance will occur.

» Release and deposition of fine sediments – the potential adverse effect of runoff transporting fine sediments to adjacent waterways during the construction and earthworks required for the formation of access roads, tracks, tank platforms, and creation of the subsurface wetland. This would lead to a reduction in water clarity and an increase in deposited fine sediment in nearby waterways, resulting in negative impacts on aquatic biota.

» Water contamination – the potential adverse effect of water contamination from construction machinery (e.g., fuel, oil, grease) and materials (e.g., concrete, grouts, mortars), that could be used during formation of the access roads, tracks, and tank platforms.

Given the types of construction work that are likely to be undertaken adjacent to waterways as part of the ATWIS, including the formation of access roads, tracks, tank platforms, creation of the subsurface wetland, as well as a pipeline that will require several stream crossings, it is anticipated that the main construction effect will be the potential for release and deposition of fine sediments to nearby waterways.

Where construction requires substantial areas of earthworks, it is expected that there will be areas of bare earth for some length of time. This allows fine sediments to be mobilised by wind and rain, with the potential that they may then enter waterways. Suspended sediment can have a range of impacts on aquatic ecosystems, including alteration of water chemistry, increasing turbidity, increasing invertebrate drift, and altering invertebrate community structure (Ryan, 1991). This increased turbidity can result in a reduction in visibility (which impacts on the feeding ability of some fish species), clogging of the gills of fish, and smothering of invertebrates.

While many aquatic biota are relatively tolerant of at least short-term increases in suspended sediment, the deposition of this sediment on the streambed is a major stressor on waterway ecosystems. Deposited fine sediment alters the physical habitat (clogging interstitial spaces in the stream bed used as refugia by fish and invertebrates), alters food resources (e.g., smothering algae), and degrades sites used for egg laying by many aquatic species. Hence sediment affects the diversity and composition of algae, macrophytes, fish, and aquatic invertebrates (Clapcott *et al.*, 2011). Ryan (1991) notes that while the aesthetic effects of sediment inputs to waterways will diminish rapidly after sediment input ceases, ecological recovery may take significantly longer.

Sensitivity of a stream to elevated fine sediment deposition is influenced by the existing state of a waterway. Modified, soft-bottomed streams or those hard-bottomed streams that already have unnatural levels of fine sediment on their beds, are generally dominated by aquatic fauna that are tolerant of or prefer such conditions. More pristine hard-bottomed streams with minimal fine sediment coverage generally have a high proportion of aquatic fauna that are intolerant to elevated levels of fine sediment. The streams in this area generally have coarse substrate at the locations surveyed for this project, albeit with some presence of fine sediments in low velocity areas. The streams surveyed support aquatic biota that are not especially tolerant to high levels of suspended and settled sediment, so it is crucial that fine sediment inputs to these waterways are kept to a minimum. Otherwise, there is potential for the macroinvertebrate community to become dominated by more tolerant species, which may be less suitable as a food source for fish communities (Ministry for the Environment, 2021). The adverse effects of fine sediment can be effectively managed by employing best practise erosion and sediment control measures for all construction activities. This includes stabilising any areas where vegetation removal is required (see Adamson (2016) for the results of field experiments testing the efficacy of erosion control products) as soon as possible and keeping disturbed areas as small as possible. Work should also be undertaken during dry conditions as far as possible. With best practise mitigation measures in place, the magnitude of effect (see section 4.2) would be expected to be negligible to low during construction.

The other main potential effect of the ATWIS construction phase is the release of contaminants to waterways. When construction machinery is working in the vicinity of waterways, there is potential for contaminants from these machines to enter waterways (e.g., fuel and lubricants), especially if machinery is used within or adjacent to the wetted channel. Likewise, when construction involves working with uncured cement products within or adjacent to waterways, there is the potential for the discharge of contaminants. Concrete wash water and uncured cement-related products can harm aquatic life, primarily though causing rapid pH shifts and the discharge of ammonia. Careless use of these products can result in significant fish kill events (McMurtrie, 2014). Such adverse effects can be avoided by ensuring any concrete waste does not enter surface waters and all mortars, grouts, and other cement-based products used are fully cured prior to contact with water. Any construction work that would involve uncured cement related products should be undertaken outside of the flowing channel and all contractors will need to be aware of the need to avoid any concrete discharge entering the waterways. Where machinery is working adjacent to waterways, it is important that refuelling occurs where it cannot enter the waterway if there is a spillage, and that fuels and chemicals are stored away from waterways. Properly maintaining all machinery on a preventative schedule will reduce the risk of breakdown. A spill kit should also remain on site at all times to contain any accidental spills and ensure no contaminants enter the waterways. With adequate controls in place, the effects of any release of contaminants to the waterway should be negligible.

4.3.2 Operational Effects

As the ATWIS involves the irrigation of treated wastewater onto land, any potential operational effects relating to freshwater ecology would be limited to any contaminants that may leach from the irrigated areas into groundwater and into the adjacent streams. However, in this case the typical domestic wastewater contaminants are not expected to have a measurable effect on stream water quality given the treatment and irrigation proposed with the ATWIS. Mellish (2022) reported on the likelihood of other typical domestic wastewater contaminants from the ATWIS entering ground and/or surface water. The contaminants considered included metals, phosphorus, pharmaceuticals, emerging contaminants, persistent organic pollutants, herbicides, and pesticides. It was reported that while copper and zinc are typically prevalent in treated wastewater samples, this would have a very low or indiscernible impact on receiving water quality, because metal contaminants introduced through irrigation become tightly bound within sediment particles and have a low risk of mobilisation at the existing soil pH values within the proposed irrigation area. Mellish (2022) also reported that phosphorus has low leaching potential, since it becomes complexed with other elements in the soil, and thus concluded that in this case, applied phosphorus would be unlikely to leach to groundwater and hence surface water. Persistent organic pollutants and contaminants of emerging concern are an area where there is little readily available data for New Zealand soils, however, overseas studies indicate that these are typically accumulated in surface soils, rather than being released to receiving waters, if the soil is not disturbed. In summary, Mellish (2022) considered the risk of most of the applied contaminants entering ground or surface water to be low, although monitoring was recommended to determine the long-term impact of contaminants accumulating in or leaching from soils and to enable mitigation measures to be instigated if required.

Meurk (2022) indicated that the wetland areas identified within Robinsons Bay Valley were all outside of the proposed irrigation area and are composed of exotic or common native rushes. Irrigation within this catchment is not expected to negatively impact on the existing values of these wetlands and they are expected to benefit from the removal of stock, and potentially, more consistent soil moisture conditions.

The key constituent from the irrigated wastewater that is anticipated to reach the stream by drainage through the soil profile or surface water runoff of the irrigation water are species of nitrogen (primarily nitrate-nitrogen). At high concentrations, nitrate has toxic effects on instream life. For this reason, nitrate toxicity is included in the NPS-FM 2020 as an attribute that focuses on providing freshwater species a level of protection against toxic effects (reduced survival or death of sensitive species). While not actually included as an attribute in the NPS-FM 2020, STAG (2020) recommended replacing the NPS-FM 2020 nitrate and ammonia toxicity attributes with a dissolved inorganic nitrogen (DIN) attribute for ecosystem health (water quality). They recommended this as the DIN attribute would protect ecosystem health, as well as avoiding the toxic effects of elevated nutrients. The ecosystem effects of nitrate become apparent at much lower nitrate concentrations with eutrophication (nutrient enrichment) typically resulting in excessive aquatic plant or algal growth. Excessive algal growth alters invertebrate community composition by skewing the food web towards algae consumers, and this change in the invertebrate community in turn alters the food supply available to fish (Canning, 2020). These food web changes occur well before toxic nitrate concentrations are reached. Another consequence of excessive plant or algal growth is large fluctuations in diurnal dissolved oxygen concentrations because of increased photosynthesis and respiration. Hypoxic (low dissolved oxygen) conditions are known to impact both fish diversity and abundance, with a range of lethal and sub-lethal effects possible depending on the dissolved oxygen concentrations experienced (Franklin, 2014).

As detailed in Section 3.4.2, the nitrate concentrations at all our water quality sampling sites were elevated for sampling rounds that occurred during and after wet weather, with lower concentrations recorded at all sites during extended dry weather periods. It was this variety of weather conditions encountered during sampling that has contributed to the highly variable nitrate concentrations seen over the 12 sampling rounds completed for this study (Figure 13). Robinsons Bay Stream had the lowest median nitrate concentration of the sites sampled and the nitrate concentrations were least variable over time for this site. In contrast, Takamātua Stream had the highest median nitrate concentration, and was the only sampling location where the median Nitrate-N value exceeded the DGV, with median Nitrate-N concentrations well below the DGV for all other sampling sites (Table 5). Our ecological surveys have shown that the existing invertebrate community of Takamātua Stream is composed of species that are known to be tolerant and indicative of organic pollution or nutrient enrichment. In contrast, the invertebrate community of Robinsons Bay Stream (upstream most site) is indicative of only mild nutrient enrichment. The implication of these differences is that the effects of any eutrophication are likely to be more evident on the more sensitive invertebrate community of Robinsons Bay Stream than they would be on other more impacted waterways.

At the time of writing this report, the CCC are still working through the details of treatment plant operations, but we understand that the target is for the median total nitrogen content of the treated wastewater to be 10 g/m^3, which corresponds to a dissolved inorganic nitrogen (DIN) concentration of 8.6 g/m^3 (McIndoe *et al*., 2022). The report by McIndoe *et al*. (2022) models the likely output of nitrate to surface water bodies within the catchments where treated wastewater is to be irrigated (based on the target 10 mg/m^3 of total nitrogen in the treated wastewater), and this is what our effects assessment has been based on.

Robinsons Bay Stream catchment

Catchment modelling has demonstrated that treated wastewater that is irrigated onto land within the catchment of Robinsons Bay Stream has the potential to enter the stream via overland flow or groundwater and that this would lead to a small increase in stream flow (7 L/s or 2% increase) and increases in nitrate concentrations in Robinsons Bay Stream (McIndoe *et al*., 2022). While the effects of the small increase in stream flow are expected to be negligible, the potential changes to water quality for the stream could result in negative impacts on aquatic biota, depending on the magnitude of any changes to water quality. There were a range of scenarios modelled by McIndoe *et al.* (2022) and these are summarised below and in Table 10:

» Modelling of the nitrogen balance for this catchment has indicated that using a conservative or worst-case scenario (referred to as the 'conservative' scenario in McIndoe *et al.* (2022)), where all dissolved inorganic nitrogen (DIN) applied in the treated wastewater is transported to the stream, the increase in stream nitrate concentrations due to irrigation would be 0.126 g/m^3, if the treated wastewater used for irrigation has a median total nitrogen content of 10 g/m^3 (McIndoe *et al*., 2022). This represents an increase of 420% compared to the measured median nitrate concentration of 0.03 g/m^3 for this stream, with a resulting nitrate concentration of 0.156 g/m^3 in the stream (Table 10).

» In the 'base case' provided by McIndoe *et al.* (2022), the modelling allowed for uptake/denitrification from the trees within the proposed 31.9 ha irrigation area, as well as an offset of nitrogen that would be provided by destocking of the irrigation area only. For the 'base case' scenario the increase in stream nitrate concentrations due to irrigation would be 0.086 g/m^3, if the treated wastewater used for irrigation has a median total nitrogen content of 10 g/m^3 (McIndoe *et al*., 2022). This represents an increase of 287% compared to the measured median nitrate concentration of 0.03 g/m^3 for this stream, with a resulting nitrate concentration of 0.116 g/m^3 in the stream (Table 10).

- In the 'preferred scenario' (also referred to as the 'destocking 1' scenario) provided by McIndoe *et al.* (2022), the modelling allowed for uptake/denitrification from the trees within the 31.9 ha irrigation area, as well as an offset of nitrogen that would be provided by destocking of the irrigation area. In addition, to allow for further uptake/denitrification and destocking within the Robinsons Bay Stream catchment, the 'preferred scenario' provides another 23 ha of non-irrigated infill/riparian planting. For the 'preferred scenario' the increase in stream nitrate concentrations due to irrigation would be 0.057 g/m^3, if the treated wastewater used for irrigation has a median total nitrogen content of 10 g/m^3 (McIndoe *et al*., 2022). This represents an increase of 190% compared to the measured median nitrate concentration of 0.03 g/m^3 for this stream, with a resulting nitrate concentration of 0.087 g/m^3 in the stream (Table 10).
- In the 'destocking 2' scenario provided by McIndoe *et al.* (2022), the modelling allowed for uptake/denitrification from the trees within the 31.9 ha irrigation area, as well as an offset of nitrogen that would be provided by destocking of the irrigation area. It also allowed for further uptake/denitrification and destocking within the Robinsons Bay Stream catchment by providing another 23 ha of non-irrigated infill/riparian planting, and for destocking the remaining area of the property (a further 63.2 ha). For the 'destocking 2' scenario, the increase in stream nitrate concentrations due to irrigation would be 0.047 g/m^3, if the treated wastewater used for irrigation has a median total nitrogen content of 10 g/m^3 (McIndoe *et al*., 2022). This represents an increase of 157% compared to the measured median nitrate concentration of 0.03 g/m^3 for this stream, with a resulting nitrate concentration of 0.077 g/m^3 in the stream (Table 10).

Table 10 summarises the modelled increases in nitrate-N for Robinsons Bay Stream based on the four scenarios modelled by McIndoe *et al*. (2022), along with the predicted level of effects that are anticipated for each scenario. For each scenario, the magnitude of effect has been assessed based on Table 8 and the level of effect also takes into consideration the existing nitrate levels in the stream, and the existing ecological values of the receiving environment (Table 7) using a matrix based approach (Table 9).

- As shown in Table 10, the 'base case' and 'conservative scenario' for wastewater irrigation would be expected to have a moderate magnitude of effect on the existing moderate to high ecological values of the Robinsons Bay Stream. Both of these scenarios represent a significant increase in the level of nitrate in the stream compared to the existing concentration based on the 12 months of water quality monitoring data for this stream (Figure 13), and in the case of the 'conservative' scenario would shift the median nitrate concentration to close to the ANZG (2018) default guideline value (DGV) of 0.17 g/m^3. If either of these scenarios were implemented, we might expect the increased availability of nutrients to enable the increased growth of periphyton and aquatic plants. Over time, this type of change would be expected to have flow on effects to biota further up the food chain (macroinvertebrates and fish). While these two scenarios would not be expected to result in a sudden change to the ecological health of the Robinsons Bay Stream, we would anticipate that consistently higher nitrate values over time would degrade the ecological health of the stream compared to its existing condition.
- In comparison, although the 'preferred/destocking 1' and 'destocking 2' scenarios are also expected to increase the nitrate concentration in the Robinsons Bay Stream, the modelled post irrigation concentrations in the stream are expected to fall within the existing interquartile range of nitrate concentrations for the stream (this is the range of nitrate concentrations already typically experienced by the ecological community) based on the 12 months of water quality monitoring data for this stream (Figure 13). The anticipated modelled post irrigation nitrate concentrations in Robinsons Bay Stream for the 'preferred/destocking 1' and 'destocking 2' scenarios are also both below the ANZG (2018) default guideline value of 0.17 g/m^3 for nitrate and fall within the 'A band' for the nitrate toxicity attribute of the NPS-FM 2020. The ANZG (2018) default guideline value is based on the 80th percentiles, which ANZG (2018) indicates is an appropriate guideline for slightly to moderately disturbed systems, while the 'A band' for the nitrate toxicity attribute indicates that there are unlikely to be toxic effects, even on sensitive species. For these reasons, we consider that the magnitude of effect on the ecological values of Robinsons Bay Stream will be low for these scenarios.

Table 10 Summary of alternative scenarios for nitrate increases in Robinsons Bay Stream (McIndoe *et al.,* 2022). The level of effects has been estimated for each scenario based on the ecological value of the site to be disturbed (Table 7) and the magnitude of potential effects (Table 8), using the matrix approach described in Roper-Lindsay *et al.* (2018). The modelling undertaken by McIndoe *et al.* (2022) was based on a median total nitrogen content of 10 g/m^3 for the treated wastewater being irrigated onto land.

Scenario	Description	Increase in nitrate concentration in stream (g/m^3)	Estimated post irrigation nitrate concentration in stream (g/m^3)	Level of effects (see Table 9)
Existing land use	No wastewater irrigation, native tree planting, or destocking.	0.000	0.030	**Nil effects** (No change from current state).
Base case	Irrigation of wastewater to 31.9 ha of land in the catchment, with 13.5 kg/ha uptake from the planted trees and 2 kg/ha offset from the destocking of the irrigation area.	0.086	0.116	**Moderate–High (minor–more than minor)** (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).
Preferred scenario (Destocking 1)	As for the 'base case', but with the addition of 23 ha of infill or riparian planting and destocking to further reduce nutrient leaching.	0.057	0.087	**Low (less than minor)** (Post irrigation Nitrate-N values within existing interquartile range; moderate – high ecological value; low magnitude of effect).
Destocking 2	As for 'preferred scenario', but with the remaining 63.2 ha area of the property destocked.	0.047	0.077	**Low (less than minor)** (Post irrigation Nitrate-N values within existing interquartile range; moderate – high ecological value; low magnitude of effect).
Conservative	Irrigation of wastewater on the assumption that there will be no uptake/denitrification occurring and without offset or destocking on any part of the property.	0.126	0.156	**Moderate–High (minor–more than minor)** (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).

Hammond Point

While surface drip irrigation is proposed for Hammond Point, there are no surface waterways located on this site (McIndoe *et al.*, 2022). Therefore, the Hammond Point irrigation area does not form part of this freshwater assessment, but the potential ecological effects of this on the estuary are covered by Burns & Hempston (2022).

Takamātua Stream catchment

There are no operational effects anticipated based on the current proposal, which does not include any treated wastewater irrigation in this catchment.

Childrens Bay Creek catchment

There are no operational effects anticipated based on the current proposal, which does not include any treated wastewater irrigation in this catchment or any surface or groundwater discharge from the proposed wetland at the Old Coach Road site.

Grehan Stream catchment

There are unlikely to be any changes to surface water quality of Grehan Stream. This is based on the assertion by McIndoe *et al.* (2022) that the potential for drainage under Jubilee Park can be minimised by deficit irrigating, which means managing the rate of irrigation to maintain soil moisture at levels high enough to keep the grass green. The area of irrigation is also small, being around 1 ha in size. Under this scenario of deficit irrigation, it is anticipated that there will be negligible discharge to the groundwater or surface water and no measurable changes to water quality and quantity for the stream are anticipated. Therefore, we do not anticipate any negative impacts on freshwater biota.

4.4 Effects Management Requirements

Several effects management measures are currently proposed to manage the potential effects of the ATWIS. The effects management activities related to the construction and operational stages of the project are discussed separately below.

4.4.1 Construction Stage

It is proposed that the effects management for the construction phase of the ATWIS will be detailed in a Construction Environment Management Plan (CEMP) which will be prepared and provided to Environment Canterbury and the Christchurch City Council (the Consent Authorities) prior to works commencing. It is expected that the requirement for this CEMP will be included as a condition of resource consent. This approach will minimise the potential for sediment migration and entrainment in surface water, as well as avoiding disturbance to freshwater habitats and fish migration. The CEMP will adopt the most appropriate methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox (ESC toolbox) for Canterbury (https://esccanterbury.co.nz/), and will include the following approaches to manage potential effects:

» Follow the general principles of erosion control, such as minimise disturbance, do construction in stages, protect slopes, protect waterways, stabilise exposed areas quickly, and select relevant tools to suit the situation.

» The CEMP will also require all necessary ESC measures to be installed prior to land disturbance and be maintained in effective working order until disturbed areas are stabilised.

» Where the wastewater pipeline needs to cross waterways that contain water, the construction methodology will involve directional drilling beneath the stream, rather than traditional trenching methods. This will avoid surface disturbance to the stream channel and margins, and the associated effects of freshwater habitat disturbance, fish migration disturbance, and the release and deposition of fine sediments. Where the wastewater pipeline needs to cross ephemeral streams, trenching methods may be used, but these works will be undertaken at a time when there is no surface water present. All such works in ephemeral streams will be completed, and disturbed areas stabilised within one working day.

» As no instream works, temporary diversions, or freshwater habitat disturbance are proposed as part of the construction phase of this project, it is not anticipated that any fish salvage or relocation will be required as part of this project.

In addition to these proposed effects management measures, we would also recommend the following general approaches be included in the CEMP or as conditions of consent in relation to the construction phase of this project:

» As the soils in the area include loess subsoils which are highly erosive and dispersive, we would recommend that particular attention and effort is applied to the erosion and sediment control measures, to ensure that the measures used are appropriate for dealing with this soil type. Adamson (2016) provides some useful guidance on erosion control measures that work best to reduce sediment runoff from exposed loess subsoils, whilst McMurtrie *et al.* (2022) provides findings on the most effective erosion control and revegetative measures for cut loess faces.

» Construction activities should avoid any wetland areas as identified by Meurk (2022) or as subsequently identified during the construction phase.

» Sediment losses to any natural waterway are to be avoided where practicable, with relevant sediment control measures in place in all circumstances.

» Construction vehicles and machinery should always operate outside of any watercourse and should not be driven through flowing water – access should be via a bridge or other suitable structure.

» All fuels and other construction liquids should be stored at least 20 metres away from waterways (including perennial, intermittent and ephemeral waterways) and in appropriately contained or bunded locations. No vehicle refuelling, repair or maintenance should occur within 20 metres of waterways or in a location where any spilled fluid could enter a watercourse.

» Appropriately maintain construction vehicles and machinery on a preventative schedule to reduce the risk of breakdown. Spill kits should be located near to all machinery and staff must be trained in how to use these.

» All practical measures must be taken to ensure that no uncured cement or cement-based products enter flowing water in any waterway. Any works involving these products should be undertaken outside of the flowing channel and new concrete or mortar should not be exposed to water until firmly set (at least 48 hours).

4.4.2 Operational Stage

As detailed in Section 4.3.2, the main operational effect of the ATWIS on freshwater ecological values is the potential for increased nitrate levels in the Robinsons Bay Stream, from drainage through the soil profile or surface water runoff of the irrigated treated wastewater. Several mitigation measures are proposed to manage this potential effect, as detailed below:

» Selection of most suitable area for irrigation –McIndoe *et al.* (2022) analysed land slopes and completed site visits to assess and refine the suitability of each irrigation site. This resulted in the removal of some parts of the irrigable area originally identified, as ephemeral streams, boggy areas, and springs were excluded from irrigation areas.

- Irrigation of native trees in irrigable areas – it is proposed that the trees will be planted in rows that are 2 m apart, with trees spaced at 1.2 m spacings within these rows. Irrigation driplines will be laid on the ground surface between each row of trees, with up to four driplines equally spaced between the tree rows. Using four driplines between each row is preferred, as that would maximise the wetted area of the soil and minimise the drainage through the soil profile (McIndoe *et al*., 2022).
- Planting of wetland species in seepages – as recommended by Meurk (2022), native wetland species should be planted to provide filtration in any areas of new wetland that develop once irrigation has been implemented, as well as in existing seepages. Recommended species for this purpose include harakeke, toetoe, *Carex secta*, *Carex virgata*, *Juncus sarophorus*, mānuka48, mikimiki, and tī kōuka, with taller wet forest species such as kahikatea and pokaka at the margins (Meurk, 2022).
- Plant uptake of nutrients from irrigation water – the CCC intends to use kanuka as the primary native species to be planted in the irrigation area. Meister & Robinson (2022) provided information on the likely uptake of nitrogen from the planting of the irrigation area and as a result, McIndoe *et al*. (2022) have based their modelling on the assumption that 13.5 kg N/ha/y of applied N will be volatilised, denitrified, or taken up and removed by the planted trees.
- Minimising surface ponding and runoff – McIndoe *et al*. (2022) indicate that runoff due to irrigation can be mitigated with good irrigation design and management and maintaining good ground cover. It will be important that the land is not over irrigated, that the irrigation run times are short, and that 20 m setbacks from streams are imposed to minimise the potential for irrigation runoff to enter streams.
- Destocking the irrigation area – Lumen Environmental Ltd completed nutrient budgets for the Robinsons Bay catchment and have indicated that the decrease in nitrogen that would result from removing stock from parts of the catchment would be around 2 kg N/ha/y (McIndoe *et al*., 2022). This value has been used in modelling to assess the impact of destocking parts of the catchment on resulting nitrate levels in the stream (this is included in the 'base case', 'preferred/destocking 1', and 'destocking 2' modelled scenarios).
- Additional destocking and planting if required – on the assumption that further native tree planting and destocking within Robinsons Bay catchment (outside of the proposed irrigation areas) would further reduce the leaching of nitrogen to the stream, there is the potential for further mitigation to be applied if the actual effects on the stream are greater than anticipated. This is included in the 'destocking 2' modelled scenario.
- Deficit irrigation for Jubilee Park – within Jubilee Park, subsurface drip irrigation is proposed. With the purpose of maintaining grass cover during the dry summer months, the irrigation volumes will be managed to ensure that only the necessary water to maintain grass cover is applied, minimising the potential for drainage or runoff to occur from these sites (McIndoe *et al*., 2022).

4.5 Summary of Effects Following Additional Effects Management

Sections 4.3.1 and 4.3.2 above described the potential construction and operational effects of the ATWIS on the freshwater ecological health of the project area. However, following proper implementation of the mitigation measures covered in Section 4.4 during the construction phase, and with implementation of the 'preferred/destocking 1' or 'destocking 2' irrigation scenario, it is expected that the potential adverse effects of building and operating the ATWIS on freshwater quality and related ecology values should be less than minor overall (Table 11). However, given the variation in the modelled scenarios it will be important to regularly audit/check the appropriate implementation of these mitigation measures, and to implement a comprehensive freshwater monitoring programme to ensure that the anticipated nutrient levels in the receiving environment are not being exceeded, that any unanticipated effects are identified, and to enable the applicant to adapt the scheme operation to best address any such effects as appropriate (see proposed monitoring in Section 5).

Table 11 Summary of the level of effect of the different aspects of the proposed Akaroa Treated Wastewater Irrigation Scheme (ATWIS) on the freshwater receiving environments, along with the subsequent potential level of effects in the Resource Management Act (RMA) terminology.

	AFTER Effects Management (Assuming the 'preferred/destocking 1' irrigation scenario)	
	Magnitude of Effect*	Level of Effect (& RMA terminology)*
Construction (all waterways)		
Pipeline stream crossings	Low	Low (less than minor)
Earthworks (including access tracks)	Low	Low (less than minor)
Construction machinery	Low	Low (less than minor)
Use of cement products	Low	Low (less than minor)
Operational (specific waterways)		
Irrigation within Robinsons Bay Stream catchment (based on the 'preferred/destocking 1' scenario)	Low	Low (less than minor)
Irrigation within Grehan Stream catchment	Low	Low (less than minor)
OVERALL		Low (less than minor)

* Magnitude & level of effect as described in Table 10, with RMA terminology as defined in Section 4.2

5 RECOMMENDED MONITORING

Given assumptions around the nutrient levels that will be in the applied wastewater, the variation in the modelled scenarios relating to nutrient levels in the receiving environment, and (albeit unlikely) possibility of other contaminants reaching the receiving environment, it will be important to implement a comprehensive freshwater monitoring programme to ensure that the anticipated water quality levels in the receiving environment are not being exceeded, and to ensure that any unanticipated effects attributable to the operation of the ATWIS are identified for rectification. It is recommended that a water quality monitoring programme be developed for Robinsons Bay Stream and Grehan Stream, to monitor trends in water quality in these streams that are within the same catchment as the proposed treated wastewater irrigation areas. The monitoring programme should include measurement of typical wastewater contaminants at sites within irrigated catchments, to detect any trends in surface water quality. Annual biomonitoring of macroinvertebrates and instream habitat would also be useful for detecting longer term trends in Robinsons Bay Stream relating to nutrient effects.

5.1 Proposed Monitoring Sites

- **Robinsons Bay Stream** – two water quality monitoring sites are recommended for this stream – one at the location of our baseline water quality sampling site (which is at Sawmill Road, downstream of the proposed irrigation area (Figure 3)), and another upstream of the irrigation area to act as a control (location dependent on flow permanence).
- **Grehan Stream** – three water quality monitoring sites are recommended for this stream – these should match the locations of the two baseline water quality sampling sites on the true left and true right branches of the Grehan Stream (Figure 3), as well as an additional monitoring site further upstream, to act as a control. As both branches of the Grehan Stream are adjacent to the proposed Jubilee Park irrigation area, neither of the existing baseline sites would be suitable as the control site.

5.2 Proposed Monitoring Approach

- Water quality samples should be collected monthly from each site and samples should be analysed for the following parameters as a minimum: dissolved oxygen (should measure daily minimum as required by the NPS-FM 2020), temperature, pH, ammonia nitrogen, nitrate nitrogen, dissolved inorganic nitrogen, dissolved reactive phosphorus, *E. coli*, dissolved copper, and dissolved zinc. Sampling should include the collection of three to five years of baseline (i.e., before the scheme is in place) data. Results from these should be analysed for trends over time once sufficient data is available and compared to the baseline monitoring levels and the predicted modelled levels for the scheme, as well as to the default guideline values of ANZG (2018), the LWRP receiving water standards, and NPS-FM 2020 attribute bands.
- Macroinvertebrates and periphyton biomass should be assessed annually and should include the collection of three to five years of baseline (i.e., before the scheme is in place) data. The methods used should be those specified for macroinvertebrate and periphyton attributes in the NPS-FM 2020. Periphyton biomass (chlorophyll-*a* concentration), QMCI, MCI, and ASPM should be calculated and compared to NPS-FM 2020 attribute bands and LWRP targets for Banks Peninsula.

5.3 Trigger for Adaptive Management

If water quality, macroinvertebrate, or periphyton attributes show a degradation over time that is statistically significantly different from established baseline values (e.g., median, interquartile range), there are several potential adaptive management options that exist to further mitigate the potentially adverse effects of the proposed activity. These include:

- Further destocking of the CCC owned land within Robinsons Bay Valley to reduce nitrogen loads (such as the 'destocking 2' scenario modelled by McIndoe *et al*. (2022)).
- Additional planting of native trees outside of the irrigation area within the Robinsons Bay Valley, to allow for additional uptake of nitrogen.
- Providing for some harvesting of the trees within the Robinsons Bay Valley irrigation site if the uptake of nitrogen in the mature trees is not sufficient to maintain stream water quality.
- Higher levels of treatment of the wastewater prior to irrigation.
- Irrigating to additional areas outside of the proposed catchments to reduce the irrigation load (and thus nutrient load) on the current irrigation catchment.

6 CONCLUSION & EFFECTS MANAGEMENT SUMMARY

The construction effects of the project relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including the stream crossings required for the associated pipeline. Potential effects include the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and concrete related contaminants) and freshwater habitat disturbance (e.g., machinery working in and around waterways during construction of pipeline and access roads, stream bed disturbance for pipeline stream crossings).

The mitigations required for the construction phase of the ATWIS will be detailed in a Construction Environmental Management Plan (CEMP) that will adopt the methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury. Where the wastewater pipeline needs to cross waterways that contain water, construction methodology will involve directional drilling beneath the stream, rather than traditional trenching methods. This will avoid surface disturbance to the stream channel and the associated effects of freshwater habitat disturbance, fish migration disturbance, and the release and deposition of fine sediments. Where the wastewater pipeline needs to cross ephemeral streams, trenching methods may be used, but these works will be undertaken at a time when there is no surface water present. This approach will minimise the potential for sediment migration and entrainment in surface water, as well as avoiding disturbance to freshwater habitats and fish migration.

Assuming proper implementation of the following mitigation measures, the effect of the construction phase on freshwater receiving environments should be 'low/less than minor':

» Ensure all erosion and sediment control measures are appropriate to the highly erosive and dispersive loess subsoils present in the area.

» Construction activities should avoid any wetland areas as identified by Meurk (2022) or as subsequently identified during the construction phase.

» Sediment losses to any natural waterway are to be avoided where practicable, with relevant sediment control measures in place in all circumstances.

» Construction vehicles and machinery should be always operating outside of the watercourse and should not be driving across flowing waterways unless over a bridge (or similar) structure.

» All fuels and other construction liquids should be stored at least 20 metres away from waterways (including perennial, intermittent and ephemeral waterways) and in appropriately bunded locations. No vehicle refuelling should occur within 20 metres of waterways.

» Appropriately maintain construction vehicles and machinery on a preventative schedule to reduce the risk of breakdown. Spill kits should be located near to all machinery and staff must be trained in how to use these.

» All practical measures must be taken to ensure that no uncured cement or cement-based products enter flowing water in any waterway. Any works involving these products should be undertaken outside of the flowing channel and new concrete or mortar should not be exposed to water until firmly set (at least 48 hours).

The operational effects relate to the ongoing effects of the proposed ATWIS once it is complete and operating. The main potential effect of irrigating treated wastewater to land is the discharge of contaminants from the irrigation areas to surface water (via surface runoff or groundwater). The main effects of this are expected to be a small increase in stream flow, as well as an increase in the concentration of nitrate nitrogen in the streams within the irrigated catchment (Robinsons Bay) once irrigation is underway. Based on investigations and modelling of the water and nitrogen balance for Robinsons Bay catchment, the CCC's preferred irrigation scenario ('preferred/destocking 1' scenario from McIndoe *et al.* (2022)) will result in mean stream flow that is 7 L/s (2%) higher than existing and a stream nitrate concentration for Robinsons Bay Stream that is 190% greater than the existing median nitrate concentration (McIndoe *et al*., 2022). However, although the nitrate concentration for the stream post irrigation is likely to increase, it should still be within the typical range of variation for nitrate concentrations in Robinsons Bay Stream based on 12 months of monthly water quality monitoring data (i.e., within the interquartile range shown in Figure 13). Based on the likelihood that the stream nitrate concentration would still be within its typical range (i.e., within the existing interquartile range), and below the DGV of 0.17 g/m^3 for nitrate, the magnitude of this effect is expected to be low, and overall level of effect of this change would be low/less than minor. Mellish (2022) confirms that there is a low risk of other contaminants entering the ground or surface water, so the potential for this does not alter the overall assessment of a 'less than minor' effect.

It has been indicated by McIndoe *et al*. (2022) that irrigation to Jubilee Park within the Grehan Stream catchment will not result in changes to the water quality and quantity of Grehan Stream, since this irrigation will only be to manage soil moisture deficits and keep the grass green during dry weather. As a result, the level of effect on Grehan Stream is also considered to be low/less than minor.

The 'low/less than minor' effect of the operational effects of the scheme is based on the following effects management approaches/mitigation measures being implemented:

» No more than a median total nitrogen content of 10 g/m^3 in the treated wastewater being irrigated onto land, and selection of the 'preferred/destocking 1' option from McIndoe *et al*. (2022) which includes the following aspects:
  - Selection of most suitable area for irrigation – avoiding irrigation of ephemeral streams, boggy areas, and springs.
  - Irrigation of native trees in irrigable areas – to enhance the uptake of irrigation water and nutrients.
  - Minimising surface ponding and runoff – by good irrigation design and management and maintaining good ground cover.
  - Irrigation setbacks from streams – maintaining setbacks from streams to minimise the potential for irrigation runoff to enter streams.
  - Destocking the irrigation area – to offset some of the nitrogen that will be applied to land in the wastewater and reduce the leaching of nitrogen to surface water. There is an initial destocking programme under the 'preferred/destocking 1' scenario, with further destocking available if needed.

» Deficit irrigation for Jubilee Park – to ensure that only the necessary water to maintain grass cover is applied, minimising the potential for drainage or runoff to occur from these sites.

With proper implementation of the described effects management approaches during construction, and with implementation of the CCC's 'preferred/destocking 1' irrigation scenario, it is expected that the potential adverse effects of the ATWIS should be able to be reduced to an overall 'less than minor' effect. However, given assumptions around the nutrient levels that will be in the applied wastewater, the variation in the modelled scenarios relating to nutrient levels in the receiving environment, and (albeit unlikely) possibility of other contaminants reaching the receiving environment, it will be important to implement a comprehensive freshwater monitoring programme to ensure that the anticipated nutrient and contaminant levels in the receiving environment are not being exceeded, and to ensure that any unanticipated effects are identified so that they can be addressed if necessary. If monitoring identifies any issues, then the following adaptive management options are available:

» Further destocking of the CCC owned land within Robinsons Bay Valley to reduce nitrogen loads (such as the 'destocking 2' scenario modelled by McIndoe *et al*. (2022)).

- Additional planting of native trees outside of the irrigation area within the Robinsons Bay Valley, to allow for additional uptake of nitrogen.
- Providing for some harvesting of the trees within the Robinsons Bay Valley if the uptake of nitrogen in the mature trees is not sufficient to maintain stream water quality.
- Higher levels of treatment of the wastewater prior to irrigation.
- Irrigating to additional areas outside of the proposed catchments to reduce the irrigation load (and thus nutrient load) on the current irrigation catchment.

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9 APPENDICES

9.1 Assessment Categories for Determining Ecological Value

Table 12 Assessment categories and criteria for determining the ecological value for an Assessment of Environmental Effects.

Value	Description	Characteristics
Very high	A pristine waterway that would be representative of conditions close to its pre-human condition (i.e., a reference condition). No anthropogenic contaminant inputs. Flora and fauna effectively unchanged from pre-human condition, e.g., waterway with 100% native forest catchment.	» Benthic invertebrate community: – Contains many taxa that are sensitive to organic enrichment and settled sediments. – Typically, with no single dominant species or group of species. – MCI, QMCI, ASPM scores in NPS-FM (2020) A band (MCI ≥130, QMCI ≥6.5, ASPM ≥0.6). – EPT richness and proportion of overall benthic invertebrate community typically high. » Fish communities typically diverse and abundant. » Presence of fish or aquatic invertebrate species with a threat classification of "Threatened – nationally critical" or equivalent regional threat classification may elevate an otherwise low, moderate, or high value site to be very high. » Riparian vegetation typically with a well-established closed canopy in smaller streams. » Riparian vegetation includes a high proportion of native species that would naturally occur in this area. » Stream channel and morphology natural. » Stream banks natural typically with limited erosion. » Habitat natural and unmodified.
High	A waterway that has been modified through loss of natural riparian vegetation, catchment land use change, to the extent it is no longer pristine or could considered to be in reference condition. However, many natural, pre-human qualities are retained. E.g., a mixed native forest-agricultural catchment.	» Benthic invertebrate community: – Contains many taxa that are sensitive to organic enrichment and settled sediments. – Typically, with no single dominant species or group of species. – MCI, QMCI, ASPM scores in NPS-FM (2020) A (MCI ≥130; QMCI ≥6.5; ASPM ≥0.6) or B Bands (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4). – EPT richness and proportion of overall benthic invertebrate community typically moderate to high. » Fish communities typically diverse and abundant. » Presence of fish or aquatic invertebrate species with a threat classification of "Threatened – nationally endangered" or "Threatened – nationally vulnerable" or equivalent regional threat classification may elevate an otherwise moderate or low value site to be high. » Riparian vegetation may have a well-established closed canopy in smaller streams. » Riparian vegetation includes native species that would naturally occur in this area. » No pest or invasive fish (excluding trout and salmon) species present. » Stream channel and morphology natural. » Stream banks natural typically with limited erosion. » Habitat largely unmodified.

Value	Description	Characteristics
Moderate	A waterway that retains components of its natural state but has been modified through a loss of riparian vegetation and land use change, e.g., a predominantly agricultural catchment.	» Benthic invertebrate community: – Dominated by taxa that are not sensitive to organic enrichment and settled sediments. – Typically, with a dominant species or group of species (especially snails, amphipods, worms, chironomid midge larvae). – MCI, QMCI, ASPM scores sometimes in NPS-FM (2020) in B Band (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4) but generally in C Band (MCI ≥90 and <110; QMCI ≥4.5 and <5.5; ASPM <0.4 and ≥0.3) – EPT richness and proportion of overall benthic invertebrate community typically low. » Fish communities typically moderate diversity with lower species richness than high or very high value sites. » Presence of fish or aquatic invertebrate species with a threat classification of “At Risk” or equivalent regional threat classification may elevate an otherwise low value site to be moderate. » Pest or invasive fish species (excluding trout and salmon) may be present. » Stream channel and morphology typically modified (e.g., channelised) » Stream banks may be modified or managed and may be highly engineered and/or evidence of significant erosion. » Riparian vegetation often lacking, and stock may have access to channel. » Habitat modified.
Low	Waterway is highly modified and may have been deepened, straightened, or created for wetland drainage purposes. Virtually no aspects of its natural state remain, e.g., modified channel in agricultural or urban landscape.	» Benthic invertebrate community: – Dominated by taxa that are not sensitive to organic enrichment and settled sediments. – Typically, with a dominant species or group of species (especially snails, amphipods, worms, chironomid midge larvae). – MCI, QMCI, ASPM scores generally below NPS-FM (2020) bottom-line (D band) (MCI ≥110 and <130; QMCI ≥5.5 and <6.5; ASPM <0.6 and ≥0.4) but generally in C Band (MCI <90; QMCI <4.5; ASPM <0.3) – EPT richness and proportion of overall benthic invertebrate community typically low or zero. » Fish communities typically low diversity and less than that of moderate value sites. Shortfin tuna/eel often dominant or the only species present. » Pest or invasive fish (excluding trout and salmon) species often present. » Stream channel and morphology typically modified (e.g., channelised). » Stream banks often highly modified or managed and maybe highly engineered and/or evidence of significant erosion. » Riparian vegetation typically without a well-established closed canopy. » Habitat highly modified.
Negligible	Waterway is ephemeral and only has surface water for a short period following significant rainfall. Terrestrial vegetation often fills the channel. Typically, no aquatic fauna or flora present.	» No aquatic invertebrates present. » No fish present, although can provide migration pathways for fish (especially tuna/eel) to upstream permanent habitats (e.g., dams, lakes, ponds). In some instances, can also provide temporary foraging habitat for fish (especially tuna/eel). » Do not meet RMA definition of “river”.

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Appendix I Estuary Ecology Report

Akaroa Treated Wastewater Irrigation Scheme (ATWIS): Assessment of Environmental Effects on Estuary Ecology

EOS Ecology Report No. STA03-21004-02 | December 2022

Prepared for Stantec

Prepared by EOS Ecology – Jesse Burns, Nick Hempston

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EXECUTIVE SUMMARY

The Christchurch City Council (CCC) is applying for resource consent to apply treated wastewater to land by irrigation within the Akaroa Inner Bays (Robinsons Bay Valley, Hammond Point, and Jubilee Park (Akaroa)). The scheme, which is known as the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), will use highly treated wastewater from a new treatment plant at Old Coach Road (Childrens Bay) to irrigate native trees on land at Robinsons Bay Valley and Hammond Point, as well as the grass at Jubilee Park, rather than discharging Akaroa's treated wastewater to Akaroa Harbour as currently occurs. The Takamātua Stream catchment was considered as a possible irrigation area at the outset of the project, but was subsequently removed when the irrigation capacity of Hammond Point and Robinsons Bay Valley was found to be sufficient.

EOS Ecology has been commissioned by Stantec to prepare an assessment of environmental effects (AEE) of the ATWIS on the estuary ecology of the area. Our assessment begins by presenting the results of baseline surveys which outline the state of the existing environment (intertidal benthic ecology) in areas where the scheme may impact on estuary ecology, then follows on to an AEE on the harbour receiving environments relevant to the proposed ATWIS.

We initially identified Robinsons Bay, Takamātua Bay, and Childrens Bay as the intertidal embayments that could be affected by the scheme as receiving environments. Although the Takamātua Stream catchment is not a part of ATWIS, the monitoring information for the receiving environment embayment is included as part of this report to provide context and information that may be relevant to future studies. Surveys of benthic infauna, epifauna, and flora were undertaken to describe the communities inhabiting the intertidal areas in these bays. We found that the estuary ecological values in Takamātua Bay were 'low' due to low flora cover and macroinvertebrate species richness, but 'moderate' for Robinsons Bay and Childrens Bay largely due to the presence of seagrass beds and relatively diverse macroinvertebrate communities. Seagrass (*Zostera muelleri*) has a national threat status of 'At Risk – Declining' in New Zealand and provides valuable habitat and food resources for many estuarine taxa.

True limpets (*Notoacmea* sp.) were the most widespread and abundant epifauna macroinvertebrate taxon, while the wedge shell bivalve (*Macomona liliana*) was the most widespread and the polychaete *Heteromastus filiformis* was the most abundant infauna taxon. Overall, there was a greater diversity and abundance of infaunal taxa across the sampled sites relative to epifauna, with polychaete worms and molluscs (snails and shellfish) comprising the majority of the infaunal macroinvertebrates. The New Zealand cockle (*Austrovenus stutchburyi*) was found in the epifauna and infauna surveys in all three embayments, but was present in notably high abundances in Robinsons Bay.

As part of the AEE, we identified the potential construction and operation effects of the ATWIS. The construction effects of the ATWIS relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including the stream crossings required for the associated pipeline. Potential effects include the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and concrete related contaminants) that may ultimately reach the harbour through freshwater runoff.

The operational effects relate to the ongoing effects of the proposed ATWIS once it is complete and operating. The main potential effect of irrigating treated wastewater to land is the discharge of contaminants (especially nitrogen) from the irrigation areas reaching Akaroa Harbour through freshwater runoff from Robinsons Bay Stream or drainage from land from Hammond Point. Based on investigations and modelling of the nitrogen balance for Robinsons Bay Stream catchment, the CCC's preferred irrigation scenario is expected to result in a post irrigation stream nitrate concentration for Robinsons Bay Stream that will be within the typical range of

variation for this water quality parameter. The effect of this modelled nitrate increase to the freshwater ecology has been assessed by Dewson (2022) as low/less than minor, and the freshwater ecosystem function in Robinsons Bay Stream is not expected to significantly change under the preferred irrigation scenario (Dewson, 2022). As such, the nutrients entering Robinsons Bay through freshwater runoff and the assessed level of effect on the intertidal benthic ecology is also expected to be less than minor, under the CCC's preferred irrigation scenario.

Modeling has indicated that the irrigation of treated wastewater to Hammond Point may result in an increase in nutrients entering Akaroa Harbour via drainage through the soil. Under the most conservative scenario, where all nitrogen in the irrigation water enters the harbour, the nitrogen load discharged annually will be significantly lower than the annual nitrogen load discharged into the harbour under the current wastewater discharge scheme. As the current scheme will be terminated with the establishment of the ATWIS, there will be an expected overall decrease in the wastewater nitrogen load discharged into the harbour. In this context, the effect of nitrogen released from Hammond Point is expected to be negligible. However, any nutrient discharge into the harbour may be more varied and seasonal, and ongoing water quality monitoring is recommended to ensure there will be no resulting adverse effects on the ecology of Akaroa Harbour.

There is also a possibility that pathogens and their indicators present in the treated wastewater could be flushed into Akaroa Harbour. The discharge from both Robinsons Bay Stream and from Hammond Point is expected to release into Robinsons Bay, where there is a relatively large New Zealand cockle population that represents an opportunity for the collection of mahinga kai. Ongoing shellfish pathogen monitoring in Robinsons Bay is recommended to ensure that any cockles that may be collected will be safe for human consumption.

Effects management will be an important part of the ATWIS and has been a consideration throughout the planning of this project. The mitigations required for the construction phase of the ATWIS will be detailed in a Construction Environmental Management Plan (CEMP) that will adopt the methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury. As for the operational stage, the preferred irrigation scenario proposed by CCC includes the planting of native trees both within the irrigation area as well as for infill and riparian planting, along with destocking of the planted areas to offset the nutrients introduced to the catchment by the treated wastewater. Additional mitigation options are available for the operational phase if monitoring indicates that this is necessary.

With proper implementation of the described effects management approaches during construction, and with implementation of the CCC's preferred irrigation scenario and subsequent modelled/predicted nutrient outputs to stream flow, it is expected that the potential adverse effects of the ATWIS should be able to be reduced to an overall less than minor effect. Monitoring of the estuary receiving environments is recommended so that scheme operators and consent authorities will become aware of any unanticipated effects in a timely manner. Several adaptive management approaches are suggested to attend to any unanticipated effects.

1 INTRODUCTION

The Christchurch City Council (CCC) has resource consent to build a new wastewater treatment plant in Akaroa to replace the existing wastewater treatment plant at Takapūneke Reserve. The new wastewater treatment plant will be located on Old Coach Road, Childrens Bay, Akaroa (Figure 1). In December 2020, the Council resolved that the highly treated wastewater from the new treatment plant would be discharged to land, rather than to the Akaroa Harbour as currently occurs. The Council also decided that the treated wastewater would be irrigated to land within the Akaroa Inner Bays (Robinsons Bay, Hammond Point, and Takamātua), and that there would be additional investigations around the feasibility of irrigating public spaces within Akaroa and the non-potable reuse of treated wastewater within Akaroa. Following a period of further design and investigation, the proposed scheme now includes a surface drip irrigation system to irrigate native trees with the treated wastewater at Robinsons Bay Valley and Hammond Point, as well as subsurface drip irrigation of Jubilee Park in Akaroa during dry periods.

To achieve the CCC's vision for Akaroa's new wastewater reuse scheme, Stantec are leading a project to undertake the detailed scheme design and consenting for the proposed Akaroa Treated Wastewater Irrigation Scheme (ATWIS). EOS Ecology was commissioned by Stantec to undertake ecological assessments and water quality sampling to support the preparation of an assessment of effects (AEE) for ATWIS. This work has included technical assessments of water quality and freshwater ecology (Dewson, 2022), as well as estuary ecology (this report).

This report describes the state of the existing environment in areas where the scheme may impact intertidal ecology in Akaroa Harbour. The report also includes an assessment of the likely effects of construction and operational stages of the project on the estuarine ecology of these areas. Baseline information about water quality, freshwater ecology, and an assessment of the potential effects of the ATWIS on freshwater ecology are presented in a related report (Dewson, 2022). Both the freshwater and estuary ecology assessments are based on the most up to date scheme design details for ATWIS, as provided by Stantec at the time of writing this assessment.

Figure 1 *…figure over page…* Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), including key geographical landmarks, the proposed locations of the irrigation areas in Robinsons Bay Valley, Hammond Point, and Jubilee Park (Akaroa), and the proposed pipeline route.

Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS)

WASTEWATER PIPELINE

- Two pipelines (raw wastewater uphill, treated wastewater downhill)
- WWTP discharge pipeline (treated wastewater)
- Pipeline stream crossings
- Irrigation areas
- Existing outfall pipe
- Waterways

0 200 400 800 Meters

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: pipeline, WWTP, outfall, irrigation areas: CCC; pipeline stream crossings: EOS Ecology from site visits; waterways: modified by EOS Ecology from site visits, original layers by LINZ & CCC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

2 METHODS

We identified the waterways that might be affected by aspects of the proposed ATWIS[1]. As this work was completed prior to the completion of detailed scheme design, the range of waterways identified was initially broad, including Robinsons Bay Stream (also known as Lavericks Drain), Takamātua Stream, Childrens Bay Creek, and Grehan Stream (Figure 1). We then identified the embayments that act as receiving environments to these waterways, including Robinsons Bay, Takamātua Bay, and Childrens Bay. We completed a literature search to gather existing ecological and water quality information for these freshwater environments and worked through a gaps analysis to identify areas where additional survey and sampling work was required. The following provides an overview of the methodology employed for the estuary ecological surveys.

2.1 Ecological Surveys

EOS Ecology undertook a site visit on 20 October 2021 to establish the predetermined intertidal survey areas within each embayment. The dimensions of each survey area were 60 m x 40 m, located 40 m out into the bay and oriented lengthwise against the inner shore (Figure 2). The survey areas were positioned to include intertidal habitat where the freshwater stream runoff flows across the mudflat at low tide, and were marked with a GPS to allow for accurate relocation of the survey sites at a later date.

Ecological surveys took place at low tide on 17–19 November 2021, with one bay surveyed on each of the three days. Following the standardised methodology defined by Robertson *et al.* (2002) for assessing and monitoring New Zealand estuaries, each survey site was divided into a grid of 16 equally-sized (15 m x 10 m) plots, and 12 of the 16 plots were randomly selected for epifaunal and infaunal surveys.

2.1.1 Epifauna and Flora

At each of the 12 selected plots per survey site, a 0.5 m x 0.5 m quadrat was placed at random to assess the cover of estuarine flora (macroalgae and seagrass) and the composition of the epifauna macroinvertebrate community. The percent cover of flora within each quadrat was estimated by counting the number of grid intersections within each quadrat (49 intersections in total) that overlapped any flora species, and converting to a percent cover value using the formula:

$$(N/49) \times 100$$

Where N = number of grid intersection points

49 = maximum number of grid intersections

Following flora estimation, macroinvertebrates dwelling on the surface were identified and counted. Any large flora was lifted, and the underside also inspected for biota. Length measurements were taken for all encountered New Zealand cockles (*Austrovenus stutchburyi*).

[1] At the time of the ecological survey, the design of the proposed scheme included an irrigation area in Robinsons Bay Stream Catchment, Takamātua Stream catchment, and a wetland discharge to Childrens Bay Stream. However, at the time of writing this report the scheme design had been finalised as having an irrigation area in Robinsons Bay Stream catchment and Hammond Point, and no wetland discharge to Childrens Bay Stream.

In addition to the epifauna quadrats, a free search was conducted in the wider intertidal area of each sampled embayment to record the presence/absence of macroinvertebrate taxa (including any that were not already identified in the quadrats), as well as to record the general extent of intertidal seagrass beds within each bay.

2.1.2 Infauna

Infauna samples were collected at each of the plots selected for epifaunal surveys. A 130 mm diameter core was pushed 150 mm into the sediment, then dug out and inverted into a 500-micron mesh bag. The samples were washed in seawater to remove sediment before preserving in 70% isopropanol (isopropyl alcohol) for laboratory processing.

In the laboratory, each infauna core sample was washed through a 500-micron sieve prior to processing. Processing involved the identification and counting of all invertebrates to the lowest practical level of classification using a full count procedure and stereo microscope. Length measurements were taken for all New Zealand cockles (*A. stutchburyi*) encountered in the infauna samples.

2.2 Data Analysis

Density (presented as numbers per 0.5 m x 0.5 m quadrat for epifauna samples, and numbers per core for infauna samples) and taxa richness of macroinvertebrates were calculated for each survey site. Distribution of infauna invertebrate communities was examined using non-metric multidimensional scaling (NMS), and the difference in community composition between each bay was tested using the analysis of similarities (ANOSIM) procedure. Half of the survey sites in Childrens Bay had insufficient epifaunal densities to allow for data analysis, so the epifauna invertebrate communities were compared with NMS and ANOSIM procedures in Robinsons and Takamātua Bays only.

NMS is a non-metric statistical technique that condenses site data to a single point in low-dimensional ordination space using some measure of community dissimilarity (Bray-Curtis metric in this instance). Interpretation is straightforward such that points on an x-y plot that are close together represent sites that are more similar in community composition than those further apart (Clarke & Gorley, 2015). ANOSIM is a non-parametric procedure applied to the similarity matrix that underlies the NMS ordination, and is an approximate analogue of the standard ANOVA (analysis of variance) and compares the similarity between groups using the R test statistic. R=0 where there is no difference in the infauna community between groups, while R=1 where the groups have completely different communities. Where ANOSIM results showed significant or near-significant differences in infauna community compositions, the similarity percentages (SIMPER) procedure was used to determine which taxa where responsible. NMS, ANOSIM, and SIMPER were all carried out in PRIMER v7.0.17 (Clarke & Gorley, 2015).

Figure 2 *...figure over page...* Map showing site locations of intertidal estuary ecology survey areas in Robinsons Bay, Takamātua Bay, and Childrens Bay in Akaroa Harbour. Surveys undertaken by EOS Ecology on 17-19 November 2021.

Estuary Ecology Survey Sites

Estuary sampling sites

Waterways

Roads

0 250 500 1,000 Meters

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Estuary ecology sites determined by EOS Ecology in 2021, Waterways: Modified by EOS Ecology from site visits, original layers by LINZ & CCC; Highways: LINZ.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3 STATE OF THE EXISTING ENVIRONMENT

3.1 Akaroa Harbour Overview

The Akaroa Harbour is a 17 km long tidal inlet occupying the drowned crater of the extinct volcano complex of Banks Peninsula (Heuff *et al.*, 2005), classified as a deep drowned valley coastal hydrosystem (Hume *et al.*, 2016). It is on a predominately north-south orientation, with the harbour mouth pointing approximately SSE. The surface area of the harbour covers 44 km^2 at high tide, with semidiurnal tides ranging between 1.2 m (average neap) and 2.3 m (average spring) and infiltrating into several large embayments around the harbour periphery (Heath, 1976; LINZ, 2021). Freshwater runoff enters the harbour at an annual mean rate of 2 m^3/s from a number of streams across the 200 km^2 catchment, however the discharge volume can vary widely with season and rain events (Heath, 1976; McDowell, 2008). The catchment comprises pasture, dairy farms, and several small townships and holiday settlements.

Intertidal mudflat covers about 4% (2 km^2) of the 44 km^2 harbour area (Heath, 1976). Subtidal areas are dominated by silt and clay, while all of the harbour embayments except Wainui and Barrys Bay have notable proportions of sandy substrate (Figure 3; Hart *et al.*, 2009). Hart *et al.* (2009) noted a particularly high presence of sand in Childrens Bay, and Bolton-Ritchie (2005) reported predominately sandy substrates in Robinsons and Takamātua Bays.

The hydrodynamics of Akaroa Harbour is dominated by tidal currents, with a strong north-south flow and influx of water into each of the harbour bays on flood tides and drainage out on ebb tides (Bell *et al.*, 2014). Wind is a secondary driver of harbour hydrodynamics, generally channeling along the main north-south access and contributing to circulation and flushing (Heuff *et al.*, 2005; Bell *et al.*, 2014). Strong winds also contribute to vertical circulation, notably increasing mixing within the water column (Heath, 1976; Heuff *et al.*, 2005). Using data collected for the Canterbury Regional Council regional coastal water quality sampling programme, Dudley *et al.* (2019) undertook exploratory multivariate statistical analyses to derive geographic 'ecosystem zones', or areas in Canterbury's coast with statistically similar water quality conditions. Their analysis shows clustering of the seven water quality sites in Akaroa Harbour, with stability in this grouping based on water quality data collected in the summer and the winter, which suggests the mixing equalises water quality conditions throughout the harbour. Although the cluster sites within Akaroa Harbour were distinct from the other geographic areas, they showed the most similarity with offshore waters rather than nearshore water or Lyttelton Harbour (Dudley *et al.*, 2019).

Deep drowned valley hydrosystems are characterised by slow flushing time, particularly in the headwaters (Hume *et al.*, 2016). Hydrodynamic model simulations of Akaroa Harbour have calculated an overall residence time of up to ~120 days for a non-decaying substance (Bell *et al.*, 2014). This time can vary on a small geographic scale, with tidal exchange reducing the flushing time closer to the harbour entrance, while contaminant loading from freshwater runoff in the upper harbour may remain in the system for longer.

Current Wastewater Discharge into Akaroa Harbour

The existing wastewater treatment plant (WWTP) is located south of Akaroa Township, at Takapūneke at the end of Beach Road, and has been in operation since its construction in the 1960s. Under the current discharge permit CRC202179, treated wastewater is discharged into the harbour through a 5.9 m deep, 100 m long outfall pipe off Redhouse Bay (Figure 1). The current treatment process includes Imhoff tanks where primary solids are settled out of the wastewater for storage and anaerobic digestion, a trickling filter for biological treatment, and a UV disinfection system to reduce micro-organisms in the wastewater (O'Brien & Dunning, 2020). There are two additional treated wastewater outfalls in Akaroa Harbour off Wainui and Duvauchelle, with all three outfalls serving predominantly residential communities to treat and discharge mainly household sewage and grey water wastewater (Bolton-Ritchie, 2013). The WWTPs are not designed to remove or reduce wastewater nutrient concentrations, except that associated with solids.

The current resource consent conditions require grab samples to be collected from the Akaroa WTTP effluent after wastewater treatment and prior to discharge into the harbour to keep a record of wastewater quality. Measured nutrients include total nitrogen (TN), ammoniacal nitrogen (NH_3-N), oxides of nitrogen (NOx), dissolved reactive phosphorous (DRP), and total Kjeldahl phosphorus (TKP). Between July 2017 and May 2022, TN ranged from 2.60 – 50.88 g/m^3 (Table 1; CCC, unpublished data), and ammoniacal nitrogen did not typically account for most of the TN in the collected samples. All of the samples where ammoniacal nitrogen accounted for at least 75% of TN concentrations fell between November and February when there is an influx of holiday-makers to the area.

The nutrient load in the effluent is irregular due to the daily variations in discharge volume and nutrient concentrations, and no measured data is available for the cumulative annual nutrient load that is released into the harbour from the Akaroa WWTP. Following the protocol used by Bolton-Ritchie (2013), the annual effluent nutrient loads were calculated using the mean and median daily wastewater nutrient concentrations and measured daily flow volume data. Annual nutrient loads were calculated for the years where data was available for the full calendar year (2018 to 2021) and were calculated using both mean and median values for each nutrient (Table 1).

The harbour receiving environment is also monitored, as required under the current consent conditions, via the collection of water quality samples from three pre-determined sites 250 m from the outfall and two additional control sites. Samples are collected on four separate occasions during each summer period to measure nutrient levels and chlorophyll-a (an indicator of phytoplankton abundance and biomass), with a total of 21 sampling occasions between December 2017 and February 2022 (including one additional sampling date in the summer of 2021/22). Of the receiving environment data collected since December 2021, there was only one site on one occasion (250 m south of the outfall on 16 Jan 2020) where median levels of DIN were slightly above the consent trigger value of 0.062 mg/L.

Although it is UV treated before discharge, wastewater effluent from the existing Akaroa WWTP contains detectable levels of faecal indicator bacteria (Table 1). The highest levels of faecal indicators were recorded between February and March, in line with the typical increase in summer tourism. Although these inputs can have a localised impact on monitored faecal indicators, modelling by Bell *et al.* (2014) shows that the combination of dilution, harbour-wide dispersal and flushing, and virus inactivation greatly reduces the concentration of faecal contaminants in the wider system. Sampling of the receiving environment between July 2017 and May 2022 (monthly sampling frequency April–November, approximately weekly sampling frequency December–March) recorded a median of 3 CFU/100 ml of faecal coliforms and 10 MPN/100 ml of enterococci at three sites 400 m from the WWTP outfall. The median initial dilution of wastewater entering the harbour is 1480-fold, although this may decrease as effluent discharge increases or current velocity drops (Bell *et al.*, 2014), so there are some periods of time when faecal indicators will be more present in the environment. Faecal coliform concentrations up to 450 CFU/100 ml and enterococci concentrations up to 690 MPN/100 ml have been recorded 400 m away from the outfall.

Data collected by Environment Canterbury between 1989 and 2009 indicates that there has been no decline in harbour water quality nor increase in nutrient concentrations over time, and ammoniacal nitrogen concentrations have remained well below levels that are toxic to marine life (Bolton-Ritchie, 2013). The sources of nutrients in Akaroa Harbour include wastewater discharge, potential discharge from unsewered areas close to the coastline, runoff from farmland, stormwater discharge, and salmon farming. Investigation into nutrient sources by Bolton-Ritchie (2013) found wastewater discharge contained two to three times more ammoniacal nitrogen than stream discharge, but streams contribute up to 7.7 times more TN than wastewater outfalls. Similar levels of DRP were discharged by streams and wastewater. Significant seasonal variations were found in nitrite, nitrate, and DRP levels measured in Robinsons, Takamātua, and Childrens Bay, with higher concentrations in winter and lower concentrations in summer (Bolton-Ritchie, 2013). No seasonal differences were noted in ammoniacal nitrogen concentrations. In a more recent analysis of water quality data by Dudley *et al.* (2019), the off-shore ocean was determined to be the dominant source of both nitrogen and phosphorus (55% and 69%, respectively) in Akaroa Harbour. Local streams were found to be the second largest contributor, supplying 33% of nitrogen and 18% of phosphorus, while WWTP discharges contributed 1-2% of each nutrient. The remaining 10-12% of nitrogen and phosphorus was determined to come from rivers along the Canterbury and Otago coasts.

Table 1 Wastewater effluent nutrient and effluent faecal bacteria concentrations, and annual loads of total nitrogen (TN), ammoniacal nitrogen (NH_3-N), oxides of nitrogen (NOx), dissolved reactive phosphorus (DRP) and total Kjekdahl phosphorus (TKP) discharged from the current Akaroa WWTP outfall into Akaroa Harbour. Data was collected by Christchurch City Council under the requirements of resource consent CRC202179 (Data supplied by CCC).

Year		Effluent nutrient concentrations (g/m^3)					Effluent faecal bacteria concentrations	
		Total nitrogen (TN)	Ammoniacal nitrogen (NH_3-N)	Oxides of nitrogen (NOx)	Dissolved reactive phosphorus (DRP)	Total Kjeldahl phosphorus (TKP)	Faecal coliforms (CFU/100 ml)	Enterococci (MPN/100 ml)
July 2017–May 2022	Minimum	2.60	0.31	0.11	0.18	0.38	10	10
	Median	24.95	11.00	10.50	2.00	2.80	80	20
	Mean	25.16	11.87	11.09	2.12	2.97	24,964	1,869
	Std. Deviation	8.30	9.10	6.94	1.20	2.15	59,509	5,914
	Maximum	50.88	42.00	29.00	5.70	21.00	1,400,000	37,000
	No. of samples	110	123	110	110	110	174	111
		Annual effluent nutrient load (kg/year)						
2018	Median	5730	2424	2865	507	661		
	Mean	5769	2445	2556	479	808		
2019	Median	5222	2687	1262	304	526		
	Mean	5603	3196	1550	320	546		
2020	Median	3682	1774	843	340	444		
	Mean	3946	2042	1238	334	478		
2021	Median	4101	760	2684	453	520		
	Mean	3983	1500	2707	470	512		

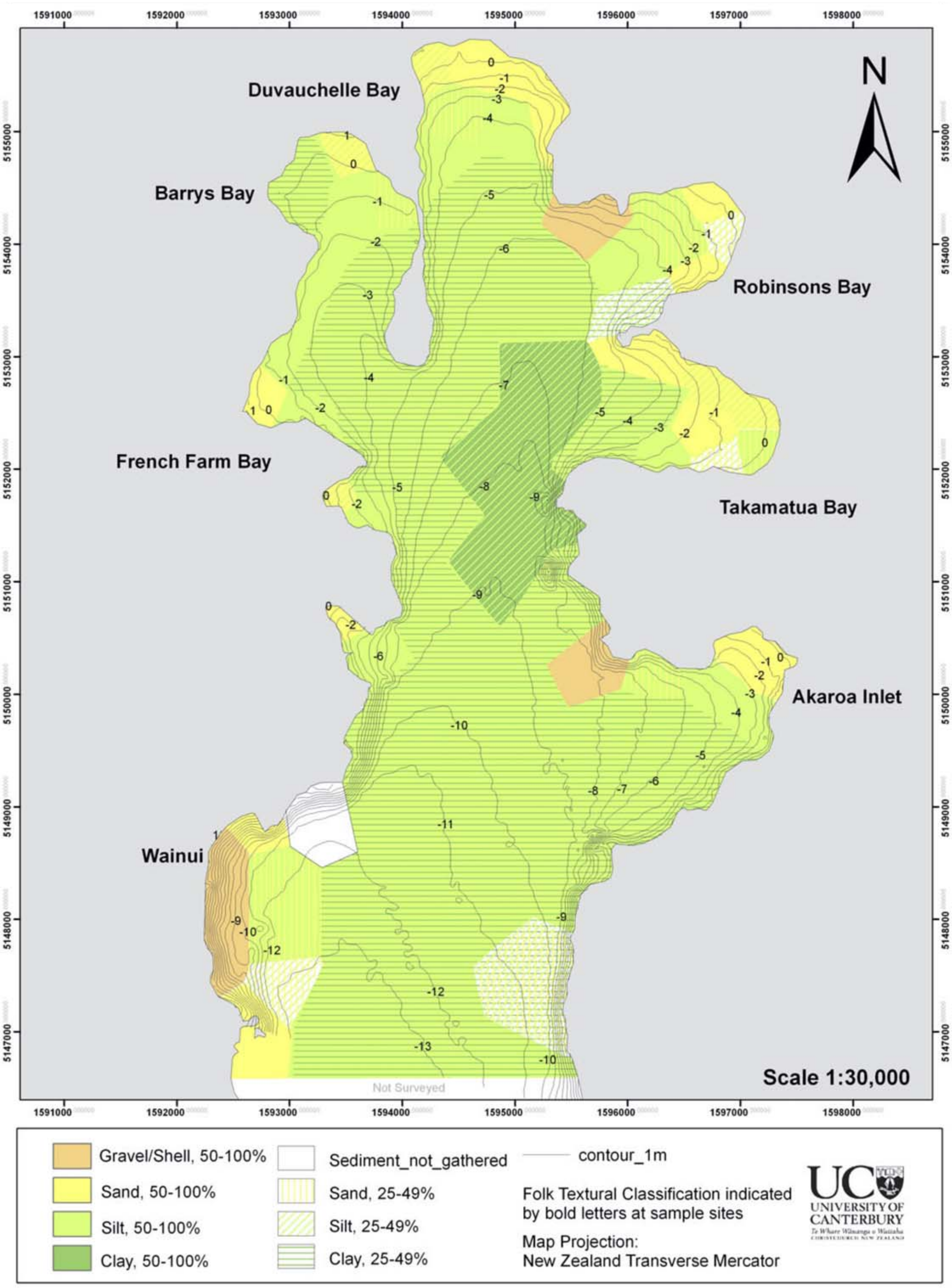

Figure 3 Map of Akaroa Harbour bathymetry and sediment distribution, as reported by the University of Canterbury for Environment Canterbury. Note: Childrens Bay is referred to as 'Akaroa Inlet' (Source: Hart *et al.*, 2009).

3.2 Flora

A total of three flora taxa were identified from the intertidal embayments surveyed by EOS Ecology in 2021: the seagrass *Zostera muelleri*, the green filamentous algae *Ulva* sp., and the red algae *Gracilaria chilensis*. At least one flora taxon was observed in 23 of the 36 total sites, however the community structure was distinctly different in each of the bays. The most widespread taxon was *Ulva* sp., which was present in all three bays and represented the greatest mean cover in Takamātua Bay. *Gracilaria chilensis* had the highest mean cover in Childrens Bay, while seagrass had the highest mean cover in Robinsons Bay (Figure 4). Robinsons Bay had the greatest overall flora cover, primarily driven by the higher seagrass coverage within the survey site. The northern half of the Robinsons Bay sample area fell across the edge of a larger seagrass bed (Figure 5), and *Z. muelleri* had a mean cover of 67.3% (range: 46.9%–91.8%) in the six quadrats that fell in this northern half. One smaller patch of *Z. muelleri* was also recorded in the Childrens Bays (24.0% cover in one site), however the investigation of the wider intertidal area revealed two larger seagrass beds on either side of the sampling area (Figure 6). Both Robinsons and Childrens Bays appeared to have subtidal seagrass beds as well, however the extent of the beds was not recorded due to the inability to access subtidal areas. No seagrass was observed in Takamātua Bay.

The presence of *Z. muelleri* in Robinsons Bay and Childrens Bay is a good indication that the system is not currently experiencing chronically high nutrient or sediment loads, as this taxon is sensitive to poor water quality conditions (Turner & Schwarz, 2006; Li *et al*., 2019; Zabarte-Maeztu *et al.*, 2020). The relatively low covers of *Ulva* sp. and *G. chilensis* further suggests the presence of low levels of nutrient in the system, as blooms of *Ulva* and *Gracilaria* species are common around the world in conditions of high nitrogen and phosphorus concentrations (Teichberg *et al.*, 2010).

Due to declining numbers around New Zealand and vulnerability to ongoing natural and anthropogenic threats, *Z. muelleri* has a national threat status of 'At Risk – Declining' (de Lange *et al*., 2018). No macroalgae taxa of conservation concern (as listed in Nelson *et al*. (2019)) were identified in the sampling areas.

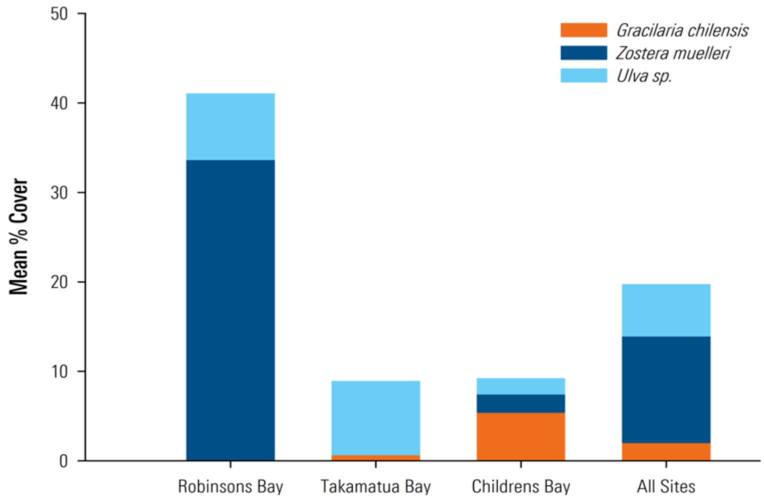

Figure 4 Mean flora percent cover in intertidal survey sites in the Akaroa Harbour by EOS Ecology on 17–19 November 2021. Site locations are shown in Figure 2.

Figure 5 *...figure over page...* Location of intertidal seagrass bed in Robinsons Bay, observed by EOS Ecology on 17 November 2021.

Figure 6 *...figure two pages over...* Location of intertidal seagrass beds in Childrens Bay, observed by EOS Ecology on 19 November 2021.

Seagrass beds in Robinsons Bay

Seagrass beds
Robinsons Bay sampling area
Waterways

0 15 30 60 Meters

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: Estuary ecology sites & seagrass beds determined by EOS Ecology in 2021, Waterways: Modified by EOS Ecology from site visits, original layers by LINZ & CCC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors


Childrens Bay Creek
Grehan Stream
Grehan Stream
Childrens Bay
eos ECOLOGY
Seagrass beds in Childrens Bay
Seagrass beds
Childrens Bay sampling area
Waterways
0 15 30 60 Meters
N
Map © EOS Ecology, 2022 / www.eosecology.co.nz
Layer source: Estuary ecology sites & seagrass beds determined by EOS Ecology in 2021, Waterways: Modified by EOS Ecology from site visits, original layers by LINZ & CCC.
Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

3.3 Macroinvertebrates

3.3.1 Epifauna Macroinvertebrates

A total of 11 macroinvertebrate taxa were identified in the epifauna samples collected from the three intertidal sites. Of these 11 taxa, true limpets (*Notoacmea* sp., 24 samples), the spotted top-shell snail (*Diloma subrostratum*, 17 samples), the New Zealand cockle (*A. stutchburyi*, 12 samples), and the mud-flat snail (*Amphibola crenata,* 11 samples) were the most widespread (Figure 7). All other taxa were found at six or fewer sites, with three taxa present at only one site. Taxa richness varied from 0–7 taxa per sample, while densities ranged from 0–52 individuals per sample. Of the 36 epifaunal samples collected across all three bays, seven (one sample in Takamātua Bay and six samples in Childrens Bay) had no epifauna taxa.

Of the 468 individuals identified in the epifauna surveys, true limpets were the most abundant taxa, representing over one third (35.7% overall abundance) of all animals. Spotted top-shell snails (27.1% abundance), cockles (18.2% abundance), and the snails *A. crenata* (11.3% abundance) and *Micrelenchus tenebrosus* (3.0% abundance) were the next most abundant taxa. The remaining six taxa each comprised less than 2% of overall abundance.

No invertebrate taxa of conservation concern (as listed in the threatened species list of Freeman *et al*. (2014)) were recorded from the project area, however the edible shellfish New Zealand cockles and pipis (*Paphies australis*) were present in the survey areas. The taxa and densities of intertidal macroinvertebrates present in Akaroa Harbour indicate there is no significant nutrient load or excessive fine sediment in the intertidal habitats (Gibbs & Hewitt, 2004; O'Brien *et al.*, 2010).

True limpets	Spotted top-shell snail	Mud-flat snail
Notoacmea sp.	*Diloma subrostratum*	*Amphibola crenata*
24 sites,35.7% relative abundance	17 sites, 27.1% relative abundance	11 sites, 11.3% relative abundance

Figure 7 Images of the most abundant and widespread epifauna macroinvertebrate taxa collected from the three intertidal survey sites in Akaroa Harbour by EOS Ecology on 17–19 November 2021.

Location Comparison

The epifauna community in Childrens Bay was a notable outlier in the three survey sites, as the total macroinvertebrate density was more than an order of magnitude lower than what was observed in Robinsons and Takamātua Bays, and mean abundance per quadrat sample was close to zero (Figure 8). Half of the survey samples had no epifauna macroinvertebrates present, which did not allow this survey area to be included in further data analysis.

NMS ordination of the infauna macroinvertebrate data in Robinsons and Takamātua Bays showed little overlap between the two communities (Figure 9), with a significant moderate (p=0.001, ANOSIM Global R=0.638) difference in community composition. SIMPER analysis indicated the difference was primarily driven by the spotted top-shell (*D. subrostratum*), which was most abundant taxa (at 37.6% total abundance) in Robinsons Bay but found in low densities (5.0% abundance) in Takamātua Bay; and the mud-flat snail (*A. crenata*), which was much more abundant in Takamātua Bay than Robinsons Bay (at 36.9% abundance and 0.3% abundance, respectively).

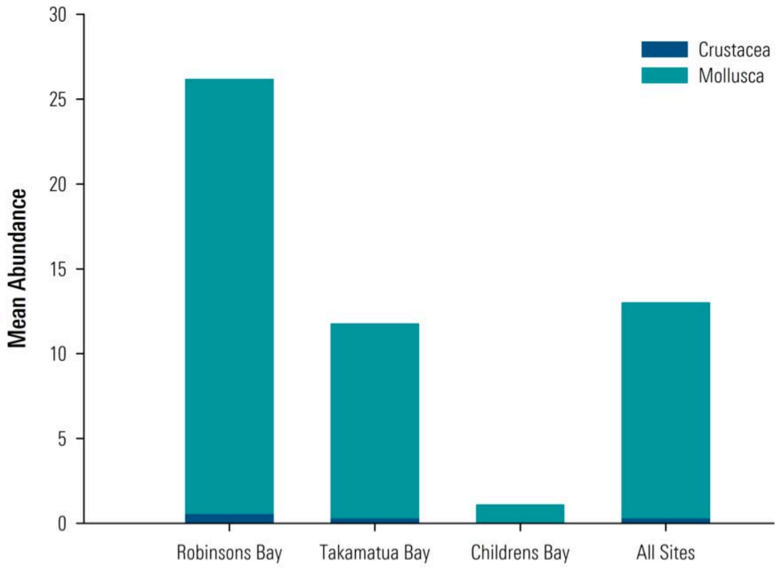

Figure 8 Mean abundance of epifauna macroinvertebrate groupings collected from three quadrat samples in the Akaroa Harbour by EOS Ecology on 17–19 November 2021.

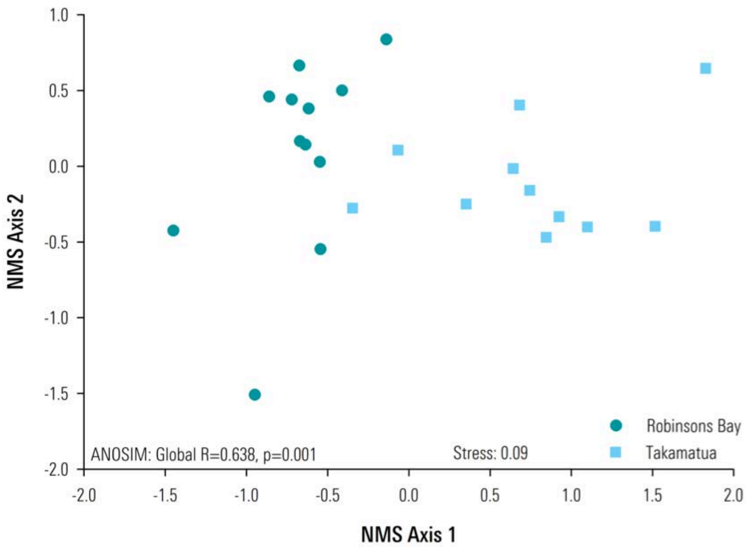

Figure 9 Non-metric multidimensional scaling (NMS) ordination of epifauna macroinvertebrates collected from two quadrat samples in the Akaroa Harbour by EOS Ecology on 17–19 November 2021.

3.3.2 Infauna Macroinvertebrates

A total of 47 taxa were identified from the infaunal samples collected from the three intertidal sites. Of these 47 taxa, the wedge shell bivalve (*Macomona liliana*, 29 samples), the polychaete *Heteromastus filiformis* (28 samples), and the New Zealand cockle (27 samples) were the most widespread (Figure 10). Other widespread taxa included Calliopiidae amphipod crustaceans *(Paracalliope* sp., 21 samples), Lasaeidae bivalves (*Arthritica* sp., 20 samples), ribbon worms (Nemertea, 18 samples), and Magelonidae polychaetes (*Magelona* sp., 17 samples). All other taxa were found at 12 or fewer sites, with 24 taxa present at three or fewer sites.

Infauna taxa richness varied from 2–16 taxa per samples, while densities ranged from 5–78 individuals per sample. A total of 1264 infauna animals were collected across all survey sites, with the *H. filiformis* polychaete representing the most abundant taxon at 24.5% of all individuals. Cockles (12.5% overall abundance), wedge shell bivalves (11.8% abundance), the polychaete *Scoloplos cylindrifer* (8.1% abundance), Lasaeidae bivalves (6.6% abundance), Calliopiidae amphipods (6.3% abundance), hooded shrimp (Cumacea, 4.7% abundance), Magelonidae polychaetes (4.0% abundance), ribbon worms (3.3% abundance) and true limpets (2.5% abundance) were the next most abundant taxa. The remaining 37 taxa each comprised less than 2% of overall abundance.

No invertebrate taxa of conservation concern (as listed in the threatened species list of Freeman *et al*. (2014)) were found in the infauna samples, and the community was not dominated by taxa that are indicative of significant nutrient enrichment or excessive fine sediment (Gibbs & Hewitt, 2004; O'Brien *et al.*, 2010).

Wedge shell bivalve
Macomona liliana
29 sites,11.8% relative abundance

Polychaete
Heteromastus filiformis
28 sites, 24.5% relative abundance

NZ cockle
Austrovenus stutchburyi
27 sites, 12.5% relative abundance

Figure 10 **Images of the most abundant and widespread infauna macroinvertebrate taxa collected from the three intertidal survey sites in Akaroa Harbour by EOS Ecology on 17–19 November 2021.**

Location Comparison

Robinsons Bay had the highest mean abundance of the three survey sites, with a particularly high mean abundance of molluscs compared to either Takamātua or Childrens Bays (Figure 11). The abundance of molluscs was driven by a particularly high relative density of cockles, with 68% (108 of 158) of the collected individuals found here. More taxonomic groups were found in Takamātua Bay, however this site also showed a lower mean abundance of crustaceans and nemerteans (ribbon worms) (Figure 11). This finding is supported by another study undertaken by Environment Canterbury in 2003 which identified Robinsons Bay as the most biologically rich intertidal flat of the inner Akaroa Harbour (including Barrys, Duvauchelle, Robinsons, and Takamātua Bays) (Bolton-Ritchie, 2005).

NMS ordination of the infauna macroinvertebrate data showed little overlap between the communities in the three survey sites (Figure 12), with a significant moderate difference (p=0.001, ANOSIM Global R=0.639) in community composition. SIMPER analysis indicated the difference was driven by several taxa creating a unique community in each area. In addition to the high cockle densities, Robinsons Bay also showed the highest total macroinvertebrate density and general taxa richness, with close to double the total density and taxa richness of the other two sampled areas. Takamātua Bay had higher numbers of the polychaete *S. cylindrifer* and lower numbers of the polychaete *H. filiformis* relative to the other two embayments, while Childrens Bay had proportionally low numbers of the wedge shell bivalve. Hooded shrimp (Cumacea crustaceans) were found in relatively high abundance in Childrens Bay (17.9% abundance), but were absent from Robinsons and Takamātua Bays.

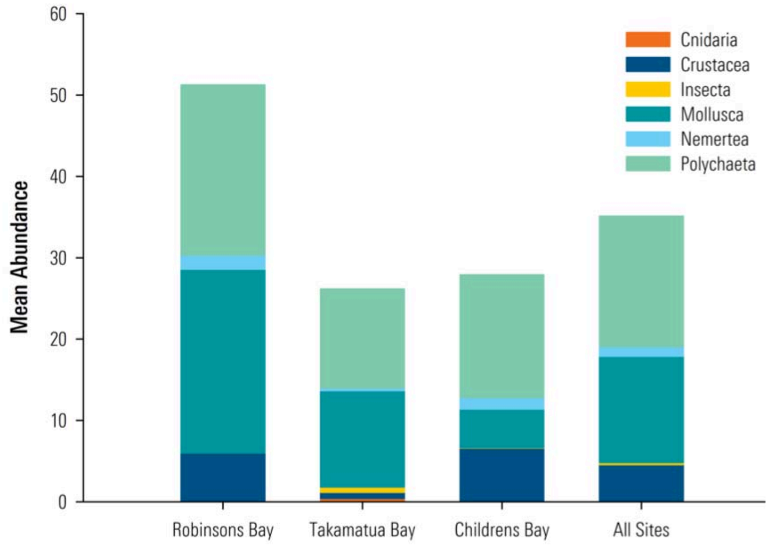

Figure 11 Mean abundance of infauna macroinvertebrate groupings collected from survey sites in the Akaroa Harbour by EOS Ecology on 17–19 November 2021.

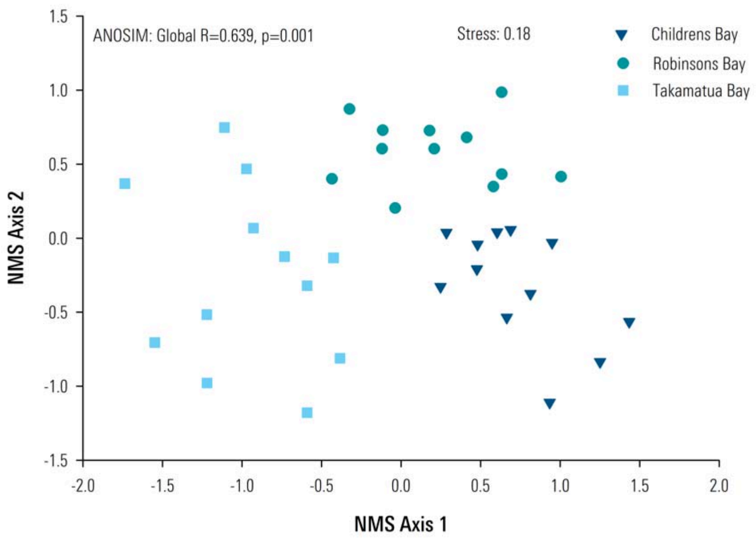

Figure 12 Non-metric multidimensional scaling (NMS) ordination of infauna macroinvertebrates collected from survey sites in the Akaroa Harbour by EOS Ecology on 17–19 November 2021.

3.3.3 Cockle Distribution and Size

All cockles collected in the epifauna (n=85) and infauna (n=158) samples were counted and measured. The total density of cockles was highest in Robinsons Bay (Figure 13), where there was a mean of 15.25 cockles (range: 0–40) per plot. This may be explained by the location of this sample area across the edge of a seagrass bed, as seagrass cover is positively correlated with high cockle density, particularly near the edge of high biomass beds (van Houte-Howes *et al.*, 2004; Lohrer *et al.*, 2016). The density of cockles was lower in Takamātua and Childrens Bays, but had comparable mean cockle densities of two cockles (range: 0–7) and three cockles (range: 0–8) per sample, respectively. No cockles were found in one plot in Robinsons Bay, five plots in Takamātua Bay, and two plots in Childrens Bay.

The mean length of cockles across all sites was 21.6 mm, with the smallest individual measuring 1.5 mm and the largest measuring 40 mm. The largest cockles were found in Childrens Bay (Figure 14), with a mean length of 28.3 mm across all samples. This may be due in part to habitat characteristics beneficial to cockle survival and growth, as they prefer sandy sediment (Gibbs & Hewitt, 2004) which is particularly prevalent in Childrens Bay (referred to as 'Akaroa Inlet' in Figure 3). While the mean cockle sizes were similar in Robinsons and Takamātua Bays, the range of cockle sizes was much smaller in Takamātua Bay (13–25 mm) relative to Robinson (1.5–32 mm) and Childrens (2–40 mm).

Cockles were more common in infauna samples than epifauna samples (Figure 13), however infauna cockles were notably smaller than cockles found on the surface in all survey areas except Childrens Bay (Figure 14). The surface cockles in Childrens Bay did have a longer mean length relative to those found in the sediment, but the range of sizes had more overlap indicating the size difference was not significant. The larger mean epifaunal cockle size was largely driven by the absence of the small individuals on the surface, as the minimum cockle size across all epifauna samples was 12 mm.

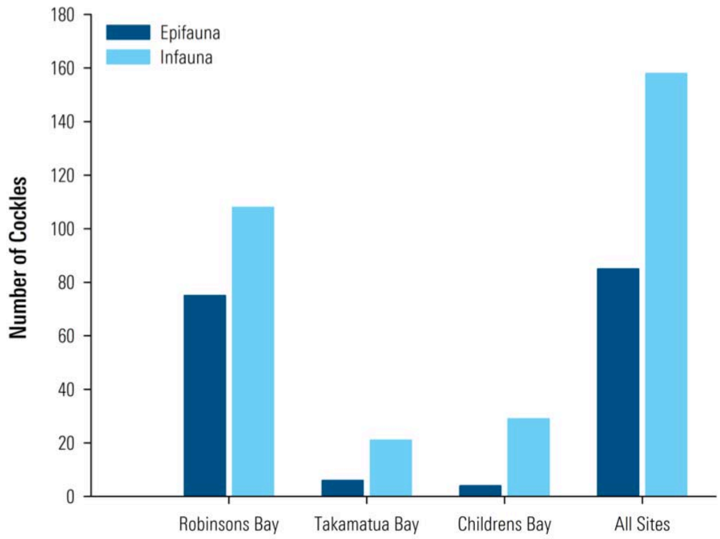

Figure 13 Mean number of cockles (*A. stutchburyi*) identified in epifauna quadrats and infauna core samples collected from survey sites in the Akaroa Harbour by EOS Ecology on 17–19 November 2021.

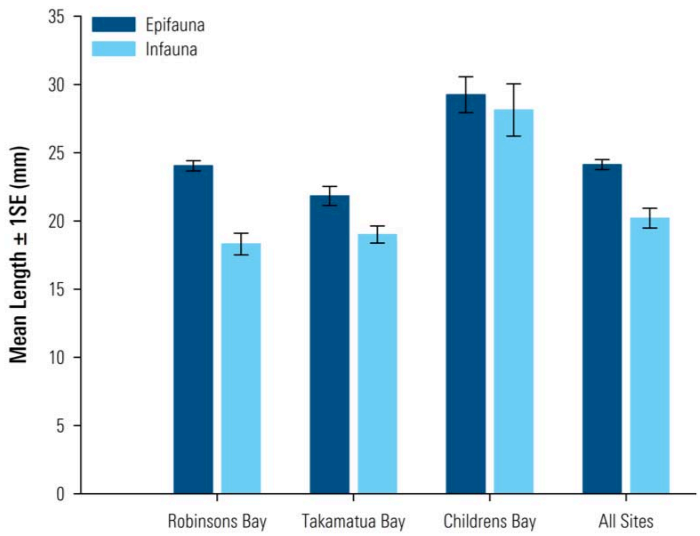

Figure 14 Mean length of cockles (*A. stutchburyi*) identified in epifauna quadrats and infauna core samples collected from survey sites in the Akaroa Harbour by EOS Ecology on 17-19 November 2021.

3.4 Ecological Values Assessment

Roper-Lindsey *et al.* (2018) provides guidance for the evaluation of ecological value or importance in terms of four “matters”: representativeness, rarity/distinctiveness, diversity and pattern, and ecological context. However, these “matters” are more suited for application to terrestrial habitats (e.g., forests, vegetation assemblages, and wetlands that have distinct boundaries) rather than waterways (the condition and values of which are strongly influenced by the land use and catchment upstream of any survey site), and the estuaries into which they feed. Roper-Lindsey *et al.* (2018) states, “*Although a wide range of metrics and measures are used in the assessment of freshwaters there is no unifying set of attributes used to assign value or significance*.” We have therefore adapted a method that uses a suite of attributes to determine ecological value and from that, to assign a value to a site following the five-point scale of Roper-Lindsey *et al.* (2018) of Very High, High, Moderate, Low, Negligible. These assessment categories and criteria are outlined in Appendix 9.3, while the characterisation of the surveyed sites/areas to the Roper-Lindsey *et al.* (2018) five-point scale is provided in Table 2. On this basis, the different embayments within the project area score slightly differently, with Takamātua Bay scoring a ‘low’ ecological value due to low flora cover and macroinvertebrate species richness, while Robinsons Bay and Childrens Bay score a ‘moderate’ value, largely because of their high habitat values and the presence of seagrass beds (Table 2). Robinsons Bay also had a moderate macroinvertebrate species richness and abundance, with a notably higher number of cockles relative to the other two surveyed embayments.

Table 2 Aquatic ecological values site assessment summary for the Akaroa Harbour. The five-point 'values' scale (Very High, High, Moderate, Low, Negligible) of Roper-Lindsay *et al.* (2018) is based off the scoring of a number of characteristics. Further detail regarding the characteristics is provided in Section 9.3.

Characteristics	Robinsons Bay		Takamātua Bay		Childrens Bay	
	Site Value	Reasoning	Site Value	Reasoning	Site Value	Reasoning
Flora	Moderate	Moderate cover (25%–75%) of habitat forming species. Presence of *Z. muelleri* ('At Risk' threat classification).	Low	Low species richness. Low cover (<25%) of habitat forming species. Species could be indicative of elevated nutrients.	Moderate	Presence of *Z. muelleri* ('At Risk' threat classification).
Macro-invertebrates	Moderate	Moderate species richness, diversity & abundance. Presence of taxa that are sensitive to enrichment & settled sediment as well as some that are more tolerant.	Low	Low species richness, diversity & abundance.	Low	Low species richness, diversity & abundance.
Habitat	High	Habitat generally heterogenous. Intertidal zone not limited through modified structures.	Moderate	Habitat generally homogenous. Sediments typically less than 50% silt & clay.	High	Habitat generally heterogenous. Sediments typically less than 35% silt & clay. Intertidal zone not limited through modified structures.
Overall Score	**Moderate**		**Low**		**Moderate**	

4 ASSESSMENT OF ENVIRONMENTAL EFFECTS

4.1 Overview of Proposed Scheme/Project Details

The Akaroa Treated Water Irrigation Scheme (ATWIS) is proposed as a replacement for the existing Akaroa Wastewater Treatment Plant which currently discharges treated wastewater to Akaroa Harbour. The existing wastewater network in Akaroa captures wastewater within the urban area by gravity, draining to three pump stations. These pump stations then pump wastewater to the wastewater treatment plant to the south of the Akaroa township. As part of the proposed ATWIS, there would be a new wastewater treatment plant (WWTP) located on Old Coach Road to the north of the town (already consented; Figure 15). As a result, the direction of flow between pump stations would be reversed and a new terminal pump station (TPS) would be built in the boat park at Childrens Bay (already consented), to pump wastewater up to the treatment plant sited at an elevation of 119 m asl. As part of the ATWIS, there would be a new pipeline constructed (~1.4 km length), to transport untreated wastewater from the TPS to the WWTP at Old Coach Road. The Christchurch City Council (CCC) owns the land for the new WWTP and TPS, and consents have already been granted for these aspects of the scheme.

To avoid the need for an oversized treatment plant to cope with peak flows, a covered wet weather raw wastewater tank is proposed at the Old Coach Road site (opposite the WWTP on Old Coach Road). The purpose of this storage facility is to hold untreated wastewater conveyed from the TPS that exceeds the treatment plant processing capacity, typically during daily peak flows or storm events. Wastewater would be pumped from the storage facility to the WWTP for treatment once capacity returns.

Treated wastewater from the WWTP would then be conveyed along a new gravity main to irrigate new areas of native trees in Robinsons Bay Valley and at Hammond Point, as well as to irrigate Jubilee Park in Akaroa during dry conditions. The new pipeline will convey the treated wastewater from the WWTP to the irrigation areas, and as necessary to storage tanks that will be sited at the Robinsons Bay Valley site. The pipeline is approximately 5.5 km in length, and will cross six waterways, including Takamātua Stream and several tributaries of Robinsons Bay Stream. Treated wastewater would be irrigated to land directly, or temporarily stored in tanks at the Robinsons Bay Valley irrigation site if field capacity is reduced following heavy or prolonged rainfall, preventing irrigation. The ATWIS also provides potential for non-potable reuse of wastewater for irrigating public parks in Akaroa. At this stage, the only area within Akaroa township that will be irrigated with reclaimed water is Jubilee Park, which is located adjacent to the true left branch of Grehan Stream.

A subsurface wetland is also proposed at the Old Coach Road site. The purpose of the subsurface wetland is to provide additional storage for treated wastewater if the storage capacity at Robinson Bay Valley is exceeded, or if emergency storage is needed for treated wastewater which would be necessary such as if the gravity main to the irrigation sites was damaged. The proposed subsurface wetland will be fully lined with impervious material and is not designed to overflow anywhere or have any discharge. The wetland will receive a continuous residual flow of treated wastewater to maintain the plants in good condition, with the volume of that flow regulated according to rainfall, evaporation, and evapotranspiration rates. The storage capacity of the wetland will be retained at as close to 100% as possible, with stormwater being decanted off as necessary and directed back through the WWTP.

The ATWIS is designed so that the only discharge will be of highly treated wastewater to land to the defined irrigation areas. As the treated wastewater will all be irrigated to land, there will be no direct discharge to surface or ground water, or to coastal water as part of this scheme. However, it is anticipated that a portion of the irrigated water will drain through the soils of the irrigation areas and ultimately enter surface waterways via groundwater (McIndoe *et al.*, 2022).

Figure 15 *…figure over page…* Overview of Features of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS), including proposed irrigation areas, wastewater pipeline, pipeline stream crossings, and wastewater treatment plant, as well as the location of the current wastewater treatment plant harbour discharge.

Overview of the Akaroa Treated Wastewater Irrigation Scheme (ATWIS)

WASTEWATER PIPELINE

- Two pipelines (raw wastewater uphill, treated wastewater downhill)
- WWTP discharge pipeline (treated wastewater)
- Pipeline stream crossings
- Irrigation areas
- Existing outfall pipe
- Waterways

0 200 400 800 Meters

N

Map © EOS Ecology, 2022 / www.eosecology.co.nz

Layer source: pipeline, WWTP, outfall, irrigation areas: CCC; pipeline stream crossings: EOS Ecology from site visits; waterways: modified by EOS Ecology from site visits, original layers by LINZ & CCC.

Image source: Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

4.2 Determining the Magnitude of Effects

Determination of the magnitude of the potential effects that have been identified as part of this project has been undertaken using Table 8 of Roper-Lindsay *et al.* (2018), which is reproduced below (Table 3). Based on the ecological value of the site to be disturbed (Table 2) and the magnitude of the potential effects (Table 3), the overall level of each potential effect has then been evaluated using the matrix approach described in Roper-Lindsay *et al.* (2018; Table 4).

Table 3 Criteria for describing magnitude of effect (taken from Table 8 of Roper-Lindsay *et al.* (2018)).

Magnitude	Description
Very high	» Total loss of, or very major alteration to, key elements/features/ of the existing baseline conditions, such that the post-development character, composition and/or attributes will be fundamentally change and may be lost from the site altogether, AND/OR » Loss of a very high proportion of the known population or range of the element/feature.
High	» Major loss or major alteration to key elements/features of the existing baseline conditions such that the post-development character, composition and/or attributes will be fundamentally changed, AND/OR » Loss of a high proportion of the known population or range of the element/feature.
Moderate	» Loss or alteration to one or more key elements/features of the existing baseline conditions, such that the post-development character, composition and/or attributes will be partially changed, AND/OR » Loss of a moderate proportion of the known population or range of the element/feature.
Low	» Minor shift away from existing baseline conditions. Change arising from the loss/alteration will be discernible, but underlying character, composition and/or attributes of the existing baseline condition will be similar to pre-development circumstances or patterns, AND/OR » Having a minor effect on the known population or range of the element/feature.
Negligible	» Very slight change from the existing baseline condition. Change barely distinguishable, approximating to the 'no change' situation, AND/OR » Having negligible effect on the known population or range of the element/feature.

Table 4 Matrix for determining the level of effects based on ecological value of site to be disturbed and magnitude of the effects of the proposed activity. Adapted from Table 10 of Roper-Lindsay *et al.* (2018).

		Ecological Value				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
Magnitude	**Very high**	Very high	Very high	High	Moderate	Low
	High	Very high	Very high	Moderate	Low	Very low
	Moderate	High	High	Moderate	Low	Very low
	Low	Moderate	Low	Low	Very low	Very low
	Negligible	Low	Very low	Very low	Very low	Very low
	Positive	Net gain	Net gain	Net gain	Net gain	Net gain

The level of effect derived from Table 3 was then adapted into planning terminology/RMA context using the continuum below, obtained from the Quality Planning website (www.qualityplanning.org.nz), with the addition of a positive effects category.

» **Positive effects** – The overall effects will be positive.

» **Nil effects** – No effects at all.

» **Less than minor adverse effects** – Adverse effects that are discernible day-to-day effects, but too small to adversely affect other persons.

» **Minor adverse effects** – Adverse effects that are noticeable but will not cause any significant adverse impacts.

» **More than minor adverse effects** – Adverse effects that are noticeable that may cause an adverse impact but could be potentially mitigated or remedied.

» **Significant adverse effects that could be remedied or mitigated** – An effect that is noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.

» **Unacceptable adverse effects** – Extensive adverse effects that cannot be avoided, remedied or mitigate.

4.3 Potential Effects

The potential effects of the planned programme on estuary ecology can be split into two distinct portions:

» **Construction effects**: these relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including any stream crossings that may be required for the associated pipeline. Potential effects are the discharge of contaminants (especially fine sediments, machinery-related hydrocarbons, and concrete related contaminants) that may ultimately reach the harbour through freshwater runoff.

» **Operational effects:** these relate to the ongoing effects of the proposed ATWIS once it is complete and operating. Potential effects of irrigating treated wastewater to land include the discharge of contaminants (especially nitrogen) that may ultimately reach the harbour through freshwater runoff or drainage from land, and the termination of direct wastewater discharge into Akaroa Harbour.

4.3.1 Construction Effects

At the time of writing this report, the specific construction methodology had not been finalised for this project. From the information available, we have identified the following potential adverse effects of the ATWIS during the construction phase:

» **Release and deposition of fine sediments** – the potential adverse effect of freshwater runoff transporting fine sediments to the harbour receiving environment during the construction and earthworks required for the formation of access roads, tracks, tank platforms, and construction of the subsurface wetland. Where construction requires substantial areas of earthworks, it is expected that there will be areas of bare earth for some length of time, which may allow fine sediments to be mobilised by wind and rain with the potential that they could then enter waterways and from there to the Akaroa Harbour. These events could lead to an increased suspended sediment load, a reduction in water clarify, and an increase in deposited fine sediment in the harbour environment, resulting in negative impacts on estuarine biota.

» **Water contamination** – the potential adverse effect of contaminants from construction machinery (e.g., fuel, oil, grease) and materials (e.g., concrete, grouts, mortars) that will be used during formation of the access roads, tracks, and tank platforms reaching the harbour receiving environment.

Given the types of construction work that are likely to be undertaken adjacent to waterways as part of the ATWIS, including the formation of access roads, tracks, tank platforms, creation of the subsurface wetland, as well as a pipeline that will require several stream crossings, it is anticipated that the main construction effect will be the potential for release and deposition of fine sediments to nearby waterways that may ultimately reach Akaroa Harbour. If there is a significant increase in land-derived (terrigenous) sediments into Akaroa Harbour, there could be some impacts to the local biota. An increase in suspended terrigenous sediments in the water column reduces light penetration, particularly when the suspended particulates have a fine grain size, which impacts primary production of pelagic phytoplankton and benthic macrophytes (algae that live in or on the sediments). Decreased primary production can lead to lower food availability for suspension feeders, herbivorous benthic grazers, and deposit feeders (Gibbs & Hewitt, 2004). An increase in suspended sediments can also interrupt feeding and respiration by clogging the gill structures of filter feeders (including cockles), and can reduce dissolved oxygen levels in the water column as oxygen is consumed by microbes that break down the organic content in the sediment. Once settled from the water column, sedimentation can further disrupt benthic environments, with increases in shoaling, embeddedness and other physical habitat modifications negatively impacting benthic biota (Cummings & Thrush, 2004; Gibbs & Hewitt, 2004; Lohrer *et al.*, 2003; Taylor & Keeley, 2009; Thrush *et al.,* 2003a; Thrush *et al.,* 2003b). Seagrasses are also sensitive to fine sediment deposition, with muddier conditions leading to a decrease in substrate oxygen levels, adversely affecting *Z. muelleri* growth and survival (Zabarte-Maeztu *et al.*, 2020).

Although fine sediments can smother habitat and impact filter feeding, the effects of terrigenous sediments on the local biota are often associated with conditions of chronic input. Experiments have shown that cockles are able to continue feeding in conditions of high suspended sediments over the short term (experiments up to 14 days) and exhibit resiliency to daily reburial under 2 cm of sediment (Anderson *et al.*, 2019; Gibbs & Hewitt, 2004; Norkko *et al.*, 2006). However, the adverse effects of both suspended and settled sediments have been highlighted in a three-month study by Norkko *et al.* (2006). The wedge shell bivalve (*M. liliana*), a common inhabitant in soft sediment estuaries around New Zealand and the most widespread infauna macroinvertebrate in this study, begins to exhibit significant adverse effects to high suspended sediment concentrations after nine days, and high mortality after 14 days (Nicholls *et al.*, 2003). Seagrass is also sensitive to increases in suspended sediments, but the greatest issues generally result from chronic or pulsed increases that lead to greater turbidity and decreased light penetration over time (Turner & Schwarz, 2006). The potential for sediment introduction from the proposed construction of the ATWIS infrastructure is expected to be intermittent and short-term, and as such is unlikely to have a significant adverse effect on the macrofauna and seagrass beds present in the harbour receiving environment.

In addition, the overall risk of fine sediment discharge into the harbour is expected to be minimal, given the current proposed construction methodology. At this stage no temporary or permanent steam crossings are proposed for the construction of access tracks. No instream works are proposed for permanently flowing waterways (those labelled 1, 2, & 5 on Figure 15), as the construction methodology for these will involve directional drilling beneath the streams, rather than traditional trenching methods. Any trenching works in ephemeral waterways (those labelled 3, 4, 6, 7, 8, 9, 10, & 11 on Figure 15) will be completed in dry conditions so that no fine sediment release is expected. Provided the effects management measures outlined in Section 4.4 are properly implemented, the level of effect from fine sediment release into Akaroa Harbour is expected to be negligible.

The other main potential adverse effect of the ATWIS construction is the release of contaminants to adjacent waterways, and ultimately Akaroa Harbour. When construction machinery is working in the vicinity of waterways, there is potential for contaminants from these machines (e.g., fuel, oil, grease) to enter the aquatic environment, especially if machinery is used within or adjacent to the wetted channel. Likewise, when construction involves working with uncured cement products within or adjacent to waterways, there is the potential for the discharge of cementitious material into the aquatic environment. Concrete wash water and uncured cement-related products can harm aquatic life, primarily though causing rapid pH shifts and the discharge of ammonia. Despite the strong buffering capacity of seawater, increases in pH can have detrimental effects on aquatic biota, from mortality of biota through to alterations in growth, photosynthesis, feeding and immune response (Calabrese & Davis, 1966; Chen & Durbin, 1994 (marine phytoplankton); Locke, 2008 (review); Ringwood & Keppler, 2002 (bivalves)). Changes in pH can also increase the bioavailability of heavy metals and can reduce recruitment rates for some benthic species (ANZECC, 2018; Calabrese & Davis, 1966; Loyless & Malone, 1997; Ringwood & Keppler, 2002; Shaw, 1981).

Such adverse effects can be avoided by ensuring any concrete waste does not enter surface waters and all mortars, grouts, and other cement-based products used are fully cured prior to contact with water. Undertaking any construction work that would involve uncured cement-related products outside of the flowing channel is the best approach, and all contractors will need to be aware of the need to avoid any concrete discharge entering the waterways. Where machinery is working adjacent to waterways, it is important that refueling occurs where it cannot enter the waterway if there is a spillage, and that fuels and chemicals are stored away from waterways. Properly maintaining all machinery on a preventative schedule will reduce the risk of breakdown. A spill kit should also remain on site at all times to contain any accidental spills and ensure no contaminants enter the waterways. With adequate controls in place, the effects of any release of contaminants to the receiving Akaroa Harbour is expected to be negligible.

4.3.2 Operational Effects

As the ATWIS involves the irrigation of treated wastewater onto land, any potential operational effects relating to estuary ecology would be limited to any contaminants that may leach from the irrigated areas into groundwater and into the adjacent streams, which would then discharge into the Akaroa Harbour. For the two proposed irrigation areas, this would entail a surface water discharge from Robinsons Bay Stream into Robinsons Bay, and a possible direct discharge of treated wastewater after passage through the ground (i.e., subsurface discharge) from the headland of Hammond Point located at the south end of Robinsons Bay. Information pertaining to the likelihood of discharges to surface water is contained within the following two documents, which form the basis of our effect assessment for the operational phase:

- McIndoe *et al.* (2022) – modelling of the likely output of nitrate to surface water bodies within the catchments where treated wastewater is to be irrigated (based on the target 10 mg/m^3 of total nitrogen in the treated wastewater). Several scenarios were modelled based on different options for nutrient uptake during irrigation.
- Mellish (2022) – reported on the likelihood of other typical domestic wastewater contaminants entering ground and/or surface water. The contaminants considered included metals, phosphorus, pharmaceuticals, emerging contaminants, persistent organic pollutants, herbicides, and pesticides. Mellish (2022) considered the risk of most applied contaminants entering ground or surface water to be low.

At the time of writing this report, the CCC are still working through the details of treatment plant operations, but we understand that the target is for the total nitrogen content of the treated wastewater to be 10 g/m^3, which corresponds to a dissolved inorganic nitrogen (DIN) concentration of 8.6 g/m^3 (McIndoe *et al*., 2022).

The report by McIndoe *et al*. (2022) models the likely output of nitrate to surface water bodies within the catchments where treated wastewater is to be irrigated (based on the target 10 mg/m^3 of total nitrogen in the treated wastewater), and this is what our effects assessment has been based on.

Contamination by Nitrogen

The main potential adverse effect of the ATWIS on the benthic ecology of Akaroa Harbour during the operation phase of the project will be related to changes in nitrogen parameters due to the termination of effluent discharge under the current wastewater scheme, and a potential localised increase in nitrogen in freshwater runoff (Robinsons Bay Stream) and drainage from land (Hammond Point) as a result of the proposed land irrigation scheme. The proposed implementation of the ATWIS should result in a reduced overall nitrogen load entering the harbour, however, there will be alterations to the nitrogen species entering the harbour, the timing of nitrogen discharge, and the location of nitrogen discharge into the harbour.

Nitrogen Load

The inclusion of nutrient removal treatment in the ATWIS is expected to reduce TN concentrations in the wastewater to 10 g/m^3 (McIndoe *et al*., 2022), which is notably lower than the median load of 24.95 g/m^3 of TN that was recorded in the effluent entering the harbour between July 2017 and May 2022 (Table 1). With the irrigation of the treated wastewater to land, the nitrogen load will be further reduced via the uptake by terrestrial plants and the loss of nitrogen through denitrification and volatilisation from the soil (Meister & Robinson, 2022; Meurk, 2022), although it is possible that some of the nitrogen in the irrigation water could make its way into Robinsons Bay Stream from the Robinsons Bay Valley irrigation site and into Akaroa Harbour from the Hammond Point irrigation site via drainage from land (McIndoe *et al*., 2022). The nitrogen entering Robinsons Bay Stream may affect the freshwater ecology (Dewson, 2022), and may ultimately result in nitrogen entering Akaroa Harbour via freshwater runoff. The concentration of nitrogen entering the aquatic environment depends on a number of factors; however, under all scenarios the nitrogen load entering the harbour is expected to be notably lower than the nitrogen load in effluent discharge under the current wastewater scheme. However, WWTPs contribute only 1-2% of the nutrients found in Akaroa Harbour (Dudley *et al.*, 2019), so the effect of this reduced nitrogen discharge may have a minimal effect on the harbour system

Nitrogen Species

In addition to an overall reduced nitrogen load with the proposed shift to the ATWIS, the nitrogen species entering the harbour may vary. Under the current scheme, nitrogen is entering Akaroa Harbour in a variety of forms (Table 1), including ammonia which is toxic to many forms of estuarine and marine taxa when present in higher concentrations. Once in the water column, dilution and dispersal temper the adverse effects of ammonia in the system, and ammonia is quickly reduced to nitrate via the process of nitrification. Indeed, receiving environment sampling under the current consent conditions (discussed in Section 3.1) has recorded a maximum ammoniacal nitrogen concentration of 0.044 g.m^3 across all sites between December 2017 and February 2022. Work by Bolton-Ritchie (2013) further indicates that the wastewater effluent does not contribute ammonia to Robinsons Bay or Childrens Bay (Takamātua Bay was not included in these analyses). Despite the continuous input of ammonia into Akaroa Harbour via wastewater effluent, it does not appear that ammonia persists in the harbour environment.

Under the new ATWIS, there will be no ammonia directly entering Akaroa Harbour as the nitrogen from the irrigated wastewater is expected to leach out of the soil as nitrate, be taken up by terrestrial vegetation, or lost through denitrification or volatilisation (McIndoe *et al.*, 2022; Meister & Robinson, 2022). The nitrate that leaches from the soil into the groundwater may drain directly into the harbour via subsurface discharge (i.e., Hammond Point) or enter surface waterways and run off into the harbour (i.e., Robinsons Bay Stream to Robinsons Bay).

The introduction of nitrate from land is prevalent in Akaroa Harbour, with previous work indicating that the streams around the perimeter of the harbour contribute much more nitrogen to Akaroa Harbour than the wastewater outfalls, with most of the nitrogen from freshwater runoff occurring in the form of nitrate (Bolton-Ritchie, 2013; Dudley *et al.*, 2019). This input of nitrate from freshwater streams into the harbour is expected to persist, we do not expect a notable change from the current load of nitrate in Akaroa Harbour. While the termination of effluent discharge from the current WWTP and the implementation of the ATWIS (which will discharge a much smaller nitrogen load overall) will reduce nitrate entering the harbour from wastewater sources, the proportion of the nitrogen in the harbour coming from wastewater sources is very small (Dudley *et al.*, 2019). As such, we do not expect a significant change from the current state of nitrate in the harbour environment.

While some of the nitrate leaching into Robinsons Bay Stream may discharge into the harbour without further transformation, it is likely that at least some will be taken up by freshwater biota (i.e., bacteria, fungi, algae and macrophytes), particularly in the spring and summer during growing season. However, unless the resulting biotic material is removed, the biological uptake of nitrate is considered only a temporary sequestration of nutrients (Howard-Williams *et al.*, 1983). A study in the Lake Taupo catchment found that most of the reduction of nitrate concentrations within the streams was due to uptake by aquatic biota (i.e., bacteria, fungi, algae and macrophytes) with very little denitrification or dissimilatory reduction occurring (Matheson *et al.*, 2011). As such, the nitrogen is not removed from the system, but is instead transformed into organic nitrogen prior to moving towards a downstream receiving environment.

Organic nitrogen is already present in stream water runoff feeding into Akaroa Harbour, with higher concentrations noted in the streams in summer months due to the growing seasons and associated increases in plant and algae growth (Bolton-Ritchie, 2013). Although Robinsons Bay Stream was not sampled by Bolton-Ritchie (2013) and Dewson (2022) did not sample organic nitrogen in the water quality monitoring of the harbour's streams, we expect there is an existing runoff of organic nitrogen into Akaroa Harbour that may increase following the establishment of the ATWIS. Dissolved organic nitrogen has a relatively high bioavailability, with estuarine primary producers (e.g., phytoplankton, autotrophic bacteria) demonstrating an ability to readily utilise nutrients that enter an estuary in this form (Seitzinger & Sanders, 1997; Seitzinger *et al.*, 2002). If the concentration of nitrate reaching the streams is high enough to cause more than minor effects to the freshwater ecology (as discussed by Dewson, 2022), this may result in an increased release of organic nitrogen entering the harbour, which may increase the possibility of bacterial and algal blooms. This risk is considered low given the existing presence and general availability of organic nitrogen and other nutrients in the system; however, it is recommended that a water quality monitoring programme is undertaken to detect the presence of blooms in the harbour.

Discharge Timing

The timing of nitrogen discharge will likely be less consistent under the ATWIS relative to the existing wastewater discharge scheme. Although daily flow volumes do vary under the current scheme, effluent is discharged into the harbour on a more or less continual basis. Alternately, the release of nitrogen into Akaroa Harbour under the ATWIS is expected to be more varied and seasonal. There may be seasonal differences in nitrogen discharge into the harbour receiving environment, as the volume of irrigation water applied to land will vary based on ground moisture levels (McIndoe *et al.*, 2022). The implementation of good irrigation management practices will reduce surface runoff under wet conditions and limit the movement of contaminants through the soil profile. It will be important to ensure these good management practices are maintained through all soil moisture conditions to prevent the release of large concentrations of nutrients into the aquatic environment during rain events. The seasonal differences in nutrient runoff entering the harbour may be further influenced by the seasonal dynamics of nitrate uptake by terrestrial plants and freshwater aquatic plants and periphyton, with a higher uptake of nutrients during the growing season and a higher subsequent release of organic nitrogen back into the water column in the autumn (Howard-Williams *et al.*, 1983).

Discharge Location

The location of nutrient discharge will change with the new scheme, with nutrients entering the system further from the mouth of the harbour. The modelled maximum flushing time of Akaroa Harbour is approximately 120 days (Bell *et al.*, 2014), but this is highly variable and is affected by the distance from the harbour entrance. While Dudley *et al*. (2019) indicates that the water within the harbour is well mixed and has characteristics similar to offshore waters, the location of the current wastewater outfall is closer to the mouth of the harbour, and therefore subject to a greater degree of tidal exchange and flushing potential. It is expected that nitrogen discharged further into the harbour under the ATWIS scheme could remain in the system for a longer period of time. Further hydrodynamic modelling would be useful to determine how long nutrients entering the harbour under the new ATWIS will be retained in the system.

In addition to an increased distance from the harbour mouth, there will be a change in the depth of the environment into which nitrogen may enter the system. The current outfall discharges effluent directly into the subtidal area of the harbour, where dilution, mixing, and distribution is relatively immediate. Alternatively, under the ATWIS, nitrogen from the treated wastewater irrigated to land may enter the harbour receiving environment through intertidal habitats (either via the Robinsons Bay Stream discharge or through leaching of groundwater from Hammond Point headland). As such, the speed of dilution and distribution through the harbour will be slower, particularly if the nitrogen reaches the harbour during lower tide levels and moves over the exposed intertidal mudflats before reaching the deeper areas of the harbour. This may disproportionately affect the intertidal habitats, due to a more concentrated exposure of nitrogen to a smaller area relative to the current discharge scheme where nutrients are mixed into the water column and only available to intertidal habitats when they are covered at high tide.

The relationship between nutrient availability and intertidal communities is complex, and is impacted by many factors including sediment type, the overall nutrient limitations in the system, and the species of nitrogen available to the biota. The effect of increased nutrients on intertidal mudflat ecology can vary widely, with some studies showing that an increase in nutrients triggers blooms of primary producers (including *Ulva* sp. and *Gracilaria chilensis*) and changes macroinvertebrate assemblages (Morris & Keough, 2003; Robertson & Savage, 2018; Teichberg *et al.*, 2010), while other studies show little effect on primary productivity rates and the intertidal community following the addition of nutrients to an intertidal mudflat habitat (Stutes *et al.*, 2006; Tolhurst *et al.*, 2020). Seagrasses are generally sensitive to nutrient enrichment and poor water quality conditions, with seagrass beds in New Zealand and around the world showing significant decline under conditions of high nitrogen loading (Li *et al.*, 2019; Lotze *et al.*, 2006; Turner & Schwartz, 2006). However, the effect of nutrient loading can be influenced by sediment conditions, with *Z. muelleri* in sandy habitats showing a lower resistance to elevated nutrient levels relative to those in muddier substrates (Li *et al*., 2019). *Z. muelleri* is the only seagrass taxon in New Zealand, growing primarily in mid-to-low intertidal areas with silty or sandy sediments and providing a nutrient-rich foundation for estuarine food web (Leduc *et al.,* 2006; Les *et al.*, 2002; Woods & Schiel, 1997) and habitat for a variety of estuarine biota including cockles, crabs, shrimp, fish, and wading birds (de Juan & Hewitt, 2011; Lohrer *et al.*, 2016; Matheson *et al.*, 2009; Thomsen *et al.*, 2000; van Houte-Howes *et al.*, 2004). As such, an increased input of nitrogen may result in seagrass declines and with carry-on effects to the local macroinvertebrate communities. However, the potential effects of the addition of nitrogen on the intertidal benthic ecology is difficult to predict, and regular monitoring of mudflat and seagrass habitats is recommended in areas that may be subject to an increase in nutrient loading under the ATWIS.

Potential Effects of Nitrate Inputs to Akaroa Harbour

The scheme design for the ATWIS assessed here includes the application of treated wastewater via irrigation to land in Robinsons Bay Stream and Hammond Point. Potential discharge of scheme-sourced water to Robinsons Bay would therefore be via the surface water discharge from Robinsons Bay or via a groundwater seepage discharge from Hammond Point (which does not have any waterways or channels).

Robinsons Bay Stream Discharge:

Catchment modelling has demonstrated that treated wastewater that is irrigated onto land within the catchment of Robinsons Bay Stream has the potential to enter the stream via overland flow or groundwater and that this would lead to increases in stream flow and nitrate concentrations in Robinsons Bay Stream (McIndoe *et al*., 2022). There is a possibility that at least some of the nitrogen load that enters Robinsons Bay Stream will ultimately run off into Akaroa Harbour, either in the form of nitrate or organic nitrogen. McIndoe *et al.* (2022) modelled the increases in nitrate for Robinsons Bay Stream based on four scenarios, and the predicted level of effect on the freshwater ecology of the stream for each of the modelled scenarios was discussed by Dewson (2022). Table 5 summarises the modelled increases in nitrate and the expected level of effect on freshwater ecology that are anticipated by Dewson (2022) for each scenario.

» The ‘base case’ and ‘conservative’ scenarios for wastewater irrigation would result in an increased availability of nutrients in Robinsons Bay Stream that may enable the increased growth of periphyton and aquatic plants. Over time, this type of change would be expected to have flow on effects to biota further up the food chain, including macroinvertebrates and fish (Dewson, 2022). As such, Dewson (2022) assessed the level of effect on freshwater ecology of these modelled scenarios as being moderate to high (e.g., minor to more than minor; Table 5). Dewson (2022) estimates that the consistently higher nitrate values modelled in the ‘base case’ and ‘conservative’ scenarios would degrade the ecological health of the stream compared to its existing condition over time. As the ecological health of the stream changes over the long term, there will be changes to the nutrient cycling that may affect the nitrogen load, nitrogen species, and timing of the discharge of nitrogen from Robinsons Bay Stream into Robinsons Bay. With these anticipated changes to nitrogen discharge from Robinsons Bay Stream into Robinsons Bay, there may ultimately be long term minor to more than minor effects the intertidal benthic biota of Robinsons Bay.

» In comparison, the modelled increases in nitrate concentrations in Robinsons Bay Stream under the ‘preferred/destocking 1’ and ‘destocking 2’ scenarios are expected to fall within the existing interquartile range of nitrate concentrations for the stream (i.e., the range of nitrate concentrations already typically experienced by the freshwater community based on 12 months of water quality monitoring). These modelled scenarios would result nitrogen loads within Robinsons Bay Stream that are comparable to current nutrient availability, and the magnitude of the effect on freshwater ecology is anticipated by Dewson (2022) to be low (e.g., less than minor). As the range of nitrate concentrations in the stream is expected to remain in the range already typically experienced by the freshwater biota, Dewson (2022) does not anticipate there will be a notable change in the ecosystem functioning within Robinsons Bay Stream, which means that we would consider there would be little discernible change to the nutrients entering Robinsons Bay through freshwater runoff. The anticipated level of effects on the intertidal benthic ecology in Robinsons Bay under these scenarios is therefore less than minor.

Table 5 Summary of alternative scenarios for nitrate increases in Robinsons Bay Stream (McIndoe *et al.,* 2022). The estimated magnitude of effect on the freshwater ecology of the stream (from Dewson, 2022) and estuary ecology of Robinsons Bay has been estimated for each scenario based on the categories of Roper-Lindsay *et al.* (2018).

Scenario	Description	Increase in nitrate concentration in stream (g/m^3)	Estimated post irrigation nitrate concentration in stream (g/m^3)	Level of effects to freshwater ecology (from Dewson, 2022)	Level of effects to estuary ecology
Existing land use	No wastewater irrigation, native tree planting, or destocking.	0.000	0.030	Nil effects (No change from current state).	Nil effects (No change from current state).
Base case	Irrigation of wastewater to 31.9 ha of land in the catchment, with 13.5 kg/ha uptake from the planted trees and 2 kg/ha offset from the destocking of the irrigation area.	0.086	0.116	Moderate–High (minor–more than minor) (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).	Moderate–High (minor–more than minor) (Increased Nitrate-N concentrations and subsequent ecological changes in the stream; possible increases to Nitrate-N concentrations discharged to intertidal estuarine habitats).
Preferred scenario (Destocking 1)	As for the 'base case', but with the addition of 23 ha of infill or riparian planting and destocking to further reduce nutrient leaching.	0.057	0.087	Low (less than minor) (Post irrigation Nitrate-N values within existing interquartile range; moderate - high ecological value; low magnitude of effect).	Low (less than minor) (Nitrate-N concentrations in the stream expected to remain within existing ranges; little to no change expected in nutrient discharge to estuarine habitats).
Destocking 2	As for 'preferred scenario', but with the remaining 63.2 ha area of the property destocked.	0.047	0.077	Low (less than minor) (Post irrigation Nitrate-N values within existing interquartile range; moderate - high ecological value; low magnitude of effect).	Low (less than minor) (Nitrate-N concentrations in the stream expected to remain within existing ranges; little to no change expected in nutrient discharge to estuarine habitats).
Conservative	Irrigation of wastewater on the assumption that there will be no uptake/ denitrification occurring and without offset or destocking on any part of the property.	0.126	0.156	Moderate–High (minor–more than minor) (Post irrigation Nitrate-N values outside of existing interquartile range but not exceeding DGV; moderate – high ecological value; moderate magnitude of effect).	Moderate–High (minor–more than minor) (Increased Nitrate-N concentrations and subsequent ecological changes in the stream; possible increases to Nitrate-N concentrations discharged to intertidal estuarine habitats).

Hammond Point Discharge

In addition to the contaminants entering Robinsons Bay via freshwater runoff from Robinsons Bay Stream, modelling by McIndoe *et al.* (2022) has also indicated that nitrate from treated wastewater irrigated to a proposed 3.8 ha area on Hammond Point has the potential to enter the subtidal areas of Robinsons Bay. As there are no flowing streams on or bordering Hammond Point, the application of irrigation water to Hammond Point is expected to discharge directly into Akaroa Harbour via drainage through the soil.

» Under a 'conservative' scenario, where all applied nitrogen in the treated wastewater is assumed to discharge into the harbour, the nitrate load is predicted to increase by 181.0 kg/y (McIndoe *et al.*, 2022). In the 'preferred/destocking 1' scenario provided by McIndoe *et al.* (2022), in which the modelling allows for nitrogen uptake by trees, denitrification in the soil, and destocking of the irrigated area, the discharge of nitrate into the harbour is expected to be 122.1 kg/y. If the entire property on Hammond Point is destocked, a further offset of 16.2 kg/y has been modelled.

» The nitrate that flushes from Hammond Point is expected to enter the subtidal areas of Robinsons Bay and be quickly diluted and dispersed across Akaroa Harbour. Under both modelled scenarios, the annual load of nitrate that may be released from Hammond Point is significantly lower than the nitrogen loads measured in effluent currently discharged into the harbour under the existing wastewater discharge scheme (Table 1). As the implementation of the ATWIS will coincide with the termination of the current treated wastewater discharge scheme, there is an expected overall decrease in nitrogen discharge to Akaroa Harbour. As such, the expected magnitude of the effect of the increase in nitrogen released from Hammond Point into the harbour is expected to be negligible, or potentially positive in the context of the termination of the current scheme.

» However, the implementation of the ATWIS and the termination of the current wastewater discharge scheme will result in a change to the regularity of discharge. Nutrient discharge is relatively continuous under the existing scheme, but will likely be more irregular and seasonal under the proposed ATWIS due to seasonal differences in the application of wastewater to irrigation areas and the nutrient uptake rates by terrestrial plants and freshwater aquatic plants and periphyton. Water quality monitoring may be useful to ensure large concentrations of nutrients are not being released into the harbour environment.

Jubilee Park Discharge

It is unlikely that there will be any discharge of nutrients entering Childrens Bay from the irrigation of treated wastewater to Jubilee Park. This is based on the assertion by McIndoe *et al*. (2022) that the potential for drainage under Jubilee Park can be minimised by deficit irrigating, which means managing the rate of irrigation to maintain soil moisture at levels high enough to keep the grass green. The area of irrigation is also small, being around 1 ha in size. Under this scenario of deficit irrigation, it is anticipated that there will be negligible discharge to the groundwater or surface water and no anticipated measurable changes to water quality and quantity for the Grehan Stream catchment (Dewson, 2022). Dewson (2022) does not anticipate any negative impacts on freshwater biota in the streams, and as such there are no anticipated changes to the nutrients entering Childrens Bay through freshwater runoff.

Potential Effects of Other Contaminants

Phosphorus

Under the current Akaroa WWTP system, several forms of phosphorus are released into the harbour via wastewater effluent (Table 1). Dudley *et al.* (2019) reports that the main sources of phosphorus in Akaroa Harbour are the off-shore ocean (69%) and local streams (18%), with wastewater only contributing 1-2% of what is present in harbour water. Mellish (2022) indicates that wastewater nutrient removal treatment can remove phosphorus prior to irrigation if too much accumulates in the soil over time. However, Mellish (2022) does consider that ongoing monitoring of soil phosphorus concentrations will be necessary to indicate if further treatment is required. Provided appropriate measures are taken, the release of phosphorus into the harbour via stream runoff is not expected to be an issue.

Heavy Metals and POPs

There is a possibility that heavy metals and persistent organic pollutants (POPs) may leach into streams and reach the harbour receiving environment. However, Mellish (2022) considers that there is adequate capacity in the soils to limit the migration of metals into the aquatic environment, and the risk of mobilisation of metals is low considering the pH of irrigation area soils and treated wastewater. As such, the irrigation of treated wastewater to land is expected to have a very low to indiscernible impact to freshwater streams and be undetectable in coastal water. The risk of POPs percolating to groundwater is also generally considered to be low, with overseas research indicating that forest soils can act as a potential sink for POPs (Maqsood & Murugan, 2017; Mellish, 2022) which suggests POPs will accumulate in soils and not be released to receiving waters unless soils are disturbed.

Pathogens and Faecal Indicators

The termination of wastewater discharge directly into Akaroa Harbour may reduce the presence of pathogens and faecal indicator microorganisms in the harbour waters. Although the current wastewater treatment process does include UV disinfection prior to discharge, wastewater is currently a source of faecal indicators in the harbour, with concentrations in the effluent and harbour receiving environment periodically surpassing trigger values in the summer months. Following the implementation of the ATWIS and the irrigation of wastewater to land, the discharge of faecal contamination and associated microorganisms into the harbour should be reduced. However, animals and birds are likely a significant source of the faeces contamination in the harbour (Bolton-Ritchie, 2013), so it is unlikely the termination of the current Akaroa wastewater discharge will significantly reduce the presence of faecal indicators in the harbour.

The irrigation of wastewater to land may result in the contamination of soil with pathogens and faecal bacteria that could wash into freshwater streams during rainfall events and ultimately reach the harbour receiving environment. The streams around Akaroa Harbour have measurable levels of faecal indicators (i.e., *Escherichia coli*), likely due to a combination of faecal contamination by wild animals and livestock, and land and stormwater runoff. Dewson (2022) noted the highest median concentrations of *E.coli* in Robinsons Bay Stream after a wet weather event, suggesting that faecal contaminants are washed into the stream with rainfall. When runoff containing *E. coli* reaches the harbour environment, there may be impacts to the safety of recreational swimming and the collection of shellfish for consumption. The density of cockles in Robinsons Bay was notably higher than in Takamātua and Childrens Bays, representing an opportunity for the collection of mahinga kai from this intertidal mudflat. However, the safety of this food source is currently uncertain and requires testing through methods such as measuring the concentration of faecal indicators, such as *E. coli* and human enteric viruses, in shellfish collected from the area. Bolton-Ritchie (2013) found that cockles collected from Robinsons Bay during wet weather had *E. coli* concentration above levels safe for eating (although cockles collected from the same spot in dry weather did not have elevated *E coli* concentrations), and suggests runoff from Robinsons Bay Stream was the source of contamination. The irrigation of wastewater to land under the ATWIS will be a new source of faecal indicators to the Robinsons Bay Stream catchment, , however, destocking the area (as included in the 'preferred/destocking 1' modelled scenario provided by McIndoe *et al.* (2022)), will likely reduce the faecal contamination of Robinsons Bay Stream and may subsequently increase shellfish safety. Ongoing regular monitoring is recommended to determine if shellfish collected from Robinsons Bay are safe for consumption during the operation of the ATWIS.

4.4 Effects Management Requirements

Several effects management measures are currently proposed to manage the potential effects of the ATWIS. The effects management activities related to the construction and operational stages of the project are discussed separately below.

4.4.1 Construction Stage

It is proposed that the effects management for the construction phase of the ATWIS will be detailed in a Construction Environment Management Plan (CEMP) which will be prepared and provided to Environment Canterbury and the Christchurch City Council (the Consent Authorities) prior to works commencing. It is expected that the requirement for this CEMP will be included as a condition of resource consent. This approach will minimise the potential for sediment migration and entrainment in surface water, as well as the eventual release into estuarine habitats. The CEMP will adopt the most appropriate methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox (ESC toolbox) for Canterbury (https://esccanterbury.co.nz/), including:

» Follow the general principles of erosion control, such as minimise disturbance, do construction in stages, protect slopes, protect waterways, stabilise exposed areas quickly, and select relevant tools to suit the situation.

» The CEMP will require all necessary ESC measures to be installed prior to land disturbance and maintained in effective working order until disturbed areas are stabilised.

» Where the wastewater pipeline needs to cross waterways that contain water, the construction methodology will involve directional drilling beneath the stream, rather than traditional trenching methods. This will avoid surface disturbance to the stream channel and margins, and the release and deposition of fine sediments. Where the wastewater pipeline needs to cross ephemeral streams, trenching methods may be used, but these works will be undertaken at a time when there is no surface water present. All such works in ephemeral streams will be completed, and disturbed areas stabilised within one working day.

In addition to these proposed effects management measures, we would also recommend the following general approaches be included in the CEMP or as conditions of consent in relation to the construction phase of this project:

» As the soils in the area include loess subsoils which are highly erosive and dispersive, we would recommend that particular attention and effort is applied to the erosion and sediment control measures, to ensure that the measures used are appropriate for dealing with this soil type. Adamson (2016) provides some useful guidance on erosion control measures that work best to reduce sediment runoff from exposed loess subsoils, whilst McMurtrie *et al.* (2022) provides findings on the most effective erosion control and revegetative measures for cut loess faces.

» Construction activities should avoid any wetland areas as identified by Meurk (2022) or as subsequently identified during the construction phase.

» Sediment losses to natural waterways are to be avoided where practicable, with relevant sediment control measures in place in all circumstances.

» Construction vehicles and machinery should always operate outside of any watercourse and should not be driven through flowing water – access should be via a bridge or other suitable structure.

» All fuels and other construction liquids should be stored at least 20 metres away from waterways (including perennial, intermittent and ephemeral waterways) and in appropriately contained or bunded locations. No vehicle refuelling, repair or maintenance should occur within 20 metres of waterways or in a location where any spilled fluid could enter a watercourse.

» Construction vehicles and machinery should be maintained on a preventative schedule to reduce the risk of breakdown. Spill kits should be located near to all machinery and staff must be trained in how to use these.

» All practical measures must be taken to ensure that no uncured cement or cement-based products enter flowing water in any waterway. Any works involving these products should be undertaken outside of the flowing channel and new concrete or mortar should not be exposed to water until firmly set (at least 48 hours).

4.4.2 Operational Stage

As detailed in Section 4.3.2, the main operational effect of the ATWIS on estuary ecological values is the potential for increased discharge of nitrogen from the irrigated treated wastewater into Akaroa Harbour through freshwater runoff from Robinsons Bay Stream or drainage from land from Hammond Point. Several mitigation measures have been proposed to manage this potential effect, as detailed below:

» **Selection of most suitable area for irrigation** – McIndoe *et al*. (2022) analysed land slopes and completed site visits to assess and refine the suitability of each irrigation site. This resulted in the removal of some parts of the irrigable area originally identified, as ephemeral streams, boggy areas, and springs were excluded from irrigation areas.

» **Irrigation of native trees in irrigable areas** – it is proposed that the trees will be planted in rows that are 2 m apart, with trees spaced at 1.2 m spacings within these rows. Irrigation driplines will be laid on the ground surface between each row of trees, with up to four driplines equally spaced between the tree rows. Using four driplines between each row is preferred, as that would maximise the wetted area of the soil and minimise the drainage through the soil profile (McIndoe *et al*., 2022).

» **Planting of wetland species in seepages** – as recommended by Meurk (2022), native wetland species should be planted to provide filtration in any areas of new wetland that develop once irrigation has been implemented, as well as in existing seepages.

» **Plant uptake of nutrients from irrigation water** – the CCC intends to use kanuka as the primary native species to be planted in the irrigation area. Meister & Robinson (2022) provided information on the likely uptake of nitrogen from the planting of the irrigation area and as a result, McIndoe *et al*. (2022) have based their modelling on the assumption that 13.5 kg N/ha/y of applied N will be volatilised, denitrified, or taken up and removed by the planted trees.

» **Minimising surface ponding and runoff** – McIndoe *et al.* (2022) indicate that runoff due to irrigation can be mitigated with good irrigation design and management and maintaining good ground cover. It will be important that the land is not over irrigated, that the irrigation run times are short, and that 20 m setbacks from streams are imposed to minimise the potential for irrigation runoff to enter streams.

» **Destocking the irrigation area** – Lumen Environmental Ltd completed nutrient budgets for the Robinsons Bay catchment and have indicated that the decrease in nitrogen that would result from removing stock from parts of the catchment would be around 2 kg N/ha/y (McIndoe *et al*., 2022). This value has been used in modelling to assess the impact of destocking parts of the catchment on resulting nitrate levels in the stream (this is included in the 'base case', 'preferred/destocking 1', and 'destocking 2' modelled scenarios).

» **Additional destocking and planting if required** – on the assumption that further native tree planting and destocking within Robinsons Bay catchment (outside of the proposed irrigation areas) would further reduce the leaching of nitrogen to the stream, there is the potential for further mitigation to be applied if the actual effects on the stream are greater than anticipated. This is included in the 'destocking 2' modelled scenario.

4.5 Summary of Effects Following Additional Effects Management

Sections 4.3.1 and 4.3.2 above described the potential construction and operational effects of the ATWIS on the estuary ecological health of the project area. However, following proper implementation of the mitigation measures covered in Section 4.4 during the construction phase, and with implementation of the 'preferred/ destocking 1' or 'destocking 2' irrigation scenario, it is expected that the potential adverse effects of the ATWIS should be able to be reduced to an overall less than minor effect (Table 6).

However, given the variation in the modelled scenarios it will be important to regularly audit/check the appropriate implementation of these mitigation measures. It will also be important to implement monitoring programmes in Akaroa Harbour to ensure that any unanticipated effects are identified, and to enable the applicant to adapt the scheme operation to best address any such effects as appropriate (see proposed monitoring in Section 5).

Table 6 Summary of the level of effect of the different aspects of the proposed Akaroa Treated Wastewater Irrigation Scheme (ATWIS) on the estuary receiving environments, along with the subsequent potential level of effects in the Resource Management Act (RMA) terminology.

	AFTER Effects Management (Assuming the 'preferred/destocking 1' irrigation scenario)	
	Magnitude of Effect*	Level of Effect (& RMA terminology)*
Construction		
Pipeline stream crossings	Negligible	Very Low (less than minor)
Earthworks (including access tracks)	Negligible	Very Low (less than minor)
Construction machinery	Negligible	Very Low (less than minor)
Use of cement products	Negligible	Very Low (less than minor)
Operational		
Irrigation to Robinsons Bay Valley (assuming the 'preferred/ destocking 1 scenario)	Low	Low (less than minor)
Irrigation to Hammond Point (assuming the 'preferred/ destocking 1 scenario)	Negligible	Very Low (less than minor)
OVERALL		Very Low (less than minor)

* Magnitude & level of effect as defined in Table 3 and Table 4, with RMA terminology as defined in Section 4.2

5 RECOMMENDED MONITORING

Given assumptions around the nutrient levels that will be in the applied wastewater, the variation in the modelled scenarios relating to nutrient levels in the receiving freshwater environment (which then enters the harbour), and (albeit unlikely) possibility of other contaminants reaching the receiving environment, it will be important to develop and implement a monitoring programme for key sites in Akaroa Harbour to monitor trends in water quality and environmental parameters as may be affected by the operation of the ATWIS. In addition, the Akaroa Harbour Tidal Flats are listed as Areas of Significant Natural Value under Schedule 1 of the Regional Coastal Environment Plan (Environment Canterbury. 2020), and as such considerations should be given to relevant monitoring requirements for resource consents that may impact these areas (Bolton-Ritchie, 2005). Relevant monitoring programmes may include:

» Ongoing water quality monitoring is recommended in the harbour receiving water, including sites in Robinsons Bay near the mouth of Robinsons Bay Stream and along the northwest coast of Hammond Point, where nitrate from irrigated wastewater may enter the harbour.

  – In line with monitoring requirements for the current consent for wastewater discharge into Akaroa Harbour, multiple monitoring sites should be selected including at least two control sites. Water quality sampling and analysis should be carried out at least once every three weeks between 1 December and 28 February each year, such that four samples are taken over the summer period.

  – Measured parameters should include the following as a minimum: temperature, total nitrogen (TN), dissolved inorganic nitrogen (DIN), total phosphorus (TP), dissolved reactive phosphorus (DRP), chlorophyll-a, enterococci, and faeacal coliforms.

» Annual biomonitoring of seagrass, macroalgae, and macroinvertebrates in the intertidal habitat of Robinsons Bay should be undertaken to detect changes to intertidal benthic ecology due to an increase in nutrient discharge from Robinsons Bay Stream.

  – Monitoring should be undertaken at impact sites in Robinsons Bay as well as at a control site in another intertidal embayment away from the area of wastewater discharge (such as Duvauchelle Bay or Barrys Bay). Monitoring should be undertaken before and after the commencement of the irrigation of wastewater to land. Monitoring should be undertaken annually, at the same time of year each year to ensure equanimity in comparisons.

  – Monitoring should follow the standardised methodology defined by Robertson *et al.* (2002).

» If shellfish may be collected from Robinsons Bay for consumption, monitoring of pathogen levels in the flesh of mahinga kai shellfish species (i.e., cockles) should be undertaken to ensure food safety standards are maintained.

  – Pathogen monitoring should be undertaken on cockles collected from Robinsons Bay (in the area where freshwater stream runoff flows across the mudflat at low tide) and from a control site in another intertidal embayment away from the ATWIS where there are sufficient cockle numbers (e.g., Duvauchelle Bay or Barrys Bay). Monitoring should be undertaken twice per year, preferably between 1 December and 31 March to align with the typical increase in local tourism and increased demand on wastewater treatment systems. Sample collection should occur around low tide (i.e., when the tidal flats are exposed to facilitate collection), and monitoring should be undertaken before and after the commencement of the ATWIS.

  – Cockles may be collected by hand by a qualified organisation that has the necessary MPI permits for the collection of shellfish for pathogen testing. Collection should aim for larger cockles that are of harvestable size, and the number of individuals needed for testing will depend on weight of shellfish flesh so calculations should be completed in conjunction with collection to ensure the sample size is sufficient. Pathogens to monitor include the faecal indicator microorganism *E. coli*, and the human pathogens Norovirus GI and GII, and enterovirus, and should be measured by accredited laboratories. Measured pathogen concentrations should be compared to food safety requirements set out by the Australia and New Zealand Food Standards Code (ANZFSC, Schedule 27, Standard 1.6.1) and MPI (MPI, 2022).

Trigger for Adaptive Management

If water quality, freshwater macroinvertebrate/periphyton attributes, or estuarine macroinvertebrate/seagrass attributes show a degradation over time that is statistically significantly different from established baseline values (e.g., median, interquartile range, mean seagrass cover), there are several potential adaptive management options that exist to further mitigate the potentially adverse effects of the proposed activity. These include:

» Further destocking of the CCC owned land within Robinsons Bay Valley to reduce nitrogen loads (such as the 'destocking 2' scenario modelled by McIndoe *et al.* (2022)).

» Additional planting of native trees outside of the irrigation area within the Robinsons Bay Valley, to allow for additional uptake of nitrogen.

» Providing for some harvesting of the trees within the Robinsons Bay Valley irrigation site if the uptake of nitrogen in the mature trees is not sufficient to maintain stream water quality.

» Higher levels of treatment of the wastewater prior to irrigation.

» Irrigating to additional areas outside of the proposed catchments to reduce the irrigation load (and thus nutrient load) on the current irrigation catchment.

6 CONCLUSIONS & EFFECTS MANAGEMENT SUMMARY

The construction effects of the project relate primarily to the earthworks and construction required to build the wastewater treatment plant infrastructure, including the stream crossings that may be required for the associated pipeline. Potential effects include the discharge of contaminants (especially fine sediment, machinery-related hydrocarbons, and concrete related contaminants) that may ultimately reach the harbour through freshwater runoff.

The mitigations required for the construction phase of the ATWIS will be detailed in a Construction Environmental Management Plan (CEMP) that will adopt the methods detailed in the Environment Canterbury Erosion and Sediment Control Toolbox for Canterbury. Where the wastewater pipeline needs to cross waterways that contain water, construction methodology will involve directional drilling beneath the stream, rather than traditional trenching methods. This will avoid surface disturbance to the stream channel and the release of fine sediments into the waterways. Where the wastewater pipeline needs to cross ephemeral streams, trenching methods may be used, but these works will be undertaken at a time when there is no surface water present. This approach will minimise the potential for sediment release and entrainment to surface water, and potential migration to Akaroa Harbour.

The following mitigation measures/effects management approaches are recommended for the construction phase of the project:

- Ensure all erosion and sediment control measures are appropriate to the highly erosive and dispersive loess subsoils present in the area.
- Construction activities should avoid any wetland areas as identified by Meurk (2022) or as subsequently identified during the construction phase.
- Sediment losses to any natural waterway are to be avoided where practicable, with relevant sediment control measures in place in all circumstances.
- Construction vehicles and machinery should be always operating outside of the watercourse and should not be driving across flowing waterways unless over a bridge (or similar) structure.
- All fuels and other construction liquids should be stored at least 20 metres away from waterways (including perennial, intermittent and ephemeral waterways) and in appropriately bunded locations. No vehicle refuelling should occur within 20 metres of waterways.
- Appropriately maintain construction vehicles and machinery on a preventative schedule to reduce the risk of breakdown. Spill kits should be located near to all machinery and staff must be trained in how to use these.
- All practical measures must be taken to ensure that no uncured cement or cement-based products enter flowing water in any waterway. Any works involving these products should be undertaken outside of the flowing channel and new concrete or mortar should not be exposed to water until firmly set (at least 48 hours).

The operational effects relate to the ongoing effects of the proposed ATWIS once it is complete and operating. The main potential effect of irrigating treated wastewater to land is the discharge of contaminants (especially nitrogen) from the irrigation areas reaching Akaroa Harbour through freshwater runoff from Robinsons Bay Stream or drainage from land from Hammond Point. Based on investigations and modelling of the nitrogen balance for Robinsons Bay catchment (McIndoe *et al*., 2022), under CCC's preferred irrigation scenario ('preferred/destocking 1' scenario from McIndoe *et al.* (2022)) the estimated post irrigation nitrate concentration in Robinsons Bay Stream is likely to be within the current typical range for this water quality parameter. The magnitude of this effect to biota in Robinsons Bay Stream is expected to be low, and the overall level of effect on the freshwater ecology has been assessed as low/less than minor (Dewson, 2022). As the freshwater ecosystem function in Robinsons Bay Stream is not expected to significantly change under the preferred irrigation scenario, the nutrients entering Robinsons Bay through freshwater runoff is expected to experience little change and the assessed level of effect on the intertidal benthic ecology in Robinsons Bay is less than minor. A water quality monitoring programme and annual biomonitoring of the intertidal benthic habitats is recommended to ensure no adverse effects arise in these areas.

Modelling has also indicated that irrigation of treated wastewater to Hammond Point may result in nutrients entering Akaroa Harbour via subsurface discharge. Under a conservative scenario, where all nitrogen in the irrigation water enters the harbour, the annual nitrogen load will be significantly lower than the annual load discharged under the current wastewater discharge scheme which will be terminated with the establishment of the ATWIS. As such, the assessed magnitude of the effect of nitrogen released into Akaroa Harbour from Hammond Point is negligible. However, the discharge of nitrogen may be varied and seasonal, and ongoing water quality monitoring is recommended to ensure there will be no resulting adverse effects to the harbour ecology.

Mellish (2022) confirms that there is a low risk of phosphorus, heavy metals, and POPs leeching into streams and entering the harbour environment. However, microorganisms such as *E.coli* that may be found in the treated wastewater could be flushed into Akaroa Harbour. Ongoing shellfish pathogen monitoring is recommended as cockles in Robinsons Bay may be collected for human consumption.

The following mitigation measures/effects management approaches are supported for the operational phase of the project:

» **Selection of most suitable area for irrigation** – avoiding irrigation of ephemeral streams, boggy areas, and springs.

» **Irrigation of native trees in irrigable areas** – to enhance the uptake of irrigated wastewater and nutrients.

» **Minimising surface ponding and runoff** – by good irrigation design and management and maintaining good ground cover.

» **Irrigation setbacks from streams** – maintaining setbacks from streams to minimise the potential for irrigation runoff to enter streams.

» **Destocking the irrigation area** – to offset some of the nitrogen that will be applied to land in the wastewater and reduce the leaching of nitrogen to surface water. There is an initial destocking programme under the 'preferred/destocking 1' scenario, with further destocking available if needed.

With proper implementation of the described effects management approaches during construction, and with implementation of the CCC's 'preferred/destocking 1' irrigation scenario, it is expected that the potential adverse effects of the ATWIS on estuary ecology in Akaroa Harbour should be able to be reduced to an overall less than minor effect. However, given assumptions around the nutrient levels that will be in the applied wastewater, the variation in the modelled scenarios relating to nutrient levels in the receiving environment, and (albeit unlikely) possibility of other contaminants reaching the receiving environment, it will be important to implement an estuary monitoring programme to monitor trends in water quality and environmental parameters. If monitoring identifies any issues, then the following adaptive management options are available:

» Further destocking of the CCC owned land within Robinsons Bay Valley to reduce nitrogen loads (such as the 'destocking 2' scenario modelled by McIndoe *et al.* (2022)).

» Additional planting of native trees outside of the irrigation area within the Robinsons Bay Valley, to allow for additional uptake of nitrogen.

» Providing for some harvesting of the trees within the Robinsons Bay Valley if the uptake of nitrogen in the mature trees is not sufficient to maintain stream water quality.

» Higher levels of treatment of the wastewater prior to irrigation.

» Irrigating to additional areas outside of the proposed catchments to reduce the irrigation load (and thus nutrient load) on the current irrigation catchment.

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9 APPENDICES

9.1 Epifauna Macroinvertebrate Data

Table 7 Summary of epifauna macroinvertebrate taxa identified in the Akaroa Harbour by EOS Ecology on 17-19 November 2021. 'Number' refers to the total number of individuals identified across all sites, with overall percent abundance in parenthesis. 'Freq' refers to the number of sites where the taxon was found.

Faunal Group	Taxa	Robinsons Bay		Takamātua Bay		Childrens Bay		TOTAL	
		Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=36)
Crustacea	Crab Burrows	2 (0.6%)	1	2 (1.4%)	2			4 (0.9%)	3
	Flabellifera					1 (7.7%)	1	1 (0.2%)	1
	Hemiplax hirtipes	1 (0.3%)	1					1 (0.2%)	1
	Amphipoda	4 (1.3%)	1	2 (1.4%)	1			6 (1.3%)	2
Mollusca	*Amphibola crenata*	1 (0.3%)	1	52 (36.9%)	10			53 (11.3%)	11
	Austrovenus stutchburyi	75 (23.9%)	7	6 (4.3%)	2	4 (30.8%)	3	85 (18.2%)	12
	Cominella glandiformis	9 (2.9%)	6					9 (1.9%)	6
	Diloma subrostratum	118 (37.6%)	12	7 (5.0%)	3	2 (15.4%)	2	127 (27.1%)	17
	Micrelenchus tenebrosus	14 (4.5%)	6					14 (3.0%)	6
	Paphies australis					1 (7.7%)	1	1 (0.2%)	1
	Notoacmea sp.	90 (28.7%)	10	72 (51.1%)	9	5 (38.5%)	5	167 (35.7%)	24
Grand Total		**314**		**141**		**13**		**468**	
Taxa Richness		**9**		**6**		**5**		**11**	

9.2 Infauna Macroinvertebrate Data

Table 8 Summary of infauna macroinvertebrate taxa identified in the Akaroa Harbour by EOS Ecology on 17–19 November 2021. 'Number' refers to the total number of individuals identified across all sites, with overall percent abundance in parenthesis. 'Freq' refers to the number of sites where the taxon was found.

Faunal Group	Taxa	Robinsons Bay		Takamātua Bay		Childrens Bay		Total	
		Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=36)
Cnidaria	*Edwardsia leucomelos*	1 (0.2%)	1	5 (1.6%)	4			6 (0.5%)	5
Crustacea	Flabellifera	6 (1.0%)	5	1 (0.3%)	1	2 (0.6%)	2	9 (0.7%)	8
	Halicarcinus	2 (0.3%)	2					2 (0.2%)	2
	Ostracoda	6 (1.0%)	4					6 (0.5%)	4
	Paracalliope sp.	55 (8.9%)	9	8 (2.5%)	5	17 (5.1%)	7	80 (6.3%)	21
	Hemiplax hirtipes	1 (0.2%)	1					1 (0.1%)	1
	Paramoera sp.	1 (0.2%)	1					1 (0.1%)	1
	Cumacea					60 (17.9%)	11	60 (4.7%)	11
Insecta	Orthocladiinae			5 (1.6%)	4	1 (0.3%)	1	6 (0.5%)	5
	Hydrobiosidae			1 (0.3%)	1			1 (0.1%)	1
	Elmidae			2 (0.6%)	1			2 (0.2%)	1
Mollusca	*Amphibola crenata*			3 (1.0%)	2			3 (0.2%)	2
	Arthritica sp.	19 (3.1%)	6	48 (15.3%)	8	17 (5.1%)	6	84 (6.6%)	20
	Austrovenus stutchburyi	108 (17.6%)	11	21 (6.7%)	7	29 (8.7%)	9	158 (12.5%)	27
	Cominella glandiformis	10 (1.6%)	6	3 (1.0%)	3			13 (1.0%)	9
	Diloma subrostrate	9 (1.5%)	5	6 (1.9%)	2			15 (1.2%)	7
	Macomona liliana	93 (15.1%)	12	48 (15.3%)	11	8 (2.4%)	6	149 (11.8%)	29
	Micrelenchus tenebrosus	10 (1.6%)	5			1 (0.3%)	1	11 (0.9%)	6
	Paphies australis	1 (0.2%)	1			1 (0.3%)	1	2 (0.2%)	2
	Potamopyrgus sp.	1 (0.2%)	1					1 (0.1%)	1
	Notoacmea sp.	18 (2.9%)	6	12 (3.8%)	3	1 (0.3%)	1	31 (2.5%)	10
	Odostomia sp.	1 (0.2%)	1					1 (0.1%)	1
	Cominella maculosa	1 (0.2%)	1					1 (0.1%)	1
	Physa			1 (0.3%)	1			1 (0.1%)	1
Nemertea	Nemertea	21 (3.4%)	7	4 (1.3%)	3	17 (5.1%)	8	42 (3.3%)	18

Faunal Group	Taxa	Robinsons Bay		Takamātua Bay		Childrens Bay		Total	
		Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=12)	Number	Freq (n=36)
Polychaeta	*Aonides* sp.	3 (0.5%)	3					3 (0.2%)	3
	Capitellidea	1 (0.2%)	1					1 (0.1%)	1
	Glycera americana	1 (0.2%)	1			1 (0.3%)	1	2 (0.2%)	2
	Heteromastus filiformis	174 (28.3%)	12	11 (3.5%)	4	125 (37.3%)	12	310 (24.5%)	28
	Lumbrineris sp.	6 (1.0%)	4	2 (0.6%)	2	1 (0.3%)	1	9 (0.7%)	7
	Nereidae	2 (0.3%)	2	19 (6.1%)	8	4 (1.2%)	2	25 (2.0%)	12
	Nicon aestuariensis	2 (0.3%)	2	1 (0.3%)	1			3 (0.2%)	3
	Orbinia papillosa	6 (1.0%)	5			10 (3.0%)	6	16 (1.3%)	11
	Perinereis brevicirris			1 (0.3%)	1			1 (0.1%)	1
	Phyllodocidae	6 (1.0%)	3					6 (0.5%)	3
	Prionospio aucklandica	2 (0.3%)	1					2 (0.2%)	1
	Scolecolepides benhami	2 (0.3%)	2			1 (0.3%)	1	3 (0.2%)	3
	Scoloplos cylindrifer	2 (0.3%)	2	101 (32.2%)	10			103 (8.1%)	12
	Syllidae	1 (0.2%)	1					1 (0.1%)	1
	Boccardia sp.			4 (1.3%)	3			4 (0.3%)	3
	Capitella sp.	6 (1.0%)	3	5 (1.6%)	1	1 (0.3%)	1	12 (0.9%)	5
	Prionospio sp.	14 (2.3%)	6	1 (0.3%)	1			15 (1.2%)	7
	Scolelepis sp.	1 (0.2%)	1			8 (2.4%)	5	9 (0.7%)	6
	Magelona sp.	19 (3.1%)	7	1 (0.3%)	1	30 (9.0%)	9	50 (4.0%)	17
	Thelepus sp.	1 (0.2%)	1					1 (0.1%)	1
	Terebella plagiostoma	1 (0.2%)	1					1 (0.1%)	1
	Hesionidae	1 (0.2%)	1					1 (0.1%)	1
Grand Total		**615**		**314**		**335**		**1264**	
Taxa Richness		**39**		**25**		**20**		**47**	

9.3 Assessment Categories for Determining Ecological Value

Table 9 Assessment categories and criteria for determining the ecological value for an Assessment of Environmental Effects.

Value	Description	Characteristics
Very high	A pristine system that would be representative of conditions close to its pre-human condition (i.e., a reference condition). No anthropogenic contaminant inputs. Flora and fauna effectively unchanged from pre-human condition.	» Habitat: – Habitat heterogenous, with the ability to support a diverse invertebrate and macroalgae community. – Marine sediments typically comprise less than 25% silt and clay grain sizes (Robertson *et al.*, 2016). – Surface sediment oxygenated. – No contaminant concentrations in surface sediment – all well below the ANZECC (2018) Default Guideline Values (DGV). – Intertidal zone not limited through modified structures. – Habitat unmodified. » Macroinvertebrate community: – High species richness, diversity, and abundance. – High abundance of taxa that are sensitive to enrichment and settled sediments, and no pollution-tolerant species in high abundance. – No invasive or pest species. – Presence of species with a threat classification of "Threatened – nationally critical" or equivalent regional threat classification may elevate an otherwise low, moderate, or high value site to be very high. » Macroalgae and seagrass community: – High species richness, diversity, and abundance. – Very high cover (>85%), of habitat forming species and absence of problem species or those indicative of excessive nutrients. – Presence of species with a threat classification of "Threatened – nationally critical" or equivalent regional threat classification may elevate an otherwise low, moderate, or high value site to be very high. » Fish community: – High species richness, diversity, and abundance of resident species. – Presence of resident species with a threat classification of "Threatened – nationally critical" or equivalent regional threat classification may elevate an otherwise low, moderate, or high value site to be very high (note this does not apply to species that are transitory through the area).
High	A system that has been modified through loss of natural intertidal/ coastal vegetation and catchment land use change, to the extent it is no longer pristine or could considered to be in reference condition. However, many natural, pre-human qualities are retained.	» Habitat: – Habitat generally heterogenous, with the ability to support a diverse invertebrate and macroalgae community. – Marine sediments typically comprise less than 35% silt and clay grain sizes. – Sediment generally oxygenated near the surface. – Low contaminant concentrations in surface sediment – rarely exceed the ANZECC (2018) Default Guideline Values (DGV). – Intertidal zone not limited through modified structures. – Habitat largely unmodified. » Macroinvertebrate community: – High species richness, diversity, and abundance. – Presence of taxa that are sensitive to enrichment and settled sediments, and no pollution-tolerant species in high abundance. – No invasive or pest species, or only present in low numbers/abundance. – Presence of species with a threat classification of "Threatened – nationally endangered" or "Threatened – nationally vulnerable "or equivalent regional threat classification may elevate an otherwise low or moderate value site to be high.

Value	Description	Characteristics
		» Macroalgae and seagrass community: – High species richness, diversity, and abundance. – High cover (>75%) of habitat forming species, and low to no abundance of problem species or those indicative of excessive nutrients. – Presence of species with a threat classification of "Threatened – nationally endangered" or equivalent regional threat classification may elevate an otherwise low or moderate value site to be high. » Fish community: – High species richness, diversity, and abundance of resident species. – Presence of resident species with a threat classification of "Threatened – nationally endangered" or equivalent regional threat classification may elevate an otherwise moderate or low value site to be high (note this does not apply to species that are transitory through the area).
Moderate	A system that retains components of its natural state, but has been modified in some areas (such as through a loss of intertidal/ coastal habitat).	» Habitat: – Habitat generally homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. – Marine sediments typically comprise less than 50% silt and clay grain sizes. – Sediment generally oxygenated near the surface. – Low contaminant concentrations in surface sediment – generally below the ANZECC (2018) Default Guideline Values (DGV) although some may be close to or just over the DGV. – Intertidal zone only partially limited through modified structures. – Habitat partly modified. » Macroinvertebrate community: – Moderate species richness, diversity, and abundance. – The presence of taxa that are sensitive to enrichment and settled sediments, as well as some that are more tolerant. – Few invasive or pest species. – Presence of species with a threat classification of "At Risk" or equivalent regional threat classification may elevate an otherwise low value site to be moderate. » Macroalgae and seagrass community: – Moderate species richness, diversity, and abundance. – Moderate cover (25%-75%) of habitat forming species, which may include some species that are considered problem species or are indicative of elevated nutrients. – Presence of species with a threat classification of "At Risk" or equivalent regional threat classification may elevate an otherwise low value site to be moderate. » Fish community: – Moderate species richness, diversity, and abundance of resident species. – Presence of resident species with a threat classification of "At Risk" or equivalent regional threat classification may elevate an otherwise low value site to be moderate (note this does not apply to species that are transitory through the area).
Low	A system that is very modified and few aspects of its natural state remain, but with a few aspects that are still in moderate condition.	» Habitat: – Habitat generally homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. – Marine sediments dominated by silt and clay grain sizes (>50%). – Surface sediment generally anoxic. – Elevated contaminant concentrations in surface sediment – some above the ANZECC (2018) Default Guideline Values (DGV). – Intertidal zone limited through modified structures. – Habitat very modified. » Macroinvertebrate community:

Value	Description	Characteristics
		– Low species richness, diversity, and abundance. – High abundance of taxa or individuals that are not sensitive to organic enrichment and settled sediments. – May have some invasive or pest species. » Macroalgae and seagrass community: – Low species richness, diversity, and abundance. – Low cover (<25%) of habitat forming species, which are dominated by those indicative of elevated nutrients. – May include some invasive or pest species. » Fish community: – Low species richness, diversity, and abundance of resident species.
Very Low	A system that is highly modified and very few aspects of its natural state remain.	» Habitat: – Habitat homogenous, limiting the ability to support a diverse invertebrate and macroalgae community. – Marine sediments dominated by silt and clay grain sizes (>60%). – Surface sediment anoxic. – Elevated contaminant concentrations in surface sediment - most above the ANZECC (2018) Default Guideline Values (DGV). – Intertidal zone severely limited through modified structures. – Habitat extremely modified. » Macroinvertebrate community: – Very low species richness, diversity, and abundance. – Dominated by taxa that are not sensitive to organic enrichment and settled sediments. – May have invasive or pest species, often in high abundance. » Macroalgae and seagrass community: – Very low species richness, diversity, and abundance. – Little to no cover of habitat forming species, which are dominated by those indicative of elevated nutrients. – May include some invasive or pest species, often in high abundance. » Fish community: – No resident species present, although the area can provide a migration pathway or a temporary foraging habitat for transient species.

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SCIENCE + ENGAGEMENT

EOS ECOLOGY

Appendix J Preliminary Site Investigation Report

Akaroa Treated Wastewater Irrigation Scheme - Preliminary Site Investigation

PREPARED FOR CHRISTCHURCH CITY COUNCIL | June 2022

We design with community in mind

Stantec

Revision Schedule

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
0	17/08/2021	Draft PSI Report	S Fellers	P Heveldt	P Heveldt	S Velluppillai
1	09/06/2022	Updated site boundary	S Fellers	J Dunning	J Dunning	
2	22/06/2022	Approve to issue				S Velluppillai

Quality Statement

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STATUS DRAFT FOR CLIENT | Project No 31013534

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Overview

A Preliminary Site Investigation (PSI) has been undertaken for the Akaroa Treated Wastewater Irrigation Scheme (the Project). The Project includes a new terminal pump station, new wastewater treatment plant, various storage ponds and irrigation areas located between Children's Bay in the south and Robinsons Bay to the north.

The PSI has been informed by:

- Historical aerial photos
- A review of Environment Canterbury's Listed Land Use Register
- Christchurch City Council's resource consent database
- A site inspection on 6 May 2021

Together this information has been used to identify properties that have had, currently have or are likely to have had an activity undertaken that appears on the Ministry for the Environment (MfE) Hazardous Activities and Industries List (HAIL list).

The HAIL list comprises a wide variety of activities that are considered to have the potential to contaminate land.

Findings

This PSI has identified the locations of the terminal pumpstation and the Jubilee Park and Akaroa Recreational Ground that may pose a risk to human health and the environment during proposed project works. These locations west of Rue Brittan in Children's Bay has been identified as being part of an area of reclamation where domestic refuse was used as part of the fill material (HAIL G3).

Next Steps

It has been recommended that a Detailed Site Investigation (DSI) be completed for the Children's Bay area. This investigation should include intrusive soil sampling to assess potential contaminant concentrations.

Requirements under the *National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations 2011* (NESCS) and the Canterbury Land and Water Regional Plan have not been directly assessed. While a full assessment of consent requirements cannot be completed at this stage it is considered likely that consent under the NES will be required for at least part of the proposed route. A full assessment of consents required should be completed during the DSI stage.

Abbreviations

CEnvP	Certified Environmental Practitioner
CLMG	Contaminated Land Management Guidelines
CCC	Christchurch City Council
DSI	Detailed Site Investigation
HAIL	Hazardous Activities and Industries List
LWRP	Land and Water Regional Plan
MfE	Ministry for the Environment
NESCS	National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health
PSI	Preliminary Site Investigation
QA/QC	Quality Assurance and Quality Control
SQEP	Suitably Qualified and Experienced Practitioner
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

1.1 SQEP CERTIFICATION OF THE REPORT

I *Scott Fellers of (Complete company details)* certify that:

1. this preliminary site investigation meets the requirements of the Resource Management (National Environmental Standard for assessing and managing contaminants in soil to protect human health) Regulations 2011 because it has been:
    a. done by a suitably qualified and experienced practitioner, and
    b. reported on in accordance with the current edition of Contaminated land management guidelines No 1 – Reporting on contaminated sites in New Zealand, and
    c. the report is certified by a suitably qualified and experienced practitioner.
2. For activities under R8(3) of the NESCS this preliminary site investigation concludes it is possible that there will be a risk to human health if the activity is done to the piece of land.
3. The activity to be undertaken as defined in R 5(4) is described:
    a. on pages 4-7of this preliminary site investigation and
    b. the area of land addressed is described on page 14 of this preliminary site investigation.

Evidence of the qualifications and experience of the suitably qualified and experienced practitioner(s) who have done this investigation and have certified this report is appended to the preliminary site investigation report.

Signed and dated: … Scott Fellers …………08 June 2022…………………………………….

1.2 PROJECT OVERVIEW

The following is an excerpt from the “Statement of Work for the Akaroa Consent Application Document” (Issued for Tender V2):

“The existing Akaroa Wastewater Treatment Plant (WWTP) discharging to Akaroa Harbour is to be replaced with a new WWTP to be built at the intersection of Long Bay Road and Old Coach Road near Akaroa.

In 2020, Council consulted on four options for the disposal/ reuse of treated wastewater that will be produced by the new treatment plant, after five years of robust options analysis[1]. The Council decided on 10 December 2020 to use the highly treated wastewater to irrigate plantings of native trees in Robinsons Bay, Takamātua and Hammond Point (also known as the Inner Bays scheme). The Council resolution and extensive background information about the project can be found on the project webpage[2]. It is strongly recommended that tenderers review these documents.

CCC are currently seeking a short-term eight-year consent for the existing outfall which is likely to expire by 2028 (this is not included in the project scope). The new scheme must therefore be consented, designed, constructed and commissioned by 2028.”

1.3 SCOPE OF WORK

Stantec has been commissioned by Christchurch City Council (CCC) to undertake a Preliminary Site Investigation (PSI) for the Akaroa Treated Wastewater Irrigation Scheme (the Project).

Methodology

To identify the likelihood of encountering contaminated soil within the proposed project area, a systematic desktop assessment of historical and current land uses has been carried out. The purpose was to identify any past or present Hazardous Activities and Industries List (HAIL) activities identified on or near the works area and to assess the risk that any identified HAIL activities pose to the project.

The purpose of this report is to identify any HAIL sites within or near any of the works areas which are part of the Project. This will be done through a review of the following sources of information:

- Review of Environment Canterbury’s Listed Land Use Register
- Review of the CCC resource consent database
- An aerial photography review, including scrutiny of historic images (Canterbury Maps, Retrolens and Google Earth) indicating land uses at properties across the project alignment
- Site inspection completed on 2 May 2021
- Review of previous reporting

This desktop PSI fulfils the reporting requirements for assessment of contaminated land effects against the *National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations 2011* (NESCS).

This PSI has been prepared in general accordance with the Ministry for the Environment’s *Contaminated Land Management Guidelines No 1: Reporting on Contaminated Sites in New Zealand (revised 2021)* and has been prepared and reviewed by a person considered to be a suitably qualified and experienced practitioner (SQEP), in accordance with the NESCS.

[1] Consultation document Akaroa treated wastewater options: https://ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/WEB-Akaroa-treated-wastewater-options.pdf
[2] Akaroa reclaimed water treatment and reuse scheme project webpage: https://ccc.govt.nz/services/water-and-drainage/wastewater/wastewater-projects/akaroa-wastewater-scheme

2.0 PROJECT LOCATION

The Akaroa Treated Wastewater Irrigation Scheme includes a pump station within the northern part of the Akaroa township at Childrens Bay, a wastewater treatment plant near the northern end of Old Coach Road and areas at Jubilee Park, the Akaroa Recreation Ground, Takamātua Bay, Hammond Point and Sawmill Road for irrigation of reclaimed water to land. The irrigation pipe network will generally travel north along the Christchurch to Akaroa Road/SH75, terminating at the Robinsons Bay Valley Sawmill Road area.

Please see Figure 1 below and the following sections for details of key aspects of the project.

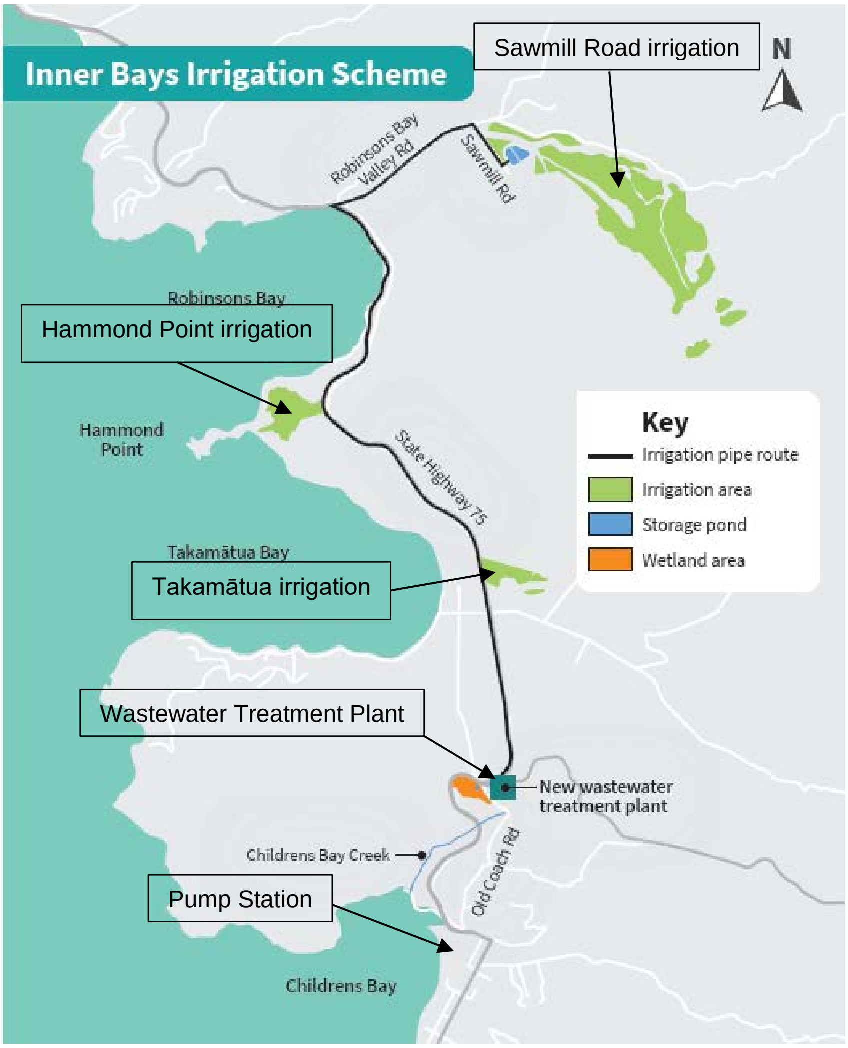

Figure 1: Proposed Wastewater Treatment Scheme key locations (Source: CCC)

2.1 CHILDRENS BAY SITES

As part of the scheme a terminal pump station is proposed to be constructed within the Childrens Bay area at the northern end of Akaroa township. At the time of this report the exact location of the pump station has not been identified, but it is expected to be within the parking lot to the east of the boat park and Rue Brittan. A lawn bowls green and a mini golf layout bound the site to the east and Grehan Stream bounds the site to the south. Rue Brittan bounds the site to the north and west. Pipes are proposed to cross under the Christchurch to Akaroa Road and connect to the new WWTP at the northern end of Old Coach Road. The exact route of the pipes was not known at the time of this report.

Please see Figure 2 below for site details.

Figure 2: Location of terminal pump station is expected to be within the area (red dotted line) shown above (Source: Canterbury Maps[3])

Additionally, Jubilee Park located immediately South of Christchurch Akaroa Road and the Akaroa Recreational Ground in the north part of the Akaroa township are proposed to be irrigated with reclaimed water. The amount of water to be irrigated at these locations is proposed to be minor with just enough water pumped to keep the grass green. No impact on ground water is expected. Please see Figure 3 for areas of proposed irrigation.

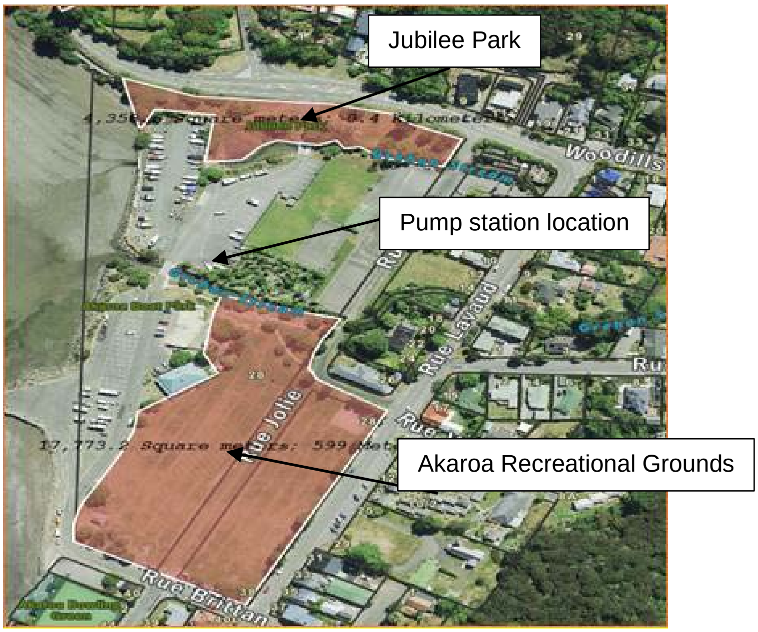

Figure 3: Irrigated areas at Jubilee Park and the Akaroa Recreational Grounds are shown in red.

[3] https://mapviewer.canterburymaps.govt.nz/

2.2 WASTEWATER TREATMENT PLANT AND STORAGE PONDS

The proposed WWTP will be located east of the intersection of Old Coach Road and Long Bay Road, approximately 1km north of the Akaroa township. An existing water reservoir tank is located in this area. The treatment plant is proposed to be sited adjacent to this water tank. Storage ponds for untreated wastewater are proposed to be located between Old Coach Road and the Christchurch to Akaroa Road, immediately west of the treatment plant on the opposite side of Old Coach Road. This area is currently a grassed paddock. Both locations are elevated approximately 120m above the proposed pump station location.

Please refer to Figure 3 below.

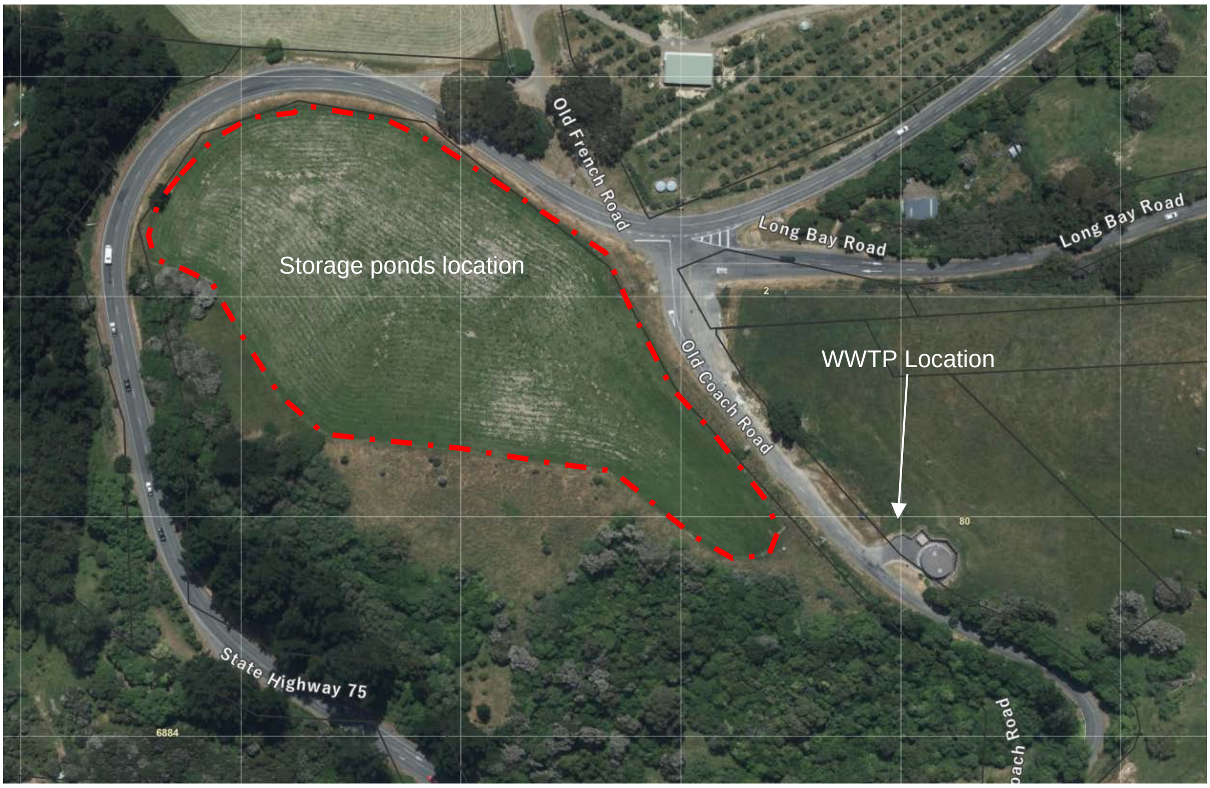

Figure 4: Approximate WWTP and storage pond locations (Source: Canterbury Maps[3])

2.3 TAKAMĀTUA IRRIGATION SITE

The proposed Takamātua irrigation site is located east of the Christchurch to Akaroa Road at Takamātua Bay, approximately 2klm north of Akaroa Township. At the time of preparing this report the irrigation site was to be located within a grassed paddock. The Takamātua Stream bounds this site to the south.

Please refer to Figure 4 below.

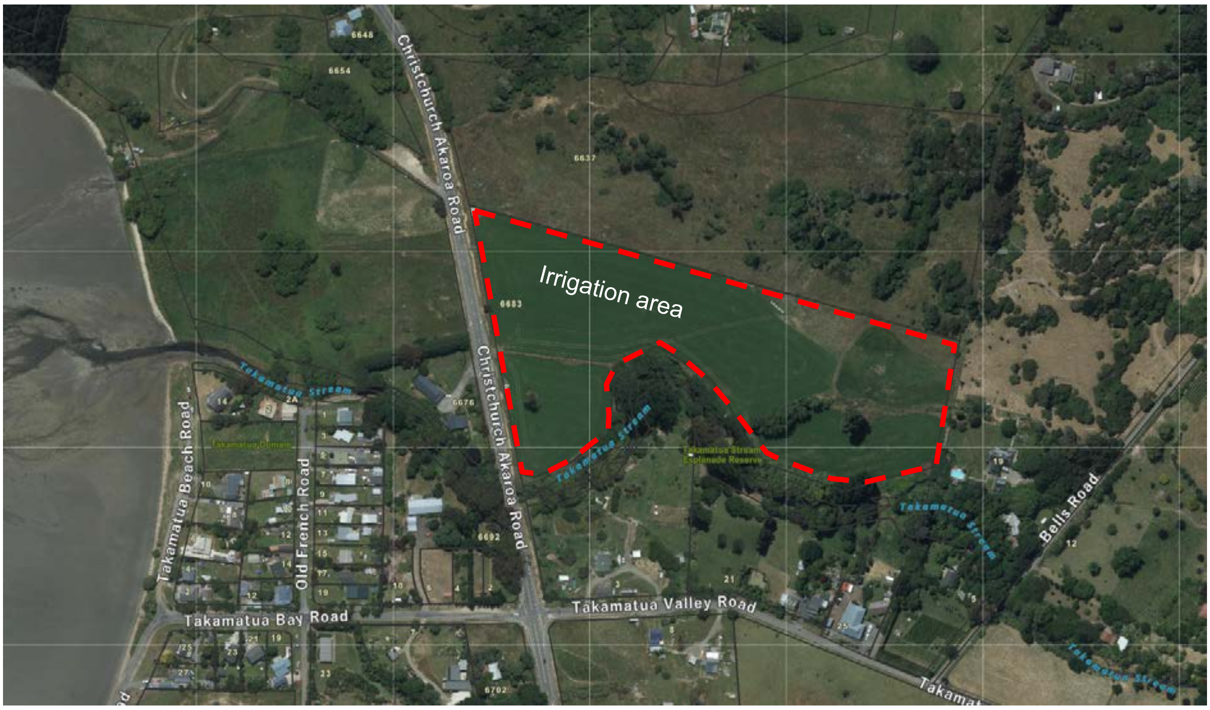

Figure 5: Takamātua irrigation area (Source: Canterbury Maps[3])

2.4 HAMMOND POINT IRRIGATION SITE

The proposed Hammond Point irrigation site is located west of the Christchurch to Akaroa Road and will cover the northeast portion of Hammond Point, approximately 3klm north of Akaroa Township. At the time of preparation of this PSI report the irrigation site was a grassed paddock sloping northwest down to the Akaroa Harbor which bounds the site to the northwest. A farm track crosses through the site connecting a holiday cottage southwest of the site to the highway.

Please refer to Figure 5 below.

Figure 6: Hammond Point Irrigation Site (Source: Canterbury Maps[1])

2.5 ROBINSONS BAY VALLEY SAWMILL ROAD SITE

This location is covered by a separate Preliminary and Detailed Site Investigation report prepared by Stantec[4]. Please refer to this document for details on this location.

3.0 EXISTING ENVIRONMENT

3.1 GEOLOGY

The project geology is mapped by GNS New Zealand.[5] The Childrens Bay and Takamātua areas are mapped as grey river alluvium beneath plains or low-level terraces (Q1A). It should be noted that the site history review has revealed that the Childrens Bay area predominantly consists of reclaimed land west of the Christchurch to Akaroa Road. The remainder of the project is mapped as yellow wind-blown silt on Banks Peninsula (mQe).

[4] Robinsons Bay Sawmill Road Site – Preliminary and Detailed Site Investigation. 2021. Stantec. Reference 31013534
[5] https://data.gns.cri.nz/geology/. Reviewed December 2020

3.2 SURFACE WATER

Various streams cross the project alignment. From north to south, the Robinsons Bay Stream, Takamātua Stream, Childrens Bay Stream and Grehan Stream generally flow cross the project alignment from east to west before discharging into the Akaroa Harbour. No additional surface water is present on or near the site.

4.0 SUMMARY OF PREVIOUS ACTIVITIES

4.1 LISTED LAND USE REGISTER RECORDS SEARCH

The Listed Land Use Register (LLUR) is a publicly available database of information about sites where hazardous activities and industries have been or are currently being carried out throughout the Canterbury region. It should be noted that LLUR is not a complete record and that information about properties is added or updated regularly as more information becomes available

The LLUR identified one site as part of the works area recorded on the HAIL list – as per Table 4-1.

Table 4-1: Properties identified as potentially contaminated on the LLUR

Site Address	Works Scope	HAIL Activity	Additional information provided
28 Rue Jolie, Akaroa	Proposed pump station	G3- landfill site	Landfill from pre 1900 to 1978. Noted as domestic landfill. ENGEO completed a PSI and a DSI in 2019 for this site.

4.2 AERIAL PHOTOGRAPHS

Aerial photographs from 1941 to 2019 for the Akaroa Treated Wastewater Irrigation Scheme area were accessed from the Retrolens website, Canterbury Maps and Google Earth. Table 4-2 summarises the general changes in land use along the alignment over the sequential timeframe of the aerial photographs. Please refer to a selection of relevant reviewed aerial photographs in Appendix B.

Table 4-2: Findings from review of aerial imagery

Year	Childrens Bay	Water treatment plant and ponds	Takamātua irrigation area	Hammond point irrigation area
1941	The location of the terminal pump station and most of Jubilee Park has yet to be reclaimed and is, at this date, currently part of Childrens Bay. The Akaroa Recreational Grounds are present and appear grassed. The exact location of the pipes connecting the pump station and the WWTP is unknown. The area predominantly comprises paddocks	Old Coach Road is visible as an unpaved farm track. The area of the storage pond and the pump station appears to be cropped and/or grazed. A row of trees is visible along the southern part of this pond area. Land along the Christchurch to Akaroa Road connecting the pump station to the Takamātua site is predominately paddocks used for	The Christchurch to Akaroa Road is visible along the west part of the irrigation area. The irrigated area appears to be cropped and/or grazed. Land along the Christchurch to Akaroa Road connecting the alignment to the Hammond Point site is predominately paddocks used for cropping and/or grazing.	The Christchurch to Akaroa Road is visible along the eastern part of the irrigation area. The irrigated area appears to be cropped and/or grazed. Land along the Christchurch to Akaroa Road connecting to the Sawmill Road site is predominately paddocks used for cropping and/or grazing.

	used for cropping and/or grazing.	cropping and/or grazing.		
1966	Reclamation works are being undertaken along the north edge of Children's Bay. Fill material including debris material can be seen being placed into the Bay (HAIL G5). Land comprising Jubilee Park has been reclaimed and a large amount of of bare fill material and stockpiles can be seen (HAIL G5). Additional land west of the Akaroa Recreational Grounds has now been reclaimed and fill and stockpiles can be seen (HAIL G5). The area for the pump station is still part of Childrens Bay.	Earthworks along the north edge of Old Coach Road are visible. It appears that material has been removed, possibly in relation to roading upgrades along the highway. The Christchurch to Akaroa Road is now paved and the intersection with Old Coach Road has been enlarged. The area proposed for the storage ponds is still cropped and/or grazed.	The area appears relatively unchanged from previous imagery.	A farm track is now visible crossing generally east-west across the site. The area still appears cropped and/or grazed.
1975	N/A	N/A	A trotting oval is visible on the site though the land generally still appears to be used for cropping and/or grazing.	The area appears relatively unchanged from previous imagery.
1977	Additional land has been reclaimed both to the north and west of the pump station location. Fill and debris are visible (HAIL G5). The pump station area is still part of Childrens Bay. Jubilee Park now appears generally grassed.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.	N/A
1984	Reclamation works can now be seen in the pump station area. The space	The area appears relatively unchanged from previous imagery.	The trotting oval is still faintly visible though now appears to be unused. The	The area appears relatively unchanged from previous imagery.

	between Children's Bay Stream and Grehan Stream is now filled. Debris and fill material can be seen (HAIL G5) as part of reclamation works. The initial construction of Rue Brittan can be seen.		area generally appears unchanged from previous imagery.	
1995	Additional land has been reclaimed along the northern part of Children's Bay extending Jubilee Park somewhat (HAIL G5). Generally, the current layout of the area is now in place with the boat parking to the west and a parking area to the east where the pump station is proposed to be located.	Old Coach Road has been widened somewhat near the junction with the highway resulting in some of the bank along the north side of the road being excavated. The row of trees has been removed along the south part of the storage pond area.	The trotting oval is no longer visible. The area appears cropped and/or grazed.	The area appears relatively unchanged from previous imagery.
2000-2004	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.
2004-2010	The carpark is now paved.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.
2014	The area appears relatively unchanged from previous imagery.	Roading material is stored along the northern side of Old Coach Road, thus this is possibly HAIL G5. The general area appears to be unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.
2019	The alignment of the parking lot is now somewhat changed, with Rue Brittan now in its current alignment crossing between the boat	A water tank is now visible approximately where the new WWTP is proposed to be located. Stockpiles of roading material are still visible now	The area appears relatively unchanged from previous imagery.	The area appears relatively unchanged from previous imagery.

	parking area and the vehicle parking lot.	west of the pump station area. The storage pond area appears relatively unchanged from previous imagery.		

4.3 RESOURCE CONSENTS

Christchurch City Council's Resource Consent Database was reviewed to assess if there are any discharge consents for relevant properties along the project route, or if bulk storage of hazardous materials is recorded for any individual properties, as these activities can present a risk of ground contamination.

Please see Table 4-3 for a list of relevant resource consents that have been issued on or within 100m of the project site.

Table 4-3: Resource Concsents

Consent number	Address/ Location	Details	Status
CRC185496	2 Old Coach Road, Akaroa (Wastewater treatment facility)	To discharge water tracer and reservoir water to groundwater. The tracer shall only be sodium chloride or rhodamine dye, or fluorescent red dye	Expired 4 July 2020
CRC185498	2 7 4 Old Coach Road (Wastewater treatment facility)	To discharge groundwater to land and surface water	Expired 4 July 2020
CRC150050	2 Old Coach Road, Akaroa (Wastewater treatment facility)	To discharge contaminants (odor) to air and a land use to store effluent	Active, expires 9 July 2054. This relates to the project and the storage of wastewater has not commenced
CRC143636	Lot 2 and 4- Corner of Old Coach Road and Long Bay Road (Wastewater treatment facility)	To install 4 geotech groundwater level monitoring piezometers	Expired 12 December 2016
CRC152814	Beach Road (Terminal pump station location)	To discharge construction phase and developed phase stormwater to water	Expiry 9 July 2054
CRC150049	Beach Road (Terminal pump station location)	To discharge contaminants to air form the terminal pump station (yet to be built)	Issued - inactive
CRC961215	State Highway 75, Childrens Bay	To reclaim the foreshore and deposit sand, gravel, and other natural materials on the foreshore to stabilize SH 75 at Childrens Bay	Terminated 19 December 2019
CRC090994	Corner of SH 75 and Takamātua Bay Road (70m southwest of the Takamātua irrigation area)	To discharge contaminants to land from domestic wastewater	Expires 19 Aug 2043
CRC090995	Corner of SH 75 and Takamātua Bay Road	To discharge contaminants to land from domestic wastewater	Expires 19 Aug 2043

Consent number	Address/ Location	Details	Status
	(85m southwest of the Takamātua irrigation area)		
CRC084742	Corner of SH 75 and Takamātua Bay Road (100m southwest of the Takamātua irrigation area)	To discharge contaminants to land from domestic wastewater	N/A

Nothing in the resource consent database indicates that a HAIL activity has or is occurring on these sites.

4.4 SITE INSPECTION

A site walkover inspection was undertaken on 6 May 2021. The various parts of the site were either driven or walked where appropriate. Please refer to site images attached in Appendix C.

The following are notes from the site inspection:

- The Childrens Bay terminal pump station area is currently a parking lot. Boat parking is located to the west and a mini golf facility and lawn bowls green are located to the west. Childrens Bay Stream is located to the north, and Grehan Stream to the south. No indication of landfill material was visible at this location during the site inspection.
- A water reservoir tank is present adjacent to the location of the proposed WWTP. Roading material was not being stored at this location at the time of the site inspection.
- The proposed area for storage ponds along Old Coach Road is currently grassed paddocks.
- The Takamātua irrigation area is currently a grassed paddock.
- The Hammond Point irrigation area is currently grass paddocks. Animal pens were located adjacent to the highway but these appeared to be used for stock loading and not for sheep dip or spray race purposes.
- No HAIL activities were identified along the proposed pipe alingment between Childrens Bay and the Sawmill Road site.

No visual evidence of contamination was noted at any site along the project route and no additional HAIL sites were identified through the site visit.

4.5 PREVIOUS REPORTING

4.5.1 CH2M Beca Ltd, 2014

A Preliminary Site Investigation was completed by CH2M Beca Ltd (Beca) in 2014 to assess the historical records with respect to contamination at the proposed location of the terminal pump station within the Akaroa Recreation Ground at Childrens Bay. The report was commissioned by CCC to support the terminal wastewater pump station and wastewater pipeline project.

Beca's review of available information identified that the land in this area is a combination of traditional reclamation comprising importing soils and landfilling. The report identified that the western part of the recreation ground has been subject to landfilling activity from the 1890s to 1978.

Details of the report are as follows:

- Coastal reclamation has taken place along the Akaroa shoreline for many years. The site in question at the recreation ground west of the Grand Hotel has been subject to extensive reclamation.
- Reclamation behind the Grand Hotel was found to have started in 1886-1887.
- Intrusive soil investigations were completed at the location of the proposed pump station in the southeast corner of the paved boat parking area adjacent to Grehan Stream. These investigations encountered fill material including plastic bags, metal, glass, fabric, cans and other household waste. Five samples were collected and analysed for heavy metals, PAH and TPH. All results were found to be below the NESCS recreational standard.

4.5.2 Engeo 2019

A preliminary site investigation was completed by ENGEO in August 2019. This report was followed up by a detailed site investigation in December 2019. Both reports were commissioned by CCC to support the remediation of the Akaroa recreation ground sea wall along Childrens Bay.

The scope of the reports is limited to a strip of land along the western edge of the recreation ground. The investigated area was located predominantly south of Grehan Stream, with only a small portion located north of the stream included in the investigation. While this is not where the proposed pump station will be located, the report gives an indication of the composition of the landfill material that may be encountered.

Details of the report are as follows:

- The current shoreline was not visible until the 1993 historical image, thus indicating that reclamation continued through to the early 1990s.
- The intrusive investigation found evidence of landfilling activity including brick, glass and charcoal.
- An initial set of four sample locations were distributed along the investigated area. From these test locations samples were collected from below the hardfill, with five samples in total being obtained. Samples were analysed for heavy metals, PAH, and asbestos. No exceedances of the NESCS recreational standards were encountered for heavy metals or PAHs in the samples. One sample, from location HA3, showed the presence of asbestos which was found to be present in a concentration that exceeded the recreational guideline.
- An additional 12 soil samples were collected for asbestos assessment. From these samples one location showed the presence of asbestos which was found to be present at a concentration above the recreational guideline.

4.6 SUMMARY OF HAIL ACTIVITES IDENTIFIED

Table 4-4 summarises information for all the properties adjacent to the Project route which have been identified through the site history check as currently or historically having had HAIL activities occur on them. These are activities that have been identified through the Listed Land Use Register, aerial photographs, resource consents and the site inspection.

Table 4-4: Summary of HAIL activities

Address	HAIL Category	HAIL Description	Description of HAIL activity
Children's Bay terminal pump station, Jubilee Park and the Akaroa Recreational Grounds	G3 G5	Waste disposal to land Landfill	The location of the pump station Jubilee Park and the Akaroa Recreational Grounds are entirely on reclaimed land. The 2014 Beca report notes that the western portion of the reclamation is landfill material and that land reclamation in the Childrens Bay area began in the late 1800s. Testing encountered domestic refuse. The 2019 ENGEO report encountered asbestos in nearby samples.
Wastewater treatment plant location on Old Coach Road	G5	Waste Disposal to land	The 2014 aerial image shows stockpiled roading material along the north side of Old Coach Road.

5.0 CONCEPTUAL SITE MODEL

A Conceptual Site Model (CSM) is based on the environmental setting of the site and assesses contaminant distributions, release mechanisms, exposure pathways, migration routes and potential receptors. The CSM for the site acknowledges that the sources of potential contamination arise from multiple different historical activities that have taken place across the site.

The Children's Bay area was found to have HAIL G3 and G5 activities occurring from pre-1984 through 1995. The general area has been filled since the late 1800s. Previous investigations encountered domestic refuse, including asbestos, in the general area. There is a risk that the landfill material is a source of risk to human health or the environment.

The potential receptors for contaminants on the site are workers during the construction of the proposed new pump station and infrastructure at Jubilee Park and the Akaroa Recreational Grounds, as well as the nearby Children's Bay Stream, Grehan Stream and Children's Bay itself. Pathways for human exposure during site works include dermal contact, inhalation and ingestion of small amounts of soil during the construction phase. Pathways to the various waterways during site works are generally via stormwater runoff from bare soils during construction.

Storage of roading materials along the northern end of Old Coach Road was identified in the 2014 aerial image this is a HAIL G5 activity. During the site inspection the stockpiles were no longer present and the area appeared tidy. While it is possible for residual soils from these stockpiles to be present at the site the likelihood of them posing a risk to human health or the environment is considered low because any source of contamination has been largely removed.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This assessment has identified that the proposed location for the Childrens Bay terminal pump station and the irrigation areas at Jubilee Park and the Akaroa Recreational Grounds are likely to be contaminated by historic landfill activities that were carried out as part of land reclamation in the area. Landfill material poses a risk to both human health and the environment during the construction phase of this project.

It is recommended that a Detailed Site Investigation (DSI) be completed for the site works at Children's Bay area once the exact location of this facilities have been identified. This investigation will need to include intrusive soil sampling to assess potential contaminant concentrations. Detailed site works plans were unavailable at the time of writing this report and therefore exact areas and volumes of soil disturbance are not known at this time.

Requirements under the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health Regulations 2011 (NESCS) and the Canterbury Land and Water Regional Plan (LWRP) have not been directly assessed. While a full assessment of consent requirements cannot be completed at this point it is considered likely that consent under the NESCS will be required for project works within the Children's Bay area. A full assessment of consents required should be completed during the Detailed Site Investigation stage.

7.0 STATEMENT OF LIMITATIONS

Stantec New Zealand (Stantec) has prepared this report for the use of Christchurch City Council (CCC) in accordance with the usual care and thoroughness of the consulting profession. It has been prepared in accordance with the scope of work and for the purpose outlined in this report. It is based on accepted practices and standards at the time it was prepared. No other warranty, express or implied, is made as to the professional advice included in this report. Stantec makes no determination or recommendation regarding a decision to provide or not to provide financing with respect to the site.

There is no investigation that is thorough enough to preclude the presence of materials at the site which presently, or in the future, may be considered hazardous. As regulatory evaluation criteria are subject to change, concentrations of contaminants present and considered acceptable may, in the future, become subject to different regulatory standards which cause them to become unacceptable and require remediation for the site to be suitable for the existing or proposed land use activities.

The methodology adopted and sources of information used by Stantec are outlined in this report. Stantec has made no independent verification of the information beyond the agreed scope of works and Stantec assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to Stantec was false.

This report was prepared in July/August 2021 and is based on the conditions encountered and information reviewed at the time of preparation. Stantec disclaims any responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

Appendices

We design with community in mind

Appendix A EVIDENCE OF SQEP QUALIFICATIONS AND EXPERIENCE

Scott Fellers

Scott Fellers has grown his career as an environmental practitioner over the last eight years working in Christchurch, New Zealand. He is responsible for many different aspects of contaminated land investigations. The most common projects involve reporting to the standard of the Ministry for the Environments Contaminated Land Management Guidelines. These investigations include Preliminary and Detailed Site reporting involving, development of the sampling and analyte testing regimes, analysis of laboratory results and assessment against various guidelines and standards. Consenting requirements under the National Environmental Standard for Assessing and Managing Contaminants in Soil (NESCS) are assessed. His role also includes development of fee proposals, project management duties, Remedial Action Plans, Site Validation reports and Site Management Plans. Scott has also planned and implemented asbestos-specific sampling and testing regimes in accordance with BRANZ guidelines including field analysis of asbestos. He is also responsible for collation and preparation of site works health and safety plans along with liaising with colleagues, clients, contractors, and project stakeholders.

Scott has gained experience working on various contaminated land jobs. Some examples of sites Scott has worked on are sheep dips/sprays, landfills- small scale domestic to large scale municipal, lead based paint on weatherboard dwellings, market gardens, burn pads/pits, fire damaged buildings, ACM in soil through both dirty demolition and natural degradation of ACM material, leaking UST/ASTs, vehicle workshops, lumber mills/timber treatment, coal tar assessment and subdivision of rural land.

EDUCATION

BSc: Geoscience, California State University, Chico, California, United States, 2005

Teaching Credential - Single Subject Science, California State University, Chico, California, United States, 2008

CERTIFICATIONS & TRAINING

Certified Environmental Practitioner - General, Environmental Institute of Australia and New Zealand, Christchurch, Canterbury, New Zealand, 2019

MEMBERSHIPS

Member, Australasian Land & Groundwater Association

Appendix B HISTORICAL AERIAL IMAGES

Figure 7: 1941 aerial (Source: Retrolens)

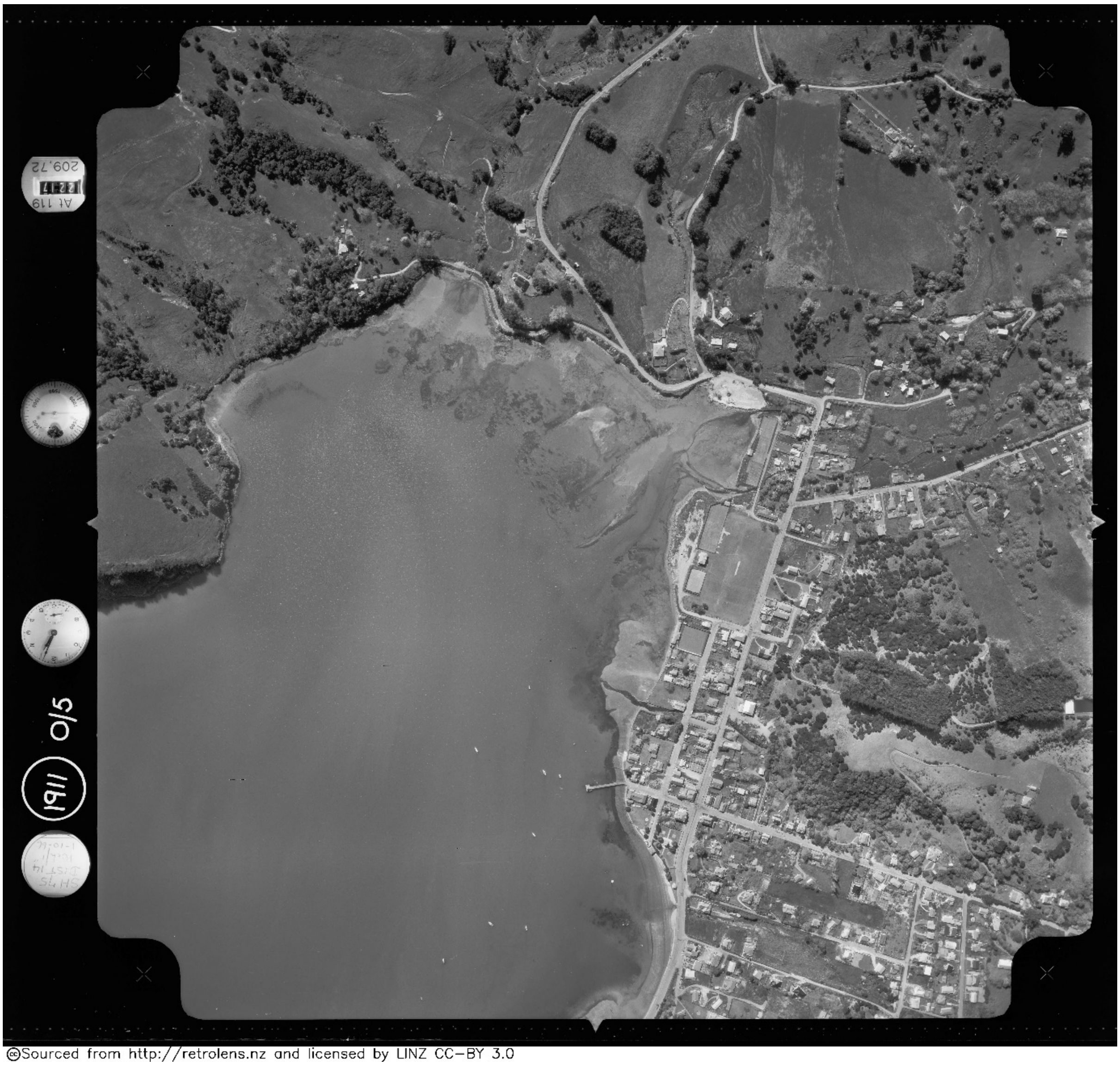

Figure 8: Children's Bay 1966 aerial (Source: Retrolens)

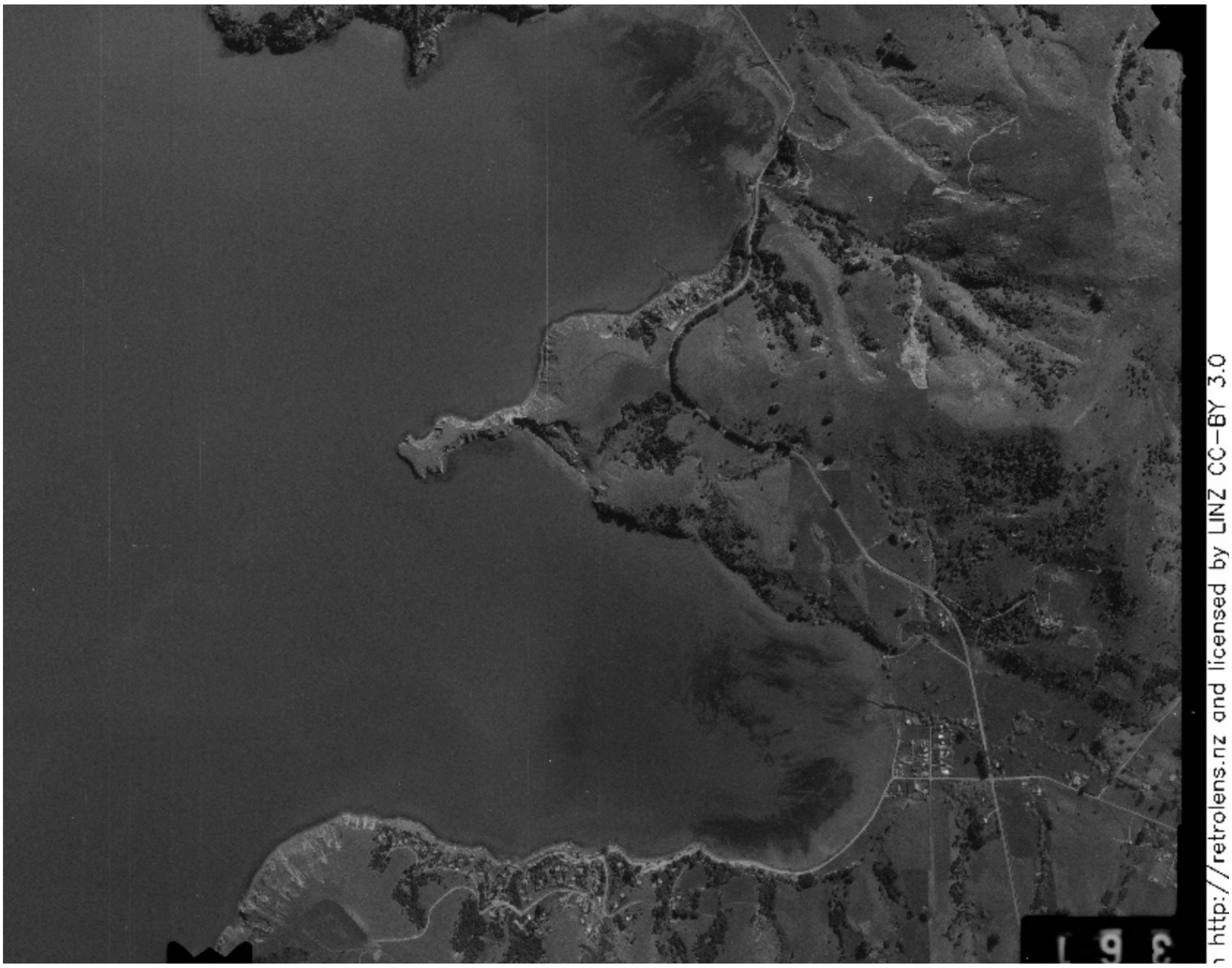

Figure 9: Hammond Point and Takamātua 1975 aerial (Source: Retrolens)

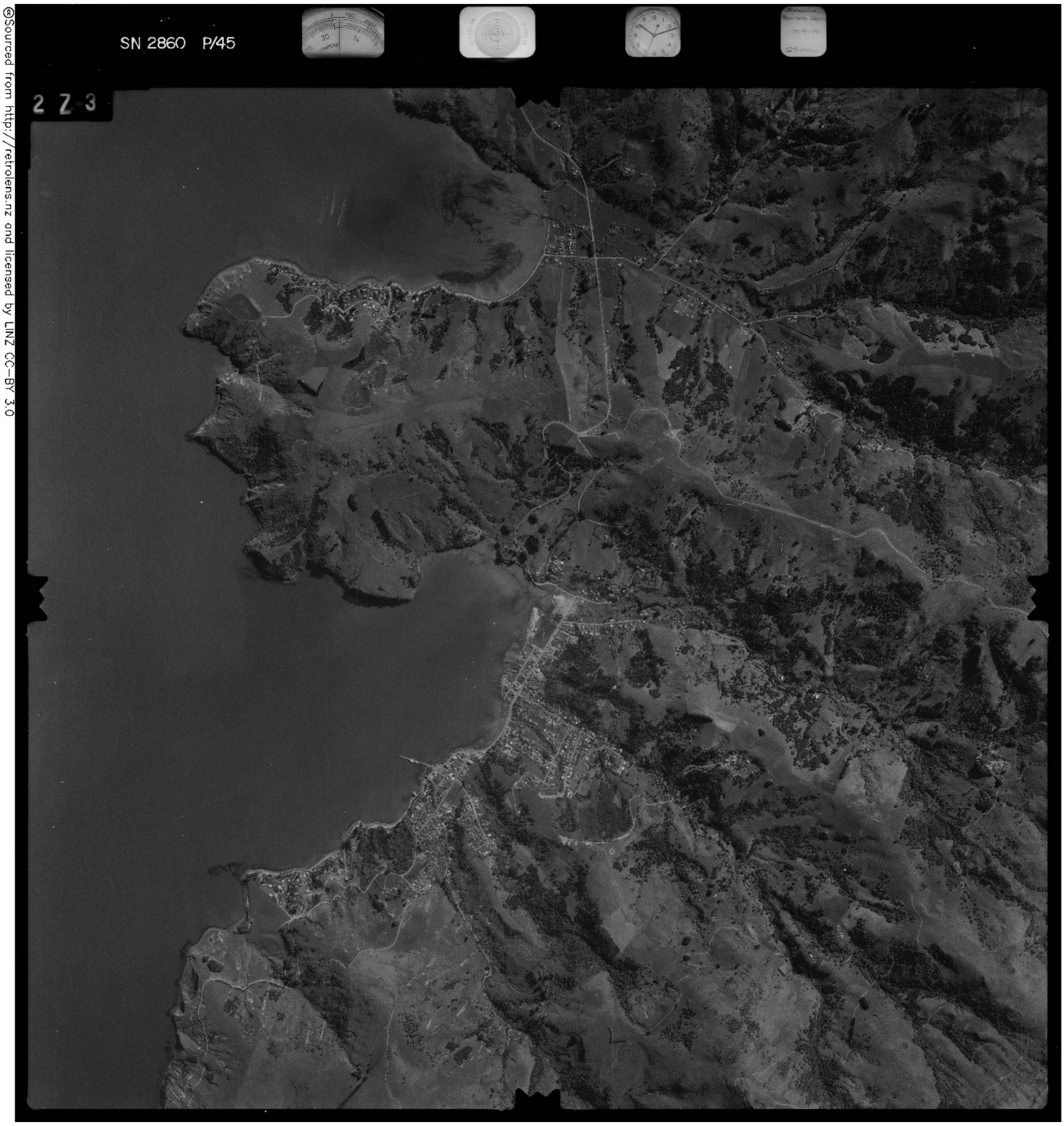

Figure 10: 1977 aerial (Source: Retrolens)

Figure 11: 1984 aerial (Source: Retrolens)

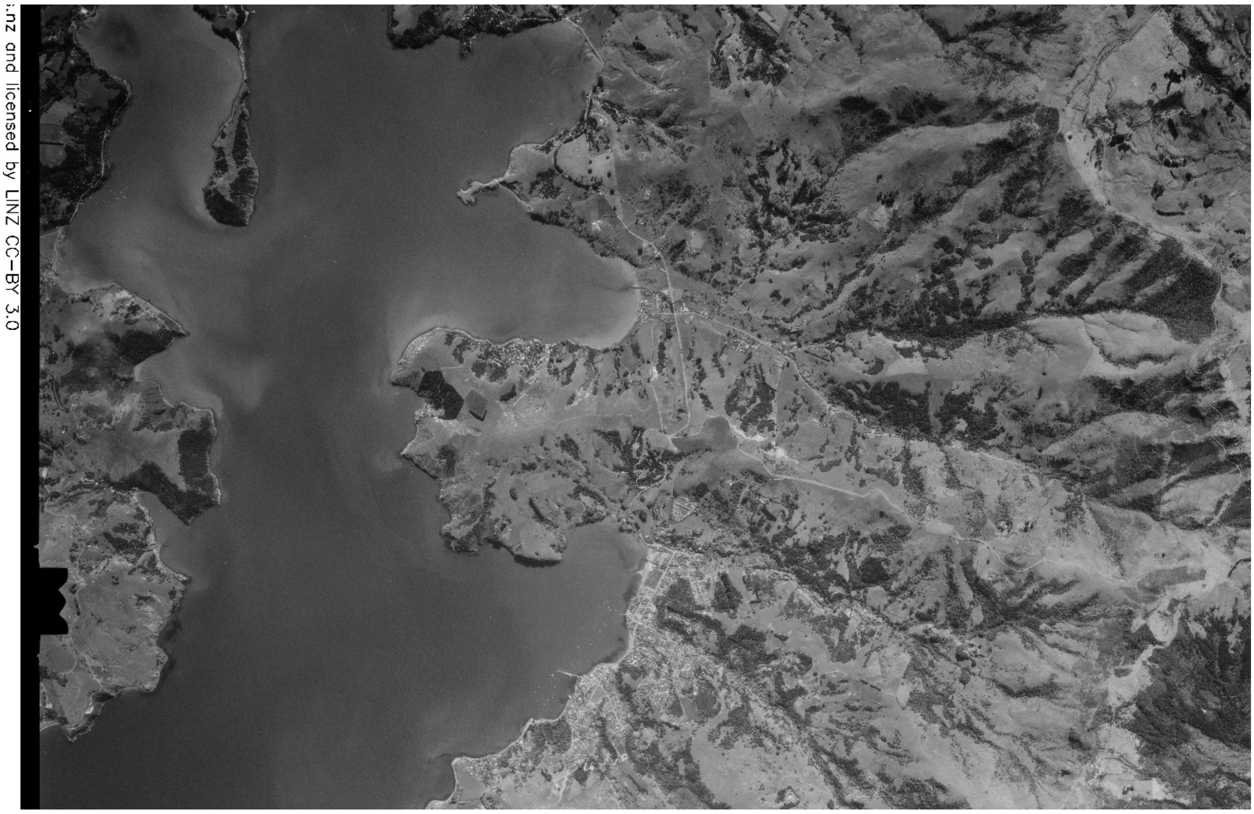

Figure 12: 1995 aerial (Source: Retrolens)

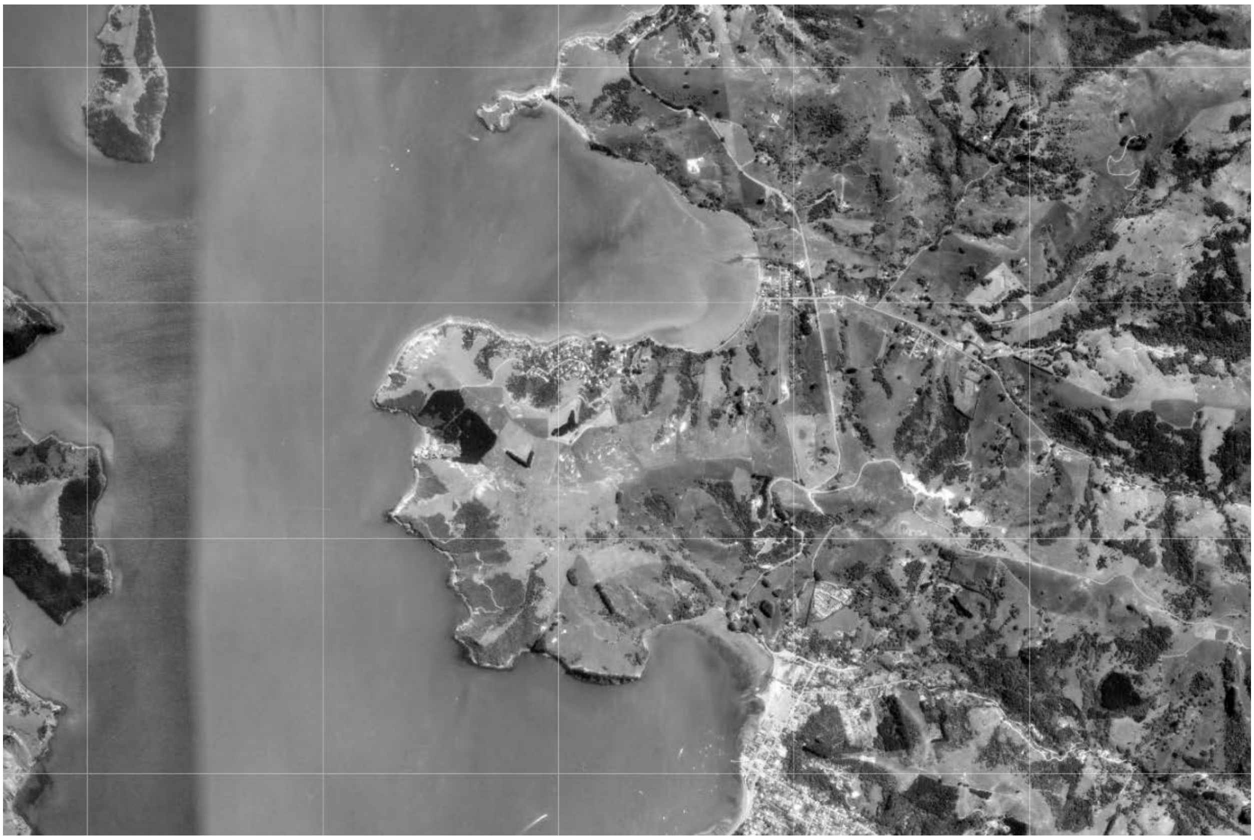

Figure 13: 2000-2004 aerial (Source: Canterbury Maps)

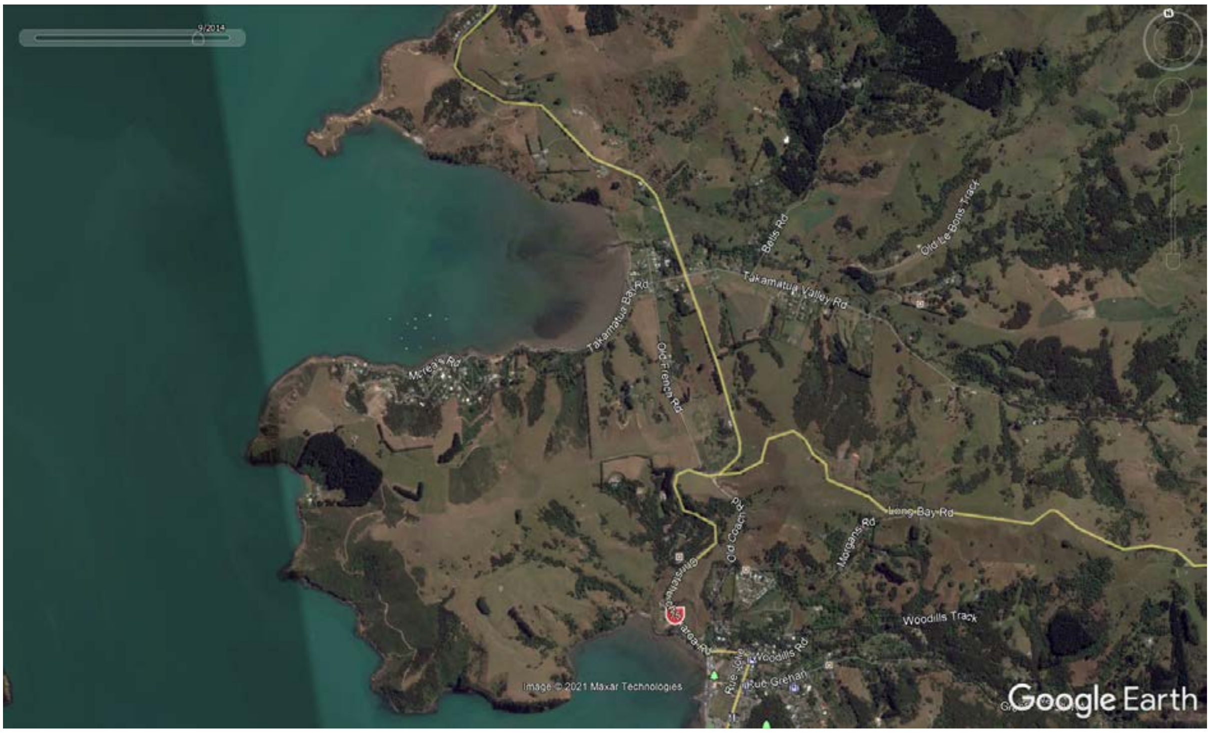

Figure 14: 2014 aerial (source Google Earth)

Figure 15: 2019 aerial (Source Google Earth)

Appendix C SITE IMAGES

Figure 16: Children's Bay terminal pump station proposed location on left hand side of image

Figure 17: Proposed WWTP location

Figure 18: Takamātua irrigation area

Figure 19: Hammond Point irrigation area

CREATING COMMUNITIES

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of belonging. That's why at Stantec, we always **design with community in mind**.

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Appendix K Air Quality Report

Odour Assessment for the Akaroa Wastewater Scheme

Rev. no	Date	Description	Prepared by	Checked & Reviewed by	Approved by
0	20/10/2021	Draft Odour Assessment Report	P Heveldt	J Dunning	S Velluppillai
1	27/10/2021	Final Odour Assessment Report	P Heveldt	J Dunning	S Velluppillai

Assessment of Environmental Effects of Discharges to Air from the Akaroa Wastewater Treatment and Disposal Scheme

1 Introduction

1.1 Background

The treatment and disposal of wastewater is generally accompanied by emissions of odours – which, on occasions and depending on a range of pertaining circumstances, can cause adverse effects to neighbouring communities that may be described as offensive or objectionable. While the proposed multi-faceted scheme for treatment and disposal of Akaroa wastewater is small in scale, given that the peak population serviced was approximately 4,000 in 2018 and is projected to increase to only around 4,560 in 2052, those numbers have no particular relationship to the potential occurrence of adverse environmental effects from odour emissions associated with the Scheme.

Many factors are relevant to the propensity of a wastewater treatment scheme to cause emissions of odour. Such causative factors include:

- The residence time of sewage in the reticulation system prior to reaching the wastewater treatment plant (WWTP);
- The types, efficiencies, and extents of enclosure of the treatment elements making up the WWTP itself;
- The capture and mitigation of WWTP odours at the points of their release;
- The extent of treatment provided to the raw wastewater, and;
- The downstream disposal options in place for the solids stream on the one hand and the treated effluent on the other.

The following assessment process considers firstly the methodology used for assessment of environmental effects arising from odour, with a focus on the use of the so-called FIDOL factors (see section A3.1) to delineate the five key contributing parameters of frequency, intensity, duration, offensiveness, and location of odours.

The nature of odours and their sensory effects are discussed, with an underlying emphasis on the relevance of the sensitivity of different population groups to odours, specifically the receiving environment for residential and rural populations as neighbours of various parts of the Scheme.

This is followed by a consideration of the relevance of the separation of any potentially odour-emitting Scheme components from nearest receptors and the extent of mitigation that such separation provides.

The FIDOL factors are then applied to the individual parts of the Akaroa Wastewater Scheme to provide a semi-quantitative assessment of the likelihood that the release of odours from parts of the Scheme will cause odour nuisance to neighbours.

1.2 Notes on Other Emissions to Air

Emissions to air other than odour which may have relevance to considerations of the Scheme's environmental impacts include dust associated with construction activities, particularly when earthworks are carried out for site preparation or other reasons. The mitigation of dust emissions will be controlled by relevant provisions of a Construction Management Plan that will be prepared for the Scheme. This will include such requirements as the use of water sprays during dry and / or windy conditions, particularly when bare earth areas are exposed, and the covering of soil stockpile areas if adverse weather conditions are expected.

There is provision in the Scheme for stand-by diesel generators to be available for use in power outages; these will be located at the Terminal Pump Station in the boat park area at the northern end of the Akaroa seafront and at the WWTP itself on Old Coach Road. While the use and/or maintenance running of these generators will be an infrequent occurrence there is the potential for emissions of exhaust gases and particulates during operation, particularly when the generators are first started. These emissions will be spatially limited to the immediate area of the generator locations and the lengths of time in operation (assuming relatively prompt rectification of a power outage can be made) will be limited to a few hours at most and will typically be around 30 minutes for maintenance running.

No further assessment of dust generation or the impacts arising from diesel generator exhaust emissions has been carried out.

There may also be other non-odour emissions to air from construction activities such as combustion exhaust emissions from diesel-powered earth-moving machinery, but these will generally be transitory in temporal terms and limited in terms of the nuisance effects likely to be caused, given the small areas of direct impact immediately near the emitting items, the short time frames of their use and the largely rural spatial environment into which the majority of such emissions will occur.

1.3 Methodology for Assessing the Environmental Effects of Discharges of Odour

The *Good Practice Guide for Assessing and Managing Odour in New Zealand* (MfE, 2003) provides guidance on methods for assessing the effects of odour discharges. For existing sources of odour, the Guide recommends that operator experience with the site, community feedback and information on the process controls and management systems are the primary sources of information that should be used to assess the effects of the activity. Where modifications are planned, information on the known performance of control technology and experience with other sites can be used to assess the impacts of the proposed changes.

Dispersion modelling can also be useful for undertaking a comparative assessment of the significance of the changes. For a new activity, the Guide recommends using dispersion modelling where reliable odour emissions data are available. Where reliable data are not available, the Guide recommends that past experience with the same type of activity in other locations is the best method of assessment. For this current assessment, experience with similar activities in other locations, evaluation of the proposed emissions control and odour mitigation systems, the sensitivity of the receiving environment and the consideration of separation distances between individual aspects of the Scheme and various sensitive receptor groups have been used to assess the potential effects of the discharges.

2 Assessing Odour Effects

2.1 The FIDOL factors as determinants of odour impacts

The effects of any odour emissions depend on a number of features of the odour exposure which are collectively referred to as the "FIDOL" factors; these are:

- **F**requency
- **I**ntensity
- **D**uration
- **O**ffensiveness
- **L**ocation

The FIDOL factors are explained in greater detail as follows:

- ***Frequency***: relates to how often an individual is exposed to odour. Factors that determine this include the frequency that the source releases odour (including its source type, characteristics, and the rate of emission of the odorous compound or compounds), the prevailing meteorological conditions, and the local topography;

- ***Intensity***: is the perceived strength of the odour or the odour detection capacity of individuals to the various compound(s). Odour intensity is typically assessed on a scale of 1 to 6 (1 = 'very weak'; 6 = 'extremely strong'). An increase in intensity of an odour will increase the potential for odour complaints to arise as a consequence;

- ***Duration***: is the amount of time that an individual is exposed to an odour. Combined with frequency, this provides an indicative measure of the exposure to odour. The duration of an odour, similarly to its frequency, is related to the source type and discharge characteristics, the meteorological conditions, and the location. The longer the odour detection persists in an individual location, the greater the level of complaints that may be expected, particularly if the odours are objectionable or offensive. The length of a particular odour event may often include the impact of prevailing winds that send an odour plume towards nearby neighbours;

- ***Offensiveness or odour character***: is a subjective rating of an odour's pleasantness or unpleasantness and relates closely to the concept of "hedonic tone". Offensiveness is related to the sensitivity of the receptors to the odour emission (i.e., whether the odorous compound(s) are more likely to cause nuisance to receptors, such as the sick or elderly, who may be more sensitive); and,

- ***Location***: is the type of land use and the nature of human activities in the vicinity of an odour source. As part of the "location" factor of a FIDOL assessment, the sensitivity of the receiving environment must be taken into account, including the type of land use and the nature of human activities in the vicinity of an odour source. The location of sensitive receptors is relevant when combined in the assessment with the prevailing wind conditions.

Odour assessments need to consider whether the odour discharge is of low-intensity odour occurring often over a lengthy period, or high-intensity odour occurring infrequently, or both. In fact, the FIDOL principle demonstrates that there are several factors that may be influenced or varied, in order to mitigate odour impacts at a particular location or activity. Employing one or more methods to alter or mitigate these factors, where appropriate, may significantly decrease the likelihood of causing a serious odour event.

2.2 Odour nuisance factors

Impacts from odorous air contaminants are generally nuisance-related rather than human health-related, although they may be both. Odour mitigation measures and other aspects of odour management are usually not intended to achieve a "no odour" environment but, rather, to mitigate odours and their impacts to levels at which, at most, only minor impacts are experienced.

In practice, the character of a particular odour can only be judged by the receiver's reaction to it, and preferably only when compared to another odour under similar exposure conditions.

The level at which an odour is perceived to be a nuisance can range significantly, depending on a combination of the following factors:

- ***Odour quality***: whether an odour results from a pure compound or from a mixture of compounds. Pure compounds tend to have a higher threshold (lower offensiveness) than a mixture of compounds;

- ***Population sensitivity***: any given population contains individuals with a range of sensitivities to odour. The larger a population, the greater the number of sensitive individuals it may contain;

- ***Background level***: whether a given odour source, because of its location, is likely to contribute to a cumulative odour impact;

- ***Public expectation***: whether a given community is tolerant of a particular type of odour and does not find it offensive, even at relatively high concentrations. For example, background agricultural odours may not be considered offensive until a higher threshold is reached;

- ***Source characteristics***: whether the odour is emitted from a point source or from an area source. Generally, point source odour emissions can be captured and treated more easily than diffuse sources; and

- ***Health effects***: whether a particular odour is likely to be associated with adverse human health effects. In general, the concentrations at which adverse odour impacts are experienced are well below the levels at which impacts on human health will arise.

Different combinations of these factors are significant when assessing adverse effects. Depending on the severity of an odour event, one single occurrence may be significantly adverse, and this is known as an "acute" odour effect. However, in other situations, where there is a higher frequency of odorous events the threshold odour level would be lower. This longer-term impact is known as a "chronic" odour effect.

2.3 Sensitivity of a receiving environment

Different locations have different sensitivities to odour and can be classified as having high, moderate, or low sensitivity. The degree of sensitivity to odour in any particular location is based on characteristics of the land use or environment into which the odour release occurs, including the time of day and the reason people are at the particular location (e.g., for work, at home or recreation). In a residential area an acceptable odour frequency is likely to be much lower than would be expected or tolerated in a rural area.

2.3.1 Rural Environments

People living in rural areas generally have a higher tolerance for rural-type odours, which are acceptable to most people and fit the description of a rural odour in a rural area. However, some types of odour are quite different to the normally expected rural odours (due either to the strength, character, and unpleasantness of the odour, or to the frequency and duration of the odour) and are therefore much less acceptable.

2.3.2 Residential Environments

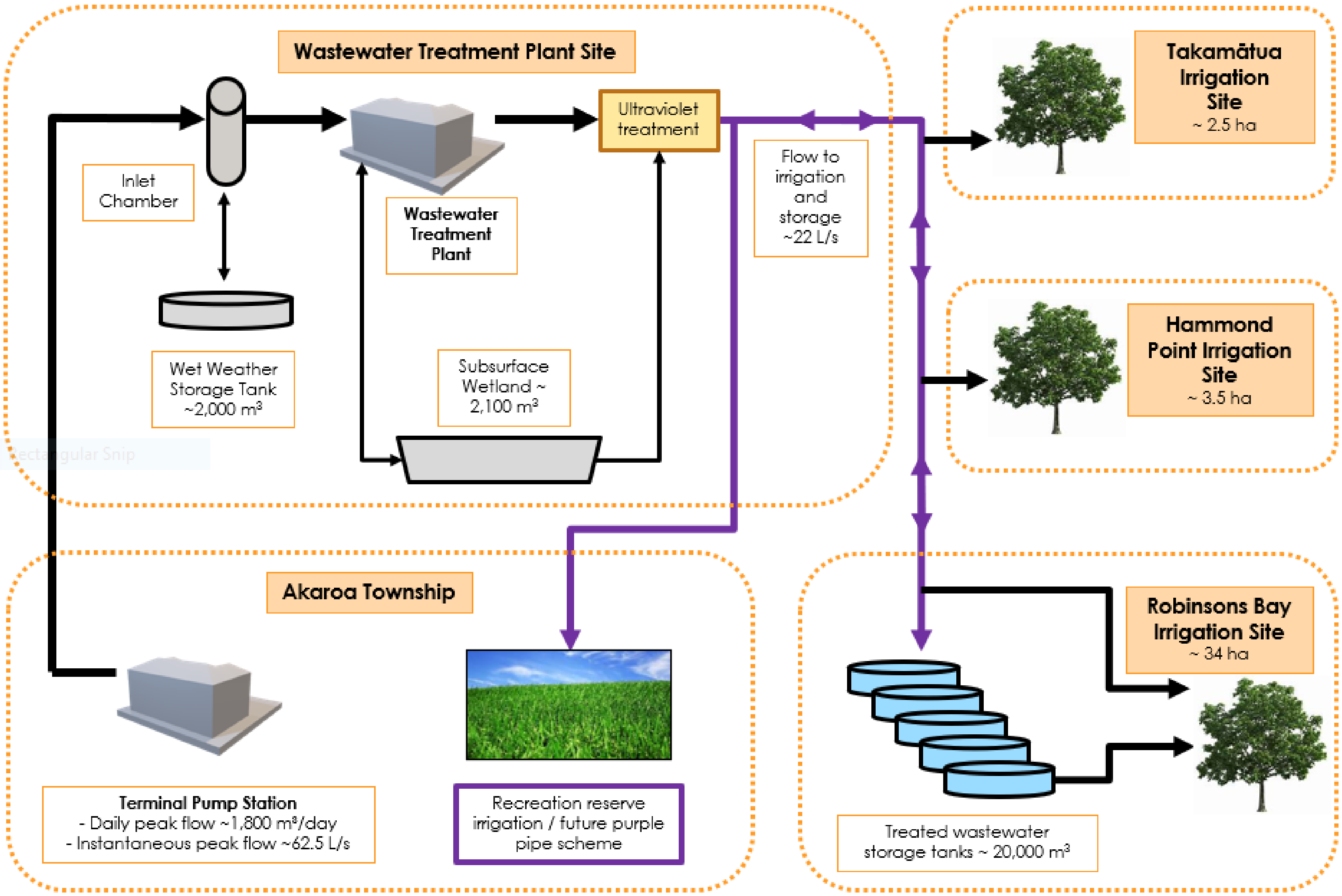
People living in residential areas typically have a high sensitivity to all types of odours, because of the following factors:

- People with high sensitivity to odours can be exposed
- People can be present at all times of the day and night, both indoors and outdoors
- People tend to carry out activities at residences which are highly sensitive to non-rural odours, such as dining, entertaining, outdoor living and sleeping
- Visitors to the area who are unfamiliar with an odour are more likely to be sensitive to odours they are not used to, and may raise awareness of a problem
- People usually expect a high level of air quality, including the absence of odours, and have a low tolerance of even typical rural odours.

3 Assessment of Odour Discharges from the Terminal Pump Station, the WWTP and other Parts of the Akaroa Wastewater Scheme

3.1 Summary of Scheme elements

There are a number of individual parts of the overall Akaroa Wastewater Scheme and all, to some extent, may have associated emissions of odour to air (Figure 2). The following paragraphs summarise the Scheme elements and the succeeding sub-sections discuss the nature and extent of expected odour emissions in each case, the sensitivity of the receiving environments, and mitigation measures with an accompanying assessment for each part of the Scheme against the FIDOL factors.


Wastewater Treatment Plant Site
Inlet Chamber
Wastewater Treatment Plant
Ultraviolet treatment
Flow to irrigation and storage ~22 L/s
Wet Weather Storage Tank ~2,000 m³
Subsurface Wetland ~ 2,100 m³
Takamātua Irrigation Site ~ 2.5 ha
Hammond Point Irrigation Site ~ 3.5 ha
Akaroa Township
Terminal Pump Station
- Daily peak flow ~1,800 m³/day
- Instantaneous peak flow ~62.5 L/s
Recreation reserve irrigation / future purple pipe scheme
Robinsons Bay Irrigation Site ~ 34 ha
Treated wastewater storage tanks ~ 20,000 m³

3.2 Pumping of wastewater to Terminal Pump Station located in the Childrens Bay boat park and then to the Wastewater Treatment Plant

The Scheme includes reversing the direction of the currently configured wastewater flow to pump from south to north to the new Terminal Pump Station (TPS) and then with further pumping, via a new rising main, to the new WWTP site at Old Coach Road.

3.3 The Wastewater Treatment Plant

The WWTP will occupy a compact site near the corner of Old Coach Road and SH75, as previously described. The central feature of the treatment train at the WWTP will be a biological nitrogen removal (BNR) process which acts to remove nitrogen from the effluent and involves the introduction of a source of carbon (probably acetic acid) as part of the process. The BNR step will be followed by membrane filtration for solids separation and then may involve treated effluent disinfection using ultraviolet (UV) light or chlorine dosing. Not all nitrogen (N) will be stripped from the treated effluent and there is sufficient residual N to make the effluent useful for irrigation to land to support, in this case, native tree plantings at various locations as noted below.

The design of the WWTP will include provision of an adjacent 2,000 m^3 covered tank for the storage of raw wastewater effluent to act as a buffer tank in the event of enhanced wet weather flows that cannot be treated continuously because of capacity constraints at the WWTP. This design philosophy is based on ensuring that all Akaroa wastewater is treated, and none is released as wet weather overflows and also on substantially reducing Inflow & Infiltration (I&I) issues.

Two other elements of the Scheme that will be sited at or near the WWTP location are a 1,000m^3 buffer tank for the temporary storage of treated effluent and a down-slope constructed subsurface wetland that will provide additional storage of treated effluent in the event of interruption to its application to the irrigation sites in Robinsons Bay, Hammond Point and Takamātua described below.

3.4 Pipeline to convey treated wastewater to Robinson Bay storage tanks

Treated effluent leaving the WWTP will be conveyed over an approximately 4.8 km pipeline route that follows, for the most part, the alignment of SH75 and then leads upslope to a series of treated effluent storage tanks at Robinsons Bay. This pipeline will be operated in a nominally full state but there will be a need, on occasions, to release gas pressure in the pipe to atmosphere via pressure release valves at nominal 800 m to 1 km intervals, depending on the profile of the pipeline route. This is likely to mean that around five such pressure release valves will be required.

3.5 Treated wastewater storage on an upper spur in open tanks at Robinsons Bay

It is proposed to have up to 20,000 m^3 of storage capacity for treated wastewater in these tanks prior to its delivery to the irrigation lines and transfer via gravity to the selected locations for application to land (see below).

3.6 Drip-Irrigation to native trees at Robinsons Bay (88 Sawmill Rd), Hammond Point and Takamātua sites

The three named sites will each be available for irrigation of treated wastewater to land, with the intention being that this method will be a beneficial reuse by way of irrigation of native tree plantings at the three locations. The application method will be via supply lines laid in grid patterns across the irrigable areas of the disposal fields and with laterals leading off the main lines to supply individual plantings by drip irrigation.

3.7 "Purple pipe" irrigation of treated wastewater for beneficial reuse

It is proposed that part of the highly treated wastewater from the WWTP will be used to irrigate public park areas within Akaroa township via a so-called "purple pipe" system. In time this may also be extended to the flushing of public toilets and other non-potable uses in Akaroa.

4 Sensitivity of the receiving environment

The proposed WWTP location at the intersection of Old Coach Road and SH75 is rural and is considered to be of no more than moderate sensitivity at most to odours. The closest sensitive receptors are some holiday cottages located approximately 250 m to the southwest and downhill of the WWTP on SH75.

As can be seen in the wind rose generated for the site using data from an on-site weather station installed by CCC (see Figure 2), southerly quarter winds occur for approximately 55% of the time. When winds are light, drainage flows might possibly carry odours generated at the WWTP down-slope towards the holiday cottages. However, given the small size of the proposed plant and the enclosure and ventilation of the majority of the equipment items to an on-site biofilter, any fugitive odours that are emitted from the WWTP are unlikely to be noticeable within approximately 20 m of the plant during normal operation.

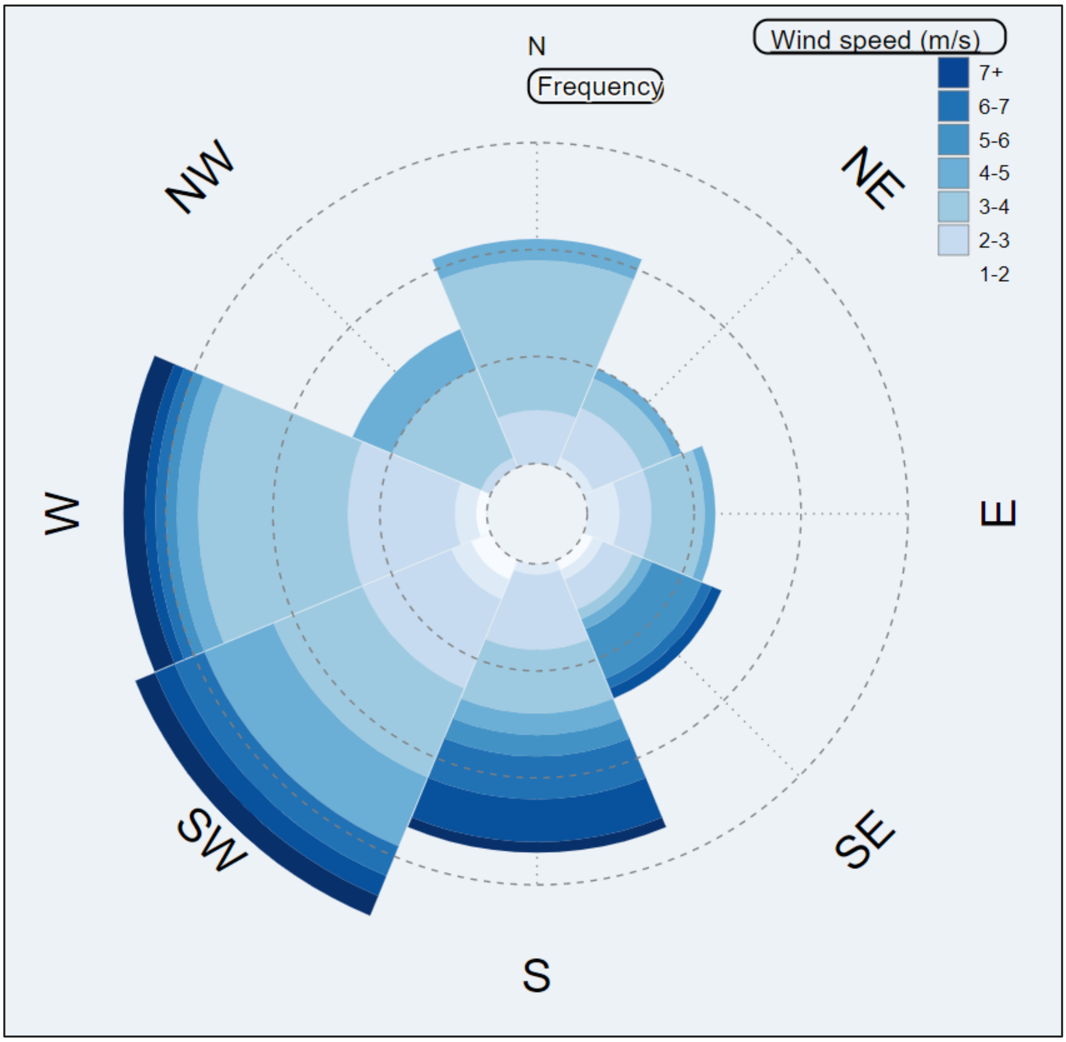


Figure 2: Wind Rose generated from CCC on-site weather station data for Old Coach Road site (10 min averages; 1 year of data for 2020 year)

Consequently, the nearest receptors are expected to be unaffected by odours from the WWTP during normal operations and any adverse effects on the environment due to odours are expected to be less than minor.

If the plant malfunctions or power is lost, there is some potential for objectionable odours to be produced which may travel further than normally expected. CCC will prepare an Operations and Maintenance (O&M) Manual for the plant which will include contingency plans that describe the procedures to be taken in the event of a plant failure. A diesel generator will be provided to supply back up power to the plant.

As noted above, the WWTP site is located 250 m from the nearest sensitive receptors. It is therefore expected that, even if a plant malfunction occurred during worst case meteorological conditions (i.e., light south-westerly winds), the effects on these nearest sensitive receptors are likely to be less than minor.

The receiving environments surrounding the Terminal Pump Station (TPS) and the associated biofilter are relatively sensitive, due to the proximity of recreational, residential, and commercial areas. The biofilter, which will be a source of potential odour if not operated and maintained appropriately, will be located at the pump station.

4.1 Terminal Pump Station

The TPS location is adjacent to the coast and Jubilee Park, which are recreational areas. The pump station will be approximately 100 m from the commercial area located between Rue Jolie and Rue Lavaud.

During daytime hours, when people are most likely to be present in the recreational and commercial areas in the vicinity of the TPS, winds blow predominantly towards the land and will have the potential to blow any odours produced towards the nearby sensitive receptors. However, during the day, winds tend to be stronger resulting in better dispersion and dilution of any odour plumes. At night, winds are often light and blow predominantly towards the coast and away from sensitive areas. South-westerly quarter winds, which occur for approximately 25% of the time, can be strong and will blow odours towards the residential area located to the north of Jubilee Park. However, the residential area is approximately 180 m from the proposed Terminal Pump Station site and any odours produced at the plant are likely to be well-dispersed and diluted prior to the plume reaching the residences.

The diesel generator will provide standby electricity supply during power failures. In the unlikely event of a malfunction at the plant that results in the extraction system failing, due to reasons other than power failure, odours should be largely contained within the building. However, such a situation could result in odours being noticeable in the adjacent recreational and commercial areas, and these odours may be offensive if they are prolonged and occur when people are present. In order to mitigate this situation, CCC will include a contingency plan as part of the O&M manual. The contingency plan will describe the procedures to be taken in the event of a plant failure to minimise the potential for objectionable odour effects.

Odours from well-designed and maintained biofilters are not typically offensive (usually slightly musty in character) and are usually only able to be noticed within approximately 5 m of the filter. The only people passing within 5 m of the biofilter will be people travelling past in cars or walking on the footpath on the side of the road, hence any exposure to these musty odours is likely to be transitory.

If the biofilter is overloaded or malfunctioning the intensity of odours produced may increase. The highest predominance of light winds (which are the worst-case wind conditions for dispersions of odours) are from the easterly quarter, which will blow odours discharged from the biofilter away from the nearby sensitive locations and towards the harbour. Winds from the southwest, which will blow odours towards the nearest residentially zoned area, tend to be strong and are likely to rapidly disperse and dilute odours prior to any plume reaching sensitive locations. Consequently, the impact of odour from the biofilter on the residences located to the northeast of the biofilter is likely to be less than minor.

Winds from the southeast, which will blow odours towards the closest residence located to the northwest of the biofilter occur for approximately 14% of the time and are frequently light. However, the nearest residence is located on elevated terrain above the proposed biofilter site on a bush-clad hillside. It is expected that during light wind conditions, the air flow will be diverted around the edge of the hill rather than up the hill and consequently, odours are unlikely to have any substantial impact on this residence.

In summary, it is expected that any adverse effects from odours discharged from the Terminal Pump Station building and biofilter will be adequately avoided, remedied, and mitigated and will have effects that are less than minor on the surrounding environment, provided that the Terminal Pump Station ventilation system and the biofilter are properly maintained and operated.

5 Measures to deal with odour emissions from Scheme components and FIDOL assessments

5.1 Wastewater Treatment Plant

The WWTP will be equipped with an on-site biofilter to treat odorous air evolved from the various treatment processes. The same biofilter will also deal with odorous air extracted from beneath the cover on the raw effluent tank. This treatment of odorous air by biofiltration will be effective in reducing potential emissions of odour from the WWTP to negligible levels. A standby generator will be available to maintain plant operations, including odour mitigation equipment, in the event of a power outage or breakdown.

FIDOL assessment

- Frequency – fugitive emissions of odour from the WWTP will be very infrequent. The enclosed nature of the plant elements and the treatment of odorous air in the on-site biofilter will ensure that odour nuisance effects will be negligible
- Intensity – odours could be of high intensity from wastewater treatment processes, thus heightening the importance of the capture and treatment of all odorous air in the biofilter
- Duration – emissions to the ambient air will be limited in duration, if they occur at all
- Offensiveness – while emissions of odour at the WWTP could be of an offensive nature the negligible likelihood of such events is the dominant factor in considerations of odour nuisance risk
- Location – the WWTP is located some distance from the nearest sensitive receptors, thus further mitigating the already negligible risk of odour nuisance

5.2 Pipeline to convey treated wastewater to Robinson Bay

The highly treated wastewater for disposal to land has a very low residual BOD and thus the odorous gas content and potential for odour nuisance can be considered negligible. Nevertheless, it will still be prudent best practice to site the five pressure release valves at suitable locations where they are relatively remote from any residences.

Rule 7.51(2) of the Canterbury Air Regional Plan (CARP) requires that:

> *The discharge of contaminants into air from reticulated sewerage networks is a permitted activity provided the following conditions are met:*
>
> *1. The discharge of odour does not cause an offensive or objectionable effect beyond the boundary of the property of origin, when assessed in accordance with Schedule 2; and*
>
> *2. Where the discharge is from an air pressure release valve, it does not occur within 100m of a residential property or site intended for residential use, unless it is fitted with an odour mitigation device that prevents odour effects occurring within any residential property.*

After scrutiny of the pipeline route, it is clear that the preferred locations for the relief valves can be confirmed such that they are all at least 100m from any residence; such considerations will ensure that Rule 7.51(2) of the CARP is complied with.

FIDOL assessment

- Frequency – releases from the air valves are expected to be limited in frequency
- Intensity – any released odours will be of very low intensity since this is highly treated wastewater that is being conveyed
- Duration – a relief valve, if activated, will be open for only a very short time period such that the pressure build-up in the conveyance pipeline can be released
- Offensiveness – any air released by the activation of a relief valve will have a negligible odour component, as discussed above
- Location – as described, the valves will be located so that they are at optimum distances from any sensitive receptors (at least 100m distance), to negate any possible odour impacts thus further

5.3 Treated wastewater storage at Robinsons Bay

Emissions of odour from stored treated wastewater will be at less than minor levels, given the high treatment standard afforded by the WWTP and the associated very limited BOD concentration. In addition, the treated wastewater will have a significant level of residual dissolved oxygen within it and the likelihood of anaerobic conditions developing within the stored treated wastewater is negligible.

FIDOL assessment

- Frequency – the emission of odour from the stored and highly treated wastewater is very unlikely to be discernible
- Intensity – the odour, such as it is, is likely to be indiscernible in this rural environment
- Duration – the duration of any odour emissions will not be measurable, given that they are highly likely to be indiscernible
- Offensiveness – any odour associated with the stored treated wastewater, while likely to be indiscernible, will not be of an offensive or objectionable nature in any case because of the aerated nature of the stored treated wastewater
- Location – the storage facility will be located a considerable distance from any neighbours and there is no risk of odour nuisance

5.4 Drip-Irrigation to land at Robinsons Bay, Hammond Point and Takamātua

Given the negligible levels of odour in the treated wastewater for irrigation and taking account of the physical parameters of the drip application method which does not result in the generation of fine droplet sprays, there is no risk of odour emissions for the proposed disposal of treated effluent to irrigate native tree plantings, as is proposed for the Robinsons Bay, Takamātua and Hammond Point areas.

FIDOL assessment

- Frequency – there will be no discernible odour emissions from this sub-surface disposal method for the treated wastewater
- Intensity – given that there will be no odour emissions, odour intensity is not an issue
- Duration – similarly, the concept of duration of odour releases has no meaning in this case where there is no odour
- Offensiveness - this concept also does not apply in this case
- Location – the location of disposal is not relevant in this case where there is no discernible odour

5.5 Storage of treated wastewater in the subsurface wetland

Treated wastewater entering the wetland will be devoid of any significant odour and there will therefore be no detectable odour from its discharge. This situation will still pertain, even if the storage extends over many days since the residual BOD levels within the treated wastewater are negligibly low.

FIDOL assessment

- Frequency – no relevance, given that the treated wastewater is devoid of significant odour in any case
- Intensity – not relevant in this case
- Duration – this is also not a factor
- Offensiveness – not relevant
- Location – no relevance, and the wetland location is not near any sensitive receptor locations either

5.6 Terminal Pump Station

Even though the TPS will be a fully enclosed facility there is potential at this sensitive location for fugitive odour emissions, and these may be significant in frequency, duration and degree of offensiveness, if not controlled. Given this risk, it is proposed that TPS air will be extracted for treatment to an on-site biofilter immediately adjacent to the pump station itself. Provided this biofilter is designed, sized, and operated appropriately it should be fully effective in mitigating any odours to acceptable levels.

The primary source of odour is expected to be at the inlet works at the TPS where the untreated wastewater enters the WWTP and receives primary treatment (fine screening and grit removal) prior to being pumped to the WWTP itself for the treatment processes to commence. To minimise the discharge of odours from the TPS, all of the individual odour-generating equipment will be covered, including the wet well, screens and grit handling equipment. The odorous air will be extracted from the equipment items and transferred to a biofilter for treatment. The TPS building itself will not be ventilated, as all of the potential odour sources will be fully enclosed. The collected screenings and grit will be washed and stored in enclosed containers which will be removed from site on an approximately weekly basis.

During normal operation, there is not expected to be any distinguishable odour within approximately 5 m of the TPS as a result of the proposed enclosure and ventilation of the odour sources.

FIDOL assessment

- Frequency – there may be frequent fugitive emissions from the TPS if capture and treatment of odorous air by biofiltration is not effective
- Intensity – the emissions of odour could be intense depending on circumstances
- Duration – emissions of odour could continue for a significant length of time unless detected and rectified promptly
- Offensiveness – the nature of odours from the TPS may well be truly offensive or objectionable unless effective mitigation measures are in place and are operated efficiently, in particular via the capture and treatment of odorous air in the on-site biofilter
- Location – the TPS location has high sensitivity, being essentially within a public recreation area (being the boat park) and adjacent to a sports ground, a walking route, and the commercial area of Akaroa township

5.7 Disposal of treated wastewater for beneficial reuse at Akaroa parks

There will be no adverse impacts associated with the use of treated wastewater for beneficial reuse as proposed as the treated wastewater is highly treated, has a negligible dissolved odorous gas content and may also have undergone UV or chlorine sterilization at the WWTP to deactivate harmful biological components such as viruses and similar organisms. It is also in an aerated state - which further negates the formation of any reduced odorous compounds and, finally, will be applied using subsurface irrigation methods.

FIDOL assessment

- Frequency – it is currently unknown as to what frequency the discharge of treated wastewater to land for beneficial reuse at public park areas in Akaroa will occur. It could be relatively frequent however, depending on requirements to maintain the parks in a green and irrigated condition
- Intensity – odour from the disposal of treated wastewater to these public park areas will be insignificant in terms of intensity as the wastewater is both highly treated and aerated, is applied using subsurface irrigation and the potential contributions of odorous compounds will be negligibly low
- Duration – similarly to frequency, the duration of disposal in this manner is unknown at this time but is likely to be limited in the number of instances that this option is used and the volume of treated wastewater, and therefore the length of time required, for disposal
- Offensiveness – odour from the treated wastewater for irrigation to Akaroa parks will be indiscernible
- Location – the park areas are within the township and thus it is essential that odour from the treated wastewater being irrigated is not discernible; this will indeed be the case given the various factors that will pertain, as outlined above.

6 Summary of Assessment of Odour Impacts from the Akaroa Wastewater Scheme

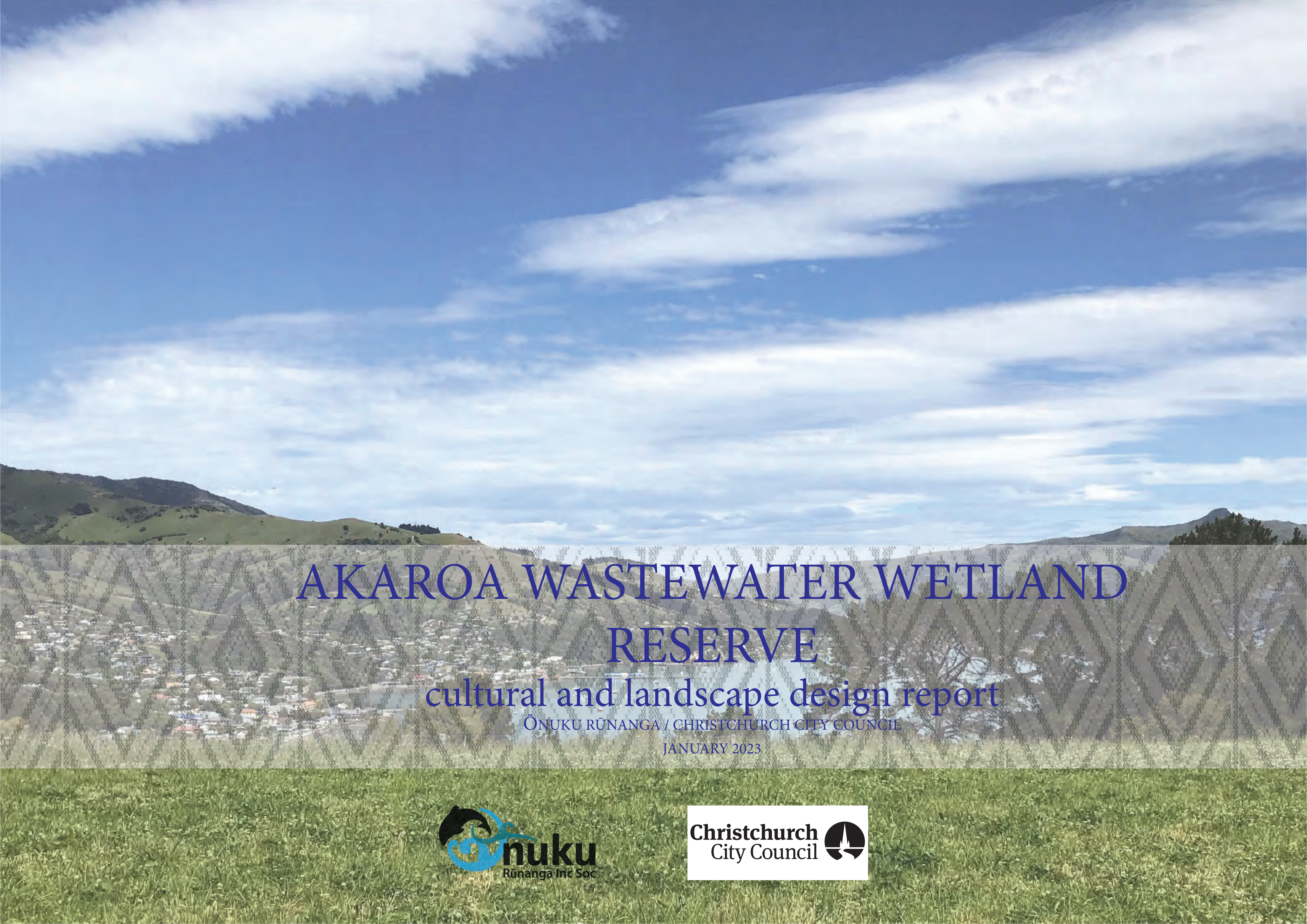
The Akaroa Wastewater Scheme comprises a sewerage reticulation system, a new Terminal Pump Station (TPS), a new wastewater treatment plant (WWTP) and various downstream approaches to the beneficial use of treated wastewater including pumping to storage tanks, drip irrigation of trees at three local sites, and sub-surface use for irrigation of recreational areas within Akaroa township itself.

The parts of the Scheme which have the highest propensity to emit odours which may be offensive or objectionable are the TPS and the WWTP. For each of these facilities, plant enclosure and extraction of odorous air to an on-site biofilter is the odour mitigation method that will be applied. Provided that containment and treatment of odorous air is fully effective and the treatment devices (i.e., the biofilters) are operated at optimum performance levels, odour nuisance associated with the TPS and WWTP respectively will be reduced to the extent that any adverse effects of odour will be less than minor.

The peripheral elements of the overall Akaroa Wastewater Scheme comprise irrigation of treated wastewater to land in various ways; in all cases the initial treated wastewater has minimal associated odorous components and is kept in an aerated condition until discharge, thus reducing the potential for development and release of odours to negligible levels.

An Odour Management Plan (OMP) should be prepared for the Scheme in due course; this should cover all aspects, even those that present minimal or zero odour risks, but the emphasis should primarily be on the TPS and the WWTP respectively. In fact, these two parts of the Scheme should each have their own stand-alone OMP, or at least they should be accorded their own individual sections in an overall OMP for the Akaroa Wastewater Scheme.

Appendix L Cultural Landscape Report and Akaroa Wastewater Cultural Assessment Report



AKAROA WASTEWATER WETLAND RESERVE

cultural and landscape design report

ŌNUKU RŪNANGA / CHRISTCHURCH CITY COUNCIL

JANUARY 2023

Ōnuku Rūnanga Inc Soc

Christchurch City Council

AKAROA WASTEWATER WETLAND RESERVE - SECTION ONE:

*“The sea was before the land
and the sky,
cleansing, joining.
And where the sea meets the
lands, there are
obligations there that are
binding as those of
whakapapa.”*

This whakatauāki, written by Teone Taare Tikao is a powerful reminder of our responsibilities to ensure we protect the health and vitality of our coastal edges.

Introduction

This integrated cultural and landscape design report has been prepared by representatives of Ōnuku Rūnanga to accompany the Christchurch City Council’s resource consent application for the Akaroa Wastewater project – Inner Bays Irrigation Scheme. This report has three sections; section one provides the background and briefly outlines the consultation and co-design process that Ōnuku Rūnanga has gone through with Christchurch City Council and the Akaroa community leading up to the lodgement of this application. Section two provides an overview of the cultural significance and context of Akaroa Harbour to Ngāti Irakehu and Ngāi Tārewa, rūnanga aspirations for a healthy harbour rich in mahinga kai and the relationship between Takapūneke Reserve and the Akaroa Wastewater project. Section three covers the cultural and landscape design intent for the proposed wetland reserve (subsurface wetland and surrounding landscape) and a description of the Inner Bays Irrigation Scheme project. This section includes the landscape concept plan for the Old Coach Road subsurface wetland pond site, and a description of the purpose of this site as both a constructed subsurface wetland to store excess treated wastewater, restore mauri and a place that tells the story of Akaroa Wastewater and demonstrates the cultural values associated with water.

Mana Whenua

Ōnuku Rūnanga represents the hapū of Ngāi Tārewa and Ngāti Irakehu who are the tangata whenua of the takiwā which covers the Akaroa Harbour, surrounding coastal environment and hills as defined by the Ngāi Tahu Claims Settlement Act 1998.

Ōnuku Rūnanga have the responsibility to act as kaitiaki over these lands and are active in the environmental management of their takiwā. For Ōnuku Rūnanga, kaitiakitanga is an inherent responsibility which comes from whakapapa and is the act of safeguarding the mauri of the environment and ensuring the area is passed down to future generations in a state which is as good or better than its current state.

*“Mō tātou, ā, mō ka uri ā muri ake nei.”
For us, and our children after us.*

AKAROA WASTEWATER WETLAND RESERVE - SECTION ONE

Background

On 10 December 2020, Christchurch City Council resolved to adopt the Inner Bays Irrigation Scheme as the preferred solution for the disposal and reuse of treated wastewater for Akaroa Township. The decision followed decades of grievance and advocacy by mana whenua regarding the culturally offensive practice of using the harbour as a receiving environment for wastewater.

The Akaroa Reclaimed Water and Reuse Scheme is the largest Infrastructure project for Akaroa and surrounding areas in the history of the area. It has been a long time in its creation, starting with a council resolution in 2011 to replace the existing sewerage treatment plant at Takapūneke. 1.

The process of getting to where we are today since the 2011 decision has been long and complex. The decision to remove the wastewater plan from Takapūneke – a wāhi tapu, was a significant win for Ōnuku Rūnanga; however, as plans for the new treatment plant developed, the issue of how and where the treated wastewater would be disposed of became the focus.

In the Ngāi Tahu creation narrative, all life begins with water. Māori believe that the health of all things depends on water. It is a taonga, a resource to be protected and treated with respect. In traditional Māori knowledge, wai (water) was classified in accordance with its particular characteristics and ceremonial use. These categories determined how the water could or could not be used. The mixing of water from separate categories was and still is considered unacceptable to Māori.2. In this regard, the mixing of wastewater which would be classified as Wai-kino (Polluted water) should not be mixed with other categories of water.

In 2014 Christchurch City Council (CCC) sought various resource consents associated with the construction of a new wastewater treatment plant for Akaroa township on a new site, and a new outfall to discharge wastewater into Akaroa Harbour.

Ōnuku Rūnanga, Wairewa Rūnanga, the Akaroa Taiāpure Management Committee and Te Rūnanga o Ngāi Tahu (collectively known as the Ngāi Tahu parties) supported the new treatment plant but opposed the wastewater discharge into Akaroa Harbour.

The Independent Hearing Panel granted the consent relating to the treatment plant and declined the consent applications relating to the outfall and wastewater discharge into the harbour. The grounds for declining the discharge were primarily due to the effects on Ngāi Tahu cultural values and the lack of consideration of alternatives as required by the Resource Management Act 1991.

The Akaroa Treated Wastewater Reuse Options Working Party was established in early 2017. This group consisted of representatives from Ōnuku Rūnanga and representatives from the communities affected by potential reuse options.

Figure 1 to the right: Proposed Wastewater Treatment Scheme key locations (Source: CCC)

1. Mahaanui Kurataiao, 2022. Akaroa Wastewater Project Cultural Assessment.

2. Goodall, A., Palmer, D., Tau, T., Tau, R., Te Whakatau Kaupapa: Ngāi Tahu Resource Management Strategy for the Canterbury Region, Aoraki Press, Wellington, 1990, pp.4-15.

Throughout this process, Ōnuku Rūnanga maintained that irrigation to land, reuse and constructed wetlands would provide the most resilient, future-proofed, ecologically beneficial, and culturally appropriate way forward. During the Working Party process, many options were explored and tested. Four feasible options were presented to Christchurch City Council at the end of 2020. The preferred option was the Inner Bays Irrigation Scheme (which had been advocated for by Ōnuku Rūnanga throughout the process). After the 2020 resolution, a community reference group was established to ensure community and rūnanga involvement in resolving issues and providing recommendations for the design of the irrigation to land scheme.

Part of the initial concept put forward by Ōnuku Rūnanga was to integrate a subsurface wetland system in the land opposite the proposed site for the new wastewater treatment plant on Old Coach Rd. The wetland is intended to provide additional storage of 2,200m2 of water during heavy rain events. The wetland will enhance the project’s resilience and restore the mauri of Wai-kino that passes through it.

NOTES

Contractors to verify all dimensions on site prior to commencing work;

Contractors are responsible for confirming the location of all underground services on site prior to commencing work;

Figured dimensions to be taken in preference to scaled dimensions.

PLAN NOTES

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"Māori heritage is a living spirituality, a living mana moving through generations. It comes to life through relationships between people and place" 3

This section aims to paint a picture of the interrelationship that exists between the ancestral landscape of which Akaroa forms a part and those who are linked to it by virtue of whakapapa.

Interpretation of this complex landscape in its entirety with its many layers of tangible and intangible values requires an understanding of the relationships between people and their environment over time.4 For Māori, landscapes are imbued with metaphysical values. Whakapapa is embedded within the landscape through the naming of geographical features and places, the composition of waiata and the recounting of ancestral feats, creation stories and legend. Myths and legends hold fundamental knowledge and are remembered because they tell of protocols, practical and ethical ways to care for places and people.5 As such, this section begins with the creation story as this underpins how Māori view the world as an open system which is entwined with the spiritual realm.

There are many variations of the creation story, but all share a common thread; all living things are connected through whakapapa. Teone Taare Tikao, rangatira of Ngāti Irakehu and advisor in Ngāi Tahu natural lore and history pertaining to the Canterbury area commences his explanation of the creation of the universe with "once there was nothing but water". 6 He stated there was no moon, sun, stars, or sky. The sea lay as a vastness of nothing but water. This was a time referred to as the long ages of darkness, called Pō, and the long ages of nothingness called Kore. There were many ages of Pō, until Io, the supreme god of Māori, brought the sky (Ranginui) and the land (Papatūānuku) into being:

Io-whatata means that he went one way on top of the water, and Io-whatamai that he went another way on the waste of water, and thereupon the two Hekeheke-i-nukus emerged from the deep. The word Hekeheke-i-nuku means "hanging upright and shifting" and Hekeheke-i-papa means "hanging horizontal or flat". 7

The movement over and under continued during the darkness of endless time. The ages of Pō were maku (dark), as the ages of Pō were nearing the end, Maku, a celestial being, emerged from the darkness, and Mahora-nui-a-tea emerged as the great expanse of whiteness. Maku and Mahora-nui-a-tea joined together and begot Rā (the sun). Maku had a second wife, her name was Hūareare; they begot a son called Marama-huakea, now called Marama (the moon).8

Two forms emerged above the expanse of water, Ranginui, the sky formed from Hekeheke-i-nuku, and Papatūānuku, the earth, formed from Hekeheke-i-papa. They lay close, Rangi lay on top, and Papatūānuku lay underneath, and between them they had many children. The children of these forms included Tāne (who would become guardian of forests and birds), Tāwhirimātea (guardian of storms and wind) and Tangaroa (guardian of the ocean). The children lay in darkness without the light from Rā or Marama. 9

3.Māori Heritage Council 2009 in: Kawharu, M., (2009) Ancestral landscapes and world heritage from a Māori viewpoint. The Journal of The Polynesian Society, Vol 118. Polynesian Society (Inc.), Auckland, New Zealand
4. Ibid
5. Kawharu, M., Ancestral landscapes and world heritage from a māori viewpoint. Auckland University, unpublished paper.
6. Beattie, J. H., Tikao Talks, p.23.
7. Beattie, J. H., Tikao Talks, p.24.
8. Ibid
9. Ibid

Rangi asked Tāne and his brothers to lift him off Papatūānuku so that light could fill the space between himself and Papatūānuku and that the world of light could commence. Tane lifted his father using the great pole called Pou-tu-te-Rangi. It rested on Papatūānuku and it had 10 hono (joints), each of which formed a heaven as it went upright. 10

*When the pole was upright it propped up the ten heavens. Tane went up to see that all was correct, and that he came down to see how Papa, his mother, was faring, for the pole was resting on her. She told him to go back up, he did so, and told Rangi that as all the heavens were firmly fixed he would change the position of the pole from upright to horizontal, and he placed it across the roof of the sky from north to south, and there it is today.*11

Tikao states that the great pole of Tāne still lies across the heavens today. 12

Tāne populated the heavens with his children. It was some of these children that he sent down to clothe his mother, Papatūānuku who lay bare. He sent down Tōtara (a son of Tāne), Mataī (a grandchild of Tāne), Kōwhai (a great-grandchild of Tāne), and many more. His offspring were called Te Waonui-a-Tāne (the great forest of Tāne) and they all grew together for protection.13 Once the trees had grown and were bearing fruit, the birds descended from the heavens to live within Te Waonui-a-Tāne.

Tāne also clothed his father, Rangi. One of these stories tells of how Tāne asked Tāwhirimātea (guardian of storms and winds), "Go you and procure the perspiration, the warmth of our mother Papa lying below, bear it upward and arrange it on the person of our father, Raki, as a warmth giving covering for him". Tāwhirimātea obtained Te Aotū, Te Aohore, Te Aonui, Te Aoroa, Te Aopōuri, and others (names of cloud formations) from Papa on account of her lamentation for her husband from whom she had been separated. The clouds were formed from the warmth and moisture emanating from Papatūānuku.14

Tāne now felt loneliness, so, wishing for a companion, sculpted the form of a woman out of the earth (whenua) of Papatūānuku. 15 She was then imbued with the mauri (life force) of the gods, and her name was Hineahuone (woman formed from earth), from whom Tāne fathered more children.

The story of creation tells us that "everything in the universe, inanimate or animate, has its own whakapapa, and all things are ultimately linked via the gods to Raki and Papa. There is no distinction or break in this cosmology, and hence in the whakapapa between supernatural and natural. Both are part of a unified whole."16

All people have strong connections to landscape that arise over time from their relationship with the natural environment. These connections to landscape help to form a sense of who we are and shape our identity. *The places, memories and stories of all our cultures are treasures to be shared, celebrated and passed on to future generations.* 17

10. Ibid. p.25
11. Ibid, pp29
12. Ibid.
13. Beattie, J. H., Tikao Talks.
14. Best, E., Maori Religion and Mythology, Part 1. A. R. Shearer, Government Printer, Wellington, 1924 (1976 2nd ed) , p.54.
15. Beattie, J. H., Tikao Talks, Penguin Books, Christchurch, 1939 (1990 2nd ed).
16. Roberts, M., Norman, W., Minhinnick, N., Wihongi, D. and Kirkwood, C., "Kaitiakitanga: Maori perspectives on conservation", in Pacific Conservation Biology, Vol.2: 2-20, 1995, p.9.
17. Christchurch City Council, 2019. Heritage Strategy. Pp12

Aotearoa and Te Waipounamu

Ngā Tiritiri-o-te-moana, the southern alps of New Zealand are said to be the youngest mountain range on earth. It was also the last substantial land mass to be colonised by humans. Ngāi Tahu whānui are tangata-whenua over a large proportion of Te Waipounamu. The modern iwi originates from three main tribal strands; Waitaha, Ngāti Māmoe and Ngāi Tahu. Ngāti Hāwea and Te Rapuwai are two iwi known to inhabit Te Waipounamu before the arrival of the Waitaha people but very little is known of them today.[18]

It was the ancestor Rākaihautū who brought the Waitaha people to Te Waipounamu on the waka called Uruao which is believed to have been guided by the tail of the summer constellation Scorpio.[19] The Uruao then became one of the principal navigational stars that guided the many waka that were to follow. Rākaihautū is famed for carving the biggest lakes of the South Island using his enchanted kō named Tūwhakaroria. After exploring the whole of Te Waipounamu, Rākaihautū and his son had a reunion in south Canterbury, eventually arriving at Banks Peninsula. Here, Rākaihautū sculpted two more lakes, Te Kete-Ika-a-Rākaihautū, and Akaroa harbour. After Rākaihautū finished carving the island, he planted his kō into Tuhiraki, the mountain known by the Pākehā as Mt Bossu, which stands directly across the harbour from Ōnuku Marae and is the prominent peak in Akaroa Harbour. Rākaihautū, thus named Banks Peninsula, Te Pātaka-a-Rākaihautū in recognition of the abundance of food sources in the area and claiming Akaroa as his home where he settled and was buried. [20]

Tuhiraki is a kōhatu mauri that rises to a height of 712m above sea level on the western ridge of the volcanic crater rim that defines Akaroa Harbour. It holds great significance to Ōnuku Rūnanga and wider Ngāi Tahu whānui. It is a wāhi tapu in the traditional, spiritual and mythological senses for its association with the Waitaha ancestor Rākaihautū. Māori maintain that, “mountains were the most significant of landmarks, their physical presence inseparable from their human association”. [21] Rocky outcrops often held special significance as rock was enduring and everlasting. Such rock formations are called wāhi kōhatu, and through spiritual personification become kaitiaki of the surrounding landscape, binding the whakapapa of Tangata Whenua to the land.

18.Sciascia, P., Cultural Narrative written for the Ōnuku Rūnanga video series.
19. Prendergast-Tarena, E, R., He Atua, He Tipua, He Takata Rānei: The Dynamics of Change in South Island Māori Oral Traditions. University of Canterbury, Unpublished Thesis, 2008.
20. Sciascia, P., Cultural Narrative written for the Ōnuku Rūnanga video series.
21. Orbell, M., Māori Myths and Legends, pp.50.
22. Anderson, A., and Tau, T., Ngāi Tahu: A Migration History. Bridget Williams Books in association with Te Rūnanga o Ngāi Tahu, Christchurch, 2008.
23. Beattie, J. H., Tikao Talks, Penguin Books, Christchurch, 1939 (1990 2nd ed).p129
24. Anderson, J.C., 1927. Place Names of Banks Peninsula.p91
25. Beattie, J. H., Tikao Talks, Penguin Books, Christchurch, 1939 (1990 2nd ed).p129
26. Anderson, J.C., 1927. Place Names of Banks Peninsula.p91
27 Beattie, J. H., Tikao Talks, Penguin Books, Christchurch, 1939 (1990 2nd ed).p.126
28. Beattie, J. H., Tikao Talks, Penguin Books, Christchurch, 1939 (1990 2nd ed).p.126
29. http://www.kahurumanu.co.nz/atlas

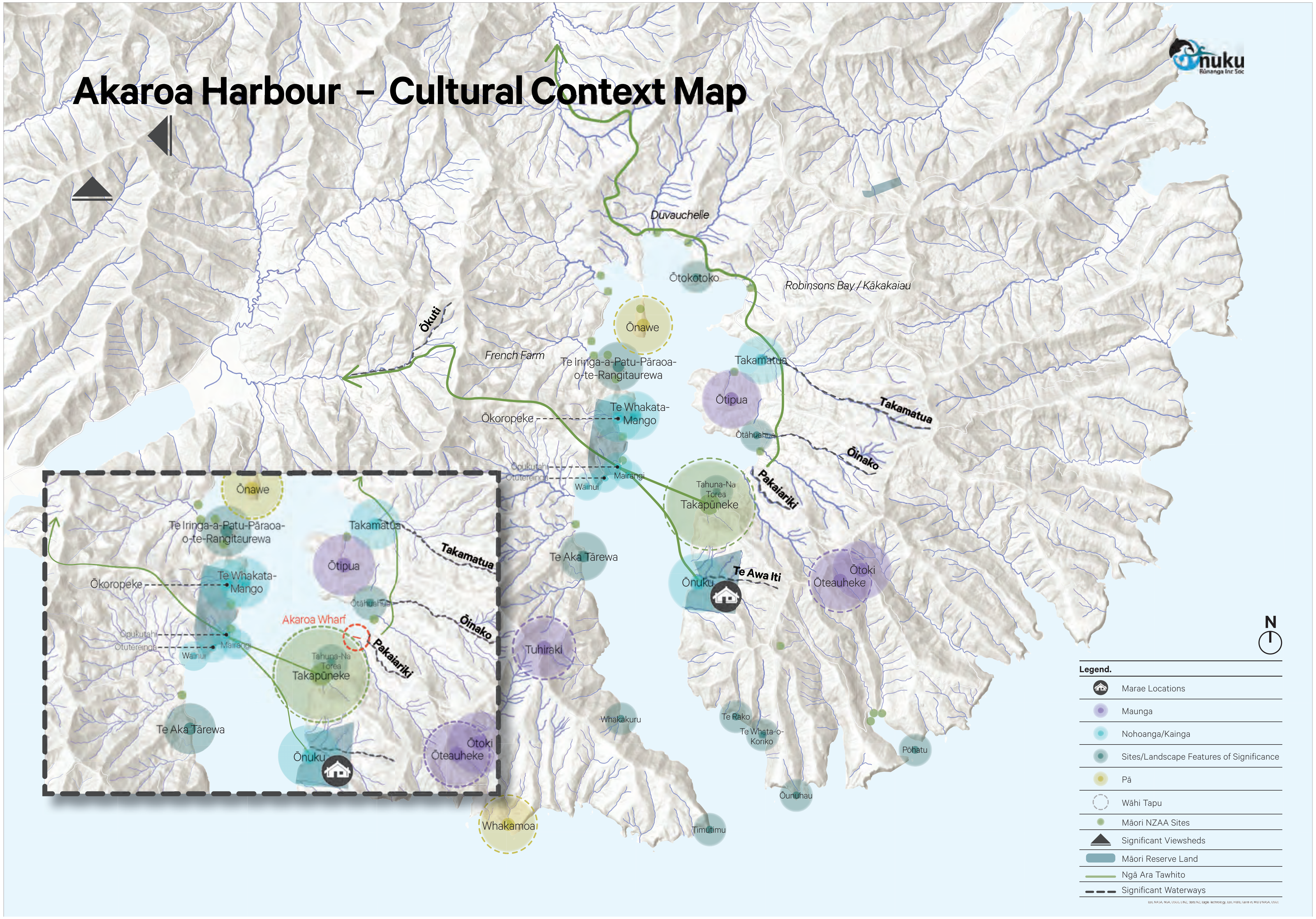
Cultural Landscape of Akaroa Harbour

The migration story of Ngāi Tahu from the east coast of the North Island to Canterbury is often told through the oral tradition of the accounts of Moki and his elder brother Tūrākautahi. Moki was the war chief of this expedition and the youngest son of Tūāhuriri, the senior Ngāi Tahu chief of the hapū Ngāi Tūhaitara (later to become Ngāi Tūāhuriri). It is not the intention to tell this story in any detail here, but in brief, Ngāi Tahu historians Te Maire Tau and Atholl Anderson in Ngāi Tahu: A Migration History tell us that the riches of Te Pātaka-a-Rākaihautū had been noted by Takakino and Kaiapu on their way back to Kaikōura after hostilities further south.[22] They told of the thickly forested Banks Peninsula, the immense number of rats and weka which were running amongst the tussock and scrub, the luxurious growth of tī kōuka , the rivers and streams which were teaming with tuna and other fish, and the endless number of flat fish within Te Waihora.

As was the custom of that time, areas of land were proclaimed in advance of land being seized. Makō claimed Wairewa; Te Ruahikihiki claimed Te Waihora, Kaitōrete Spit and the surrounding landscape as his. Te Rakiwhakaputa (father-in-law of Tūrākautahi) claimed Te Whakaraupō and established himself at the place now known as Rāpaki. Te Wheke (son of Te Rakiwhakaputa) settled at the mouth of the Ōpāwaho (Heathcote River). Te Ake, on hearing of the kuku, pipi and mako in Akaroa Harbour, made his claim there.[23] After landing at the head of the harbour, Te Ake attempted to make his way round to Wainui but due to the rugged terrain he retraced his steps and went back around to the other side of the harbour. It is at the headland between Duvauchelle Bay and Kakakaiau (Robinsons Bay) that he placed his tokotoko.[24] According to Tikao, Te Ake then proclaimed “Taku kaika, ko Ōtokotoko”[25] and so named Ōtokotoko for the headland. At the request of Te Ake, Te Rakitaurewa crossed over the harbour to a specific headland where he held up his whalebone patu to mark the boundary of the land Te Ake had claimed. This headland was named Te Iringa-patu-parāoa-o-Te-Rakitaurewa which means ‘the holding-up of the whalebone club of Te Rakitaurewa”.[26,27]

Te Rakitaurewa was married to Te Ao Taurewa. They had a son named Manaia. The story, as told by Teone Taare Tikao, explains how Te Rakitaurewa was killed when he insulted Tutepopoarangi at Waipapa. As was custom at that time, the widow, Te Ao Taurewa married her younger sister’s husband, Te Ruahikihiki. Te Ruahikiki at that time had a settlement at Whakamoa, near the south eastern head to Akaroa Harbour (he would later relocate to Te Waihora). He fell in love with Te Ao Taurewa, which had a devastating effect on the younger sister, Hikaiti. She fell into a deep depression and resided to commit suicide (whaka-momori).[28] She cast herself over the cliff near Whakamoa with her cloak wrapped around her. The place where her body lay was named Te Tarere a Hikaiti (the place where Hikaiti lept). The son of Te Rakitaurewa and Te Ao Taurewa, Manaia would remain at Whakamoa and later marry Irakehu, granddaughter of Makō who claimed Wairewa and daughter of Te Wheke, great grandaughter of Te Rakiwhakaputa who had claimed Te Whakaraupō during the time of the Ngāi Tahu mirgration south as noted above. The hapū, Ngāti Irakehu descend from the union of Irakehu and Manaia.

Akaroa Harbour is the largest harbour on the southern coast of Te Pātaka-a-Rākaihautū. Whakaroa is another spelling of Akaroa which means long harbour.[29] The harbour provided an abundance of kaimoana, such as pāua, kūtai, pipi, tuaki , tio, kina, shark, pātiki, hāpuka, mākā , pākirikiri , hoka , kōura and many other fish species. The surrounding bush provided a variety of native birds; building, weaving and rongoā resources; and the plentiful streams provided īnaka, tuna, freshwater mussels and kōura to name but a few.



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Cultural Landscape of Akaroa Harbour CONT.

In an interview with Waitai Tikao discussing settlements dating from pre-European and early European contact and the old ways of Māori life, he states “our people lived all around Akaroa Harbour, mostly on the Wainui side. Tikao Bay was a large settlement. Forest came down to the water’s edge; our people lived amongst the trees in small whare. Although the Ngāti Mamoe urupā along the coastal edge in from the whare-nui at Onuku would indicate that this bay was an old Ngāti Mamoe settlement, according to Waiatai, Ōnuku didn’t became a Ngāi Tahu settlement until around the time of the Treaty.”[30]

Takapūneke was one of many Māori settlements located throughout Akaroa Harbour. It was established in 1820 by Ūpoko Ariki of Ngāi Tahu, (Paramount Chief) Te Maiharanui as a major trading post and kāinga (village). Akaroa Harbour at the time was a favoured port for Europeans seeking fresh suppliers.[31] The trading post primarily traded in processed harakeke for the purpose of cordage to early Europeans; however, other fresh supplies such as potatoes were also traded. The historical events that occurred on this site have been recorded in detail in the Takapūneke Cultural Narrative and the Takapūneke Conservation Report, so won’t be repeated here, but it is important to emphasise that the massacre of 1830 sent shock waves back to England. The tragedy was aided by an English Captain of a British brig, the Elizabeth. It was this incident that prompted England to appoint a British Resident in 1832. This appointment in turn led to Britain assuming sovereignty over New Zealand and the signing of the Treaty of Waitangi in 1840.[32] The massacre was not the only atrocity to occur on this site; in 1960, the Council of that time built a sewage treatment plant directly where the original kāinga once stood, and then above this area, in 1970, built a landfill site. This epitomised the lack of understanding within the general population of New Zealand for Māori values associated to ancestral whenua at that time. The people of Ngāti Irakehu and Ngāi Tārewa considered these two acts as a defilement of their land. Historian Harry Evison considers these acts as “the ultimate in modern cultural oppression”.

To the north of Takapūneke, situated between Barrys Bay and Duvauchelle Bay is the narrow peninsula of Ōnawe Pā. It is shaped like a giant teardrop and forms a dominant feature of Akaroa Harbour. In 1831, Ōnawe was the site of a massacre. Following the sacking of Kaiapoi Pā by Ngāti Toa, Te Rauparaha led his taua southwards to Banks Peninsula to continue their attacks on Ngāi Tahu. Although Ōnawe was built for musket warfare, Te Rauparaha captured the pā by subterfuge, using Ngāi Tahu prisoners taken at Kaiapoi to negotiate a supposed truce, and as “cover” for his warriors to infiltrate the pā. Although some people escaped, a large number were killed and taken as prisoners, including Karaweko, who would later return to become a leading rangatira of Ōnuku. [33]

Other settlements within Akaroa included Takamatua, Wainui, Ōpukutahi, Ōkoropeke (Tikao Bay) and Ōnuku. Ōkoropeke means “to be doubled up” and is said to be named to commemorate the death of an elderly chieftainess, who was found dead in a doubled-up position from the cold. The more recent name of Tikao Bay was named after Hone Tikao, also known as John Love Tikao, who had lived there and was an uncle of the renowned Ngāi Tahu leader and scholar Teone Taare Tikao.[34] Ōnuku was one of the settlements the survivors of the Takapūneke massacre of 1830 fled to and is today home to two hapū of Ngāi Tahu, Ngāi Tārewa and Ngāti Irakehu. Ōnuku marae is located towards the heads of Akaroa Harbour within a sheltered bay that is bound to the east by steep bush clad hills and Te Awaiti Stream. Behind the marae stands the craggy peak called Ōteauheke.

Ōteauheke is the maunga of the Ngāi Tārewa chief, Wiremu Harihona Karaweko Puhirere. The maunga is often hidden in mist and has been regard by tangata whenua as a dwelling place for atua and as a place associated with tīpuna. ‘Heke’ references the freshwater springs that emerge from the outcrops of the peak, descending the mountain into waterways such as Te Awaiti Stream, which flows beside Ōnuku Marae. Ōteauheke is a wāhi tapu and is always referred in the whaikōrero on Ōnuku marae when speakers mihi to the sea and hills.[35]

Image: taken from Onuku, looking accross the harbour toward Tuhiraki

30. Waitai Tikao, in conversation with Debbie Tikao 8th July 2019
31. Evison, H., 1993. Te Waipounamu The Green Stone Island. Aoraki Press, Christchurch. P35
32. Christchurch City Council, 2012. Takapūneke Conservation Report. Unpublished report. P10.
33. http://www.kahurumanu.co.nz/atlas
34. Ibid
35. Mahaanui Kurataio Ltd, 2017. Cultural Values report for Misty Peaks.

AKAROA WASTEWATER WETLAND RESERVE - SECTION TWO: cultural and historical context

Akaroa Harbour Today

When the famed Waitaha ancestor, Rākaihautū planted his kō into Tuhiraki (Mt Bossu) and named the surrounding area Te Pātaka-a-Rākaihautū. He believed it would be, "the storehouse of Rākaihautū". This was once a landscape that was wealthy with natural beauty and resources. The harbour, rocky shoreline, sandy beaches, forested hills, streams, and lakes constituted a basket brimming with kai. For Ngāi Tahu, these natural resources formed the basis of their way of life, their belief system and economy. Ngāi Tahu understood that these natural resources were taonga, and they had to be respected and harvested sustainably. These natural resources, the places where these resources were obtained, and the philosophies and practices that surround them are all part of the system of mahinga kai. Mahinga kai is still, to this day, of central importance to Ngāi Tahu in regard to our culture and identity. The meaning of mahinga kai is complex and encompasses more than just growing vegetables or fruit. Ngāi Tahu whānui had to travel far and wide, to key food gathering areas to gather and prepare food to sustain them through the year.

"Mahinga kai encompasses the social and educational elements of food gathering. It includes customs practised in accordance with rangatiratanga (chieftainship), kaitiakitanga (custodianship) and whakapapa (genealogy). Particularly with regard to kaitiakitanga, tangata tiaki (guardians) have a role to implement and pass down customs and associated sustainable management methods, including the use of animal and plant species as tohu. In this way, mahinga kai ensures the continuation of traditional practices and the passing down of values to children and grandchildren, ensuring the survival of the practices through the generations. Mahinga kai includes the way resources are gathered, the places they are gathered from and the actual resources themselves. "[36]

Over the past twenty to thirty years, we have seen an accelerated rate in environmental decline. In 2015 at the Council Hearing for Akaroa Wastewater, Ōnuku kaumātua, Wi Tainui gave evidence. His evidence painted a picture of his knowledge of Akaroa Harbour, and the decline in kaimoana. In his evidence, he states that he lived in Akaroa harbour all his life and had gathered kaimoana from various areas of the harbour since childhood. Wi grew up at the Kaik where Ōnuku Marae currently is, and in his evidence he states:

"Akaroa harbour was renowned from early times through to living memory for the quality and quantity of its kaimoana.
When I was a child, kaimoana was abundant both within the harbour and out in the open ocean beyond the heads.
Fishing was the main employer in Akaroa Harbour and during this time I estimate there were around 40 crayfish boats and 15 trawlers, a portion of these would come into the harbour and deliver their catch. The main catch for these boats was crayfish, herrings, groper, red cod, blue cod, elephant fish, rig, gurnard, kingfish and tarakihi.
The harbour had excellent fishing grounds, as did the adjacent bays. The rocky shoreline of the peninsula and its beaches, were papatipu, containing many varieties of kaimātaitai species, including pupu (catseye), cockles, pāua, mussels, oysters, pipi, flounder, red cod, blue cod, crayfish, etc. The freshwater species of inanga, tuna could be obtained also. Kaimoana gatherers used natural landmark features to locate and relocate their gathering areas.
Fishing grounds for various species were well known to the tangata whenua, and this information has been handed down to us from previous generations. We, in turn, are handing it down to the generations after us.

I have witnessed first-hand the changes to the cultural health of Akaroa harbour that have affected our ability to gather kaimoana." 37

For Ngāi Tahu, the primary management principle is the maintenance and enhancement of mauri. The health of our waterways and water bodies is of the highest priority, as water is considered the lifeblood of Papatūānuku. To enhance water quality is to enhance its mauri (life force). The health of mauri in all living things is believed to be directly related to the health and well–being of people. Mauri is energy that animates life, similar to the electricity used to make a light bulb glow. Without it, the light bulb will not glow.

The Ngāi Tahu Freshwater Policy identifies a number of factors that reflect the status of mauri within waterways such as its life-supporting capacity and ecosystem robustness; fitness for cultural use; natural character and indigenous flora and fauna; and continuity of flow from the mountain source of a river to the sea. 38

Ōnuku whanau have maintained that their aspiration is to restore the mauri of the water and to restore the way of life painted by Wi Tainui so that future generations can also say that they were taught by their father to fish and to gather kaimoana, and that their harbour nurtured and sustained them and they too can name all the species of the harbour, when and how to fish in order to maintain and protect the resource for future generations.

"Kō a mātou kainga nohoanga, ko a mātou mahinga kai me waiho mārie mō mātou, mō a mātou tamariki, mō muri iho i a mātou."

"Our permanent and seasonal settlements and our mahinga kai are to be set aside for us and our descendants after us." Waitangi Tribunal's Ngāi Tahu Land Report (section 2.4).

36. Te Waihora Joint Management Plan, 2005. Te Runanga o Ngai Tahu, DOC. P32
37. Tainui, W., 2015. Statement of Evidence of Wi Puhirere Tainui on behalf of Ōnuku Rūnanga, Wairewa Rūnanga, Te Rūnanga o Ngāi Tahu and Akaroa Taiāpure Management Committee – Applications CRC150046, CRC150047, CRC150048, CRC150049, CRC150020, CRC152814 & RMA92026256 to build a wastewater treatment plant and ocean outfall at Akaroa
38. Te Rūnanga o Ngāi Tahu Freshwater Policy.

AKAROA WASTEWATER WETLAND RESERVE - SECTION TWO: cultural and historical context

Akaroa Harbour Today

Today, Takapūneke Reserve is a registered wāhi tapu with Heritage New Zealand Pouhere Taonga (HNZPT)., The HNZPT Act defines wāhi tapu as "a place sacred to Māori in the traditional, spiritual, religious, ritual, or mythological sense",39 and provides statutory protection of the site. Under the guidance of the Takapūneke Reserve Co-Governance Group, and the Ōnuku tipuna who fought for decades to get us to where we are today, in particular Waitai (George) Tikao and Pere Tainui, Takapūneke has been undergoing a process to:

- to share the story of this ancestral landscape with all people of Aotearoa
- to safeguard and grow mātauranga Māori
- to restore the mauri and mana of the land and people
- to bring back the traditional practices of raranga and other mahi toi to Takapūneke.

The connection between Takapūneke and the Akaroa Wastewater scheme is significant. The Akaroa Wastewater scheme, to Ōnuku Rūnanga, represents the fruition of many years of battle. As such, the cultural and landscape concepts expressed within the proposed wetland reserve, are directly connected to and an extension of the concepts embedded within Takapūneke.

Both Takapūneke Reserve and the Akaroa Wastewater scheme are expressions of kaitiakitanga.

*The ultimate goal of kaitiakitanga is to conserve and promote the health and wellbeing of the natural environment and sacred places, which in turn, by extension, protects and fosters the health and wellbeing of the people. It is humanity's role to be the consciousness of mother earth/Papatūānuku. This consciousness is expressed through kaitiakitanga. Humanity must see its relationship to nature as being part of an interdependent greater whole, a strand in the fabric of the universe. What happens to Papatūānuku and her children will eventually befall/affect us all. That is the reciprocal nature of the universe.*409

Image above - Takapuneke Reserve.

Images to the left showing the opening of stage one landscpe works and the blessing of Pou tu te Raki o Temaiharanui at Takapuneke Reserve.

39. https://www.heritage.org.nz/
40. Ōnuku Rūnanga 2021, Takapūneke Reserve Cultural Design Framework

Description of The Akaroa WW Proposal

The Akaroa Wastewater project consists of a number of components:

1. A new purpose-built wastewater treatment plant (WWTP) on high ground immediately north of Akaroa (Old Coach Road Site).

2. Irrigation to land using a drip feed system: irrigation of the highly treated wastewater to native trees over two sites within the Akaroa Harbour basin (Sawmill Road = Robinsons Bay Site and Hammond Point). Currently, the land of both sites is in pasture; the scheme includes the planting of indigenous species to approximately 40 ha.

3. The proposal also includes a covered raw wastewater storage pond, a subsurface wetland, and a treated water storage pond on land opposite the proposed treatment plant on Old Coach Road, with the bulk of the treated water storage in Robinsons Bay.

4. The subsurface wetland site, Robinsons Bay site and Hammond Point will all provide public amenities via walkways, seating and resting areas, education opportunities, artwork and interpretation that will tell the stories of place, cultural values of water and landscape and showcase the innovations of this scheme. As identified by the Reference Group and noted in the Mahaanui Kurataiao cultural assessment, this would contribute toward achieving the CCC Public Open Space Strategy goal for an Akaroa Harbour Coastal Path. There is potential to link Akaroa with the Old Coach Road site, then Old French Road to Takamātua, and use paper roads to connect with Hammonds Point, the DoC reserve and the area being reforested by students from Akaroa Area School. This could then link with Robsons Bay walkways.

5. Re-use via purple pipe is initially proposed for the irrigation of Jubilee Park within Akaroa Township. Re-use via a purple pipe to private properties and other public amenity areas, and public toilets were identified as important by community members of both the Working Party and Reference Group. It is anticipated that Christchurch City Council will consider installing a purple pipe system in Akaroa Tow ship at a later date.

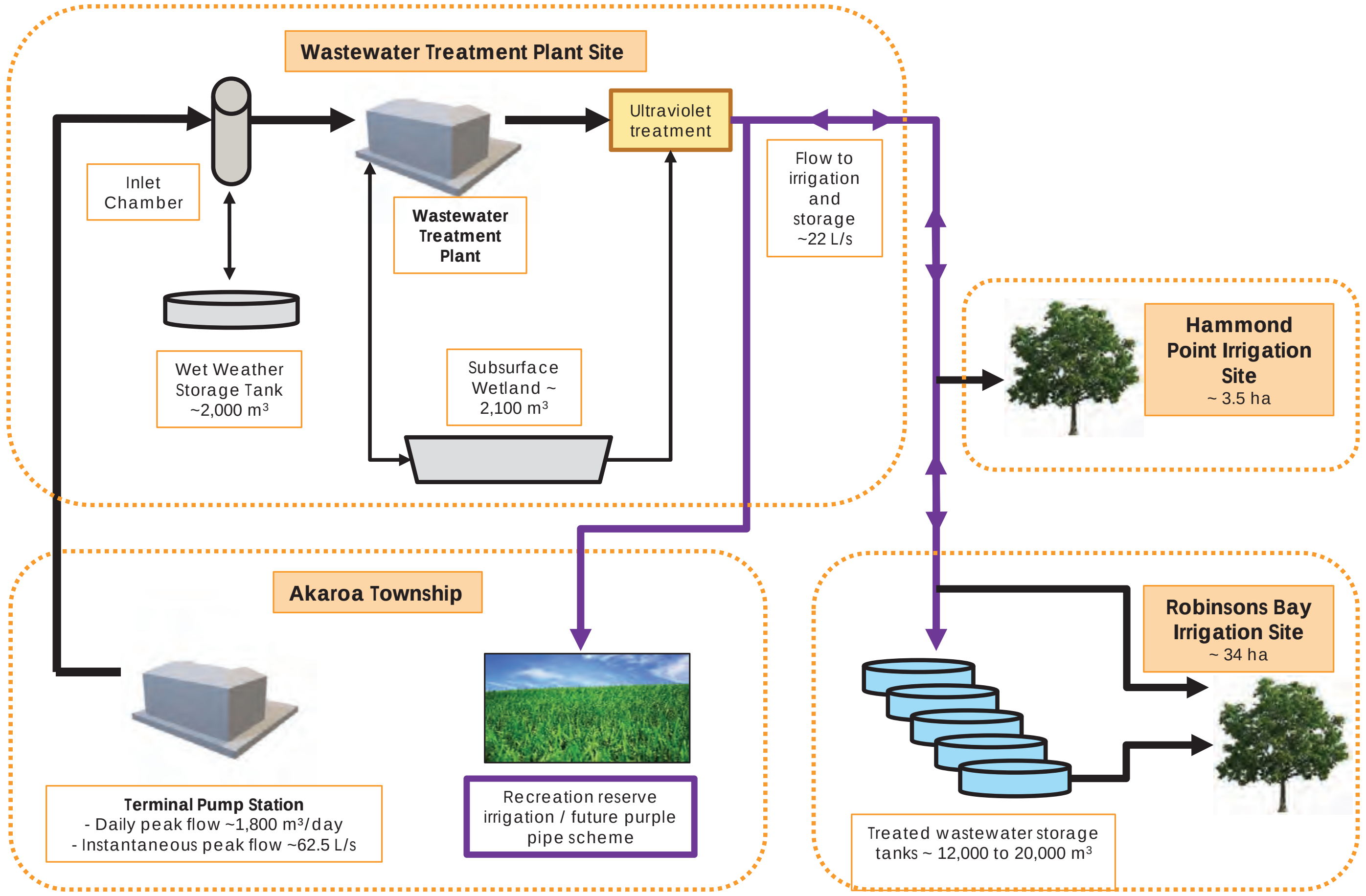


Figure 2: Proposed Wastewater Treatment Process Diagram (Source: CCC)

AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent

Site description:

The site is located at 6864 Christchurch Akaroa Road, approximately 1.8km north of the Akaroa township. The site has a teardrop shape, with the top of the drop to the north defining the area identified for the wetland reserve, then narrowing towards Children's Bay.

The wetland reserve site is located opposite the land that will accommodate the future Akaroa Wastewater Treatment Plant, which is at the intersection of Old Coach Road and Christchurch Akaroa Road. The wetland reserve site is relatively flat and is currently used as a hay paddock. The remainder of the site has a steeper topography with some areas of flatter land towards Children's Bay. The whole site is predominantly in pasture with some pocked of native regenerating forest.

The wetland reserve site will accommodate a 2,200m square subsurface wetland (refer to the following page for details on its many functions), and a 30m diameter, 3m high untreated wastewater tank with cover, on a 3m recessed platform. The site will also contain a public carpark to accommodate visiting school groups and community groups, walkways, boardwalks, interpretation panels, a shelter structure and extensive native planting. The use of the land outside the wetland reserve area (the narrower part of the teardrop that falls towards Children's Bay) provides future opportunities for additional native regeneration, or the establishment of a community orchard, walking tracks, picnic areas, and other community amenities.

The site is within close proximity to a number of boutique accommodation offerings, the Akaroa Holiday Park, retreats, and the popular Rhino walking track (located to the west of the site) which connects to the Children's Bay walking track to the north and Children's Bay to the south. The site is well-positioned to enhance the visitor and community experience of this area.

KEY

Old Coach Road site boundary

Location for the Akaroa WW Treatment Plant

Flat poprtion of the Old Coach Road site that will be utilised for the wetland reserve / subsurface wetland and storage pond.

Figure 3 (the to right): Old Coach Road site map. Map sourced from Canterbury Maps.
Images below taken from the wetland reserve area of the Old Coach Road site, looking towards Akaroa township and the harbour.

AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent

Purpose of the subsurface wetland system:

It is proposed that the wetland reserve pond area supports the function and resilience of the Akaroa WW scheme by providing additional storage and treatment, supports the aspirations and values of Tangata Whenua by restoring the mauri to the water, and demonstrating cultural values associated with water, as well as acting as a place of education and amenity. As an amenity area, the reserve would showcase Māori values, the significance of water and provide information on how the wider Akaroa Wastewater scheme functions and how it is protecting and enhancing Māori values.

The functions of the subsurface wetland system are as follows:

o "Dry duty" - running the wetland at a low ground water level, just adding enough water to keep the plants healthy. This would be in anticipation of wet weather, operational maintenance of other parts of the system, or perhaps going into Christmas when we might want some extra flexibility.

o "Extra Treatment Duty" where treated wastewater is directed through the wetland before sending it back to the WWTP for final UV and on to irrigation or re-use. This might be for times of high load such as over Christmas or if there is an issue elsewhere in the system and need some extra treatment. In this mode the system will maintain the water level at the surface without seeking to flood or surcharge it.

o "Treated Holding Pond Duty". This is when the wetland will fill with treated water as there is something wrong at the irrigation end or pipeline to irrigation. Either a major wet weather situation or unexpected breakdown (ie someone digs up our pipeline to the irrigation fields). The water would be pumped out a few days later, sent through the UV, then off to re-use or irrigation. In this mode we'd flood it to get as much storage as possible.

o "Partially treated holding pond". This is an unlikely scenario, but in the event of failure at the treatment plant, rather than send partially treated wastewater direct to harbour, the wetland wouild hold the treated wastewater. When the WWTP is back to normal we would pump the water back to the headworks for re-processing and give the wetland several weeks dry duty before considering a return to service. This wouldn't be a desirable operating mode but is an emergency option rather than spill to harbour. In this mode we'd flood it to get as much storage as possible.

o Final option, to configure the system to send the Akaroa re-use water through the wetland before going to Akaroa. (with a UV step added). This would provide additioonal nutrient uptake, and the restoring of mauri before reuse for non-potible residential purposes.

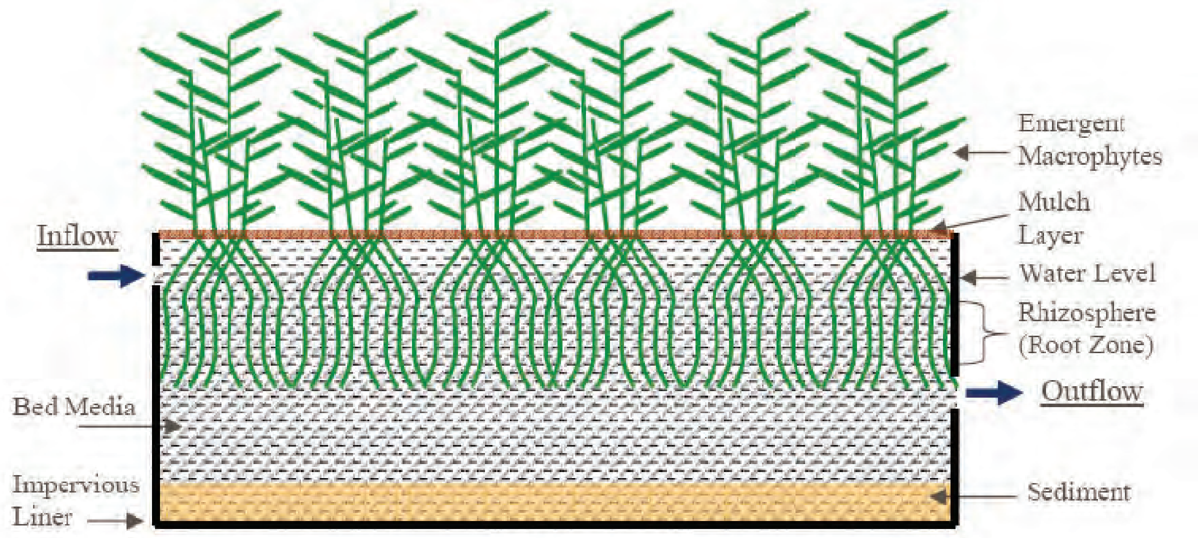


Figure 4: Example of a typical constructed subsurface wetland. Image sourced from https://www.researchgate.net/publication/235257297_Pathogen_removal_in_constructed_wetlands

Image above is an example of a subsurface wetland. Image sopurced from https://adoa.net/latest-news/making-wetlands-work-municipality/attachment/making-wetlands-work-in-your-municipality/

AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent

Description of the concept:

The wetland reserve will provide multiple community, cultural and ecological benefits:

- Enhance biodiversity
- Restore mauri
- Sequester carbon
- Further cleanse treated wastewater to enhance safety and appeal for reuse
- Showcase innovation in wastewater management
- Showcase co-design / partnership between a local body and Tangata Whenua
- Provide a place of education and amenity which can impart cultural values associated with water to the wider community, schools and visitors.

Wetland systems are one of the technologies that are being supported by other iwi around the country for the further treatment of wastewater as they understand the cleansing function of these natural systems to further remove contaminants and to restore the mauri to water.

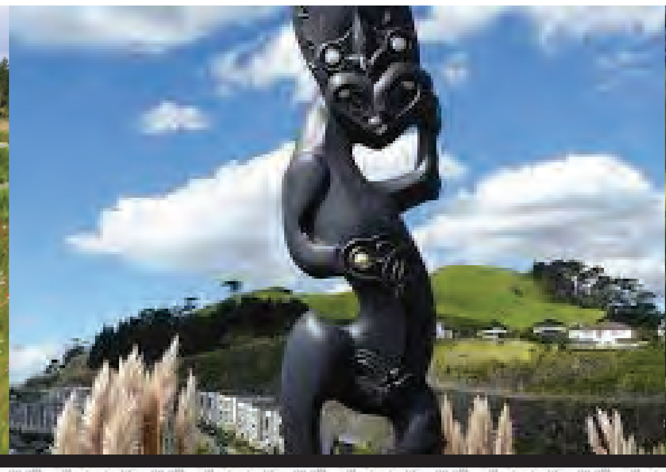
From a Māori perspective, the combined processes of subsurface wetlands, aeration and daylighting of the water over a rocky stream bring into play the actions of te taiao (the environment); water passes through Papatūānuku (the earth) to transform and cleans the polluted water and re-establish the mauri; Tane Mahuta, the use of plants, roots, micro-organisms and insects to form the natural biological processes to remove contaminants; Tāwhirimātea (the wind) to oxygenate the water and te Ra (the sun) to add UV light. Thus, utilising the natural processes found in nature. Nature provides all the answers to our environmental issues:

"kia whitikia e te rā, kia purea e te hau, kia horoia e te ua, ā, kia hurihia e ngā kōwhatu, to be shone upon by the sun, to be purified by the wind, to be washed by the rain, and to be tumbled by the rocks.

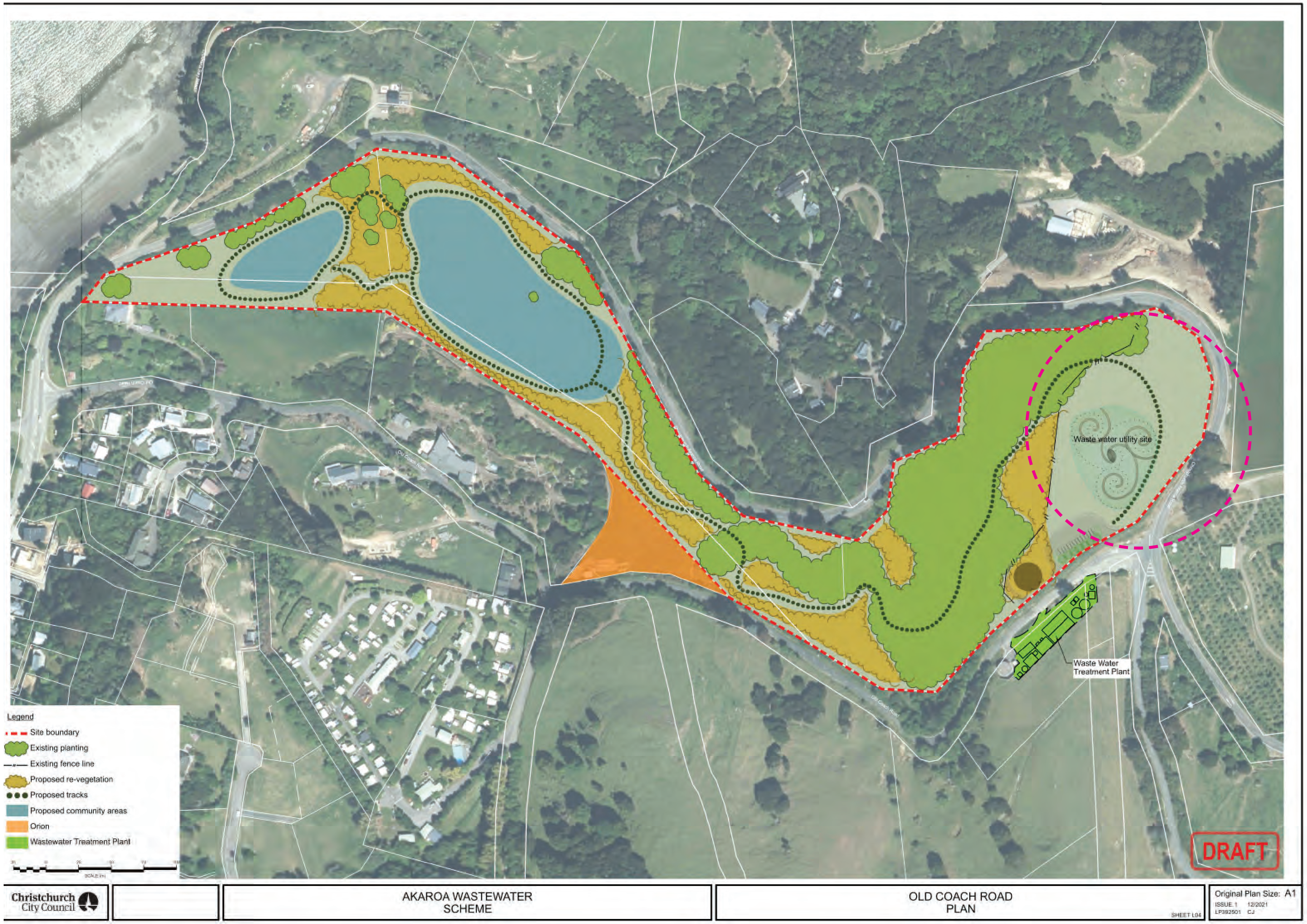
The wetland reserve landscape concept design is a key feature in achieving cultural outcomes for the project. The concept includes:

1. A small carpark and bus pull-in area off Old Coach Rd, opposite the treatment plant to accommodate school groups, community, and visitors.
2. Walkways through native planting and a boardwalk through the wetland (the toi Māori elements have been designed by local carver Simon Rogers).
3. Extensive native revegetation planting
4. Shelter structure for school groups to gather under, art and interpretation panels

The images on this page are primarily of Maungarei Springs in Mt Wellington, Auckland. The demonstrate an extensive stormwater treatment system consisting of multiple constructed wetland ponds that have been transformed into an attrative public amenity and educational area. The images have been provided by Debbie Tikao who was the lead landscape architect on this project.
The image to the right is taken of one of the shelter structures and Maori design within Dallington Landing by Christchurch City Council and Matapopore.



AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent
OLD COASH ROAD SITE - LANDSCAPE SCHEME PLAN



The Akaroa Wastewater scheme plan for the Old Coach Road site (sourced from Christchurch City Council), identifies the proposed wetland reserve area with car-parking, subsurface wetland and covered storage tank (area circled in pink). The landscape concept for this area is shown in more detail on the following page.

The remainder of the site shows areas of proposed native planting and walking track. The areas in blue are open padtural areas that could be utilised for community activities or orchards at a later date.

NOTES

Contractors to verify all dimensions on site prior to commencing work;

Contractors are responsible for confirming the location of all underground services on site prior to commencing work;

Figured dimensions to be taken in preference to scaled dimensions.

PLAN NOTES

PROJECT

Akaroa Wastewater Wetland Reserve

CLIENT

Christchurch city council

ISSUED: XX

Christchurch City Council

CONSULTANTS

Onuku Rūnanga
&
Christchurch City Council

Ōnuku Rūnanga Inc Soc

CONTACT US

AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent
LANDSCAPE CONCEPT PLAN

LEGEND:

- Subsurface wetland with native grasses and reeds.
- Native planting and screen planting around the covered tank.
- Path.

- A Carparkand entrance.
- B Covered WW storage tank.
- C Akaroa WWTP site.
- D Seating area with views across to Akaroa harbour
- E Central gathering and seating area of the kowhaiwhai board-walk.
- F Kowhaiwhai boardwalk with in-terpretation panels- refer to the following page for the meaning of the design.
- G Seating area connected to the pavillion for school groups and visitors.
- H Pavillion / shelter for education-al and community purposes.
- I Path to connect to proposed path net work.

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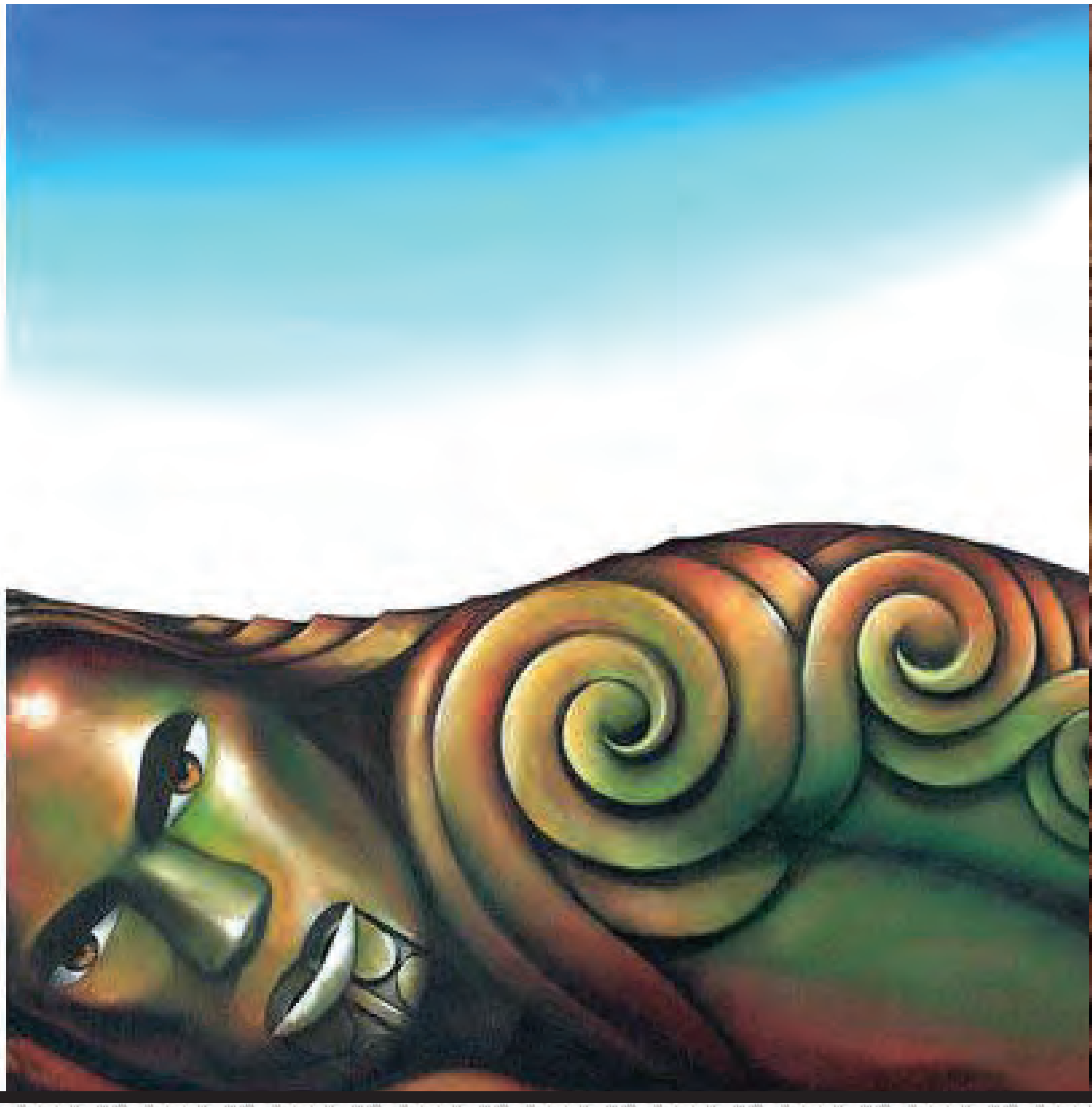
AKAROA WASTEWATER WETLAND RESERVE - cultural and landscape design intent - Papatūānuku

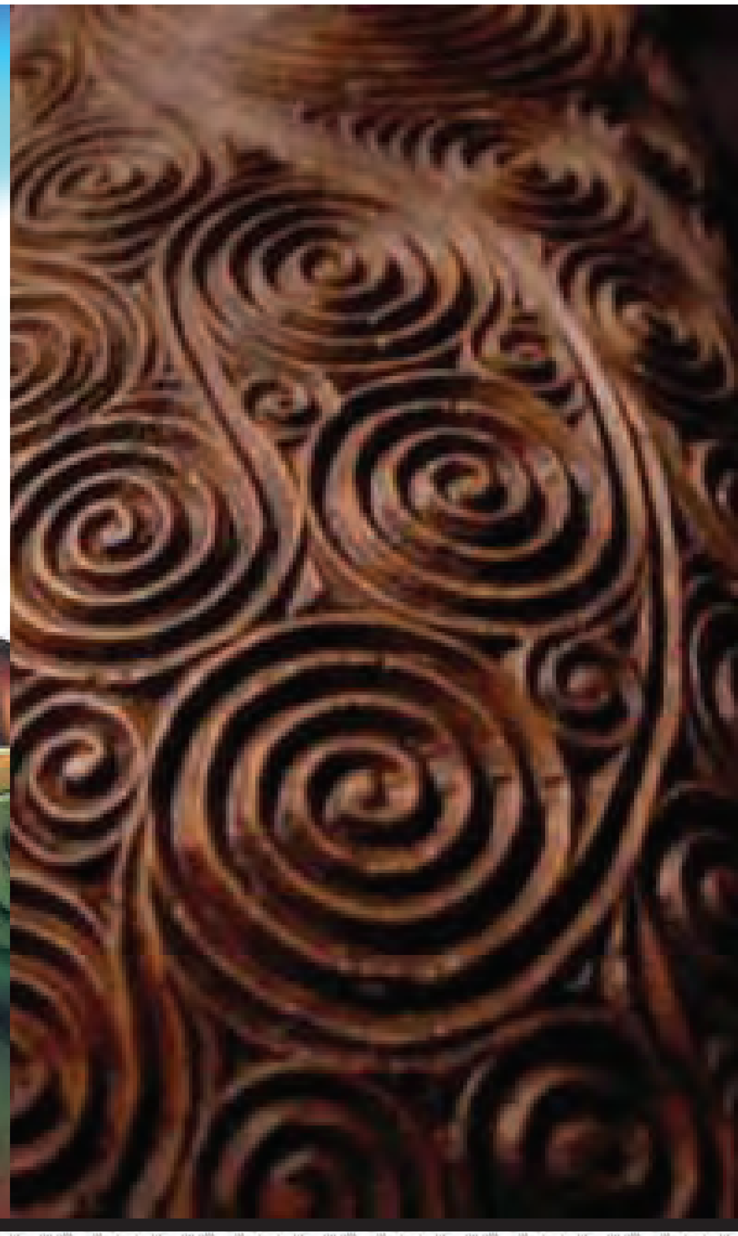
The kōwhaiwhai design bottom right, forms the basis of the design for the boardwalk structure within the subsurface wetland. It has been designed by carver, Simon Rogers to represent the cleansing ability of Papatūānuku. The interconnecting takaranga and koru demonstrate the dynamic, interconnected nature of all living things.

Kōwhaiwhai are beautiful patterns that were traditionally applied by hand to narrow boards placed between woven tukutuku panels, carved figurines and ceiling features which represent the internal ribcage of our wharenui. Traditionally, kōwhaiwhai have been applied as painted scroll designs, abstract and curvilinear in form. Kōwhaiwhai designs often symbolise whakapapa or genealogical decent and the many branches that continue to grow. Kōwhaiwhai, like other toi Māori forms communicate important connections, relationships, transformative and generative processes.

The kōwhaiwhai design for the subsurface wetland integrates several symbols, the 'koru' which is the most basic design element of kōwhaiwhai. The koru resembles the young shoot of a native fern with its unfurling ability and can represent growth and the beginning of a new entity. The koru or spiral symbol conveys the idea of perpetual movement, beginnings, and regeneration. In traditional Māori beliefs, creation is described as a dynamic movement. At the heart of this view is the understanding that "humanity and all things in the natural world are always emerging, always unfolding." This process is depicted by Māori artists, trained in the traditional schools of learning, as the double spiral. The double spiral, or takarangi, swirls into and out of a primal centre, expressing the unfolding of the cosmos. This form depicts life as a dynamic force, sometimes creative and sometimes destructive.1

1. Henare, M., Williams, T., The Double Spiral and Ways of Knowling. 2009. www.review.mai.ac.nz
The image to the righ and centre have been sourced from: https://www.pinterest.nz/christinegaumer/papatuanuku/. The image to the right has been provided by carver Simon Rogers.





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Christchurch City Council

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Mahaanui Kurataiao Ltd

Akaroa Treated Wastewater Irrigation Scheme:

Cultural Assessment

November 2022

1. Executive Summary

Christchurch City Council is developing a new system for the treatment and reuse of wastewater from Akaroa Township. Following decades of grievance and advocacy by manawhenua regarding the culturally offensive practice of using the harbour as a receiving environment for wastewater, the shift to a culturally informed land-based system represents significant progress. Collaboration between the council, Ōnuku Rūnanga, and community members has resulted in a scheme that delivers multiple benefits. This report describes manawhenua involvement in co-designing the scheme and its features in the cultural context of the location. It provides an assessment of anticipated cultural effects for consenting purposes. The relevant provisions of the Mahaanui Iwi Management Plan and regional planning instruments inform the cultural assessment of the project. Appropriate methodologies and limits will need to be in place to protect cultural values such as mahinga kai from potential adverse effects of construction activities and the discharge of treated wastewater to land. Overall, the project is anticipated to have a significant positive effect on the mauri of Akaroa Harbour though ceasing (to the greatest degree practicable) the direct discharge to the harbour. The cultural landscape values of Akaroa will be significantly improved by the project through extensive restoration of indigenous biodiversity enhancement and the establishment of a new wetland. The project respresents a positive shift towards partnership and affording appropriate recognition of kaitiakitanga and cultural values in the decision making and deisgn process.

2. Scope and Structure

Christchurch City Council (the Council) is developing a new wastewater system for Akaroa township. A new treatment plant with an associated irrigation and reuse system will replace the existing plant at Takapūneke Reserve, and the ocean outfall that currently discharges to the harbour. The development of an alternative to the ocean outfall has a long and complex history, and the new scheme is the result of extensive collaboration between the Council and Ōnuku Rūnanga. The project has also received substantial input from the wider community. The Council has engaged Mahaanui Kurataiao to prepare a report to accompany the resource consent applications that are required for the development and operation of the new scheme.

The report is mandated by Ōnuku Rūnanga and articulates their experience of partnership with the Council in developing and progressing the Akaroa wastewater project. It provides evidence of this relationship, and an assessment of cultural effects to inform the processing of the resource consent applications.

The report collates the project background and collaboration between the council and manawhenua. It provides discussion of the anticipated cultural outcomes, and analysis of objectives and policies in both the Iwi Management Plan and the applicable district and regional planning instruments.

This report has been structured as follows:

a. A history of wastewater management in Akaroa Harbour.

b. An overview of the development of the new scheme, and the partnership between Ōnuku Rūnanga and the Council.

c. A description of the key features of the new wastewater treatment and disposal scheme.

d. A cultural assessment in the context of the location, scheme design and anticipated outcomes.

e. An analysis of the objectives and policies of the Mahaanui Iwi Management Plan.

f. An assessment of the proposal in relation to the relation to the relevant cultural objectives and policies of the Canterbury Regional Policy Statement, Coastal Environment Plan, and the Land and Water Regional Plan.

g. A conclusion addressing how the project responds to cultural concerns and the outcomes sought by manawhenua.

3. Manawhenua and takiwā

Mahaanui Kurataiao (Mahaanui) is an environmental advisory company established in 2007 by six Papatipu Rūnanga – being Ngāi Tūāhuriri Rūnanga, Te Hapū o Ngāti Wheke Rūnanga, Te Rūnanga o Koukourārata, Ōnuku Rūnanga, Wairewa Rūnanga and Te Taumutu Rūnanga. These six Rūnanga hold manawhenua rights and interests over the lands and waters within their respective takiwā (from the Hurunui River in the north, to the Hakatere/Ashburton River in the south, and inland to Kā Tiritiri o Te Moana (the Southern Alps). Mahaanui has a general mandate to represent the interests of these Papatipu Rūnanga in environmental management issues in their takiwā.

Ōnuku Rūnanga is the Papatipu Rūnanga who holds manawhenua rights and responsibilities in and around Akaroa Harbour. Ōnuku Rūnanga is the modern-day representative of the hapū Ngai Tarewa and Ngāti Irakehu at Ōnuku. As described in the Te Rūnanga o Ngāi Tahu (Declaration of Membership) Order, 2001: *The takiwā of Te Rūnanga o Ōnuku centres on Ōnuku and the hills and coasts of Akaroa to the adjoining takiwā of Te Rūnanga o Koukouārata and Wairewa Rūnanga.* Wairewa Rūnanga also hold manawhenua interests in Akaroa Harbour through whakapapa to Ngāti Irakehu. The cultural and historical context of Akaroa Harbour is explained in further detail in the Akaroa Wastewater Wetland Reserve Cultural and Landscape Design Report (Integrated Cultural and Landscape Design Report) prepared by representatives of Ōnuku Rūnanga.

4. Background

4.1 Akaroa wastewater history

In 1960, the then Akaroa County Council purchased a site at Takapūneke for the development of a wastewater treatment plant (WWTP). Takapūneke was the location of a kainga that became a significant centre of trade between Ngāi Tahu and Europeans. The brutal raid and slaughter undertaken by Te Rauparaha at Takapūneke was a significant event that left the site highly tapū. Not only did the history of the location make it an inappropriate for a WWTP, but the associated discharge to the harbour is offensive and degrading to its significance and mahinga kai values.

The highly tapu status of Takapūneke continued to be disregarded through the establishment of a Council landfill uphill of the bay in 1979. By 1998 it was acknowledged that the site was an inappropriate location for subdivision, the wastewater treatment plant, and the landfill. While the landfill was closed, it was the prevailing belief of the Council that removal of the wastewater treatment plant was not a viable option. This perspective remained unchanged until registration of Takapūneke Reserve as a wāhi tapu with Heritage New Zealand Pouhere Taonga in 2002.

Throughout its operation, the Akaroa wastewater system has caused regular overflows of raw sewage into the harbour during periods of capacity overwhelm. These events are not only highly affronting to the spiritual and cultural values associated with the harbour, but also compromise wider community values, such as recreational opportunities.

In 2013, existing consents were due to expire and Christchurch City Council (the Council), lodged applications to continue the operation of the existing WWTP until such time as an upgraded plant sited away from Takapūneke could be established. Submissions from Ōnuku Rūnanga, Wairewa Rūnanga, and Te Rūnanga o Ngāi Tahu culminated in a statement of evidence on the adverse cultural effects of the discharge. This highlighted the frustration from manawhenua that, while relieving Takapūneke of the WWTP and upgrading the capacity, the ultimate objective of ceasing the direct discharge to the harbour did not appear to inform the Council’s plans. The manawhenua position was pragmatic and recommended that the application be granted with a maximum duration of three to five years to enable exploration of a robust alternative to the harbour discharge. The independent hearing commissioners agreed with this approach and reduced the Council's proposed duration from seven years to five.

The establishment of a working party exploring alternatives to the harbour discharge had generated a sense of optimism for manawhenua that was soon quashed. In 2014, Christchurch City Council applied for a range of resource consents associated with the construction of a new WWTP at an alternative site but retaining the ocean outfall and a continuation of the harbour discharge. Whilst the upgraded plant and opportunity to restore Takapūneke Reserve was supported by Ōnuku Rūnanga, Wairewa Rūnanga, the Akaroa Taiāpure Management committee, and Te Rūnanga or Ngāi Tahu, the continuation of discharge was strongly opposed. Evidence by Ms Ngaire Tainui of Ōnuku Rūnanga told the Independent Hearing Panel of the loss of mana kai for the hapū and whānau of Akaroa, who have had to source kaimoana from outside their own moana[1].

The hearing panel took the view that the investigation of alternatives had been inadequate and that the harbour outfall would not achieve the sustainable management of resources consistent with the purpose of the Resource Management Act (1991). The decision was made to grant the consents for the establishment of a new WWTP but refuse those for the ocean outfall and associated discharge. Fundamental to that decision was that the ongoing direct discharge of wastewater (however treated) was having a significant adverse effect on the cultural and spiritual values associated with the harbour.

Christchurch City Council challenged this decision in an appeal to the Environment Court. Environment Canterbury was supported by the Ngāi Tahu parties in their defence of the decision. Christchurch City Council then withdrew their appeal to undertake further consultation and investigation of an alternative.

[1] Decision of Hearings Commissioners David W Collins and Hoani Langsbury, July 9th, 2015

4.2 Partnership and the development of an alternative

The decision by Environment Canterbury to refuse consents associated with the discharge of wastewater to the harbour and the acknowledgement of the cultural harm caused represented a paradigm shift regarding how the issue was to be managed.

The Akaroa Treated Wastewater Reuse Options Working Party was established early 2017. This group consisted of representatives from Ōnuku Rūnanga and community members. The topography and soil characteristics of Akaroa harbour limited the number of sites suitable for irrigation. The investigation of alternative options was further complicated when it was discovered that a faulty flow meter was underestimating the volumes of wastewater being produced by the Akaroa township, meaning a larger area would be required than initially estimated.

A comprehensive analysis of alternative options to the harbour discharge was prepared by Beca in 2020[2]. Four options for the disposal and reuse of treated wastewater were presented for community consultation:

1. Inner Bays Irrigation Scheme
2. Goughs Bay Irrigation Scheme
3. Pompey's Pillar Irrigation Scheme
4. Mid-harbour outfall

A drilling investigation was also undertaken to assess the viability of injecting treated wastewater to deep bores (managed aquifer recharge). However, this option was rejected due to the possibility of contaminating drinking water sources, and the extent of volcanic rock limiting infiltration capacity.

For manawhenua, any land-based alternative to the harbour outfall was considered viable.

Following the 2020 community consultation, submissions, and hearings, Christchurch City Councillors and Mayor made the decision to adopt the Inner Bays Irrigation option. The option was preferred by the Council and manawhenua. However, community members including residents of Robinsons Bay held significant concerns about potential risks and adverse effects resulting from the proposed scheme. This led to the Council establishing a Community Reference Group to ensure these concerns

[2] Akaroa Wastewater Summary of Disposal and Reuse Options, CH2M Beca 2020.

could be suitably addressed throughout the design of the proposal. The group consisted of community members, community board members, and two representatives from Ōnuku Rūnanga. The Terms of Reference Objectives for the group were:

- To assist the project team to develop the preliminary design of the Akaroa Reclaimed Water and Reuse Scheme in a way that addresses community concerns where possible.
- To suggest ways that the Akaroa Reclaimed Water and Reuse Scheme could be improved so that it can deliver multiple benefits for the community in the geographic areas considered.

The advice of the Community Reference Group was based on a series of principles:

- That the scheme must be safe, sustainable, resilient, and account for the risks and uncertainties of climate change.
- Each facet of the project must be designed to avoid, or minimise, adverse effects on the environment, historical sites, and affected communities – Particularly at Robinsons Bay.
- To provide for public access and enjoyment where appropriate, with an emphasis on creating pathways to connect Takapūneke through to Robinsons Bay.
- To honour and preserve the histories of both Tangata Whenua and European settlers through narrative interpretations.
- Advocacy for wastewater reduction, reuse, and purple pipe initiatives, with the hope that this can become an exemplar for other communities in Aotearoa.

These principles in part also reflect manawhenua aspirations for wastewater management and the cultural health of Akaroa Harbour.

The following section describes the key features of the scheme.

5. Akaroa Treated Wastewater Irrigation Scheme

5.1 Project overview

The Akaroa Treated Wastewater Irrigation Scheme includes the establishment of pipe network from Akaroa township to a pump station which will connect to a new Wastewater Treatment Plant and irrigation pipelines. Treated wastewater will be piped to storage tanks located at Robinsons Bay with a combined capacity of 20,000m^3. From the tanks, gravity fed driplines will irrigate new plantations of native trees. The scheme intends to integrate a “purple pipe” network which would reuse highly treated wastewater to irrigate parks and flush public toilets

A fundamental driver of the selection and design of the scheme has been addressing the core objective of manawhenua – the need to cease the direct discharge of wastewater (however treated) to the harbour. The project has been designed with the scope to deliver a broad range of benefits, including:

- Ecological restoration and biodiversity enhancement.
- Water conservation through the reuse scheme, which will reduce the demand on often constrained freshwater resources.
- Recreational opportunities through establishing walkways and areas for public use and access.
- Educational opportunities through narrative interpretations on cultural values associated with Akaroa Harbour and water, and how the scheme enhances those values.
- Climate resilience including carbon sequestration through tree planting and resilient design to accommodate uncertainty and extreme climate events.

The features specific to each site are described below. A map is included as Appendix A depicting the three sites across the project area.

5.1.1 Old Coach Road

The Old Coach Road site will be the location of the new Wastewater Treatment Plant (WWTP). Treatment at the plant will consist of a biological nitrogen removal (BNR) process which removes nitrogen from the effluent. Additional processes are being explored to ensure the most effective and reliable treatment results. Further treatment using ultraviolet (UV) light is expected to achieve a sufficient level of pathogen reduction for the irrigation scheme, and the standard of treatment is anticipated to be among the highest in New Zealand. It is likely that water piped to Akaroa for non-potable reuse will need to be chlorinated to comply with the direction of the drinking water regulator, Taumata Arowai (despite the beneficial reuse not including drinking water).

Adjacent to the treatment plant will be a 2,000m^3 buffer tank to store raw wastewater in the event of wet weather flows overwhelming the capacity of the treatment plant. This site will also be the location of a new subsurface wetland. The wetland enhances the resilience of the project, providing additional storage of 2,200m^2 and restoring the mauri of overland flows that will inevitably be generated in extreme rainfall events. It will enhance biodiversity, featuring indigenous plants and providing habitat to birds and insects. A wetland concept design has been developed by Debbie Tikao on behalf of Ōnuku Rūnanga and can be found in detail in the Integrated Cultural and Landscape Design Report. The wetland is a key feature in achieving cultural outcomes for the project, as discussed further in Section 5. It is proposed that this area will become a wetland reserve featuring boardwalks and educational signage. This will showcase Māori values associated with water, and how the scheme is designed to protect and enhance these values.

Pipelines from this site will be established to convey treated wastewater to storage tanks at Sawmill Road above Robinsons Bay.

5.1.2 Takamātua

The Council had originally planned to acquire a site at Takamātua on the Christchurch-Akaroa highway to provide sufficient irrigable land to receive projected wastewater volumes. Takamātua Stream runs adjacent to the Southern Boundary of the site, and the Community Reference Group have indicated the potential for the Council to acquire land to the seaward site of the highway and integrate further restoration planting with coastal pathways. It has subsequently been determined that the other sites will be able to meet the anticipated irrigation demand, and this site will no longer form part of the irrigation areas.

5.1.3 Hammond Point

Situated predominantly within the coastal environment, the Hammond Point irrigation area covers 3.1ha. A dripline fed by pipes from the Old Coach Road WWTP will irrigate mixed native plantings. The Community Reference Group has identified significant potential for enhancing recreational and amenity access at this site, including walking links from Robinsons Bay Wharf to Sandy Bay at Takamātua. The vantage point to Ōnawe Peninsula makes this a prime site to establish interpretation panels regarding the historical significance of this site to manawhenua. Ōnawe was a strategic pā which was brutally raided by Te Rauparaha in the 1830s. Nearly 300 Ngāi tahu were massacred here, hence the wāhi tapu status of the site.

5.1.3 Sawmill Road

This site located at Robinsons Bay is the key location for storage of treated wastewater prior to being pumped into the pipes supplying the irrigation driplines across the four sites. The original plan to establish storage ponds was a major source of contention for residents of Robinsons Bay who were represented on the Community Reference Group. Concerns included the proliferation of pest insect species such as midges, odour, reduced visual amenity, and the risks of dam break flooding downstream properties. The use of land at Sawmill Road to store and distribute treated wastewater was critical to the success of the project, and the adoption of storage tanks as an alternative to an open pond has to a significant degree addressed the risks associated with water storage at this location. It is intended that this site will also incorporate public access and educational signage, with a particular emphasis on its European Heritage Features.

6. Resource consent application

6.1 Consenting requirements

The Council has already been granted a range of consents associated with the construction of the WWTP and terminal pump station. Existing consents authorise activities including:

- The take and discharge of dewatering during the construction of the pump station and trenching works for pipe installation.
- The discharge of odour from the new pump station and the wastewater treatment plant.
- Construction phase stormwater discharges.
- Land use consent for the development and operation of the WWTP and pump station facilities.

The Council holds a global consent to undertake works in the beds and margins of waterways in the Christchurch District. This will authorise pipe installation beneath streams.

Resource consent applications will be required for a range of activities associated with the project, including:

- Discharge treated wastewater to land (to irrigate trees).
- Store treated wastewater in tanks and in a wetland.
- Store untreated wastewater in a storm buffer tank at the Old Coach Road site.
- Construct a new wetland and storage tanks.
- Discharge treated water to the cricket ground and north Akaroa parks for irrigation

6.2 Documentation

For the purposes of this assessment, Mahaanui Kurataiao has been provided with a range of key documents and technical reviews that form the Council's Assessment of Environmental Effects (AEE), including:

- Irrigation design, modelling, and assessment of effects
- Ecological assessments – Freshwater, estuarine, and terrestrial

- Nutrient and contaminant assessments
- Landscape assessment
- Archaeological Assessment
- Geotechnical assessment
- Master Plan concept diagrams
- Summary of Disposal and Reuse Options
- Community Reference Group reports
- Odour Assessment
- Project Charter

Technical reviews of effects on water quality and ecology are critical in understanding the cultural effects of the development and operation of the scheme. The reports produced by EOS Ecology provide estimates of in-stream nitrate concentrations under a range of land use scenarios. The planned combination of irrigation to native plantings with some destocking in the catchment is expected to result in average nitrate concentrations of 0.087 mg/L in Robinsons Bay Stream. This is an increase from current land use which averages 0.030 mg/L. Importantly, this value is below the critical nitrate toxicity limit defined in the National Policy Statement for Freshwater Management – 1.0mg/L which is unlikely to have adverse effects on aquatic ecology (including sensitive species). This estimate among other conclusions made in relevant technical reviews indicate that the irrigation will occur within cultural and environmental baselines. The planned scenario leaves scope for further destocking to occur should monitoring indicate that nutrients are elevated beyond the expected acceptable level.

It is recommended that further engagement with manawhenua (via Mahaanui Kurataiao) be initiated via the Tangata Whenua Advisory Service (TWAS) process, whereby Environment Canterbury initiate a request for cultural advice during their processing of the consent applications. This is to enable the sharing of technical specialist advice regarding potential adverse effects, and the development of consent conditions.

7. Cultural Assessment

7.1 Sites and areas of significance

Akaroa Harbour is a significant cultural landscape. Natural features of the harbour and its coastline, streams, and ridgelines embed within them Ngāi Tahu history and identity. Freshwater supplied by the streams of the inner harbour where the scheme is situated influenced the positioning of early kāinga/temporary campsites used by Ngāi Tahu tūpuna. The Cultural Design Framework and Landscape Concept Plan being prepared for the Old Coach Road site and subsurface wetland will describe in detail the key values and associations relevant to this area.

The coastline of Te Pātaka o Rākaihautū/Banks Peninsula is part of a Te Tai o Mahaanui, a coastal statutory acknowledgement provided for in the Ngāi Tahu settlement with the crown[3]. This imposes a statutory duty on Councils to have regard to the Ngāi Tahu relationship with this area when making decisions that affect the coastal environment. This includes any activities within, <u>adjacent to, or impacting directly on</u>, the statutory area.

The Christchurch District Plan includes a range of objectives, policies, and rules for sites of Ngāi Tahu Cultural Significance. These range from the protection of wāhi tapu, to the recognition of cultural landscape values.

Table 1 below identifies the Sites of Ngāi Tahu Cultural Significance scheduled in the Christchurch District Plan that are relevant to the project area.

[3] Ngāi Tahu Claims Settlement Act, 1998, Schedule 101.

Table 1: District Plan Sites and Areas of Ngāi Tahu Cultural Significance affected by the Akaroa Wastewater Treatment and Reuse Project Area:

Name / Location	Category	ID	Description
Whakaroa (Akaroa)	Ngā Tūranga Tūpuna		Areas of cultural landscapes with large concentrations of significant tribal history and archaeological sites, and prominent natural features that form landmarks.
Takamātua	Wāhi tapu / Wāhi taonga Mahaanui Iwi Management Plan Silent files	14a 14b	Area mapped by tribal experts to indicate a higher probability of encounter with sensitive tangible and/or intangible Ngāi Tahu values. Referred to as silent file 027 in the Mahaanui Iwi Management Plan 2013.
Ōtipua / Takamatua Hill and Ōtahuahua (Childrens Bay).	Wāhi tapu / Wāhi taonga and Mahaanui Iwi Management Plan Silent files	15a 15b	Area mapped by tribal experts to indicate a higher probability of encounter with sensitive tangible and/or intangible Ngāi Tahu values. Referred to as silent file 028 in the Mahaanui Iwi Management Plan 2013.
Te Tai o Mahaanui (Christchurch, Banks Peninsula and Selwyn Coastal Marine Area)	Ngā Wai	96	Part of the Te Tai o Mahaanui statutory acknowledgement area and the significant cultural values that fall within it, or lie immediately adjacent to it.
Ōinaka / Grehan Stream	Ngā Wai	91	A significant stream flowing into Akaroa Harbour

It should be noted that the sites identified in the District Plan and Archaeological records do not articulate the full extent of manawhenua associations with the landscape or locations of cultural significance.

Traditional place names or “ingoa wāhi” offer tangible connections between the past and the present, the people, the landscape, and associated practices and traditions. Ingoa wāhi associated with the project area include:

- **Te Umu-Te Rehua**: Hammond Point.
- **Kākakaiau:** Robinsons Bay and associated stream. The bay was a renowned pātiki/flounder fishery, and the name is derived from “Ngā ka kai au”, a technique used to transport fish back to the pā by threading them together with a bone needle[4].
- **Takamātua**: The name given to both the bay and the stream flowing into comes from the phrase “o takamātua” or “rest after a journey”.

7.2 Mahaanui Iwi Management Plan Assessment

The Mahaanui Iwi Management Plan (MIMP) is an expression of kaitiakitanga and rangatiratanga prepared by the six Papatipu Rūnanga with manawhenua rights over lands and waters within the takiwā from the Hurunui River to the Hakatere River and inland to Ngā Tirititi o Te Moana. It outlines key resource management issues for manawhenua, and states objectives and policies aimed at achieving meaningful cultural and environmental outcomes in resource management planning and decision-making.

The effective recognition of Kaitiakitanga is a fundamental issue identified in the MIMP, which identifies opportunities for collaboration between manawhenua as kaitiaki and local government as an important pathway to exercising kaitiakitanga. Though it has been a long and challenging process, the resolution and project design has eventually reflected an effective collaboration between manawhenua and local government and is consistent with kaitiakitanga.

[4] Tī kōuka whenua, Christchurch City Libraries.

Section 6.8 of the plan outlines catchment specific issues, objectives, and policies for Akaroa Harbour. Four of the five objectives for Akaroa Harbour are given effect to through the new wastewater scheme:

1. **Elimination of discharges of contaminants to Akaroa Harbour.**
2. **Integrated approach to the management and development of Akaroa Harbour, based on the principle of Ki Uta Ki Tai and recognising the relationship between land use and coastal waters.**
3. **Ngāi Tahu, as tangata whenua, are strongly involved in planning and decision making for the land, waters and historic and cultural heritage of Akaroa Harbour.**
4. **Akaroa Harbour is recognised and provided for as a Ngāi Tahu cultural landscape, and territorial and regional plans and policies reflect this.**

The discharge of wastewater to Akaroa Harbour is the issue at the forefront of this section of the MIMP. The policy framework for this issue specifically requires the elimination of this discharge. The policies promote the irrigation of treated wastewater to land planted with indigenous species that can assimilate contaminants as an alternative solution to the harbour discharge. The Plan includes assessment criteria for the selection of sites for the discharge of wastewater to land, highlighting the need to consider:

1. Cultural landscape values;
2. Slope of sites;
3. Proximity to surface waterways, wetlands, waipuna;
4. Proximity to coast;
5. Type of soil (assimilative capacity); and
6. Current and potential land use.

This section also states that situating a wastewater treatment plant near wāhi tapu or near waterways should be avoided (A1.5). Ōnuku have been highly engaged in assessing the risks and benefits of potential options for the location of the treatment plant, and its associated infrastructure and irrigation areas. The topographical and geological features of Akaroa have constrained the potential options for the project. Having considered all feasible options, the rūnanga are supportive of the proposed location of the plant, pumpstations, and irrigation fields. It is understood that during storm events, overflows of treated wastewater will still directly discharge to the harbour. The wetland will to some degree mitigate this.

The new scheme also gives effect to the holistic approach to wastewater management promoted in the Plan. This includes weighting tikanga and cultural effects and accommodating projected population growth and demand.

The regional section of the MIMP includes objectives and policies for the recognition and protection of cultural landscapes, wāhi tapu and wāhi taonga. As discussed in this report and in the Integrated Cultural and Landscape Design Report, the project area is within a significant cultural landscape and interacts with areas that are sensitive for wāhi tapu and wāhi taonga. The sites are at risk of disturbance during earthworks and construction activities. Policy CL3.8 provides a range of strategies to manage these risks in accordance with tikanga. These are discussed further in section 7.3.

Discharge to land is promoted as a culturally appropriate alternative to discharging to water in the MIMP, with Papatūānuku (the Ātua/God associated with the earth) providing an assimilative capacity that restores the mauri of water before it reaches ground and surface water. The biophysical characteristics of soil and vegetation also contribute to removing contaminants from the discharge, therefore protecting the receiving environment. Policy WM6.11 requires conditions for consented discharges to land, including waterway setbacks, application rates to avoid saturation and nutrient overloading, the use of native plants to assimilate nutrients, and monitoring requirements. The project design is influenced by these factors. It is expected that the scrutiny of the consenting process will ensure that the irrigation to land is undertaken within environmentally protective limits, and that robust monitoring is in place.

The relationship of land use with water quality and quantity, and between ground and surface water are primary themes in the MIMP. This informs a policy requirement to establish limits on nutrients and other contaminants, and to refine irrigation management to reduce nutrient runoff.

The project is consistent with the direction of the MIMP regarding biodiversity enhancement, with indigenous restoration plantings a core feature of the reuse scheme. The project directly gives effect to policy WM6.19 through the establishment of a wetland as environmental infrastructure.

The MIMP promotes water conservation measures to reduce pressure on often scarce freshwater resources. The policies do not explicitly promote the reuse of treated wastewater, and tikanga requires separation between waste and other activities. The purple pipe reuse scheme is consistent with the kaupapa of promoting low-impact urban design and reducing the demand on freshwater resources. It is not viewed as inconsistent with tikanga to undertake **non-potable** reuse, provided reused water is not used to irrigate crops that would be used for food.

A more comprehensive list of applicable MIMP objectives and policies is included as Appendix B. The design and anticipated cultural outcomes of the project are consistent with the direction of the MIMP, giving effect to the kaitiakitanga aspirations of Ōnuku Rūnanga.

7.3 Assessment of Cultural Effects

The development and operation of the irrigation scheme and associated infrastructure will have a range of actual and potential effects on cultural values. The policy framework of the Mahaanui Iwi Management Plan discussed in section 7.2 provides a lens through which these effects can be assessed. The following assessment addresses how any potential negative effects may be addressed.

Wai Māori

Two streams run through or adjacent to the project areas: Robinson's Bay Stream and Ōinaka (Grehan Stream). The protection and enhancement of freshwater is an issue of critical importance to manawhenua. The mauri of freshwater is vulnerable to degradation through physical modification and the introduction of contaminants. Protecting and enhancing the freshwater tributaries of Akaroa Harbour is also an important aspect of restoring the harbour as a mahinga kai, contributing to the mana of the hapū.

Irrigating treated wastewater to land has the potential to introduce nutrients and other contaminants to streams, either via hydraulically connected groundwater, or directly via overland flow if soils become saturated. This has the potential to compromise the mauri and intrinsic value of freshwater. Nutrients present in wastewater (such as nitrogen and phosphorus) at elevated levels can adversely impact freshwater ecosystems through promoting excessive growth of plants and algae which can diminish habitat quality and deplete oxygen.

Ōnuku Rūnanga are anticipating that the risk of adversely affecting Wai Māori will be sufficiently avoided or mitigated through the following features:

- The high standard of treatment provided by the new WWTP.
- Irrigation design and application rates to avoid saturating soils.
- Plant selection to optimise nutrient assimilation and water uptake to protect groundwater.
- Waterway setbacks from irrigation areas, including 20m setbacks from permanently flowing streams.
- Enhancement of indigenous biodiversity through reforestation.
- The establishment of a subsurface wetland which will restore the mauri of treated wastewater as well as further enhancing biodiversity habitat.
- Comprehensive monitoring of treatment standards.
- Contingency such as holding tanks for use when system capacity is overwhelmed.

The technical reports accompanying the AEE are to provide detailed evidence of realisation of these outcomes and the protection of Wai Māori. It is also anticipated that these details will be refined and enhanced through specialist advice and scrutiny in the consenting process.

The earthworks associated with constructing the plant and pump stations, installing pipes and irrigation lines, establishing the wetland, and extensive planting will mobilise soils and release fine sediments. These can adversely affect mahinga kai and taonga species through reducing clarity and changing the character of benthic habitat. It will be essential to minimise these effects by ensuring effective erosion and sediment controls are in place. Any short-term effects will be outweighed by the long-term benefits of revegetation which will stabilise soils.

For manawhenua the project goes beyond protection of a scientifically based water quality - It will enhance the cultural values and the mauri of with water. The restoration of riparian habitat quality will have a direct positive impact on the taonga and mahinga kai species that inhabit these streams, including tuna and īnaka. This will be further enhanced through showcasing Te Ao Māori concepts and values associated with water in educational signage.

Tangaroa is the Atua/god associated with the sea. For Ōnuku, the cultural health of the marine and coastal environment is a fundamental priority in achieving their kaitiakitanga obligations and aspirations. The summary of effects on freshwater above can similarly apply to effects on coastal values. Akaroa Harbour is vulnerable to fine sediment runoff resulting from land use activities such as earthworks.

Overwhelmingly the effects of the project will be positive for the cultural health of Akaroa Harbour through addressing the priority issue for manawhenua as kaitiaki – removal of the constant direct discharge to the harbour that has degraded its mauri and limited its utility as a mahinga kai. The long-term effects on the mahinga kai values associated with the harbour will therefore be positive.

The use of indigenous planting and the new wetland will contribute to the restoration of the mauri of treated wastewater that may still reach the harbour. It is acknowledged that discharges to the harbour will still occur in high rainfall events when system capacity becomes overwhelmed, particularly given the increasing extremity of these events under climate change projections. However, Ōnuku are confident that the design of the new scheme goes as far as is feasible in minimising the incidence of this occurring.

Wāhi tapu and wāhi taonga

As summarised in section 7.1 (Sites and Areas of Significance), the project area interacts with several sites that are sensitive for their wāhi tapu and wāhi taonga associations. The occupation and use of the project sites for the necessary infrastructure and disposal fields has already been determined by manawhenua to be appropriate in the context of their cultural significance. Earthworks have the potential to disturb or damage taonga, or highly sensitive sites such as urupā – The precise location of which may not be known. Any potential adverse effects of such discoveries can be sufficiently mitigated through the presence of rūnanga-appointed cultural monitors to oversee excavations in silent file areas. Ōnuku Rūnanga have confirmed that a cultural monitor will need to be engaged to oversee earthworks at the Takamātua and Hammond Point sites. An Accidental Discovery Protocol will be sufficient for the remaining sites. These methods of mitigating adverse effects of earthworks on cultural values should be included as consent conditions.

The extensive ecological restoration being undertaken for this project will have a significant positive effect on the cultural landscape values of Akaroa.

7. Regional Policy Framework

8.1 Canterbury Regional Policy Statement

The Canterbury Regional Policy Statement (CRPS) highlights the resource management issues facing the region and defines objectives, policies, and methods to address these issues. Chapter 2 of the CRPS identifies the resource management issues that are of most significance to Ngāi Tahu, which largely reflect the issues described in the MIMP. Avoiding the discharge of contaminants to the coastal environment is identified as a key cultural outcome desired by Ngāi Tahu. Consultation methods are outlined to direct regional and territorial authorities to fulfil their statutory obligations to manawhenua under the Resource Management Act (1991) which include:

1. Recognising and providing for the relationship of Māori and their culture and traditions with their ancestral lands, water, sites, wāhi tapu and other taonga (Section 6(e) of the RMA);

2. Having particular regard to Kaitiakitanga (Section 7(a) of the RMA); and

3. Taking into account the principles of the Treaty of Waitangi (Section 8 of the RMA).

The CRPS provisions for wastewater infrastructure specifically recognise the cultural implications of wastewater treatment and disposal, and the potential for development to adversely affect the relationship of manawhenua with their ancestral land, water, sites, wāhi tapu and other taonga. The Akaroa Wastewater Treatment and Reuse Scheme goes further than the CRPS directive to engage with Ngāi Tahu in determining their values. It has been developed through co-design and partnership with manawhenua to deliver cultural outcomes.

8.2 Regional Coastal Environment Plan

The Regional Coastal Environment Plan for Canterbury is consistent with the CRPS and recognises the particular relationship of Ngāi Tahu with the coastal environment. A key objective regarding the use of the coastal environment is to protect, and where appropriate enhance, certain areas, sites and habitats of high natural, physical, heritage or cultural value. For coastal water quality, it is recognised that contaminant discharges adversely affect the cultural relationship Tangata Whenua have with water. Policy 7.5 specifically addresses the issue of directly discharging human sewage to the coastal marine area, stating that this should only be consented under particular conditions such as if the discharge would better meet the purpose of the RMA than a land-based alternative.

Overall, the project gives effect to the relevant cultural objectives and policies of the Coastal Environment Plan for Canterbury.

8.3 Land and Water Regional Plan

The Canterbury Land and Water Regional Plan sets out objectives, policies, and rules for the integrated management of land and water in the region. It gives effect to the CRPS. The region-wide section of the plan includes objectives that provide for manawhenua kaitiakitanga aspirations, including:

> **3.1** Land and water are managed as integrated natural resources to recognise and enable Ngāi Tahu culture, traditions, customary uses and relationships with land and water.
>
> **3.2** Water management applies the ethic of ki uta ki tai – from the mountains to the sea – and land and water are managed as integrated natural resources recognising the connectivity between surface water and groundwater, and between fresh water, land, and the coast.
>
> **3.3** Nationally and regionally significant infrastructure is enabled and is resilient and positively contributes to economic, cultural, and social wellbeing through its efficient and effective operation, on-going maintenance, repair, development and upgrading.

The Akaroa Wastewater Treatment and Reuse Scheme takes into account the integrated management of land and water and shifts the wastewater issue for Akaroa in a direction that better enables Ngāi Tahu culture and traditions with water to be realised. Riparian enhancement and conditions to protect coastal and freshwater quality apply the ethic of ki uta ki tai. The multiple benefits delivered by this new infrastructure will have a positive contribution to cultural wellbeing, particularly through biodiversity restoration and educational opportunities.

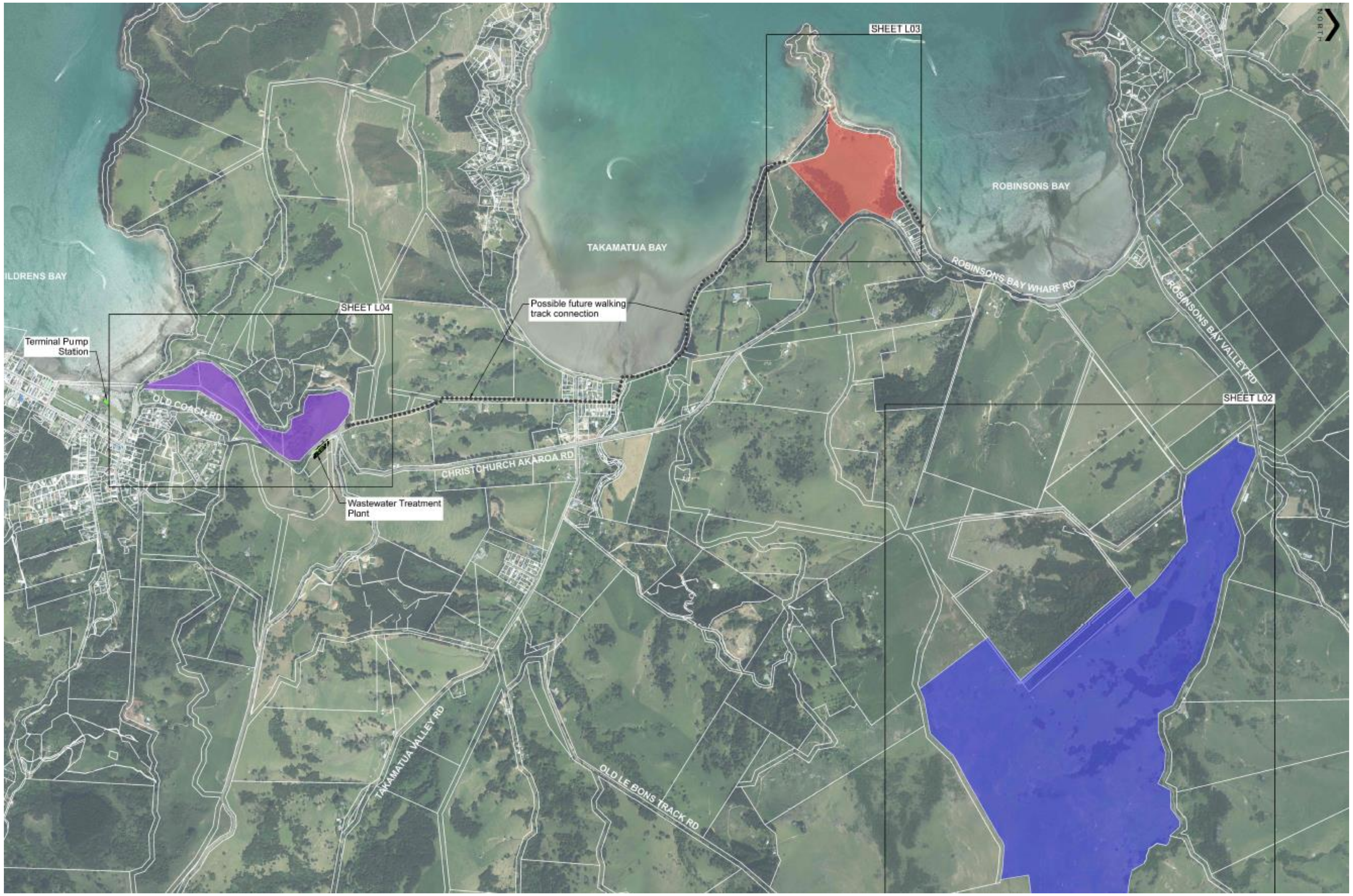
8. Conclusion

The development of the Akaroa Wastewater Treatment and Reuse Scheme has been heavily influenced by manawhenua and their kaitiakitanga obligations to restoring the mauri and mahinga kai values of Akaroa Harbour.

The cultural effects of the scheme development and operation are assessed as overwhelmingly positive. Any temporary adverse effects can be appropriately addressed through consent conditions, such as engaging cultural monitors to oversee any earthworks undertaken in Silent File areas.

Further assessment of AEE material that describes the specific effects on water quality and ecology will enhance the understanding of cultural effects. Mahaanui Kurataiao request the opportunity to review additional technical reports prepared as part of the consent applications. Mahaanui Kurataiao are also available to support Ōnuku Rūnanga during the processing of consent applications, where specialist advice will further inform the Assessment of Environmental Effects and develop consent conditions.

Appendix A: Project location map



Appendix B: Mahaanui Iwi Management Plan Provisions

5.2 WAI MAORI

Nga Paetae: Objectives

1. Water management effectively provides for the taonga status of water, the Treaty partner status of Ngai Tahu, the importance of water to cultural well-being, and the specific rights and interests of tangata whenua in water.
2. Water quality and quantity in groundwater and surface water resources in the takiwa enables customary use mo tatou, a, mo ka uri a muri ake nei.
3. Water and land are managed as interrelated resources embracing the practice of Ki Uta Ki Tai, which recognises the connection between land, groundwater, surface water and coastal waters.
4. Mauri and mahinga kai are recognised as key cultural and environmental indicators of the cultural health of waterways and the relationship of Ngai Tahu to water.
5. Land and water use in the takiwa respects catchment boundaries, and the limits of our land and freshwater resources.
6. Wetlands and waipuna are recognised and protected as wahi taonga, and there is an overall net gain of wetlands in the takiwa as wetlands are restored.
7. All waterways have healthy, functioning riparian zones and are protected from inappropriate activities, including stock access.
8. The practice of using water as a receiving environment for the discharge of contaminants is discontinued, and all existing direct discharges of contaminants to water are eliminated.

Nga Kaupapa: Policy

WM2.1 To consistently and effectively advocate for a change in perception and treatment of freshwater resources: from public utility and unlimited resource to wahi taonga.

WM2.2 To require that water is recognised as essential to all life and is respected for its taonga value ahead of all other values.

WM2.3 To require that decision making is based on intergenerational interests and outcomes, mo tatou, a, mo ka uri a muri ake nei.

WM6.1 To require that the improvement of water quality in the takiwa is recognised as a matter of regional and

immediate importance.

WM6.2 To require that water quality in the takiwa is of a standard that protects and provides for the relationship

of Ngai Tahu to freshwater. This means that:

(a) The protection of the eco-cultural system (see Box - Eco-cultural systems) is the priority, and land or resource use, or land use change, cannot impact on that system; and

(b) Marae and communities have access to safe, reliable, and untreated drinking water; and

(c) Ngai Tahu and the wider community can engage with waterways for cultural and social well-being;

and

(d) Ngai Tahu and the wider community can participate in mahinga kai/food gathering activities without risks to human health.

WM6.8 To continue to oppose the discharge of contaminants to water, and to land where contaminants may enter water.

WM6.9 To require that local authorities work to eliminate existing discharges of contaminants to waterways, wetlands and springs in the takiwa, including treated sewage, stormwater and industrial waste, as a matter of priority.

WM6.10 To require that the regional council classify the following discharge activities as prohibited due to significant effects on water quality:

(a) Activities that may result in the discharge of sewage (treated or untreated), stormwater, industrial waste, animal effluent or other contaminants to water, or onto land where contaminants may enter water.

WM6.11 Consented discharge to land activities must be subject to appropriate consent conditions to protect ground and surface water, including but not limited to:

(a) Application rates that avoid over saturation and nutrient loading;

(b) Set backs or buffers from waterways, wetlands and springs;

(c) Use of native plant species to absorb and filter contaminants; including riparian and wetland establishment and the use of planted swales;

and

(d) Monitoring requirements to enable assessment of the effects of the activity.

WM6.19 To promote the restoration of wetlands and riparian areas as part of maintaining and improving water quality, due to the natural pollution abatement (treatment) functions of these taonga.

WM6.22 To require that local authorities afford appropriate weight to tangata whenua values when assessing the costs and benefits of activities that may have adverse effects on water quality.

WM6.23 To ensure that economic costs do not take precedence over the cultural, environmental, and intergenerational costs of poor water quality.

WM8.11 To support activities and strategies to improve the efficiency of water use in urban and rural situations, including:

(a) Water efficiency technology in residential, commercial, industrial and urban environments:

(i) rainwater storage tanks;

(ii) greywater reuse;

(iii) reduced or low flow devices (e.g. low flush toilets and efficient showerheads); and

(iv) water efficient appliances.

WM12.2 To require the protection and restoration of native riparian vegetation along waterways and lakes in the takiwa as a matter of priority, and to ensure that this can occur as a permitted activity.

WM13.3 To support the establishment, enhancement and restoration of wetlands, riparian areas and waipuna as a measure to avoid, remedy or mitigate any actual or potential adverse effects of land use and development activities on cultural and environmental values.

WM13.5 To advocate, where appropriate, for the creation of wetland areas to assist with the management of onsite/site sourced stormwater and other wastewater, to utilise the natural capacity of these ecosystems to filter contaminants. These wetlands must be constructed wetlands; natural wetlands are not to be used to treat or dispose of wastewater. However, they may be adjacent to natural wetlands, to mitigate the impacts on natural systems.

WM13.7 To recognise the protection, establishment and enhancement of riparian areas along waterways and lakes as a matter of regional importance, and a priority for Ngai Tahu.

Papatūānuku

Nga Paetae: Objectives

1. The mauri of land and soil resources is protected mo tatou, a, mo ka uri a muri ake nei.
2. The ancestral and contemporary relationship between Ngai Tahu and the land is recognised and provided for in land use planning and decision making.
3. Land use planning and management in the takiwā reflects the principle of Ki Uta Ki Tai.
4. Rural and urban land use occurs in a manner that is consistent with land capability, the assimilative capacity of catchments and the limits and availability of water resources.
5. Inappropriate land use practices that have a significant and unacceptable effect on water quality and quantity are discontinued.
6. Ngai Tahu has a prominent and influential role in urban planning and development.
7. Subdivision and development activities implement low impact, innovative and sustainable solutions to water, stormwater, waste and energy issues.
8. Ngai Tahu cultural heritage values, including wahi tapu and other sites of significance, are protected from damage, modification or destruction as a result of land use.

Ngā Kaupapa: Policy

P7.1 To require that local authorities recognise that there are particular cultural (tikanga) issues associate with the disposal and management of waste, in particular:

(a) The use of water as a receiving environment for waste (i.e. dilution to pollution); and

(b) Maintaining a separation between waste and food.

P7.2 To actively work with local government to ensure that waste management practices protect cultural values such as mahinga kai and wāhi tapu and are consistent with Ngai Tahu tikanga.

P7.3 To require waste minimisation as a basic principle of, and approach to, waste management. This means reducing the volume of waste entering the system through measures such as:

(a) Education about wise water use;

(b) Composting and recycling programmes;

(c) Incentives for existing and new homes, business, developments and council services to adopt greywater recycling and install low water use appliances; and

(d) On site solutions to stormwater that avoid stormwater entering the wastewater system.

P7.4 To continue to oppose the use of waterways and the ocean as a receiving environment for waste.

P7.5 To require alternatives to using water as a medium for waste treatment and discharge, including but not limited to:

(a) Using waste to generate electricity;

(b) Treated effluent to forestry; and

(c) Treated effluent to non-food crop.

P7.6 To require higher treatment levels for wastewater: 'we should not have to rely on mixing and dilution of wastewater to mitigate effects'.

P8.1 To require that discharge to land activities in the takiwa:

(a) Are appropriate to the soil type and slope, and the assimilative capacity of the land on which the discharge activity occurs;

(b) Avoid over-saturation and therefore the contamination of soil, and/or run off and leaching; and

(c) Are accompanied by regular testing and monitoring of one or all of the following: soil, foliage, groundwater and surface water in the area.

P8.2 In the event that that accumulation of contaminants in the soil is such that the mauri of the soil resource is compromised, then the discharge activity must change or cease as a matter of priority.

P11.1 To assess proposals for earthworks with particular regard to:

(a) Potential effects on wahi tapu and wahi taonga, known and unknown;

(b) Potential effects on waterways, wetlands and waipuna;

(c) Potential effects on indigenous biodiversity;

(d) Potential effects on natural landforms and features, including ridge lines;

(e) Proposed erosion and sediment control measures; and

(f) Rehabilitation and remediation plans following earthworks.

P11.8 To require the planting of indigenous vegetation as an appropriate mitigation measure for adverse impacts that may be associated earthworks activity.

Tāne Mahuta

Ngā Paetae: Objectives

1. Regional policy, planning and decision making in the takiwa reflects the particular interest of Ngai Tahu in indigenous biodiversity protection, and the importance of mahinga kai to Ngai Tahu culture and traditions.
2. The customary right of Ngai Tahu to engage in mahinga kai activity is recognised, protected and enhanced, as guaranteed by Article 2 of Te Tiriti o Waitangi, and the NTCSA 1998.
3. The presence of indigenous biodiversity on the Canterbury landscape is enhanced, both in rural and urban environments.
4. The taonga value of indigenous ecosystems as natural capital and provider of essential ecosystem services is increasingly valued in the community.
5. Customary use, and therefore mahinga kai, is given effect to as a first order priority for freshwater management in the takiwa.
6. Traditional and contemporary mahinga kai sites and species are protected and restored.
7. Existing areas of indigenous vegetation are protected, and degraded areas are restored.
8. The establishment and spread of invasive pest and weed species is progressively and effectively controlled.
9. The protection and enhancement of indigenous biodiversity and mahinga kai occurs through a shared, co-ordinated effort between tangata whenua, local authorities, conservation groups and communities

Nga Kaupapa / Policy

TM2.1 To require that local authorities and central government actively recognise and provide for the relationship of Ngai Tahu with indigenous biodiversity and ecosystems, and interests in biodiversity protection, management and restoration, including but not limited to:

Importance of indigenous biodiversity to tangata whenua, particularly with regard to mahinga kai, taonga species, customary use and valuable ecosystem services.

(a) To require the integration of robust biodiversity objectives in urban, rural land use and planning, including but not limited to:

(b) Indigenous species in shelter belts on farms.

(c) Use of indigenous plantings as buffers around activities such as silage pits, effluent ponds, oxidation ponds, and industrial sites;

(d) Use of indigenous species as street trees in residential developments, and in parks and reserves and other open space; and

(e) Establishment of planted indigenous riparian margins along waterways.

TM2.10 To require that indigenous biodiversity is recognised and provided for as the natural capital of Papatuanuku, providing essential and invaluable ecosystem services.

TM2.11 To work with the wider community to increase community understandings of indigenous biodiversity and the ecosystem services it provides.

TM3.5 To require that seeds and plants for restoration projects are appropriate to the area, and as much as possible locally sourced.

Tangaroa

Nga Paetae: Objectives

1. There is a diversity and abundance of mahinga kai in coastal areas, the resources are fit for cultural use, and tangata whenua have unhindered access to them.
2. The role of tangata whenua as kaitiaki of the coastal environment and sea is recognised and provided for in coastal and marine management.

3. Discharges to the coastal marine area and the sea are eliminated, and the land practices that contribute to diffuse (non-point source) pollution of the coast and sea are discontinued or altered.
4. Traditional and contemporary mahinga kai sites and species within the coastal environment, and access to those sites and species, are protected and enhanced.

Ngā Kaupapa/Policy

TAN2.1 To require that coastal water quality is consistent with protecting and enhancing customary fisheries, and with enabling tangata whenua to exercise customary rights to safely harvest kaimoana.

TAN2.2 To require the elimination of all direct wastewater, industrial, stormwater and agricultural discharges into the coastal waters as a matter of priority in the takiwa.

TAN2.8 To require that coastal water quality is addressed according to the principle of Ki Uta Ki Tai. This means:

(a) A catchment-based approach to coastal water quality issues, recognising and providing for impacts of catchment land and water use on coastal water quality.

TAN3.1 To require that coastal wetlands, estuaries and hāpua are recognised and protected as an integral part of the coastal environment, and for their wahi taonga value as mahinga kai, or food baskets, of Ngai Tahu.

TAN3.2 To require that local authorities recognise and address the effects of catchment land use on the cultural health of coastal wetlands, estuaries and hapua, particularly about sedimentation, nutrification and loss of water.

TAN6.4 To require that Ngai Tahu cultural and historic heritage sites are protected from:

(a) Inappropriate coastal land use, subdivision and development;

(b) Inappropriate structures and activities in the coastal marine area;

(c) Inappropriate activities in the marine environment, including discharges; and

(d) Coastal erosion.

Ngā Tūtohu Whenua

Nga Kaupapa / Policy

CL3.8 To require, where a proposal is assessed by tangata whenua as having the potential to affect wāhi tapu or wāhi taonga, one or more of the following:

(a) Low risk to sites:

(i) Accidental discovery protocol (ADP) - See Appendix 3.

(b) High risk to sites:

(i) Cultural Impact Assessment (CIA);

(ii) Site visit;

(iii) Archaeological assessment, by a person nominated by the Papatipu Runanga;

(iv) Cultural monitoring to oversee excavation activity, record sites or information that may be revealed, and direct tikanga for handling cultural materials;

(v) Inductions for contractors undertaking earthworks;

(vi) Accidental discovery protocol agreements (ADP); and/or

(vii) Archaeological Authority from the New Zealand Historic Places Trust.

CL7.3 To support the use of interpretation as a tool to recognise and provide for the relationship of Ngai Tahu to particular places, and to incorporate Ngai Tahu culture and values into landscape design.

CL7.4 The interpretation of Ngai Tahu values and history is best provided by Ngai Tahu, and Papatipu Runanga and Te Runanga o Ngai Tahu should be commissioned

Akaroa Harbour

Nga Paetae: Objectives

(1) Elimination of discharges of contaminants to Akaroa Harbour.

(2) Integrated approach to the management and development of Akaroa Harbour, based on the principle of Ki Uta Ki Tai and recognising the relationship between land use and coastal waters.

(3) Ngai Tahu, as tangata whenua, are strongly involved in planning and decision making for the land, waters and historic and cultural heritage of Akaroa Harbour.

(5) Akaroa Harbour is recognised and provided for as a Ngai Tahu cultural landscape, and territorial and regional plans and policies reflect this.

Ngā Kaupapa: Policy

A1.1 To support incentives and initiatives to reduce the volume of wastewater entering the system, as per general policy on Waste management (Section 5.4, Issue P7), including but not limited to:

a) Requiring on site stormwater treatment and disposal to avoid stormwater entering the wastewater system.

A1.2 To require the elimination of the discharge of wastewater to Akaroa Harbour, as this is inconsistent with Ngai Tahu tikanga and the use of the harbour as mahinga kai. This includes:

a) Direct discharge from treatment plants;

b) Indirect discharge via land (run-off), surface waterways or groundwater; and wastewater coming back into harbour with tides and currents (if pumping out of harbour via pipeline).

A1.3 Wastewater should be treated and irrigated to land; subject to the following conditions:

a) Effluent is treated to the highest possible standard;

b) The land used as a receiving environment is suited to the nature and volume of discharge, to avoid run off or groundwater contamination;

c) The land used as a receiving environment is used productively, in a way that is conducive to assimilating waste, such as native or exotic timber plantation; and

d) Monitoring programs include both water and soil, and include clear strategies for responding to negative monitoring results.

A1.4 To assess potential sites for discharge to land with the following considerations:

a) Cultural landscape values;

b) Slope of site;

c) Proximity to surface waterways, wetlands, waipuna;

d) Proximity to coast;

e) Type of soil (assimilative capacity); and

f) Current and potential land use.

A1.5 To avoid locating a wastewater treatment plant at:

a) Takapuneke;

b) Near Onuku marae;

c) Near waterways; or

d) Near sites identified by tangata whenua as wahi tapu.

A1.6 To adopt a holistic and creative approach to finding a solution for wastewater management in the Akaroa

Harbour area, including but not limited to:

a) Recognising and providing for the cumulative effects of discharges on the harbour, as opposed to assessing effects of individual discharges;

b) Minimising the volume of wastewater produced (Policy A1.1);

c) Recognising and providing for future urban growth and rural land use change;

d) Providing increased weight to cultural, social and environment costs and benefits, including costs to future generations; and

e) Affording equal weighting to those cultural effects that may be intangible (e.g. effects on tikanga) with effects identified and measured by western science.

A3.5 To recognise the following areas as exclusion, or 'no-go' areas for subdivision and coastal land development:

(a) Takapuneke;

(b) Takamatua (Red Point); and

(c) Onawe.

A5.3 To improve water quality in the Akaroa Harbour using the methods identified in general policies on Water quality (Section 5.3 Issue WM6), with particular focus on:

a) Eliminating existing discharges of pollutants;

b) Establishing native riparian buffer zones along all waterways and drains;

c) Restoring degraded waipuna and wetlands;

d) Requiring appropriate controls on land use to control sedimentation; and

e) Prohibiting stock access to waterways, wetlands and waipuna.

A10.1 To require that the Akaroa Harbour catchment is recognised and provided for as a Ngai Tahu cultural landscape with significant historical, traditional, cultural and contemporary associations. This means:

a) Local authority assessments and decision making should adopt a cultural landscape approach to assessing effects on Ngai Tahu values, as per general policy on Cultural landscapes (Section 5.8 Issue CL1).

A10.2 Land and marine based wahi tapu and wahi taonga associated with Akaroa Harbour are the responsibility of Papatipu Runanga.

A10.3 To use the methods set out in general policy on Wahi tapu me wahi taonga (Section 5.8 Issue CL3) to protect wahi tapu and wahi taonga from inappropriate land use, subdivision and development.

A10.4 Silent files remain an appropriate mechanism for protecting sites of significance in the Akaroa Harbour region as per general policy on Silent files (Section 5.8 Issue CL4).

Appendix C: Accidental Discovery Protocol

PRIOR TO COMMENCEMENT OF ANY WORKS, A COPY OF THIS ADP SHOULD BE MADE AVAILABLE TO ALL CONTRACTORS WORKING ON SITE.

Purpose

This Accidental Discovery Protocol (ADP) sets out the procedures that must be followed in the event that taonga (Māori artefacts), burial sites/kōiwi (human remains), or Māori archaeological sites are accidentally discovered. The Protocol is provided by [delete ones not applicable] Ngāi Tūāhuriri Rūnanga / Te Hapū o Ngāti Wheke (Rāpaki) / Te Rūnanga o Koukourārata / Ōnuku Rūnanga / Wairewa Rūnanga / Te Taumutu Rūnanga. Ngāi Tūāhuriri Rūnanga / Te Hapū o Ngāti Wheke (Rāpaki) / Te Rūnanga o Koukourārata / Ōnuku Rūnanga / Wairewa Rūnanga / Te Taumutu Rūnanga [delete ones not applicable] are the representative body of the tangata whenua who hold manawhenua in the proposed area.

Background

Land use activities involving earthworks have the potential to disturb material of cultural significance to tangata whenua. In all cases such material will be a taonga, and in some cases such material will also be tapu. Accidental discoveries may be indicators of additional sites in the area. They require appropriate care and protection, including being retrieved and handled with the correct Māori tikanga (protocol).

Under the Heritage New Zealand Pouhere Taonga Act 2014, an archaeological site is defined as any place associated with pre-1900 human activity, where there is material evidence relating to the history of New Zealand. It is unlawful for any person to destroy, damage or modify the whole or any part of an archaeological site (known or unknown) without the prior authority of the Heritage New Zealand Pouhere Taonga (HNZPT). This is the case regardless of the legal status of the land on which the site is located, whether the activity is permitted under the District or Regional Plan or whether a resource or building consent has been granted. The HNZPT is the statutory authority for archaeology in New Zealand.

Note that this ADP does not fulfil legal obligations under the Heritage New Zealand Pouhere Taonga Act 2014 regarding non-Māori archaeology. Please contact the HNZPT for further advice.

Immediately following the discovery of material suspected to be a taonga, kōiwi or Māori archaeological site, the following steps shall be taken:

1. All work on the site will cease immediately.
2. Immediate steps will be taken to secure the site to ensure the archaeological material is not further disturbed.
3. The contractor/works supervisor/owner will notify the Kaitiaki Rūnanga and the Area Archaeologist of the HNZPT. In the case of kōiwi (human remains), the New Zealand Police must be notified.
4. The Kaitiaki Rūnanga and HNZPT will jointly appoint/advise a qualified archaeologist who will confirm the nature of the accidentally discovered material.
5. If the material is confirmed as being archaeological, the contractor/works supervisor/owner will ensure that an archaeological assessment is carried out by a qualified archaeologist, and if appropriate, an archaeological authority is obtained from HNZPT before work resumes (as per the Heritage New Zealand Pouhere Taonga Act 2014).
6. The contractor/works supervisor/owner will also consult the Kaitiaki Rūnanga on any matters of tikanga (protocol) that are required in relation to the discovery and prior to the commencement of any investigation.
7. If kōiwi (human remains) are uncovered, in addition to the steps above, the area must be treated with utmost discretion and respect, and the kōiwi dealt with according to both law and tikanga, as guided by the Kaitiaki Rūnanga.
8. Works in the site area shall not recommence until authorised by the Kaitiaki Rūnanga, the HNZPT (and the NZ Police in the case of kōiwi) and any other authority with statutory responsibility, to ensure that all statutory and cultural requirements have been met.
9. All parties will work towards work recommencing in the shortest possible time frame while ensuring that any archaeological sites discovered are protected until as much information as practicable is gained and a decision regarding their appropriate management is made, including obtaining an archaeological authority under the Heritage New Zealand Pouhere Taonga Act 2014 if necessary. Appropriate management may include recording or removal of archaeological material.
10. Although bound to uphold the requirements of the Protected Objects Act 1975, the contractor/works supervisor/owner recognises the relationship between Ngāi Tahu whānui, including its Kaitiaki Rūnanga, and any taonga (Māori artefacts) that may be discovered.

IN DOUBT, STOP AND ASK; TAKE A PHOTO AND SEND IT TO THE HNZPT ARCHAEOLOGIST

Contact Details

HNZPT Archaeologist: (03) 363 1893 archaeologistcw@heritage.org.nz

HNZPT Southern Regional Office (03) 363 1880 infosouthern@heritage.org.nz

HNZPT Pouarahi South / Māori Heritage Advisor (03) 357 9620 PouarahiSouth@heritage.org.nz

Kaitiaki rūnanga:

Te Rūnanga o Koukourārata: 03 3398 308, koukourarata@ngaitahu.iwi.nz

Ōnuku Rūnanga: Office 03 381 2082, Marae 03 304 7607, onuku@ngaitahu.iwi.nz

Appendix M Landscape and Visual Assessment Report

AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Landscape and Visual Impact Assessment

Project No. 2021_034 | C

AKAROA TREATED WASTEWATER IRRIGATION SCHEME, LVIA

Project no:	2021_034
Document title:	Landscape and Visual Impact Assessment
Revision:	C
Date:	25 November 2022
Client name:	Stantec (on behalf of Christchurch City Council)
Author:	Chris Greenshields
File name:	2021_034_Stantec_Akaroa Treated Wastewater Irrigation Scheme_LVIA_C

DOCUMENT HISTORY AND STATUS

REVISION	DATE	DESCRIPTION	BY	REVIEW	APPROVED
A	30/08/2022	DRAFT LVIA	CG		
B	19/10/2022	LVIA	CG	DCM	DCM
C	25/11/2022	LVIA	CG	HB	DCM

DCM URBAN DESIGN LIMITED

10/245 St Asaph Street

Christchurch 8011

CONTENTS

1. INTRODUCTION AND PROPOSAL

DCM Urban have been commissioned by Stantec on behalf of Christchurch City Council (the applicant) to assess the potential landscape and visual effects of the Akaroa Treated Wastewater Irrigation Scheme.

The existing Akaroa Wastewater Treatment Plant (WWTP) discharging to Akaroa Harbour is to be replaced with a new WWTP to be built near the intersection of Long Bay Road and Old Coach Road near Akaroa. In 2020, Council consulted on four options for the disposal / reuse of treated wastewater that will be produced by the new treatment plant. The Council decided to use the highly treated wastewater to irrigate plantings of indigenous trees in Robinsons Bay Valley, Takamātua and Hammond Point (previously known as The Inner Bays scheme during CCC consultation), and to irrigate Jubilee Park in Akaroa as part of a scheme to use the treated wastewater for non-potable purposes. The scheme also includes a covered storage tank to temporarily store untreated wastewater flows in wet weather, and a subsurface wetland to be built on Council-owned land opposite the WWTP on Old Coach Road. For the purpose of this report the Takamātua site has been removed from the scope of the project and the Jubilee Park irrigation is considered not to require landscape assessment. Refer to below figure 1 for site locations. A description of the proposed development of each site is further detailed below.

This report is supported by an appendix of figures, Appendix 2, which includes photos of the existing sites and surrounding areas, proposal plans and a photo illustration of the proposal.

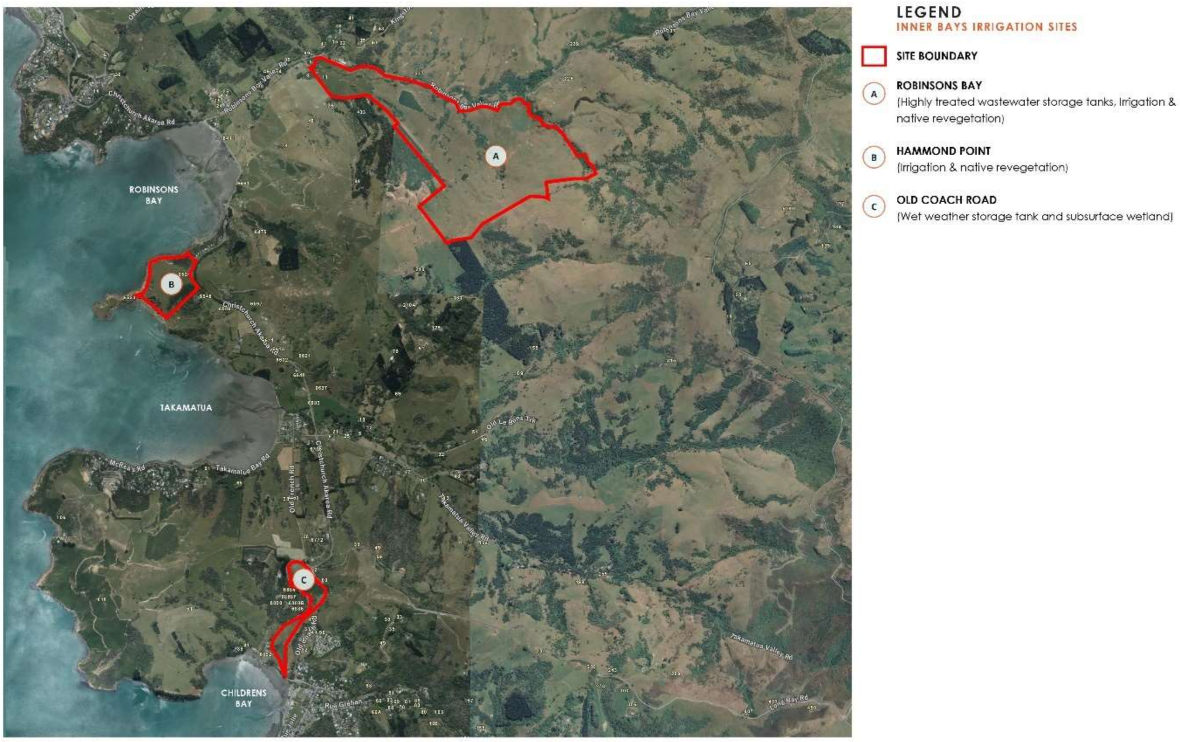


Figure 1 – Site Locations (Source: Appendix 2, DCM appendix of figures, page3)

1.1 ROBINSONS BAY VALLEY

The site is located at Council owned 11 Sawmill Road (Lot 2 DP 82749), Robinsons Bay Valley, approximately 7km north off the Akaroa township off the Christchurch Akaroa Road, State Highway 75. The 114ha site extends up the valley towards Summit Road and has a predominantly northwest aspect with Robinsons Bay Valley Stream bordering the site to the north. Council has also purchased a 70m width strip of 88 Sawmill Road which immediately adjoins the proposed tank sites within 11 Sawmill Road and increases the overall area of the site. The Robinsons Bay Valley site is the largest of the proposed irrigation sites.

The proposal positions up to 10 covered water storage ‘Kliptanks’ that are 22m in diameter and 6m in height to top of tank (roof / cover shape and height is currently unknown at this time), on a natural mid-slope plateau, including associated earthworks and a small axillary pump control building. Refer to Figure 2 example of ‘Kliptank’ below. An additional 3 future tanks of the same size are proposed south of the main 7 tanks. A new main access track to the tanks site is proposed off upper Robinsons Bay Valley Road which runs south across the site to the tank positions. The majority of the lower to mid-slope of the site is proposed to be revegetated with indigenous tree and shrub species, of which approximately 34ha will be drip irrigated with the highly treated wastewater. Other high-slope areas of the site where irrigation is not proposed at this stage or cannot be irrigated, will be revegetated with indigenous tree and shrub species or left as grazing for land management. The proposal also includes an area of minimum intervention for natural succession of indigenous regeneration, university growing trials, future resource for community projects and public access walking tracks for recreation, education, and historical value.

Refer to Appendix 2, pages 6 to 9 for General Arrangement engineer plans and landscape concept plans.

Figure 2. Example of ‘Kliptank’ storage with cover (Dimensions unknown)

1.2 HAMMOND POINT

The site is located at Council owned 6538 Christchurch Akaroa Road, State Highway 75 (Lot 1 DP 563448), approximately 5km north of the Akaroa township. The 11.9ha site forms the prominent peninsula between Robinsons Bay and Takamātua Bay, extending down to the coastal edge of Akaroa Harbour.

The proposal is to predominantly revegetate the site with indigenous tree, shrub, and tussock species, considerably enhancing the indigenous vegetation existing on the site. Approximately 3.1ha of the site will be drip irrigated with the highly treated wastewater. No storage tanks are proposed at this site. The existing site entry and access track to 6528 Christchurch Akaroa Road will be retained through the site, as well as a vegetation clearance corridor underneath the existing overhead power lines. A new walking track for recreation through the site will provide walking access linking the coastal edge of Robinsons Bay to the north and Takamātua Bay to the South. A viewing and interpretation area is proposed to the northwest of the site providing a resting point, and educational, historical and cultural interpretation, and associations with the area. The existing ‘lean to’ will be retained.

Refer to Appendix 2, page 18 for landscape concept plans.

1.3 OLD COACH ROAD

The site is located at Council owned 6864 Christchurch Akaroa Road, State Highway 7 (Lots 10,7,8,9 DP 7273), approximately 1.8km north of the Akaroa township and is located opposite land where key related WWTP infrastructure is proposed to be located.

The Old Coach Road proposal is to construct a wet weather storage tank with cover up to 30m diameter, and approximately 3.7m above ground level to apex of roof, on an 3m recessed platform into the existing ground level to lessen the visibility of the tank. A subsurface wetland is proposed to be constructed west of the tank to provide a storage facility for treated wastewater in addition to the storage tanks proposed for the Robinsons Bay Valley site, as well as for emergency storage if the tanks are unavailable. A car park is proposed on Old Coach Road where the existing farm gate is allowing public access to the site. The remainder of the site slopes south to towards Childrens Bay, where existing indigenous vegetation is retained and will be enhanced with new planting. A network of walking tracks may be developed to provide access to the full site and open space areas towards Childrens Bay.

The site is proposed to be further enriched with cultural narrative from the Onuku Runanga. Refer to Appendix 2, pages 27-29 for landscape concept plans.

2. METHODOLOGY

2.1 STATUTORY DOCUMENTS

2.1.1 Resource Management Act 1991

Section 6 of the RMA identifies matters of national importance:

> *"In achieving the purpose of this Act, all persons exercising functions and powers under it, its relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:*

s.6 (b) *The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development;*

s.6 (c) *The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna."*

Other matters are included under Section 7:

> *"In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to-*

(c) *The maintenance and enhancement of amenity values."*

2.1.2 New Zealand Coastal Policy Statement (NZCPS)

The purpose of the NZCPS is to state policies in order to achieve the purpose of the Resource Management Act 1991 in relation to the coastal environment of New Zealand. Regional policy statements, regional plans and district plans must give effect to this NZCPS.

To that effect assessment of the relevant district plan provisions in turn respond to the influence of the NZCPS.

2.1.3 The Canterbury Regional Policy Statement (CRPS)

In reading, the principal reasons and explanation, it is apparent that the RPS is encouraging local councils to; firstly recognise that the landscapes other than those considered outstanding may have important character, amenity attributes, cultural and historic associations, and therefore should be managed accordingly; and secondly, that councils need to identify these landscapes in accordance with the criteria set in the objectives, policies and methods of the CRPS through their district plan.

To that effect assessment of the relevant district plan provisions in turn respond to the influence of the CRPS.

2.1.4 Christchurch District Plan (CDP)

The CDP identifies several relevant objectives, policies, and rules with regard to the zoning of each site and further defines relevant aspects through the associated planning map overlays. These have been noted below and relevant landscape matters assessed on a site-by-site basis in section 3.

2.1.4.1 Robinsons Bay Valley

The site is located entirely within the Rural Banks Peninsula Zone. Associated overlays are:

- 160m Contour Line (applies only to Rural Banks Peninsula Zone),
- Environmental Asset Waterway, Hill Waterway and Water Body Setback,
- Remainder of Port Hills and Banks Peninsula Slope Instability Management Area,
- Rural Amenity Landscape.

2.1.4.2 Hammond Point

The site is located mostly within the Rural Banks Peninsula Zone with north portion of the site located with Residential Small Settlement Zone. Associated overlays are:

- Remainder of Port Hills and Banks Peninsula Slope Instability Management Area,
- Coastal Environment,
- Area of at least High Natural Character in the Coastal Environment (NHC 19.0)
- Natural Character in the Coastal Environment (NCCE1.0)
- Identified Important Ridgeline (*within a lesser portion of the site*)
- Rural Amenity Landscape (*within a lesser portion of the site*)
- Ngā Tūranga Tūpuna

2.1.4.3 Old Coach Road

The site is located entirely within the Rural Banks Peninsula Zone. Associated overlays are:

- 33kV Electricity Distribution Lines
- Hill Waterway and Water Body Setback,
- Remainder of Port Hills and Banks Peninsula Slope Instability Management Area,
- Coastal Environment, (*within a small southern corner closest to Christchurch Akaroa Road/ Childrens Bay*)

- Rural Amenity Landscape
- Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit (*14a, 15a*)
- Wahi Tapu/Wahi Taonga (*14b, 15b*)
- Ngā Tūranga Tūpuna (*Table 3: Ngā Tūranga Tūpuna - ID73 Akaroa Harbour - Areas of cultural landscapes with large concentrations of significant tribal history and archaeological sites, and prominent natural features that form landmarks*)

3. ASSESSMENT OF EFFECTS

3.1 ROBINSONS BAY VALLEY

3.1.1 ROBINSONS BAY VALLEY EXISTING SITE CHARACTER

The existing receiving environment is characterised by distinctive volcanic landforms with highly legible crater rims, prominent ridgelines and peaks which extended to a series of gullies, spurs, and rock outcrops. The landscape is dominated by openness and vegetation, with pastoral farming as the predominant landuse on the peninsula, all of which form key components of the natural and rural landscape character of this area.

At a site scale, the upper valleys are enclosed by scattered vegetation - particularly regenerating indigenous kanuka forest, small pockets of exotic plantation and the surrounding natural hills landscape. Views are largely internal with a rural aspect and little coastal influence. At higher elevations, particularly south facing viewpoints, the site is back dropped by the wider expansive landscape of Akaroa Harbour and surrounding headlands. The lower valley of the site flattens, with the working rural practices and landuse more prevalent, largely owed to the more the accessible nature of the topography. To the northern boundary of the site, the ‘Robinsons Bay Valley stream’ follows the natural valley contour with varying indigenous and exotic vegetation types. The southern boundary, though separated, rises up towards a prominent spur which connects the coastal edge to the crater rim.

Development within this rural landscape is very low density, with structures and facilities generally spaced out with large distances in between. The built form of dwellings and farm or auxiliary buildings are common throughout the area. The lower valley contains a distinct cluster of housing with varying density and age. The scale, character, form, colour, and materiality of the buildings vary greatly, with no common style or palette. Development becomes particularly sparse at higher elevations, consisting only of few unsealed ‘back roads’, farm tracks and stock fencing.

Vegetation types in the receiving environment are categorised as exotic pastoral grassland, regenerating indigenous vegetation and some small pockets of exotic plantation. Indigenous vegetation is generally clustered throughout open grassy hills or nestled within the hillside water courses/ gullies and largely consist of kanuka. Despite the variation in vegetation present, the area remains predominantly open grassy paddocks.

In terms of sensory qualities, the distinctive slopes of this landscape descending to the coastline provides impressive views to those who explore the area from both higher and lower elevations. Generally, the atmosphere is quiet, while the air is fresh and clear, characteristic of the rural character and landuse.

3.1.2 ROBINSONS BAY VALLEY EFFECTS ON LANDSCAPE CHARACTER

Landscape character is the combination and composition of biophysical elements such as topography, vegetation, built form and sensory qualities perceived by humans, which also encompasses spiritual, cultural, and social associations. Change to the character of a landscape may not necessarily be adverse. Whether effects are adverse or not depends to a large extent on public expectation of what can be reasonably anticipated to occur in the landscape. Linked to this is the landscape context in terms of its existing degree of naturalness/modification, patterns, scale, visibility and levels of public appreciation, and the capacity of the landscape to absorb change. The likely tangible effects on landscape character from the proposal are considered as the following;

<u>Proposed tank site and associated earthworks</u>

The rural character of the landscape reflects its modified state, where an expectation of farming infrastructure, utilities, and small scale ‘man made’ infrastructure is present within the landscape. The introduction of the tanks and associated earthworks may not be entirely unexpected, with tanks commonly seen throughout the rural landscape. The proposal is for up to 10 covered water storage ‘Kliptanks’ that are 22m in diameter and 6m in height to top of tank (roof/ cover shape and height is currently unknown at this time), and a small axillary pump control building. The tanks are considered to create an increased intensity of infrastructure within the rural landscape due to their scale and bulk, and at an elevation where comparable surrounding development (built form) is sparse. This is not necessarily adverse and when considered within the landscape context, does not result in a reduction of naturalness due to the sites already modified (rural) state and does not fundamentally change the character of the site, which remains rural. The tank proposal is not considered to give rise to cumulative effects due to the physical separation from nearby by built form (development) which remains very low density and spaced out with large distances in between. The landscape is considered to have a **moderate-low** ability to absorb this change and is further discussed below with regard to effects on visual amenity and the proposed mitigation measures.

The proposed location of the tanks (within the application site) is a naturally flatter mid slope area helping reduce the overall earthworks required to construct the platform for the tanks. The cut material is proposed to be retained on site, re-contoured and initially grassed for erosion and sediment control. The landscape plan proposes to revegetate the cut material with indigenous planting. Consequently, any adverse landscape effects will be temporary during construction and diminish over time as vegetation establishes with likely minimal residual effects due to the vegetated cover.

The proposed tanks and associated earthworks are assessed as having a **moderate-low (or minor)** effect on the overall landscape character of the site and wider receiving environment, reducing to **low (or less than minor)** with the proposed mitigation measures and revegetation establishing over time.

<u>Proposed access track to tank site</u>

A new access track up to 4.0 m wide is proposed from upper Robinsons Bay Valley Road to the tank site. The alignment has been chosen to best align with an existing farm track and the natural contour of the site, which in turn reduces the overall earthworks required, allowing the access track to retain a ‘farm like’ track appearance within the landscape. The alignment requires minimal removal of existing vegetation. Like the tank site, cut material will be re-contoured and initially grassed for erosion and sediment control, then revegetate with indigenous planting. Consequently, any adverse landscape effects will be temporary and diminish over time as vegetation establishes. It is understood the new access track will be used for construction access and ongoing operational maintenance.

The proposed access track and associated earthworks are assessed as having a **low (or less than minor)** effect on the landscape character of the site and wider receiving environment, reducing to **very low (or less than minor)** with the proposed mitigation measures and revegetation establishing over time.

Change in Landuse and Landcover

While the most noticeable built form of the proposal will be the tanks, the majority of the site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. A perceived effect on the existing landscape character could be the loss of openness, an attribute closely associated with the appearance and appreciation of the rural landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposed planting will not look out of place in the landscape context of the site, which contains existing clusters and gullies of regenerating indigenous vegetation. Te proposed planting will look like an extension or infill of the existing vegetation and will not visually obscure dominant landforms, which remain as the prominent ridgelines, peaks, gullies, spurs, and rock outcrops. The landscape proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

The proposed revegetation is assessed as having a **very low (or less than minor)** effect on the landscape character and is considered a **positive** effect for the site and wider receiving environment.

3.1.3 ROBINSONS BAY VALLEY EFFECTS ON LANDSCAPE VALUES

The site is located within the Rural Banks Peninsula Zone and the proposal is considered a discretionary activity. The proposal has been assessed against the relevant Objectives, Policies and Rules of the Christchurch District Plan (CDP) which relate to landscape character and visual amenity. The proposal is also located within several overlays (listed under 2.1.4.1 of this report), of relevance for specific assessment is the Rural Amenity Landscape (RAL). The effects on Landscape Values are considered and assessed in the relevant statutory context and matters of direction below:

Chapter 17 Rural (CDP),

Objective 17.2.1.1 – The rural environment

a. *Subdivision, use and development of rural land that:*
   i. *supports, maintains and, where appropriate, enhances the function, character and amenity values of the rural environment and, in particular, the potential contribution of rural productive activities to the economy and wellbeing of the Christchurch District;*
   ii. *avoids significant, and remedies or mitigates other reverse sensitivity effects on rural productive activities and natural hazard mitigation works;*
   iii. *maintains a contrast to the urban environment; and*
   iv. *maintains and enhances the distinctive character and amenity values of Banks Peninsula and the Port Hills, including indigenous biodiversity, Ngāi Tahu cultural values, open space, natural features and landscapes, and coastal environment values.*

Response

The proposal is consistent with this objective, the character of the landscape will remain rural. The proposed tanks could be perceived as being part of the rural working landscape and the proposal provides a greater wellbeing for the residents, economy, and environment by removing historic 'wastewater' disposal into the harbour. Overtime the proposal will reduce the existing pastoral openness of the site through using a considerable portion of the site to revegetate with indigenous planting. This is not considered out of character for the site where existing gullies are regenerating with indigenous vegetation. Furthermore, planting is considered a positive enhancement for naturalness, amenity values and enhances indigenous biodiversity, ecological values, and cultural associations. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident.

Policy 17.2.2.3 – Contributing elements to rural character and amenity values

a. Recognise that rural character and amenity values vary across the Christchurch District resulting from the combination of natural and physical resources present, including the location and extent of established and permitted activities.

b. Recognise that the elements that characterise an area as rural, from which desired amenity is derived, include the predominance of:

i. a landscape dominated by openness and vegetation;

ii. significant visual separation between residential buildings on neighbouring properties;

iii. where appropriate, buildings integrated into a predominantly natural setting; and

iv. natural character elements of waterways, water bodies, indigenous vegetation and natural landforms, including the coastal environment where relevant.

c. Recognise that rural productive activities in rural areas can produce noise, odour, dust and traffic consistent with a rural working environment, including farming, plantation forestry and quarrying activities, that may be noticeable to residents and visitors in rural areas.

<u>Response</u>

The proposal is considered consistent with this policy and will largely retain the valued openness and vegetated character typical of the rural landscape, albeit it one that is more vegetated over time. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident. The tank locations are sufficiently away from nearby dwellings to retain a sense of separation, retaining a low density characteristic of the rural working landscape. Proposed vegetation will act as mitigation to partiality screen and soften potential visibility of the tanks for nearby residences and provide an enhanced predominance of natural character though the use of indigenous vegetation.

Policy 17.2.2.8 – Rural Banks Peninsula

a. Ensure that subdivision, use and development in the Rural Banks Peninsula Zone recognises, maintains and, where practicable, enhances the quality of the rural working environment by:

i. restricting the scale, location and reflectivity of buildings to maintain a low density of built form that is not visually dominant and does not detract from views of cultural landscapes identified in the District Plan, sites of Ngāi Tahu cultural significance, or natural landforms and features;

ii. encouraging the protection, maintenance and enhancement of indigenous biodiversity, natural features and landscapes, historic heritage, coastal environment values, and open space; and

iii. encouraging public walking and cycling access connections where appropriate.

<u>Response</u>

The proposal locates the tanks on a naturally flatter mid slope which reduces the earthworks extent and volumes. The clustered arrangement of tanks is considered appropriate as this reduces the overall physical footprint of the tanks while also reducing the earthworks that effect the natural landform. The tanks will not break the skyline from any vantage point and where open views are available, the tanks are back dropped by topography and/or the existing eucalyptus plantation forest. Mitigation measures such as indigenous revegetation and use of a low reflective value recessive colour for the tanks aid in reducing visual effects to not detract from the character and dominance of the surround landscape.

Existing vegetation is mostly retained with only minimal removal likely required to construct the access track and tank platforms. Retention of the existing vegetation provides immediate partial screening and softening of the works. The proposal drastically enhances the predominance of indigenous vegetation which will mostly be irrigated with the highly treated wastewater.

The proposal allows for public access through the creation for walking tracks for recreation and maintains identified historical and cultural associations within the site.

Chapter 9 Natural and Cultural Heritage (CDP),

Policy 9.2.2.2.5 Recognising and maintaining the qualities of rural amenity landscapes

a. Recognise the qualities of the identified rural amenity landscapes described in Appendix 9.2.9.1.4 and maintain them by:
   i. avoiding use and development that breaks the skyline, including the crater rim, ridgelines on Banks Peninsula and radial spurs of the Port Hills;
   ii. avoiding visually prominent development;
   iii. ensuring subdivision, use and development does not result in over domestication of the landscape;
   iv. requiring development to be separated from identified important ridgelines on Banks Peninsula, taking into account visual separation and horizontal and vertical separation; and
   v. enabling farming, conservation activities and recreation activities which contribute to rural landscape character of Banks Peninsula.

Response

The proposed tanks are not considered to visually break the skyline from available viewpoints and are sufficiently separated from important ridgelines to not detract from their dominance. While the tanks will introduce an intensification of infrastructure, they are clusters in arrangement to reduce their footprint and spread. Proposed surrounding vegetation as mitigation aims to partially screen and soften the visual dominance of the tanks. The tanks will be in keep with the small, clustered arrangement of low density dwellings with separation.

The proposal supports conservation activities through a predominance of proposed indigenous revegetation, which will be irrigated with the highly treatment wastewater. Recreational activities are provided through the creation of walking tracks.

Appendix 9.2.9.1.4 Rural amenity landscapes

a. The following are the Christchurch District's identified rural amenity landscapes and their qualities:
   i. Banks Peninsula:
      A. A predominantly farming, rural working landscape.
      B. Distinctive volcanic landforms with highly legible crater rims, prominent ridgelines and peaks extending to a series of gullies, spurs and lower slopes, and continuity of rock outcrops.
      C. The presence of important areas of indigenous vegetation.
      D. Important landscapes and features to Ngāi Tahu especially those prominent peaks and passes, streams and vegetation that relate to key tribal origin, migration and settlement traditions, including mahinga kai.
      E. A predominance of natural features, processes and patterns with existing development generally well integrated into the landscape.
      F. Within the coastal environment, the presence of generally highly legible landforms, visually impressive cliffs, islands and caves.
      …

Response

The proposal is considered consistent with this policy and will largely retain the valued openness and vegetated character typical of the rural landscape, albeit it one that is more vegetated over time. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident. The tank locations are sufficiently away from nearby ridgelines and natural features to not detract from them. Proposed vegetation will act as mitigation to partiality screen and soften potential visibility of the tanks integrating them within the landscape and providing a maintained sense of natural character.

9.2.8.2 Significant features and rural amenity landscapes

a. *Whether the proposal is consistent with maintaining the qualities of the significant feature and/or rural amenity landscape;*
   b. *Any adverse effects on adjoining outstanding natural features, outstanding natural landscapes or natural character in the coastal environment, and whether there is a sufficient separation to avoid detracting from the qualities of those areas. When assessing separation, account shall be taken of visual separation, vertical and horizontal setback distances and retention of indigenous vegetation;*
   c. *On Banks Peninsula, the extent to which the proposal will detract from visual amenity landscape values. This shall include consideration of the extent to which the proposal is consistent with design guidance;*
   d. *Within greater Christchurch (including the Port Hills), the extent to which the proposal will detract from the natural landscape values;*
   e. *Whether the proposal recognises the context and values of historic and cultural significance and the relationship, culture and traditions of Ngāi Tahu;*
   f. *Whether the proposal will integrate into the landscape and the appropriateness of the scale, form, design and finish (materials and colours) proposed and mitigation measures such as planting. This shall include consideration of any adverse effects of reflectivity, glare and light spill;*
   g. *The proximity and extent to which the development is visible from public places and roads (including unformed legal roads), ease of accessibility to that place, and the significance of the view point;*
   h. *The extent to which natural elements such as landforms and vegetation within the site mitigate the visibility of development;*
   i. *The capacity of the landscape to absorb change and the extent to which opportunity has been taken to cluster built development in areas of existing built development with a higher potential to absorb development while retaining areas which are more sensitive to change;*
   j. *The extent to which the proposal will result in adverse cumulative effects;*
   k. *Whether the proposal supports the continuation of farming activities in rural zones;*
   l. *Whether the proposal is connected to reticulated water and the need to provide water supply (for firefighting), and the ability to integrate water tanks into the landscape and mitigate any adverse visual effects;*
   m. *For new access tracks whether the access supports conservation activities, farming or recreation activities, the ability to integrate with the landscape, follow natural contours and mitigate any adverse visual effects;*
   n. *The extent to which the proposal has technical or operational needs for its location;*
   o. *For proposed activities in connection with a recovery activity in the Flat Land Recovery Zone, the extent to which the qualities of the significant natural feature of the Avon River will be maintained; and*
   p. *Within a Site of Ngāi Tahu Cultural Significance, the matters set out in Rule 9.5.5 as relevant to the site classification:*
      i. *Rule 9.5.5.1 - Wāhi Tapu / Wāhi Taonga, Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit;*
      ii. *Rule 9.5.5.2 - Ngā Tūranga Tūpuna; and*
      iii. *Rule 9.5.5.3 - Ngā Wai.*

Response

The rural character of the landscape reflects its modified state, where an expectation of farming infrastructure, utilities, and small scale 'man made' infrastructure is present within the landscape. The introduction of the tanks and associated earthworks may not be entirely unexpected. The tanks are considered to create an increased intensity of infrastructure within the rural landscape due to their scale and bulk, and at an elevation where comparable surrounding development (built form) is sparse. This is not necessarily adverse and when considered within the landscape context, does not result in a reduction of naturalness due to the sites already modified (rural) state and does not fundamentally change the character of the site, which remains rural. The tank proposal is not considered to give rise to cumulative effects due to the physical separation from nearby by built form (development) which remains very low density and spaced out with large distances in between. The landscape is considered to have the ability to absorb this change due to the internalised views and dominance of the surround large scale landscape, further enhanced with proposed mitigation measures outlined below, such as using recessive colours with a low reflective value.

The proposed access track from upper Robinsons Bay Valley Road to the tank site follows an existing farm track and aligns with the natural contour of the site, which in turn reduces the overall earthworks required, allowing the access track to retain a 'farm like' track appearance within the landscape.

While the most noticeable built form of the proposal will be the tanks, the majority of the site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance, integrating the tanks into the landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

3.1.4 ROBINSONS BAY VALLEY EFFECTS ON VISUAL AMENITY

Visual amenity is a measure of the visual quality of a landscape as experienced by people living in, working in, or travelling through it. Visual amenity is invariably associated with the pleasantness, memorability and aesthetic coherence of an area or a view. The degree of visual effect relates to the visibility of the proposal, both within and beyond the application site. Generally speaking, the closer people are to a development, the greater visual effects there will be.

In terms of visual effects relating to the proposal, the tanks and associated earthworks will be the most visually apparent (built form) change that will effect existing amenity values. This visual assessment has therefore been mostly focused on the tank locations with the application site. The greatest effects will be experienced from vantage points directly 'across' from the tanks where views are at or above the same elevation. Generally, at the lower elevations, the site's topography and existing vegetation intervene, screening visibility of the tanks. Visibility of the tanks may not be entirely unexpected to the viewer in the context of the rural working landscape, nonetheless it is the combined scale and bulk of the tanks, through considered appropriate in arrangement, which will detract the most from the existing amenity.

Visual effects from the associated earthworks will be temporary for the duration of the tank platform construction. Effects will reduce once cut material is contoured to sympathetically integrate with the existing landform and vegetated with exotic grass for erosion and sediment control. As the proposed indigenous revegetation establishes any perceived residual effects of earthworks will be diminished, if apparent at all, and will take on a naturalised appearance.

Despite this visual change and the technical project parameters for this location, the tank site is well located to mitigate potential adverse visual effects. The site is located on a naturally flatter mid slope which reduces the earthworks extent and volumes. The clustered arrangement of tanks is considered appropriate as this reduces the overall physical footprint and spread of the tanks while also reducing the earthworks. The tanks will not break the skyline from any vantage point and where open views are available, the tanks are back dropped by topography and/or the existing eucalyptus plantation forest, of which a portion of this plantation is within with the site boundary and can be relied on for visual mitigation. The tank site is also at an elevation where there are few dwellings which overlook the site and is of a separation from existing rural development which does not give the perception of built form 'visual sprawl'.

Retention of these site attributes combined with further mitigation measures outlined below will determine how effects will diminish over time. Residual effects on visual amenity will likely be enduring, with the mitigation measures (over time) achieving an integration and softening of the tanks into the landscape, but not fully screening from all available views, predominantly from higher elevations than the tank site itself. The proposed tanks and associated earthworks are assessed as having a **moderate-low (or minor)** temporary effect on visual amenity owing to the site location, elevation and the somewhat limited viewpoints from nearby dwellings, recreational areas, and public roads. Effects will reduce to **low (or less than minor)** as vegetation establishes over time, with some enduring residual visual effects when viewed from above the tank site elevation.

Other elements of the proposal, such as the new access track is considered compatible with the rural working landscape and may not be entirely unexpected to the viewer. The access track has been located in a way that allows an integrated and coherent alignment which responds to the natural topography and utilises the screening benefits of the existing vegetation on site. Any perceived visual effects resulting from the formation of the new access track will be temporary for the duration of the track construction. The track will exhibit a more 'farm like' appearance once cut and contoured slopes are vegetated with exotic grass for erosion and sediment control, reducing any perceived visual effects. Once the proposed indigenous revegetation establishes to a height that screens the new access track (likely in 5-7years), residual effects of the new access track will be diminished, if apparent at all when assessed in the context of the existing rural landscape. The proposed access track and associated earthworks are assessed as having a **low (or less than minor)** temporary effect on visual amenity within the site and wider receiving environment, reducing to **very low (or less than minor)** once revegetation establishes over time.

The proposed indigenous revegetation is considered a positive effect on visual amenity, likely improving the pleasantness and appreciation of the area, as well as enhancing indigenous biodiversity, ecological values, and cultural associations. Though the revegetation will change the landuse and landcover from open pastoral rural landscape to one that is planted, vegetation is commonly considered to enhance amenity values. The revegetation will not look out of place, more an extension to the existing regenerating indigenous vegetation currently spread across site and gullies. The revegetation also has the practical and project purpose of highly treated wastewater uptake and with regard to landscape mitigation considerations, provides the benefit of screening, visual integrating and softening of the proposed tanks over time. Walking tracks for recreational use as well as opportunities for educational, historical and cultural awareness through interpretation signage will enhance user experience, in turn providing a positive memorability of the landscape. These elements are assessed as having a **positive** effect on amenity values of the site.

<u>Visual Assessment</u>

The visual context of the receiving environment is considered to be a 5000m offset from proposed tank site location within the application site due to this being the most noticeable change. This distance has been determined by the scale of the proposal and the openness of the receiving environment. At distances further than 5000m it is unlikely to be unnoticeable due to the site being viewed at a macro scale and effects ameliorated by distance. A series of key viewpoints were selected to show a representative sample of the likely visual effects which could result from the proposal (refer to Appendix 2, page 10). Viewpoints are generally located on public land, and where practical located as close as possible to existing or proposed dwellings or other key viewpoints. In assessing the potential effects of a proposal, the quality and openness of the view is considered. The viewpoints selected were as follows:

1) VP1 – View southwest from 5080 Summit Road (looking down the valley across site)

2) VP2 – View East from Ōnawe Peninsula track

3) VP3 – View south-east from 200 Okains Bay Road (looking across valley to site)

4) VP4 – View south-east from 228 Robinsons Bay Valley Road (looking up the valley across the site)

In assessing the potential effects on visually sensitive receptors, the key viewpoints outlined above have been used as a reference point where it is considered that the effects are likely to be similar to the viewpoint and for a group of viewers. The viewpoint is a representative view, as close as possible to the view likely to be experienced from a private residence or property but obtained from a public location.

The following table outlines the potential visual effects each Visually Sensitive Receptor might receive and how the effects may potentially be mitigated. The effects take into account the type of receptor, combined with the likely magnitude of effects (a combination of distance from the proposal and degree of change) to determine what the likely residual effects from the proposal will be. Mitigation measures are outlined in Section 4.

Table 1: Assessment of Effects on Visually Sensitive Receptors (Robinsons Bay Valley Site)

<u>Definition:</u> With regard to 'Distance from Proposal', for this Robinsons Bay Valley site the measurement is to the tank locations site, being the likely most apparent change to affect existing amenity values.

Viewpoint	Visually Sensitive Receptors (VSR)	Distance from Proposal (m)	Type of View (open, partial, screened)	Magnitude of Change	Mitigation Measures	Effects after mitigation
1	Vehicle Users along Summit Road	2400	Open	Low	MM1, MM2,MM3 ,MM4,MM 5,MM6	Less than Minor
2	Recreation User along Ōnawe Peninsula track	4500	Partial/ Screened	Very Low	MM1, MM2,MM3 ,MM4,MM 5,MM6	Nil
3	Vehicle Users along Okains Bay Road	2000	Open	Low	MM1, MM2,MM3 ,MM4,MM 5,MM6	Less than Minor
	Residents at 194/ 196 Okains Bay Road	1800		Moderate-Low		Minor
4	Vehicle Users along Robinsons Bay Valley Road	500	Partial	Low	MM1, MM2,MM3 ,MM4,MM 5,MM6	Less than Minor

Viewpoint	Visually Sensitive Receptors (VSR)	Distance from Proposal (m)	Type of View (open, partial, screened)	Magnitude of Change	Mitigation Measures	Effects after mitigation
	Residents at 85 & 99 Robinsons Bay Valley Road	1000		Moderate-Low		Less than Minor

3.1.5 ROBINSONS BAY VALLEY SUMMARY OF EFFECTS ON VISUAL AMENITY

The most visually apparent change in terms of visual effects, will be the tank site and associated earthworks with the greatest effects experienced from vantage points directly 'across' from the tanks where views are at or above the same elevation. Views of the proposal from the formed roads are generally limited to Robinsons Bay Valley Road, Sawmill Road, Summit Road, and Okains Bay Road. Some unformed legal roads within the visual catchment will have the same or similar available views of the site as the formed legal roads, though less frequented. For the purpose of this assessment the formed legal road viewpoints and the likely visual effects are considered representative of those likely from the unformed legal roads. Effects on the identified visually sensitive receptors are summarised as follows:

<u>Effects on road users</u>

Where the proposal is visible from the roads as outlined above, views are generally from a distance, back dropped by topography and/or existing vegetation and viewed in context of the surrounding large-scale landscape. Views specifically from Robinsons Bay Valley Road which look up the valley towards the tank site are partially intervened by existing topography and vegetation. Views from the higher elevations of Okains Bay Road and Summit Road are dominated by the surrounding large-scale landscape with direct views of the tank site, though in parts, intervened by existing roadside topography and vegetation. The sensitivity of road users, mainly motorists and cyclists, is considered less given the transient nature and speeds moving past the site and attention to the road required, reducing visual effects arising from specifically the tank site. Any perceived visual effects of the new access track and proposed revegetation of the site will potentially go unnoticed, with the later likely viewed as a positive effect of the proposal.

Visual effects of the proposal for road users are assessed as **low (or less than minor)**, with residual effects reducing to **very low (or less than minor)** with mitigation measures as outlined below, and over time. The proposed indigenous revegetation will likely have a **positive** visual effect.

<u>Effects on nearby residents</u>

Views of the proposal will be possible from some residences along Okains Bay Road which look south across the valley to towards the tank site and were they are at the same or higher elevation than the tank site, such as 196, 196A and 200 Okains Bay Road. Some views are available from residences along Robinsons Bay Valley Road, though to a lesser extent due to intervening topography and existing vegetation. Due to the more static nature of residences, the landscape can be examined in finer detail and visual effects are therefore likely to be more apparent. Though infrastructure of this kind may not entirely be unexpected within the (rural) landscape context, the scale and bulk of the tanks will create potential adverse effects on the current amenity enjoyed from these residences. In all cases, available views from residences of the tank site, are back dropped by topography and/or existing vegetation and the tanks themselves will not visually break the skyline. The selection of recessive, non-reflective colour(s) for the tanks, clustering the arrangement of the tanks to reduce overall footprint and eventual screening by the proposed indigenous vegetation will all aid in mitigating temporary visual effects and will diminish over time.

Visual effects of the proposal for residents are assessed as **moderate-low (or minor)** temporary effect on visual amenity owing to the site location, elevation, and available viewpoints from nearby residences. Effects will reduce to **low (or less than minor)** as vegetation establishes over time, some residual visual effects will endure when viewed from above the tank site elevation. The proposed indigenous revegetation will likely have a **positive** visual effect once established on amenity values.

3.2 HAMMOND POINT

3.2.1 HAMMOND POINT EXISTING SITE CHARACTER

Hammond Point forms the outer headland which protrudes to define both Robinsons Bay and Takamātua Bay, characteristic of Bank Peninsula's long spurs extending done to the coastal edge ending in large headlands creating the 'headland/ bay pattern' of Akaroa Harbour. Steep distinctive coastal cliffs form an abrupt edge to a portion of the site and are highly valued for their naturalness and lack of obvious modification. Views are largely external from the within the site, out across Akaroa Harbour to the wider bays and highly legible volcanic landforms, prominent ridgelines, peaks, gullies, and spurs of Banks Peninsula. The site is contained by the coastal edge, Christchurch Akaroa Road (SH75) and flanked to the north and south by existing clusters of indigenous vegetation composing of mostly kanuka forest.

The site has little in the way of development and farm or auxiliary buildings with the most notable modifications, beyond exotic pastoral grassland, being the stock yard at the entrance to the site, stock fencing and powerlines which connect nearby residences. The surrounding development is low density with a small settlement to the north of the site, cloaked in kanuka forest. A single farm track traverses the site providing access to the property at 6528 Christchurch Akaroa Road (SH75).

Vegetation types are categorised as predominantly open exotic pastoral grassland and regenerating indigenous vegetation, characteristic of the surrounding rural Banks Peninsula landscape.

In terms of sensory qualities, the tidal coastline provides a changing landscape with impressive views to the Akaroa Harbour the landscape beyond. Generally, the atmosphere is quiet, while the air is fresh and clear with identifiable coastal aromas.

3.2.2 HAMMOND POINT EFFECTS ON LANDSCAPE CHARACTER

Landscape character is the combination and composition of biophysical elements such as topography, vegetation, built form and sensory qualities perceived by humans, which also encompasses spiritual, cultural, and social associations. Change to the character of a landscape may not necessarily be adverse. Whether effects are adverse or not depends to a large extent on public expectation of what can be reasonably anticipated to occur in the landscape. Linked to this is the landscape context in terms of its existing degree of naturalness/modification, patterns, scale, visibility and levels of public appreciation, and the capacity of the landscape to absorb change. The likely tangible effects on landscape character from the proposal are considered as the following;

<u>Change in Landuse and Landcover</u>

The proposal is to almost revegetate the site entirely with indigenous tree, shrub, and tussock species, considerably enhancing the indigenous vegetation and naturalness of the existing site. There are no noticeable built form changes effecting landscape character being proposed. Modifications such as the existing access track to 6528 Christchurch Akaroa Road and overhead powerline will remain as part of the existing landscape character. The majority of the site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. A perceived effect on the existing landscape character could be the loss of openness, an attribute closely associated with the appearance and appreciation of the rural landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposed planting will not look out of place in the landscape context of the site, which contains existing clusters of regenerating indigenous vegetation. The proposed planting will look like an extension or infill of the existing vegetation flanking the site and not visually obscure dominant landforms, which remains as a prominent headland with steep coastal cliffs.

The landscape proposal also includes a new track for recreation through the site which will provide walking access linking the coastal edge of Robinsons Bay to the north and Takamātua Bay to the South. A viewing and interpretation area is proposed to the northwest of the site providing a resting point, and educational, historical and cultural interpretation, and associations with the area. The existing 'lean to' will be retained.

The site is considered to have a **very low** ability to absorb this change. The proposal is assessed as having **positive** effect on the landscape character for the site and wider receiving environment, owed to the proposed indigenous vegetation improving the natural qualities of the site. Over time, the site will appear increasingly natural as vegetation matures and natural succession takes place with no distinguishable residual effects.

3.2.3 HAMMOND POINT EFFECTS ON LANDSCAPE VALUES

The site is located within the Rural Banks Peninsula Zone and the proposal is considered a discretionary activity. The proposal has been assessed against the relevant Objectives, Policies and Rules of the Christchurch District Plan (CDP) which relate to landscape character and visual amenity. The proposal is also located within several overlays (listed under 2.1.4.2 of this report), of relevance for specific assessment is the Rural Amenity Landscape (RAL), Coastal Environment, Area of at least High Natural Character in the Coastal Environment (NHC 19.0), Natural Character in the Coastal Environment (NCCE1.0) and Ngā Tūranga Tūpuna. *(The Identified Important Ridgeline and Rural Amenity Landscape overlays are within a lesser portion of the site and assessment against these mattered are not considered a requirement due to relative simplicity of the proposal as indigenous revegetation)*.

The effects on Landscape Values are considered and assessed in the relevant statutory context and matters of direction below:

Chapter 17 Rural (CDP),

Objective 17.2.1.1 – The rural environment

a. Subdivision, use and development of rural land that:

i. supports, maintains and, where appropriate, enhances the function, character and amenity values of the rural environment and, in particular, the potential contribution of rural productive activities to the economy and wellbeing of the Christchurch District;

ii. *avoids significant, and remedies or mitigates other reverse sensitivity effects on rural productive activities and natural hazard mitigation works;*
iii. *maintains a contrast to the urban environment; and*
iv. *maintains and enhances the distinctive character and amenity values of Banks Peninsula and the Port Hills, including indigenous biodiversity, Ngāi Tahu cultural values, open space, natural features and landscapes, and coastal environment values.*

Response

The proposal is consistent with this objective, the character of the landscape will remain rural with the distinctive coastal cliffs left intact and visible with the headland remaining a dominant feature. Overtime the proposal will reduce the existing pastoral openness of the site through planting the majority of the site with indigenous vegetation. This is not considered out of character for the site where it is flanked by existing regenerating indigenous vegetation. Furthermore, planting is considered a positive enhancement for naturalness, amenity values and enhances indigenous biodiversity, ecological values, and cultural associations. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident.

Policy 17.2.2.3 – Contributing elements to rural character and amenity values

a. *Recognise that rural character and amenity values vary across the Christchurch District resulting from the combination of natural and physical resources present, including the location and extent of established and permitted activities.*
b. *Recognise that the elements that characterise an area as rural, from which desired amenity is derived, include the predominance of:*
   i. *a landscape dominated by openness and vegetation;*
   ii. *significant visual separation between residential buildings on neighbouring properties;*
   iii. *where appropriate, buildings integrated into a predominantly natural setting; and*
   iv. *natural character elements of waterways, water bodies, indigenous vegetation and natural landforms, including the coastal environment where relevant.*
c. *Recognise that rural productive activities in rural areas can produce noise, odour, dust and traffic consistent with a rural working environment, including farming, plantation forestry and quarrying activities, that may be noticeable to residents and visitors in rural areas.*

Response

The proposal is considered consistent with this policy and will largely retain the valued openness and vegetated character typical of the rural landscape, albeit it one that is more vegetated over time providing an enhanced predominance of natural character though the use of indigenous vegetation. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident.

Policy 17.2.2.8 – Rural Banks Peninsula

a. *Ensure that subdivision, use and development in the Rural Banks Peninsula Zone recognises, maintains and, where practicable, enhances the quality of the rural working environment by:*
   i. *restricting the scale, location and reflectivity of buildings to maintain a low density of built form that is not visually dominant and does not detract from views of cultural landscapes identified in the District Plan, sites of Ngāi Tahu cultural significance, or natural landforms and features;*
   ii. *encouraging the protection, maintenance and enhancement of indigenous biodiversity, natural features and landscapes, historic heritage, coastal environment values, and open space; and*
   iii. *encouraging public walking and cycling access connections where appropriate.*

Response

The proposal does not introduce new built form and structures into the landscape. Irrigation lines and associated operational equipment will largely go unnoticed or not be entirely unexpected due to the rural working landscape.

Existing vegetation flanking the site is retained and the proposal will enhance the predominance of indigenous vegetation. The proposal allows for public access through the creation for a walking track for recreation and provides the opportunity for historical and cultural interpretation and associations.

Chapter 9 Natural and Cultural Heritage (CDP),

Policy 9.2.2.2.5 Recognising and maintaining the qualities of rural amenity landscapes

a. Recognise the qualities of the identified rural amenity landscapes described in Appendix 9.2.9.1.4 and maintain them by:
  i. avoiding use and development that breaks the skyline, including the crater rim, ridgelines on Banks Peninsula and radial spurs of the Port Hills;
  ii. avoiding visually prominent development;
  iii. ensuring subdivision, use and development does not result in over domestication of the landscape;
  iv. requiring development to be separated from identified important ridgelines on Banks Peninsula, taking into account visual separation and horizontal and vertical separation; and
  v. enabling farming, conservation activities and recreation activities which contribute to rural landscape character of Banks Peninsula.

Response

The proposal is almost all indigenous revegetation and does not introduce dominant built form into the landscape. The proposal supports conservation activities through a predominance of proposed indigenous revegetation, which will be irrigated with the highly treatment wastewater. Recreational activities are provided through the creation of walking tracks.

Appendix 9.2.9.1.4 Rural amenity landscapes

a. The following are the Christchurch District's identified rural amenity landscapes and their qualities:
  i. Banks Peninsula:
    A. A predominantly farming, rural working landscape.
    B. Distinctive volcanic landforms with highly legible crater rims, prominent ridgelines and peaks extending to a series of gullies, spurs and lower slopes, and continuity of rock outcrops.
    C. The presence of important areas of indigenous vegetation.
    D. Important landscapes and features to Ngāi Tahu especially those prominent peaks and passes, streams and vegetation that relate to key tribal origin, migration and settlement traditions, including mahinga kai.
    E. A predominance of natural features, processes and patterns with existing development generally well integrated into the landscape.
    F. Within the coastal environment, the presence of generally highly legible landforms, visually impressive cliffs, islands and caves.
    …

Response

The proposal is considered consistent with this policy, the indigenous vegetation will atop the distinctive coastal cliffs with the headland remaining a dominant feature. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident.

9.2.8.2 Significant features and rural amenity landscapes

a. Whether the proposal is consistent with maintaining the qualities of the significant feature and/or rural amenity landscape;

b. Any adverse effects on adjoining outstanding natural features, outstanding natural landscapes or natural character in the coastal environment, and whether there is a sufficient separation to avoid detracting from the qualities of those areas. When assessing separation, account shall be taken of *visual separation, vertical and horizontal setback distances and retention of indigenous vegetation;*

c. *On Banks Peninsula, the extent to which the proposal will detract from visual amenity landscape values. This shall include consideration of the extent to which the proposal is consistent with design guidance;*
d. *Within greater Christchurch (including the Port Hills), the extent to which the proposal will detract from the natural landscape values;*
e. *Whether the proposal recognises the context and values of historic and cultural significance and the relationship, culture and traditions of Ngāi Tahu;*
f. *Whether the proposal will integrate into the landscape and the appropriateness of the scale, form, design and finish (materials and colours) proposed and mitigation measures such as planting. This shall include consideration of any adverse effects of reflectivity, glare and light spill;*
g. *The proximity and extent to which the development is visible from public places and roads (including unformed legal roads), ease of accessibility to that place, and the significance of the view point;*
h. *The extent to which natural elements such as landforms and vegetation within the site mitigate the visibility of development;*
i. *The capacity of the landscape to absorb change and the extent to which opportunity has been taken to cluster built development in areas of existing built development with a higher potential to absorb development while retaining areas which are more sensitive to change;*
j. *The extent to which the proposal will result in adverse cumulative effects;*
k. *Whether the proposal supports the continuation of farming activities in rural zones;*
l. *Whether the proposal is connected to reticulated water and the need to provide water supply (for firefighting), and the ability to integrate water tanks into the landscape and mitigate any adverse visual effects;*
m. *For new access tracks whether the access supports conservation activities, farming or recreation activities, the ability to integrate with the landscape, follow natural contours and mitigate any adverse visual effects;*
n. *The extent to which the proposal has technical or operational needs for its location;*
o. *For proposed activities in connection with a recovery activity in the Flat Land Recovery Zone, the extent to which the qualities of the significant natural feature of the Avon River will be maintained; and*
p. *Within a Site of Ngāi Tahu Cultural Significance, the matters set out in Rule 9.5.5 as relevant to the site classification:*
    i. *Rule 9.5.5.1 - Wāhi Tapu / Wāhi Taonga, Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit;*
    ii. *Rule 9.5.5.2 - Ngā Tūranga Tūpuna; and*
    iii. *Rule 9.5.5.3 - Ngā Wai.*

Response

The rural character of the landscape reflects its modified state. The distinctive coastal cliffs and headland will remain intact. The most noticeable change will be the site undergoing a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. The landscape is considered to have the ability to absorb this change. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation (amenity) of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

9.6.2.1.1 Objective - The coastal environment

a. *People and communities are able to provide for their social, economic and cultural wellbeing and their health and safety, while maintaining and protecting the values of the coastal environment, including:*
    i. *indigenous biodiversity and the maintenance of the ecological function and habitats;*
    ii. *natural features and landscapes;*
    iii. *natural character;*
    iv. *historic heritage;*
    v. *Ngāi Tahu cultural values;*
    vi. *visual quality and amenity; and*
    vii. *recreation values.*

<u>Response</u>

The proposal is considered to maintain and enhance the intentions of this objective. The distinctive coastal cliffs are left intact and visible, with the headland remaining a dominant feature. The site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. Indigenous vegetation is generally accepted as a positive to enhance the appreciation (amenity) of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

9.6.2.2.1 Policy - Effects of activities on the coastal environment

a. *Ensure that subdivision, use and development is of a scale, and located, to maintain and protect the values of the coastal environment, including:*
    i. *indigenous biodiversity and the dynamic, complex and interdependent processes of ecosystems;*
    ii. *natural features and landscapes;*
    iii. *natural character, including the natural integrity and functioning of contributing and associated coastal processes;*
    iv. *historic heritage, recognising that historic heritage may span the line of mean high water springs;*
    v. *Ngāi Tahu cultural values;*
    vi. *visual quality and amenity values; and*
    vii. *recreation values.*
b. *Recognise and provide for the operation, maintenance, upgrade and development of strategic infrastructure and utilities that have a technical, locational or functional need to be located in the coastal environment.*

<u>Response</u>

Refer to the above response under *9.6.2.1.1 Objective - The coastal environment.*

Furthermore, the site has been chosen for its functional purpose of providing a location for strategic infrastructure which will irrigate indigenous revegetation with highly treated wastewater, replacing existing discharge into the Akaroa Harbour. In turn providing positive and improved community, ecosystem and cultural outcomes.

9.6.3 Rules - Matters of discretion

9.6.3.1 Effects of activities on the coastal environment

a. *The location, scale and intensity of the activity and/or buildings and the extent to which the proposal will adversely affect the values of the coastal environment, including:*
    i. *indigenous biodiversity and ecosystems;*
    ii. *natural character, natural landscapes and features, visual qualities and amenity values;*
    iii. *historic heritage; and*
    iv. *Ngāi Tahu – mana whenua cultural and traditional associations, 'Te Tai o Mahaanui' statutory acknowledgement area and Sites of Ngāi Tahu Cultural Significance identified in Appendix 9.5.6.*
b. *Whether the proposal will maintain or enhance public access to and along the coast, including:*
    i. *the potential for use and development to adversely affect existing customary access or public access to and along the coast; and*
    ii. *whether the location of public access has the potential to adversely affect public health and safety, Ngāi Tahu mana whenua, cultural values, including effects on Sites of Ngāi Tahu Cultural Significance identified in Appendix 9.5.6, mahinga kai, riparian vegetation, water quality and connections between fresh water resources, amenity values associated with freshwater, the coastal environment and their margins.*
c. *Whether any mitigation measures are proposed, including planting and restoration of natural character.*
d. *Extent to which the proposed subdivision, use or development is likely to result in adverse cumulative effects on the values of the coastal environment.*

e. Whether the proposal is susceptible to the effects of coastal hazards.
f. Whether the proposal supports coastal recreation activities and/or facilities.
g. The contribution the proposed subdivision, use or development activity makes to the social, cultural and economic wellbeing of people and communities.
h. Within a Site of Ngāi Tahu Cultural Significance identified in Appendix 9.5.6, the matters set out in Rule 9.5.5 as relevant to the site classification:
   i. 9.5.6.1 - Wāhi Tapu/Wāhi Taonga,
   ii. 9.5.6.2 - Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit;
   iii. 9.5.6.3 - Ngā Tūranga Tūpuna; and
   iv. 9.5.6.4 - Ngā Wai.

Response

The proposal is consistent with this rule. The distinctive coastal cliffs are left intact and visible, with the headland remaining a dominant feature. The site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. Indigenous vegetation is generally accepted as a positive to enhance the appreciation (amenity) of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

9.2.8.3 Natural character in the coastal environment

a. Whether the proposal is consistent with preserving the natural character qualities of the coastal environment;
b. Within areas of outstanding natural character in the coastal environment, whether adverse effects are avoided and the proposal does not damage, diminish or compromise natural character;
c. Within areas of at least high natural character, whether development can be practicably located outside the area of high natural character;
d. Whether any restoration or rehabilitation of the natural character of the coastal environment is proposed;
e. Whether the proposal recognises the context and values of historic and cultural significance and the relationship, culture and traditions of Ngāi Tahu;
f. Whether the development will integrate into the landscape and the appropriateness of the scale, form, design and finish (materials and colours) proposed and mitigation measures such as planting. Any adverse effects of reflectivity, glare and light spill;
g. The proximity and extent to which the proposal is visible from public places and roads (including unformed legal roads), ease of accessibility to that place, and the significance of the view point;
h. The extent to which natural elements such as landforms and vegetation within the site mitigate the visibility of development;
i. The capacity of the landscape to absorb change and the extent to which the opportunity has been taken to cluster built development in areas with a higher potential to absorb development while retaining areas which are more sensitive to change;
j. The extent to which the proposal will result in sprawling or sporadic development along the coastline and adverse cumulative effects;
k. Whether the proposal is connected with the need to provide water supply (for firefighting), and the ability to integrate water tanks into the landscape and mitigate any adverse visual effects;
l. For new access tracks, whether the access supports conservation activities, farming or recreation activities that are complementary to natural character, and the ability to integrate with the landscape, follow natural contours and mitigate any adverse visual effects;
m. The extent to which the proposal has technical or operational needs for its location; and
n. Within a Site of Ngāi Tahu Cultural Significance, the matters set out in Rule 9.5.5 as relevant to the site classification:
   i. Rule 9.5.5.1 - Wāhi Tapu / Wāhi Taonga, Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit;
   ii. Rule 9.5.5.2 - Ngā Tūranga Tūpuna;
   iii. Rule 9.5.5.3 - Ngā Wai.

Response

The proposal is consistent with this rule. The distinctive coastal cliffs are left intact and visible, with the headland remaining a dominant feature. The proposal does not add more built form the existing site. The proposal is considered to positively maintain and enhance the natural character of the coastal environment. The site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. Indigenous vegetation is generally accepted as a positive to enhance the appreciation (amenity) of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

9.5.2.2.2 Policy - Ngā Tūranga Tūpuna

a. *Recognise the historic and contemporary relationship of Ngāi Tahu with the areas and landscapes identified as Ngā Tūranga Tūpuna and:*
   i. *facilitate opportunities to provide information about the historic occupation or use of these areas by Ngāi Tahu and associated values;*
   ii. *incorporate representation of the association of Ngāi Tahu with these areas into the design of public buildings and/or community facilities, and in the subdivision and development or redevelopment of residential or commercial areas;*
   iii. *manage earthworks involving disturbance of soils below a depth not previously disturbed by cultivation or building foundations;*
   iv. *facilitate opportunities to enhance mahinga kai and other customary use of taonga species through planting and landscaping;*
   v. *enhance the natural character and cultural values of water bodies, waipuna / springs, repo / wetlands and coastal waters, including reinstating original water courses where practicable;*
   vi. *maintain or restore natural features with cultural values within these areas; and*
   vii. *ensure that cultural values are recognised and provided for in the design, location and installation of utilities, while enabling their safe, secure and efficient installation.*

<u>Response</u>

It is understood the local Iwi and Runanga have been engaged with or will be engaged with to provide specific input into the design and outcomes of the project. The proposal is considered consistent with the intention of this policy through providing opportunity for cultural associations and interpretation. Proposed indigenous revegetation uses some taonga species and enhances the natural character of the site.

9.5.5.2 Ngā Tūranga Tūpuna

a. *The effects of the proposed activity on Ngāi Tahu values and the appropriateness of any mitigation measures;*
b. *Effects on sites of archaeological value including consideration of the need to impose an accidental discovery protocol or have a cultural monitor present;*
c. *The extent to which the proposed development or activity recognises and incorporates Ngāi Tahu history, identity and values into development or redevelopment within these areas;*
d. *Whether the proposal maintains or restores natural features with cultural values within these areas;*
e. *Whether the relevant Papatipu Rūnanga has been consulted, the outcome of that consultation and whether the development or activity responds to, or incorporates the outcome of that consultation;*
f. *Whether the proposal provides an opportunity to recognise Ngāi Tahu culture, history and identity associated with specific places and affirms connection between mana whenua and place;*
g. *Whether any site of historic Ngāi Tahu occupation will be disturbed;*
h. *The provision of information on Ngāi Tahu history and association with the area;*
i. *The effect of removing indigenous vegetation on mahinga kai and other customary uses; and*
j. *In respect of utilities, the extent to which the proposed utility has technical or operational needs for its location.*

<u>Response</u>

As above, it is understood the local Iwi and Runanga have been engaged with or will be engaged with to provide specific input into the design and outcomes of the project. The proposal is considered consistent with the intention of this policy through providing opportunity for cultural associations and interpretation. Proposed indigenous revegetation uses some taonga species and enhances the natural character of the site.

3.2.4 HAMMOND POINT EFFECTS ON VISUAL AMENITY

Visual amenity is a measure of the visual quality of a landscape as experienced by people living in, working in, or travelling through it. Visual amenity is invariably associated with the pleasantness, memorability and aesthetic coherence of an area or a view. The degree of visual effect relates to the visibility of the proposal, both within and beyond the application site. Generally speaking, the closer people are to a development, the greater visual effects there will be.

In terms of visual effects relating to the proposal, the proposed indigenous revegetation is considered a positive effect on visual amenity, likely improving the pleasantness and appreciation of the area, as well as enhancing indigenous biodiversity, ecological values, and cultural associations. Though the revegetation will change the landuse and landcover from open pastoral rural landscape to one that is planted, vegetation is commonly considered to enhance amenity values. The revegetation will not look out of place, more an extension to the existing regenerating indigenous vegetation currently flanking the north and south boundaries of the site. The revegetation also has the practical and project purpose of highly treated wastewater uptake through irrigation. Proposed walking tracks for recreational use, as well as opportunities for educational, historical and cultural awareness through interpretation signage, will enhance user experience, in turn providing a positive memorability of the landscape.

The proposal is assessed as having a **positive** effect on the amenity values of the site, increasing overtime as vegetation establishes.

<u>Visual Assessment</u>

The visual context of the receiving environment is considered to be a 5000m offset from proposed application site. This distance has been determined by the scale of the proposal and the openness of the receiving environment. At distances further than 5000m from the proposal site, when view at a macro scale will integrate with the wider rural amenity and landscape of Banks Peninsula. A series of key viewpoints were selected to show a representative sample of the likely visual effects which could result from the proposal (refer to Appendix 2, page 19). Viewpoints are generally located on public land, and where practical located as close as possible to existing or proposed dwellings or other key viewpoints. In assessing the potential effects of a proposal, the quality and openness of the view is considered. The viewpoints selected were as follows:

1) VP1 – View south-west at entrance to site
2) VP2 – View south from Archdalls Road
3) VP3 – View south from 6395 Christchurch Akaroa Road (H75), Robinsons Bay
4) VP4 – View north-east from 403 Wainui Main Road (looking across Akaroa Harbour to site)
5) VP5 – View East from Ōnawe Peninsula track

In assessing the potential effects on visually sensitive receptors, the key viewpoints outlined above have been used as a reference point where it is considered that the effects are likely to be similar to the viewpoint and for a group of viewers. The viewpoint is a representative view, as close as possible to the view likely to be experienced from a private residence or property but obtained from a public location.

The following table outlines the potential visual effects each Visually Sensitive Receptor might receive and how the effects may potentially be mitigated. The effects take into account the type of receptor, combined with the likely magnitude of effects (a combination of distance from the proposal and degree of change) to determine what the likely residual effects from the proposal will be. Mitigation measures are outlined in Section 4.

Table 2: Assessment of Effects on Visually Sensitive Receptors (Hammond Point Site)

Viewpoint	Visually Sensitive Receptors (VSR)	Distance from Proposal (m)	Type of View (open, partial, screened)	Magnitude of Change	Mitigation Measures	Effects after mitigation
1	Vehicle Users along SH75	10	Open	Very Low	MM6	Nil
2	Vehicle Users along Archdalls Road	1200	Partial	Nil	MM6	Nil
	Residents at Archdalls Road which look south	1200	Partial	Very Low	MM6	Nil
3	Vehicle Users along SH75	1000	Open	Very Low	MM6	Nil
	Residents at 6395 Christchurch Akaroa Rd (and nearby residents)			Very Low		Nil
4	Vehicle Users along Wainui Main Road	4000	Open	Very Low	MM6	Nil
	Residents at 403 Wainui Main Road			Very Low		Nil
5	Recreation User along Ōnawe Peninsula track	2200	Open	Very Low	MM6	Nil

3.2.5 HAMMOND POINT SUMMARY OF EFFECTS ON VISUAL AMENITY

The most visually apparent change in terms of visual effects, will be the change in landuse and landcover from open pastoral rural landscape to one that is planted with indigenous vegetation. The landform will remain the same with the existing steep distinctive coastal cliffs unchanged and the characteristic headland retaining its dominance. Existing human made features within the site, such as the access track and powerlines also remain changed. Residual effect from theses existing features will likely reduce over time as result of the proposed revegetation. The site will visually become increasing natural in appearance as vegetation matures and natural succession takes place having a **positive** effect on amenity values. Effects on the identified visually sensitive receptors are summarised as follows:

Effects on road users

Where the proposal is visible from SH75 views are of short duration as vehicles, cyclists, and the like transit past the site, with only the proposed revegetation being visible. Views of the site from this location will appear continuous with the flanking vegetation and is characteristic of indigenous roadside vegetation seen throughout Banks Peninsula. Available views from more distant roads, including unformed legal roads, are back dropped by topography and/or existing vegetation or ameliorated by distance and viewed in context of the surrounding large-scale landscape. The sensitivity of road users is considered less given the transient nature and speeds moving past the site and attention to the road required.

Visual effects of the proposal for road users, cyclists and the like are assessed **very low (or less than minor)**, with likely nil residual effects. The proposed indigenous revegetation will likely have a **positive** visual effect resulting from the proposal.

Effects on nearby residents

Due to the more static nature of residences, the landscape can be examined in finer detail and visual effects are therefore likely to be more apparent. Views of the proposal are possible from some residences in Robinsons Bay / Ngaio Point, Takamātua Bay and where residences are overlooking the site from other surrounding hillside and bay locations within the Akaroa Harbour Basin. Many of these residences are of a separation from the site where available views are ameliorated by distance and viewed in context of the surrounding large-scale landscape, reducing any perceived visual effects. The proposal is predominately revegetation of the site and will appear as a continuation or infilling to the sites existing vegetation changing the landuse and landcover to indigenous vegetation.

Visual effects of the proposal for residents are assessed as **very low (or less than minor)**, with likely nil residual effects. The proposed indigenous revegetation will likely have a **positive** visual effect resulting from the proposal.

Effects on Recreationists

Views of the site are available from harbour water users and those walking along Ōnawe Peninsula track. These views are generally at the same elevation to the site, or more often below the elevation of the site. From these viewpoints the existing steep distinctive coastal cliffs remain the dominant feature of this headland. The proposal will atop these cliffs with indigenous vegetation and take on a comparative visual appearance to the existing cliffs with vegetation to the north of the site. The proposed revegetation will appear as a continuation or infilling to the sites existing vegetation, changing the landuse and land cover to indigenous vegetation.

Visual effects of the proposal for recreationists are assessed as **very low (or less than minor)**, with likely nil residual effects. The proposed indigenous revegetation will likely have a **positive** visual effect resulting from the proposal.

3.3 OLD COACH ROAD

3.3.1 OLD COACH ROAD EXISTING SITE CHARACTER

The site is located on a long, distinctive spur which descend gradually from the higher ridgeline, forming the prominent Takamātua headland separating the Akaroa township from Takamātua Bay to the north. Landcover on this headland is primarily pasture, with indigenous vegetation concentrated in gullies and around the foreshore. The site is bound by SH75 to the north, south and west, with Old Coach Road forming the eastern boundary.

This site is an unbuilt setting and currently used as a hay paddock, with the lower slopes grazed or cloaked in regenerating indigenous kanuka forest. Access to the site is via the farm gate off Old Coach Road, close to the intersection with Long Bay Road, and opposite the WWTP site. The existing WWTP is most apparent built form in proximity to the site. Nearby residences and structures around this area are predominately nestled amongst indigenous vegetated slopes. Vegetation within the site is a mix of modified pastoral grasslands, exotic amenity planting and regenerating indigenous forest.

In terms of sensory qualities, the site offers a changing landscape with its proximity to the Akaroa township. Views are at lower elevations and more confined by topography and existing vegetation. Generally, the atmosphere is quiet, while the air is fresh and clear with identifiable aromas.

3.3.2 OLD COACH ROAD EFFECTS ON LANDSCAPE CHARACTER

Landscape character is the combination and composition of biophysical elements such as topography, vegetation, built form and sensory qualities perceived by humans, which also encompasses spiritual, cultural, and social associations. Change to the character of a landscape may not necessarily be adverse. Whether effects are adverse or not depends to a large extent on public expectation of what can be reasonably anticipated to occur in the landscape. Linked to this is the landscape context in terms of its existing degree of naturalness/modification, patterns, scale, visibility and levels of public appreciation, and the capacity of the landscape to absorb change. The likely tangible effects on landscape character from the proposal are considered as the following;

<u>Proposed tank and associated earthworks</u>

The rural character of the landscape reflects its modified state, where an expectation of farming infrastructure, utilities, and small scale 'man made' infrastructure is present within the landscape. The introduction of the untreated wastewater tank with cover and associated earthworks may not be entirely unexpected, with tanks commonly seen throughout the rural landscape. The proposed tank with cover is up to 30m diameter, and approximately 3.7m above ground level to apex of roof, nestled amongst proposed indigenous revegetation. This encapsulation by vegetation is consistent with the surround context, where residences and other structures are integrated and partially absorbed by the regeneration indigenous forest. The tank is considered to create an increased intensity of infrastructure within the rural landscape due to its scale, however at an elevation comparable to surrounding development (built form). This is not necessarily adverse and when considered within the landscape context, does not result in a reduction of naturalness due to the sites already modified (rural) state and does not fundamentally change the character of the site, which remains rural. The proposed tank is not considered to give rise to cumulative effects due to the proposal continuity with the interaction between built form surrounded by vegetation. The landscape is considered to have a **low** ability to absorb this change and is further discussed below with regard to effects on visual amenity and the proposed mitigation measures.

The proposed location of the tank (within the application site) is a naturally flatter slope area helping reduce the overall earthworks required to construct the tank platform. The proposal cuts the tank platform into the existing topography, recessing the tank it into the landscape. Consequently, any preserved adverse landscape effects will be temporary during construction and diminish over time as vegetation establishes with likely no residual effects.

The proposed tank and associated earthworks are assessed as having a **low (or less than minor)** effect on the overall landscape character of the site and wider receiving environment, reducing to **very low (or less than minor)** with the proposed mitigation measures and revegetation establishing over time.

<u>Proposed subsurface wetland</u>

Constructed west of the tank, the proposed subsurface wetland provides a storage facility for treated wastewater in addition to the storage tanks proposed for the Robinsons Bay Valley site, as well as for emergency storage if the tanks are unavailable. The subsurface wetland will largely go unnoticed due to the topography and orientation of the site. It is proposed to be planted with indigenous wetland species giving a naturalised character, further enhanced with cultural narrative.

The proposed subsurface wetland is assessed as having a **very low (or less than minor)** effect on the landscape character and wider receiving environment.

<u>Change in Landuse and Landcover</u>

While the most noticeable built form of the proposal will be the untreated wastewater tank with cover and proposed public carpark. The majority of the site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance. A perceived effect on the existing landscape character could be the loss of openness, an attribute closely associated with the appearance and appreciation of the rural landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposed planting will not look out of place in the landscape context of the site, which contains existing clusters and gullies of regenerating indigenous vegetation. Planting will look like an extension or infill of the existing vegetation and not visually obscure dominant landforms, which remains as the prominent ridgelines, peaks, gullies, spurs, and rock outcrops. The landscape proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks, interpretation signage and cultural narrative.

The proposed revegetation is assessed as having a **very low (or less than minor)** effect on the landscape character and is considered a **positive** effect for the site and wider receiving environment.

3.3.3 OLD COACH ROAD EFFECTS ON LANDSCAPE VALUES

The site is located within the Rural Banks Peninsula Zone and the proposal is considered a discretionary activity. The proposal has been assessed against the relevant Objectives, Policies and Rules of the Christchurch District Plan (CDP) which relate to landscape character and visual amenity. The proposal is also located within several overlays (listed under 2.1.4.3 of this report), of relevance for specific assessment is the Rural Amenity Landscape (RAL), Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit (*14a, 15a*), Wahi Tapu/Wahi Taonga and Ngā Tūranga Tūpuna. The effects on Landscape Values are considered and assessed in the related statutory context and matters of direction below:

Chapter 17 Rural (CDP),

Objective 17.2.1.1 – The rural environment

a. Subdivision, use and development of rural land that:

i. supports, maintains and, where appropriate, enhances the function, character and amenity values of the rural environment and, in particular, the potential contribution of rural productive activities to the economy and wellbeing of the Christchurch District;

ii. avoids significant, and remedies or mitigates other reverse sensitivity effects on rural productive activities and natural hazard mitigation works;

iii. maintains a contrast to the urban environment; and

iv. maintains and enhances the distinctive character and amenity values of Banks Peninsula and the Port Hills, including indigenous biodiversity, Ngāi Tahu cultural values, open space, natural features and landscapes, and coastal environment values.

Response

The proposal is consistent with this objective, the character of the landscape will remain rural. The proposed tank could be perceived as being part of the rural working landscape and the proposal provides a greater wellbeing for the residents, economy, and environment by removing historic 'wastewater' disposal into the harbour. Overtime the proposal will reduce the existing pastoral openness of the site through planting the site with indigenous revegetating. This is not considered out of character for the site where existing gullies are regenerating with indigenous vegetation and nestling existing surrounding built form and development into the landscape. Furthermore, planting is considered a positive enhancement for naturalness, amenity values and enhances indigenous biodiversity, ecological values, and cultural associations. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident. The landscape proposal for the subsurface wetland has been collaborated with and design by the local Ōnuku runanga to enrich cultural associations and interpretation within the project.

Policy 17.2.2.3 – Contributing elements to rural character and amenity values

a. Recognise that rural character and amenity values vary across the Christchurch District resulting from the combination of natural and physical resources present, including the location and extent of established and permitted activities.

b. Recognise that the elements that characterise an area as rural, from which desired amenity is derived, include the predominance of:

i. a landscape dominated by openness and vegetation;

ii. significant visual separation between residential buildings on neighbouring properties;

iii. where appropriate, buildings integrated into a predominantly natural setting; and

iv. natural character elements of waterways, water bodies, indigenous vegetation and natural landforms, including the coastal environment where relevant.

c. Recognise that rural productive activities in rural areas can produce noise, odour, dust and traffic consistent with a rural working environment, including farming, plantation forestry and quarrying activities, that may be noticeable to residents and visitors in rural areas.

Response

The proposal is considered consistent with this policy and will largely retain the valued openness and vegetated character typical of the rural landscape, albeit it one that is more vegetated over time. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident. The tank location is well positioned to be screened from nearby dwellings and retains the characteristic of the rural working landscape. Proposed vegetation will act as mitigation to partiality screen and soften potential visibility of the tank, though potential viewpoints are limited and at a separation where distance ameliorates potential adverse effects. The predominance of naturalisation will be enhanced through the use of indigenous vegetation.

Policy 17.2.2.8 – Rural Banks Peninsula

a. Ensure that subdivision, use and development in the Rural Banks Peninsula Zone recognises, maintains and, where practicable, enhances the quality of the rural working environment by:
   i. restricting the scale, location and reflectivity of buildings to maintain a low density of built form that is not visually dominant and does not detract from views of cultural landscapes identified in the District Plan, sites of Ngāi Tahu cultural significance, or natural landforms and features;
   ii. encouraging the protection, maintenance and enhancement of indigenous biodiversity, natural features and landscapes, historic heritage, coastal environment values, and open space; and
   iii. encouraging public walking and cycling access connections where appropriate.

Response

The proposal locates the tank on a naturally flatter slope which reduces the earthworks extent and volumes, while utilising the slope to recess the tank into the landscape. The tank will not break the skyline from any vantage point and where open views are available, the tank is back dropped by topography and/or the existing vegetation. Mitigation measures such as indigenous revegetation and use of a low reflective value recessive colours for the tank will aid in reducing visual effects, to not detract from the character and dominance of the surround landscape.

Existing vegetation is mostly retained with only minimal removal likely required to construct the tank platform and subsurface wetland. Retention of the existing vegetation provides immediate partial screening and softening of the works. The proposal enhances the predominance of indigenous vegetation.

The proposal allows for public access through the formation of a carpark accessed off Old Coach Road and creation of walking tracks for recreation. The proposal maintains and enhances identified historical and cultural associations within the site.

Chapter 9 Natural and Cultural Heritage (CDP),

Policy 9.2.2.2.5 Recognising and maintaining the qualities of rural amenity landscapes

a. Recognise the qualities of the identified rural amenity landscapes described in Appendix 9.2.9.1.4 and maintain them by:
   i. avoiding use and development that breaks the skyline, including the crater rim, ridgelines on Banks Peninsula and radial spurs of the Port Hills;
   ii. avoiding visually prominent development;
   iii. ensuring subdivision, use and development does not result in over domestication of the landscape;
   iv. requiring development to be separated from identified important ridgelines on Banks Peninsula, taking into account visual separation and horizontal and vertical separation; and
   v. enabling farming, conservation activities and recreation activities which contribute to rural landscape character of Banks Peninsula.

Response

The proposed tank is not considered to visually break the skyline from available viewpoints and is sufficiently separated from important ridgelines to not detract from their dominance. While the tank will introduce infrastructure not previously seen within the site, it may not be entirely unexpected, with tanks commonly seen throughout the rural landscape. The tank is located well within the site and is in keeping with the surrounding development, which is built form nestled amongst indigenous vegetated slopes. Proposed surrounding vegetation as mitigation aims to partially screen and soften the visual dominance of the tank, noting that potential viewpoints are limited and at a separation where distance ameliorates potential adverse effects.

The proposal supports conservation activities through a predominance of proposed indigenous revegetation. Recreational activities are provided through the creation of a carpark and walking tracks.

Appendix 9.2.9.1.4 Rural amenity landscapes

a. The following are the Christchurch District's identified rural amenity landscapes and their qualities:
   i. Banks Peninsula:
      A. A predominantly farming, rural working landscape.
      B. Distinctive volcanic landforms with highly legible crater rims, prominent ridgelines and peaks extending to a series of gullies, spurs and lower slopes, and continuity of rock outcrops.
      C. The presence of important areas of indigenous vegetation.
      D. Important landscapes and features to Ngāi Tahu especially those prominent peaks and passes, streams and vegetation that relate to key tribal origin, migration and settlement traditions, including mahinga kai.
      E. A predominance of natural features, processes and patterns with existing development generally well integrated into the landscape.
      F. Within the coastal environment, the presence of generally highly legible landforms, visually impressive cliffs, islands and caves.
      …

<u>Response</u>

The proposal is considered consistent with this policy and will largely retain the valued openness and vegetated character typical of the rural landscape, albeit it one that is more vegetated over time. The surrounding large-scale landscape remains dominated by openness and vegetation, with distinctive natural landform and processes continuing to be evident. The tank location is sufficiently separated from nearby ridgelines and natural features to not detract from them. Proposed vegetation will act as mitigation to partiality screen and soften potential visibility of the tank and will integrate it within the landscape and provide an enhanced sense of natural character.

9.2.8.2 Significant features and rural amenity landscapes

a. Whether the proposal is consistent with maintaining the qualities of the significant feature and/or rural amenity landscape;
b. Any adverse effects on adjoining outstanding natural features, outstanding natural landscapes or natural character in the coastal environment, and whether there is a sufficient separation to avoid detracting from the qualities of those areas. When assessing separation, account shall be taken of visual separation, vertical and horizontal setback distances and retention of indigenous vegetation;
c. On Banks Peninsula, the extent to which the proposal will detract from visual amenity landscape values. This shall include consideration of the extent to which the proposal is consistent with design guidance;
d. Within greater Christchurch (including the Port Hills), the extent to which the proposal will detract from the natural landscape values;
e. Whether the proposal recognises the context and values of historic and cultural significance and the relationship, culture and traditions of Ngāi Tahu;
f. Whether the proposal will integrate into the landscape and the appropriateness of the scale, form, design and finish (materials and colours) proposed and mitigation measures such as planting. This shall include consideration of any adverse effects of reflectivity, glare and light spill;
g. The proximity and extent to which the development is visible from public places and roads (including unformed legal roads), ease of accessibility to that place, and the significance of the view point;
h. The extent to which natural elements such as landforms and vegetation within the site mitigate the visibility of development;
i. The capacity of the landscape to absorb change and the extent to which opportunity has been taken to cluster built development in areas of existing built development with a higher potential to absorb development while retaining areas which are more sensitive to change;
j. The extent to which the proposal will result in adverse cumulative effects;
k. Whether the proposal supports the continuation of farming activities in rural zones;
l. Whether the proposal is connected to reticulated water and the need to provide water supply (for firefighting), and the ability to integrate water tanks into the landscape and mitigate any adverse visual effects;
m. For new access tracks whether the access supports conservation activities, farming or recreation activities, the ability to integrate with the landscape, follow natural contours and mitigate any adverse visual effects;
n. The extent to which the proposal has technical or operational needs for its location;

o. *For proposed activities in connection with a recovery activity in the Flat Land Recovery Zone, the extent to which the qualities of the significant natural feature of the Avon River will be maintained; and*

p. *Within a Site of Ngāi Tahu Cultural Significance, the matters set out in Rule 9.5.5 as relevant to the site classification:*
   i. *Rule 9.5.5.1 - Wāhi Tapu / Wāhi Taonga, Mahaanui Iwi Management Plan Silent Files and Kaitōrete Spit;*
   ii. *Rule 9.5.5.2 - Ngā Tūranga Tūpuna; and*
   iii. *Rule 9.5.5.3 - Ngā Wai.*

Response

The rural character of the landscape reflects its modified state, where an expectation of farming infrastructure, utilities, and small scale 'man made' infrastructure is present within the landscape. The introduction of the tank and associated earthworks may not be entirely unexpected. While the tank will introduce new infrastructure into the landscape this is not necessarily adverse and when considered within the landscape context, does not result in a reduction of naturalness due to the sites already modified (rural) state and does not fundamentally change the character of the site, which remains rural. The tank proposal is not considered to give rise to cumulative effects due to the exiting site having no built form, the physical separation from nearby by development and is in keeping with the surrounding development, which is generally nestled amongst indigenous vegetated slopes. The landscape is considered to have the ability to absorb this change due to its modified (rural) state and dominance of the surround large scale landscape, further enhanced with proposed mitigation measures outlined below, such as using recessive colours with a low reflective value.

While the most noticeable built form change of the proposal will be the tank, the majority of the site will undergo a transition from open pastoral farmland to one that is planted with indigenous revegetation and will exhibit a more 'naturalised' appearance integrating the tank (and subsurface wetland) into the landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposal also includes recreational, educational, historical, and cultural opportunities through the introduction of walking tracks and interpretation signage.

9.5.2.2.2 Policy - Ngā Tūranga Tūpuna

a. *Recognise the historic and contemporary relationship of Ngāi Tahu with the areas and landscapes identified as Ngā Tūranga Tūpuna and:*
   i. *facilitate opportunities to provide information about the historic occupation or use of these areas by Ngāi Tahu and associated values;*
   ii. *incorporate representation of the association of Ngāi Tahu with these areas into the design of public buildings and/or community facilities, and in the subdivision and development or redevelopment of residential or commercial areas;*
   iii. *manage earthworks involving disturbance of soils below a depth not previously disturbed by cultivation or building foundations;*
   iv. *facilitate opportunities to enhance mahinga kai and other customary use of taonga species through planting and landscaping;*
   v. *enhance the natural character and cultural values of water bodies, waipuna / springs, repo / wetlands and coastal waters, including reinstating original water courses where practicable;*
   vi. *maintain or restore natural features with cultural values within these areas; and*
   vii. *ensure that cultural values are recognised and provided for in the design, location and installation of utilities, while enabling their safe, secure and efficient installation.*

Response

It is understood the local Iwi and Runanga have been engaged with to provide specific input into the design and outcomes of the project. The proposal is considered consistent with the intention of this policy through providing opportunity for cultural associations and interpretation. Proposed indigenous revegetation uses some taonga species and enhances the natural character of the site.

9.5.5.2 Ngā Tūranga Tūpuna

a. *The effects of the proposed activity on Ngāi Tahu values and the appropriateness of any mitigation measures;*
b. *Effects on sites of archaeological value including consideration of the need to impose an accidental discovery protocol or have a cultural monitor present;*
c. *The extent to which the proposed development or activity recognises and incorporates Ngāi Tahu history, identity and values into development or redevelopment within these areas;*
d. *Whether the proposal maintains or restores natural features with cultural values within these areas;*
e. *Whether the relevant Papatipu Rūnanga has been consulted, the outcome of that consultation and whether the development or activity responds to, or incorporates the outcome of that consultation;*
f. *Whether the proposal provides an opportunity to recognise Ngāi Tahu culture, history and identity associated with specific places and affirms connection between mana whenua and place;*
g. *Whether any site of historic Ngāi Tahu occupation will be disturbed;*
h. *The provision of information on Ngāi Tahu history and association with the area;*
i. *The effect of removing indigenous vegetation on mahinga kai and other customary uses; and*
j. *In respect of utilities, the extent to which the proposed utility has technical or operational needs for its location.*

<u>Response</u>

As above, it is understood the local Iwi and Runanga have been engaged with to provide specific input into the design and outcomes of the project. The proposal is considered consistent with the intention of this policy through providing opportunity for cultural associations and interpretation. Proposed indigenous revegetation uses some taonga species and enhances the natural character of the site.

3.3.4 OLD COACH ROAD EFFECTS ON VISUAL AMENITY

Visual amenity is a measure of the visual quality of a landscape as experienced by people living in, working in, or travelling through it. Visual amenity is invariably associated with the pleasantness, memorability and aesthetic coherence of an area or a view. The degree of visual effect relates to the visibility of the proposal, both within and beyond the application site. Generally speaking, the closer people are to a development, the greater visual effects there will be.

In terms of visual effects relating to the proposal, the tank and associated earthworks will be the most visually apparent (built form) change that will effect existing amenity values. This visual assessment has therefore been mostly focused on the tank with the other elements such the proposed car park, subsurface wetland, indigenous revegetation of the site, recreational tracks, and cultural features and narrative, all considered to have less effect or indeed have a positive effect on amenity values.

The greatest effects will be experienced from vantage points directly ‘across’ from the tank where views are at or above the same elevation. Generally, at the lower elevations, the site’s topography and existing vegetation intervene, screening visibility of the tank. Visibility of the tank may not be entirely unexpected to the viewer in the context of the rural working landscape.

Visual effects from the associated earthworks will be temporary for the duration of the tank platform construction. Effects will reduce once cut material is contoured to sympathetically integrate with the existing landform (or removed from site) and vegetated with exotic grass for erosion and sediment control. As the proposed indigenous revegetation establishes around the tank, any perceived residual effects of earthworks will be diminished, likely not apparent at all, and will take on a naturalised appearance. Despite this visual change and the technical project parameters for this location, the tank is well located to mitigate potential adverse visual effects. The tank will not break the skyline from any vantage point and where open views are available of the tank, it is back dropped by topography and/or the existing vegetation. The tank site is also at an elevation that there are few dwellings which overlook the site or they are of a separation to the site where visibility is ameliorated by distance.

Residual effects on visual amenity will likely be **low**, with the mitigation measures (over time) achieving an integration and softening of the tank into the landscape. The proposed tank and associated earthworks are assessed as having a **low (or less than minor)** temporary effect on visual amenity owing to the tank location with the application site and the limited viewpoints from nearby dwellings, recreational areas, and public roads. Effects will reduce to **very low (or less than minor)** as proposed vegetation surround the tank establishes over time.

Other elements of the proposal, such as the proposed car park, subsurface wetland, indigenous revegetation of the site, recreational tracks, and cultural features and narrative are considered compatible with existing amenity of the site. The proposed indigenous revegetation is considered a **positive** effect on visual amenity, likely improving the pleasantness and appreciation of the area, as well as enhancing indigenous biodiversity, ecological values, and cultural associations. Though the revegetation will change the landuse and landcover from open pastoral rural landscape to one that is planted, vegetation is commonly considered to enhance amenity values. The revegetation will not look out of place, more an extension to the existing regenerating indigenous vegetation currently spread across site and surrounding hills and gullies. Walking tracks for recreational use, as well as opportunities for educational, historical and cultural associations through interpretive design and signage will enhance user experience, in turn providing a positive memorability of the landscape. These elements are assessed as having a **positive** effect on amenity values of the site.

<u>Visual Assessment</u>

The visual context of the receiving environment is considered to be a 5000m offset from proposed tank site location within the application site due to this being the most noticeable change. This distance has been determined by the scale of the proposal and the openness of the receiving environment. At distances further than 5000m it is unlikely to be unnoticeable due to the site being viewed at a macro scale and effects ameliorated by distance. A series of key viewpoints were selected to show a representative sample of the likely visual effects which could result from the proposal (refer to Appendix 2, page 31). Viewpoints are generally located on public land, and where practical located as close as possible to existing or proposed dwellings or other key viewpoints. In assessing the potential effects of a proposal, the quality and openness of the view is considered. The viewpoints selected were as follows:

1) VP1 – View north-west from 80 Old Coach Road
2) VP2 – View west from 39 Long Bay Road
3) VP3 – View north-east from Main Wharf
4) VP4 – View north from 40 Lighthouse Road

In assessing the potential effects on visually sensitive receptors, the key viewpoints outlined above have been used as a reference point where it is considered that the effects are likely to be similar to the viewpoint and for a group of viewers. The viewpoint is a representative view, as close as possible to the view likely to be experienced from a private residence or property but obtained from a public location.

The following table outlines the potential visual effects each Visually Sensitive Receptor might receive and how the effects may potentially be mitigated. The effects take into account the type of receptor, combined with the likely magnitude of effects (a combination of distance from the proposal and degree of change) to determine what the likely residual effects from the proposal will be. Mitigation measures are outlined in Section 4.

Table 2: Assessment of Effects on Visually Sensitive Receptors (Old Coach Road Site)

Definition: With regard to 'Distance from Proposal', for this Old Coach Road site the measurement is to the tank location, being the likely most apparent change to effect existing amenity values.

Viewpoint	Visually Sensitive Receptors (VSR)	Distance from Proposal (m)	Type of View (open, partial, screened)	Magnitude of Change	Mitigation Measures	Effects after mitigation
1	Vehicle Users on Old Coach Road	0	Open	Low	MM1,MM3 ,MM4,MM 5,MM6	Less than Minor
2	Vehicle Users on Long Bay Road	70	Open	Low	MM1,MM3 ,MM4,MM 5,MM6	Less than Minor
3	Pedestrians on Main Wharf	2000	Open/ Partial	Very low	MM1,MM3 ,MM4,MM 5,MM6	Less than Minor
4	Vehicle Users on Lighthouse Road	3100	Open	Very low	MM1,MM3 ,MM4,MM 5,MM6	Less than Minor

3.3.5 OLD COACH ROAD SUMMARY OF EFFECTS ON VISUAL AMENITY

The most visually apparent change in terms of visual effects will be the tank, with the greatest effects experienced from vantage points directly 'across' from the tank where views are at or above the same elevation. Views of the proposal from the formed roads are generally limited to Old Coach Road, Long Bay Road and to a lesser extent Akaroa Main Wharf and Lighthouse Road. Some unformed legal roads within the visual catchment will have the same or similar available views of the site as the formed legal roads, though less frequented. For the purpose of this assessment the formed legal road viewpoints and the likely visual effects are considered representative of those likely from the unformed legal roads. Effects on the identified visually sensitive receptors are summarised as follows:

Effects on road users

Where the proposal is visible from the roads as outlined above, views are confined to intermittent 'snapshots' of the site and back dropped by topography and/or existing vegetation and/ or viewed in context of the surrounding large-scale landscape and ameliorated by distance. The sensitivity of road users, mainly motorists and cyclists, is considered less given the transient nature and speeds moving past the site and attention to the road required, reducing visual effects arising specifically from the tank. Any perceive visual effects of the proposed car park, subsurface wetland, revegetation, and tracks within the site will potentially go unnoticed and likely viewed as expected within the landscape context and/or viewed as a **positive** effect of the proposal.

Visual effects of the proposal for road users are assessed as **very low (or less than minor)**, with any perceived residual visual effects reduced by mitigation measures as outlined below, and over time. The proposed indigenous revegetation will likely have a **positive** visual effect.

<u>Effects on nearby residents</u>

There are no views possible from nearby residences due to the site elevation, existing topography, and existing vegetation. Residences are more static nature allowing the landscape to be examined in finer detail and visual effects are therefore likely to be more apparent. Though infrastructure of this kind may not entirely be unexpected within the rural landscape context, the scale and bulk of the tank could create potential adverse visual effects on the current amenity enjoyed. In all instances, any potential available views of the tank from residences are ameliorated by distance and back dropped or intervened by topography and/or existing vegetation. The selection of a recessive, non-reflective colour(s) for the tank and eventual screening by the proposed indigenous vegetation will aid in mitigating any perceived visual effects and will diminish over time.

Visual effects of the proposal for residents are assessed as **low (or less than minor)** temporary effect on visual amenity owing to the site location, elevation, and available viewpoints from nearby residences. Effects will reduce to **very low (or less than minor)** as vegetation establishes over time. The proposed indigenous revegetation will likely have a **positive** visual effect, once established, on amenity values.

4. MITIGATION MEASURES

The following mitigation measures are suggested to either avoid, remedy, or mitigate any potential adverse effects on Landscape Character, Landscape Values and/or Visual Amenity. The below measures are not relevant to all sites. Applicable sites have been noted against each measure.

MM1	**EARTHWORKS**	**APPLICABLE SITES**
	Earthworks should aim to be minimising and where practical retain existing vegetation. Cuts should be made and/or finished to follow the natural contours and should avoid the creation of ‘unnatural’ straight lines within the landscape. To manage temporary effects of earthworks, cut material retained on site shall be shaped and contoured to sympathetically integrate with the surrounding natural landform. Slope/ batters should vary and shall not be one continuous grade.	Robinsons Bay Valley and Old Coach Road
MM2	**NEW ACCESS TRACK**	**APPLICABLE SITES**
	Track alignment should be carefully considered with the intent of minimising earthworks and flowing the natural contour to avoid the creation of ‘unnatural’ landform and straight lines within the landscape. Where possible existing vegetation should be retained and utilised as screening for the track. Consideration should be given to the existing tracks and appropriate upgrade of these where existing landscape and visual effects are known.	Robinsons Bay Valley

MM3	**SCALE and FORM**	**APPLICABLE SITES**
	Regarding the most visible infrastructure (water storage tanks), should be of a scale and form shown in the proposal and clustered in arrangement to reduce overall footprint of the development. Where possible, tanks should be recessed into the surrounding ground level using the natural topography to reduce overall height and bulk of the tank(s). It is understood the tanks cannot be partially buried due to operational inspection requirements of tank edges.	Robinsons Bay Valley and Old Coach Road
MM4	**COLOUR**	**APPLICABLE SITES**
	The water storage tanks, including covers and axillary pump control buildings to be finished in a low reflective, recessive colours/ materials to blend in with the surrounding landscape to minimise the visibility of the tanks, particularly when viewed from locations at or above the same elevation of the tanks. A colour consistent with the surroundings and proposed revegetation is suggested, as this will mostly likely reduce any residual effects in the longer term once surrounding vegetation has established. A maximum LRV rating of 40% is recommended, as per CDP rule 17.4.2.2. (Of note, many darker colours sit within the 5% to 20% LRV range. Darker colours are encouraged). Consideration should be given to using a variety colours for each tank with the intent to break up the monotony. Use of only one colour could potentially highlight the scale of the tank(s).	Robinsons Bay Valley and Old Coach Road
MM5	**VEGETATION – Existing**	**APPLICABLE SITES**
	Where possible existing established and intervening vegetation should be retained to reduce the impacts of the proposals and maintain the existing coherence and values of the site.	Robinsons Bay Valley, Old Coach Road
MM6	**VEGETATION – For Screening, Character and Amenity**	**APPLICABLE SITE(S)**
	Where possible proposed vegetation for screening purposes or proposed vegetation that will provide the benefit of screening should be implemented as early as practical prior to start of earthworks and construction with the intent of getting a ‘head start’ on growth. Consideration should be given to how the planting is arranged with the intent of appearing as natural as possible and as an extension to the existing regenerating indigenous vegetation for enhancement of landscape character and amenity values. All proposed indigenous plant species shall be eco-sourced and have consideration to fire resistance, local ecological values, cultural associations and to be consistent with the recommendation made in the Terrestrial Ecological Assessment (Aug 2022)[1]	Robinsons Bay Valley, Hammond Point, Old Coach Road

[1] Bay Baseline and Terrestrial Ecology Effects Assessment - Akaroa Treated Wastewater Irrigation Scheme (ATWIS), *C. Meurk, August 2022*

5. CONCLUSIONS

In terms of the landscape character and values, the Robinsons Bay Valley, Hammond Point and Old Coach Road sites exhibit the typical pastoral open environment which make up the Banks Peninsula and Akaroa rural landscape. Other than the tank sites of Robinson Bay Valley and Old Coach Road and associated earthworks, the proposals are mostly indigenous revegetation. The majority of the sites will undergo a transition in landuse and landcover from open pastoral farmland to one that is planting with indigenous revegetation and will exhibit a more ‘naturalised’ appearance. A perceived effect on the existing landscape character could be the loss of openness, an attribute closely associated with the appearance and appreciation of the rural landscape. Planting, specifically indigenous species, is generally accepted as a positive to enhance the appreciation of an area, as well as indigenous biodiversity, ecological values, and cultural associations. The proposed planting will not look out of place in the landscape context of the sites, which contain existing clusters and gullies of regenerating indigenous vegetation and is considered to have a **positive** effect on landscape character.

The most noticeable effect on landscape character and values, will be the introduction of tanks, specifically at the Robinsons Bay Valley site. While they may not entirely be unexpected in the rural context, the tanks are considered to create an increased intensity of infrastructure within the rural landscape due to their scale and bulk, and are at an elevation where comparable surrounding development (built form) is sparse. The tanks are not considered to result in a reduction of naturalness due to the sites already modified (rural) state and they do not fundamentally change the character of the site, which remains rural.

In all site, the landscape is considered able to absorb the proposed changes, further reduced by mitigation measures and revegetation establishing over time. Other elements of the proposals such as recreational tracks provide the ability to positively integrate education, history and cultural interpretation and associations with the area.

In each section above for each site, effects of the proposals are assessed and stated under ‘Effects on Landscape Character’ and Effects on Landscape Value’. The proposals for each site are not seen to be inconsistent with the receiving physical and natural environment of the rural landscape.

In terms of visual amenity, the Robinsons Bay Valley, Hammond Point and Old Coach Road sites are varied in orientation and elevation, therefore varying in visibility from public roads, residential properties, and recreational areas. Visual effects of the proposals largely relate to the Robinsons Bay Valley site due to the proposed tanks and associated earthworks being the most visually apparent (built form) change. The greatest visual effects will be experienced from vantage points at or above the same elevation as the tanks. Generally, at the lower elevations, the site’s topography and existing vegetation intervene, screening visibility of the tanks. Visibility of the tanks may not be entirely unexpected to the viewer in the context of the rural working landscape, nonetheless it is the combined scale and bulk of the tanks in Robinsons Bay Valley, through considered appropriate in arrangement, which will detract the most from the existing amenity.

Despite this visual change and the technical project parameters for the tank locations, the tank sites are well located to mitigate potential adverse visual effects. In both Robinsons Bay Valley and Old Coach Road sites the tanks will not break the skyline from any vantage point and where open views are available the tanks are back dropped by topography and/or the existing vegetation or ameliorated by distance and viewed in context of the surrounding large-scale landscape. Associated earthworks will be temporary for the duration of the tank platform construction. Effects will reduce once cut material is contoured to sympathetically integrate with the existing landform and vegetated with exotic grass for erosion and sediment control. As the proposed indigenous revegetation establishes, any perceived residual effects of earthworks will be diminished, if apparent at all, and will take on a naturalised appearance.

Other elements of the proposals such as recreational tracks provide the ability to integrate education, history and cultural interpretation and associations with the area, in turn providing a positive memorability and pleasantness of the landscape.

In each section above for each site, visual effects of the proposals are assessed and stated under ‘Effects on Visual Amenity’ and summarised under ‘Summary of Effects on Visual Amenity’. The proposals for each site are not seen to be inconsistent with the existing amenity of the rural landscape and predominantly enhances visual amenity through the proposed indigenous vegetation.

APPENDIX 1: LANDSCAPE AND VISUAL IMPACT ASSESSMENT METHODOLOGY

The landscape and visual impact assessment considers the likely effects of the proposal in a holistic sense. There are three components to the assessment:

1. Identification of the receiving environment and a description of the existing landscape character, including natural character;
2. The landscape assessment is an assessment of the proposal against the existing landscape values;
3. The visual impact assessment is primarily concerned with the effects of the proposal on visual amenity and people, evaluated against the character and quality of the existing visual catchment.

The methodology is based on the Te Tangi a te Manu Aotearoa New Zealand Landscape Assessment Guidelines (July 2022)

1.0 LANDSCAPE ASSESSMENT

1.1 Landscape Description and Characterisation

Landscape attributes fall into 3 broad categories: biophysical features, patterns and processes; sensory qualities; and spiritual, cultural and social associations, including both activities and meanings.

- Biophysical features, patterns and processes may be natural and/or cultural in origin and range from the geology and landform that shape a landscape to the physical artefacts such as roads that mark human settlement and livelihood.
- Sensory qualities are landscape phenomena as directly perceived and experienced by humans, such as the view of a scenic landscape, or the distinctive smell and sound of the foreshore.
- Associated meanings are spiritual, cultural, or social associations with particular landscape elements, features, or areas, such as tupuna awa and waahi tapu, and the tikanga appropriate to them, or sites of historic events or heritage. Associative activities are patterns of social activity that occur in particular parts of a landscape, for example, popular walking routes or fishing spots. Associative meanings and activities engender a sense of attachment and belonging.

Describing the landscape character is a process of interpreting the composite and cumulative character of a landscape, i.e. how attributes come together to create a landscape that can be distinguished from other landscapes. International best practice in characterisation has two dimensions of classification: the identification of distinctive types of landscape based on their distinctive patterns of natural and cultural features, processes and influences; and their geographical delineation. The characterisation of a landscape is not to rank or rate a landscape, as all landscapes have character, but determine what landscape attributes combine to give an area its identity, and importantly to determine an area's sensitivity, resilience or capacity for change.

- Table 1: Continuum of Natural Character

Natural	Near-natural	Semi-natural (including pastoral agriculture and exotic forests)		Agricultural (arable and intensive cropping)	Near-cultural	Cultural
Very high-pristine	High	Moderate High	Moderate	Moderate-low	Low	Very Low-nil

1.2 Landscape Values

Following the descriptive phase of landscape assessment, an evaluative phase is undertaken whereby values or significance is ascribed to the landscape.

Where Planning Documents have identified Outstanding Natural Features or Landscapes, the objectives, policies and rules contained within the plan are used as the basis for landscape significance or value, and it is these values which the proposal is assessed against. Where there is some uncertainty of the landscape value, such as when the District Plan has a broad description of an Outstanding Natural Landscape (ONL), but it is not site specific, or the site neighbours an ONL, it is often necessary to complete an assessment against the values of the District Plan for completeness sake. Most district plans have policies or objectives which are relevant to Landscape and Natural Character if proposed in a rural or sensitive environment.

An accepted approach, where the landscape value of the site is not identified in the District Plan under Section 6(b) of the RMA, is to use criteria identified in Wakatipu Environmental Society Inc. & Ors v QLDC [2000] NZRMA 59 (generally referred to as the Amended Pigeon Bay criteria). The assessment criteria have been grouped into 3 broad categories or 'landscape attributes' which are to be considered:

1. Biophysical elements, patterns and processes;
2. Associative meaning and values including spiritual, cultural or social associations; and
3. Sensory or perceptual qualities.

2.0 VISUAL ASSESSMENT METHODOLOGY

In response to section 7(c) of the RMA, an evaluation is undertaken to define and describe visual amenity values. As with aesthetic values, with which amenity values share considerable overlap, this evaluation was professionally-based using current and accepted good practice. Amenity values are defined in the Act as *"those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes."* The visual assessment looks at the sensitivity of receptors to changes in their visual amenity through the analysis of selected representative viewpoints and wider visibility analysis. It identifies the potential sources for visual effect resulting from the Proposal and describes the existing character of the area in terms of openness, prominence, compatibility of the project with the existing visual context, viewing distances and the potential for obstruction of views.[1]

The visual impact assessment involves the following procedures:

- Identification of key viewpoints: A selection of key viewpoints is identified and verified for selection during the site visit. The viewpoints are considered representative of the various viewing audiences within the receiving catchment, being taken from public locations where views of the proposal were possible, some of which would be very similar to views from nearby houses. The identification of the visual catchment is prepared as a desktop study in the first instance using Council GIS for aerials and contours. This information is then ground-truthed to determine the key viewpoints and potential audience. Depending on the complexity of the project a 'viewshed' may be prepared which highlights the 'Theoretical Zone of Visual Influence' (TZVI) from where a proposal will theoretically be visible from. It is theoretical as the mapping does not take into account existing structures or vegetation so is conservative in its results.
- Assessment of the degree of sensitivity of receptors to changes in visual amenity resulting from the proposal: Factors affecting the sensitivity of receptors for evaluation of visual effects include the value and quality of existing views, the type of receiver, duration or frequency of view, distance from the proposal and the degree of visibility. For example, those who view the change from their homes may be considered highly sensitive. The attractiveness or otherwise of the outlook from their home will have a significant effect on their perception of the quality and acceptability of their home environment and their general quality of life. Those who view the change from their workplace may be considered to be only moderately sensitive as the attractiveness or otherwise of the outlook will have a less important, although still material, effect on their perception of their quality of life. The degree to which this applies also depends on factors such as whether the workplace is industrial, retail or commercial. Those who view the

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[1] Reference: NZILA Education Foundation - Best Practice Guide – Landscape Assessment and Sustainable Management/ Best Practice Guide – Visual Simulations (2.11.2010)

change whilst taking part in an outdoor leisure activity may display varying sensitivity depending on the type of leisure activity and a greater sensitivity to those commuting. For example, walkers or horse riders in open country on a long-distance trip may be considered to be highly sensitive to change while other walkers may not be so focused on the surrounding landscape. Those who view the change whilst travelling on a public thoroughfare will also display varying sensitivity depending on the speed and direction of travel and whether the view is continuous or occasionally glimpsed.

- Identification of potential mitigation measures: These may take the form of revisions/refinements to the engineering and architectural design to minimise potential effects, and/or the implementation of landscape design measures (e.g. screen tree planting, colour design of hard landscape features etc.) to alleviate adverse visual effects and generate potentially beneficial long-term effects.
- Prediction and identification of the effects during operation without mitigation and the residual effects after the implementation of the mitigation measures.

3.0 EFFECTS METHODOLOGY

Analysis of the existing landscape and visual environment is focused upon understanding the functioning of how an environment is likely to respond to external change (the proposal). In terms of the receiving environment, this is the environment upon which a proposed activity might have effects. It is permissible (and often desirable or necessary) to consider the future state of the environment upon which effects will occur, including:

- the future state of the environment as it might be modified by the utilisation of rights to carry out permitted activities
- the environment as it might be modified by implementing resource consents that have been granted at the time a particular application is considered, where it appears likely that those resource consents will be implemented.

The assessment evaluates the resilience of the existing character, values or views and determines their capacity to absorb change. The proposal is assessed in its 'unmitigated' form and then in its mitigated form to determine the likely residual effects. The analysis identifies opportunities, risks, threats, costs and benefits arising from the potential change.

Assessing the magnitude of change (from the proposal) is based on the Landscape Assessment Guidelines (July 2022)[2] with a seven-point scale, being:

VERY LOW / LOW / MODERATE-LOW / MODERATE / MODERATE-HIGH / HIGH / VERY HIGH

[2] Te Tangi a te Manu Aotearoa New Zealand Landscape Assessment Guidelines (July 2022)

The guidelines provide the below table 2, which is a useful comparison for analysis of the magnitude of change (NZILA) with the likely effects (RMA).

- Table 2: Change and Effects comparison table, comparison, Te Tangi a te Manu Aotearoa New Zealand Landscape Guidelines, Page 151

						SIGNIFCANT	
RMA LEVEL OF EFFECTS	LESS THAN MINOR	MINOR		MORE THAN MINOR			
MAGNITUDE OF CHANGE	VERY LOW	LOW	MODERATE – LOW	MODERATE	MODERATE - HIGH	HIGH	VERY HIGH

The Te Tangi a te Manu Aotearoa New Zealand Landscape Guidelines however do not quantify ‘what’ the Magnitude of Change is. Below is a guide to how we have assessed the Magnitude of Change for this proposal:

(a) Very Low – the change is negligible or are not readily discernible. For example the proposal may not be visible to the receptor or the change in character is negligible when compared to the permitted baseline and/or receiving environment.

(b) Low – the change is discernible but do not adversely affect the viewer experience. For example it may be possible for the receptor to see the proposal but the effects are not considered adverse due to the quality of the current view or the oblique nature of the view.

(c) Moderate – Low – the change is discernible and start to adversely affect viewer experience.

(d) Moderate – the change is discernible and have an effect on the quality of the view but with the main ‘view qualities’ still intact.

(e) Moderate-High – the change is discernible and changes the quality of the existing view, potentially with the loss of views.

(f) High – the change is discernible and there is a loss of views or the changes greatly affect the quality of the view so that the character of existing view is fundamentally changed.

(g) Very High – the change is discernible and there is a total loss of views or the changes significantly affect the quality of the view so that the character of existing view is fundamentally changed.

In determining the extent of adverse effects. taking into account the sensitivity of the landscape or receptor combined with the Magnitude of Change proposed, the level of effects is along a continuum to ensure that each effect has been considered consistently and in turn cumulatively.

This continuum may include the following effects (based on the descriptions provided on the Quality Planning website – Determining the Extent of Adverse Effects[3]):

- **Indiscernible Effects** No effects at all or are too small to register.
- **Less than Minor Adverse Effects** Adverse effects that are discernible day-to-day effects, but too small to adversely affect other persons.
- **Minor Adverse Effects** Adverse effects that are noticeable but will not cause any significant adverse impacts.
- **More than Minor Adverse Effects** Adverse effects that are noticeable that may cause an adverse impact but could be potentially mitigated or remedied.
- **Significant Adverse Effects that could be remedied or mitigated** An effect that is noticeable and will have a serious adverse impact on the environment but could potentially be mitigated or remedied.
- **Unacceptable Adverse Effects** Extensive adverse effects that cannot be avoided, remedied or mitigated.

4.0 PHOTOGRAPHY METHODOLOGY

All photos are taken using a SONY ALPHA A7 II digital camera with a focal length of 50mm. No zoom was used. In the case of stitched photos used as the viewpoint images, a series of 4 portrait photos were taken from the same position to create a panorama. The photos were stitched together automatically in Adobe Photoshop to create the panorama presented in the figures.

Reference: NZILA Education Foundation - Best Practice Guide – Landscape Assessment and Sustainable Management/ Best Practice Guide – Visual Simulations (2.11.10)

5.0 STATUTORY DOCUMENTS

Relevant statutory documents in terms of Landscape Values and Visual Amenity are referred to in the LVIA.

[3] https://www.qualityplanning.org.nz/node/837

APPENDIX TWO - LANDSCAPE AND VISUAL IMPACT ASSESSMENT FIGURES

AKAROA TREATED WASTEWATER IRRIGATION SCHEME,

FOR STANTEC (ON BEHALF OF CHRISTCHURCH CITY COUNCIL)

25 NOVEMBER 2022

REVISION A

AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Project no: 2021_034
Document title: LANDSCAPE AND VISUAL IMPACT ASSESSMENT
Revision: A
Date: 25 November 2022
Client name: Stantec

Author: Sophie Beaumont / Chris Greenshields
File name: \\goose\storage\4_DCM - Projects\2021_034 Stantec Akaroa Sewerage Treatment LVIA\3_Working Files\3_InDesign\2021_034 Stantec Akaroa WWTP LVIA figures_A

DOCUMENT HISTORY AND STATUS

REVISION	DATE	DESCRIPTION	BY	REVIEW	APPROVED
A	25/11/2022	LVIA Figures	SB	CG	DCM

DCM URBAN DESIGN LIMITED

10/245 St Asaph Street
Christchurch 8011

CONTENTS

A. LANDSCAPE ASSESSMENT

map / image source: Canterbury Maps - not to scale

LEGEND

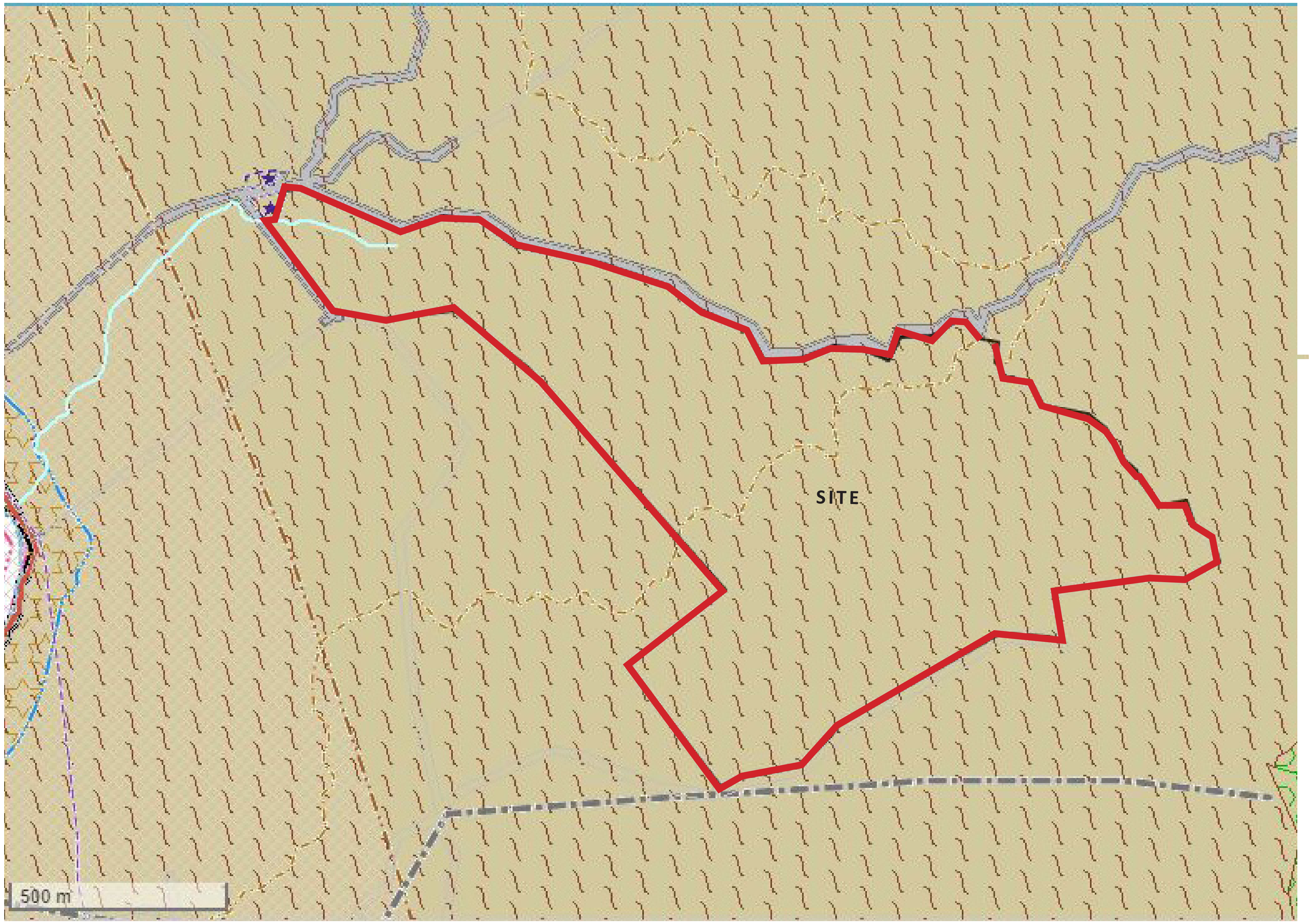
INNER BAYS IRRIGATION SITES

SITE BOUNDARY

A **ROBINSONS BAY**
(Highly treated wastewater storage tanks, Irrigation & native revegetation)

B **HAMMOND POINT**
(Irrigation & native revegetation)

C **OLD COACH ROAD**
(Wet weather storage tank and subsurface wetland)



Land Use Zones

Labels

Zone Labels

Zone

OWM Open Space Water and Margins Zone

RSS Residential Small Settlement Zone

RuBP Rural Banks Peninsula Zone

Transport Zone

Designations and Heritage Orders

Designation

Designation

Other Notations

Contour Line

160m Contour Line (applies only to Rural Banks Peninsula Zone)

Power Line

33kV Electricity Distribution Lines

Road Hierarchy

Collector

Major Arterial

Minor Arterial

Central City Local Distributor

Central City Main Distributor

Waterway

Downstream Waterway (except Mona Vale)

Downstream Waterway (Mona Vale)

Environmental Asset Waterway

Upstream Waterway

Natural and Cultural Heritage

Coastal Environment

Coastal Environment

Coastal Natural Character

Natural Character in the Coastal Environment

Heritage

Heritage Item

Heritage Setting

Natural Landscape

Identified Important Ridgeline

Outstanding Natural Landscape/Feature

Rural Amenity Landscape

Significant Feature

Ngai Tahu Cultural Significance

Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit

Wahi Tapu/Wahi Taonga

Ngā Tūranga Tūpuna

Ngā Wai Coast ID 78

Ngā Wai Coast ID 96

Protected Vegetation

Significant Street Tree

SITE BOUNDARY

map / image source: Christchurch City Council District Plan - not to scale

SITE OVERVIEW PLAN

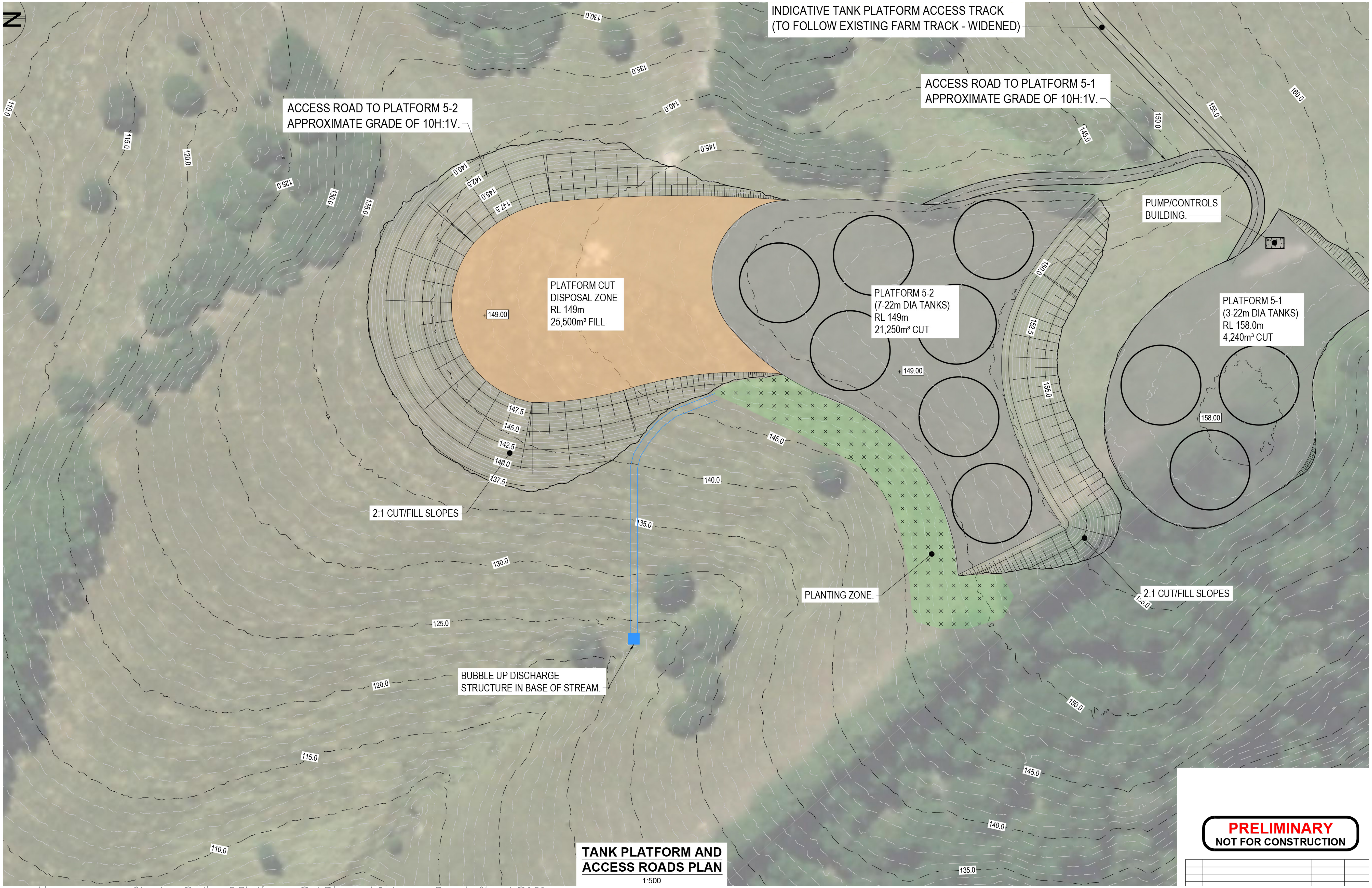
SCALE 1 : 2000

PRELIMINARY
NOT FOR CONSTRUCTION

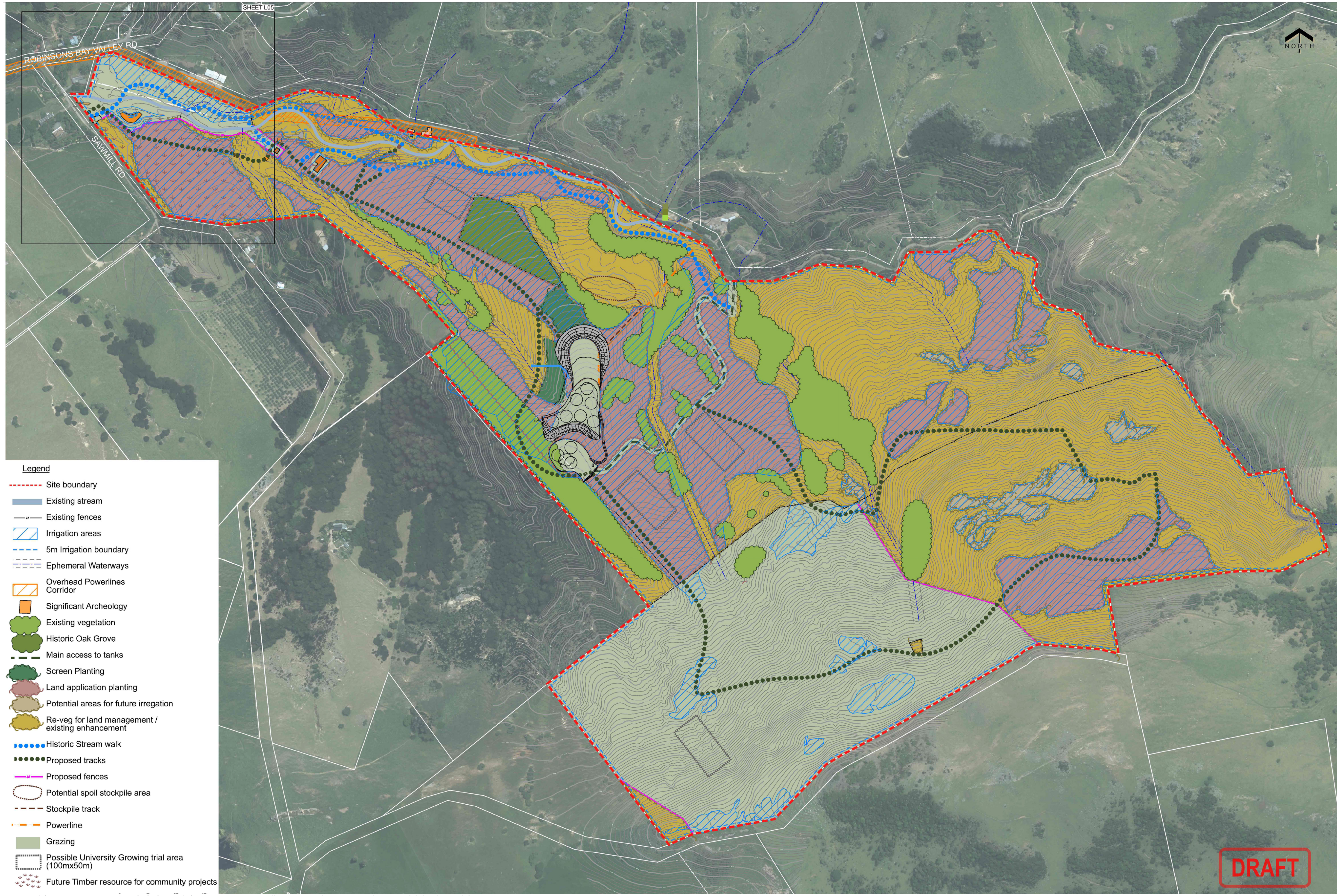
50 0 50 100m
SCALE 1:2000

ISSUE	AMENDMENTS	SIGNED	DATE
B	ISSUED FOR INFORMATION ONLY	SW	24.02.22
A	ISSUED FOR INFORMATION ONLY	SW	20.11.21

map / image source: Stantec Site Overview Plan Option 5_Sheet C150



map / image source: Stantec Option 5 Platforms, Cut Disposal & Access Roads_Sheet C151

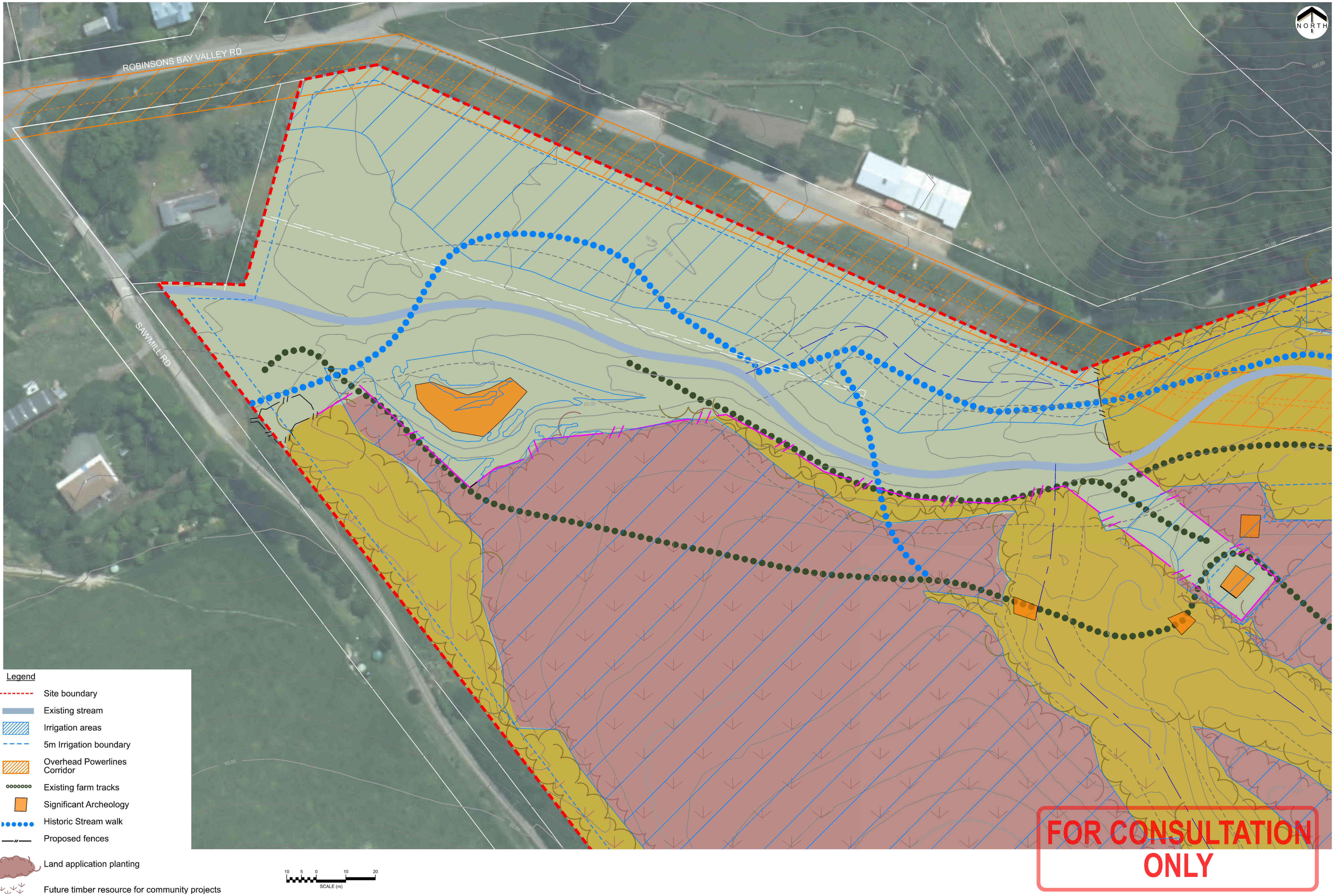


map / image source: CCC Robinsons Bay Valley Landscape Plan LP392501_L02

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

LANDSCAPE CONCEPT PLAN 1

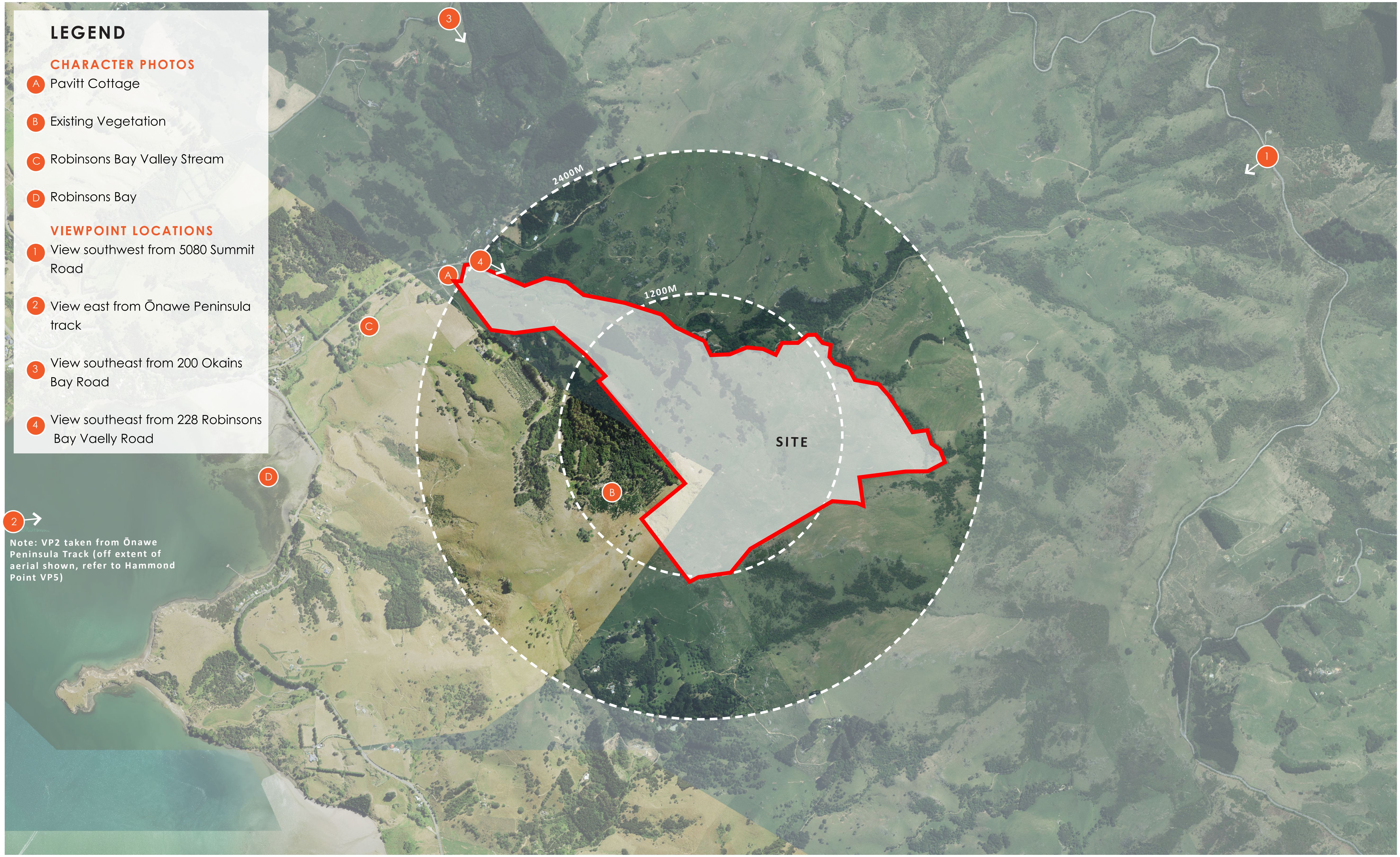
STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME



Legend

- Site boundary
- Existing stream
- Irrigation areas
- 5m Irrigation boundary
- Overhead Powerlines Corridor
- Existing farm tracks
- Significant Archeology
- Historic Stream walk
- Proposed fences
- Land application planting
- Future timber resource for community projects

map / image source: CCC Robinsons Bay Valley Landscape Plan LP392501_L05



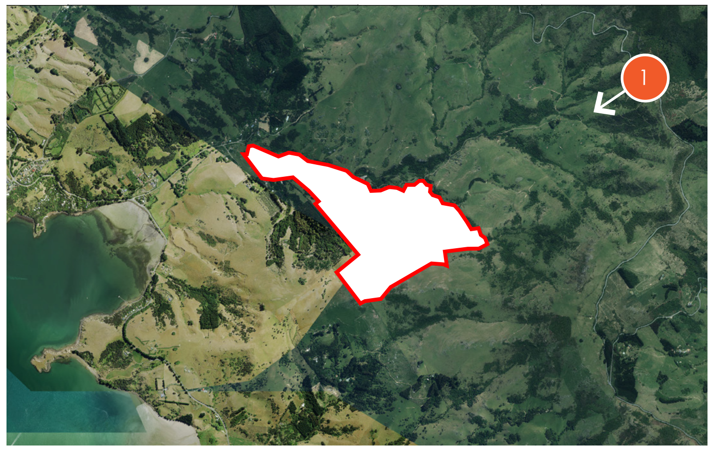
A. LOCATION MAP FOR CHARACTER PHOTOS AND KEY VIEWPOINTS

A Existing Site - sits in the valley above Robinsons Bay. The land is undulating and is predominantly grassland used for rural activity. A few residential dwellings are located within the valley and are often supported by sheds.

B Existing Vegetation - is typically clustered through the landscape, creating large pockets containing both native and exotics. Naturally regenerating native bush is found in the under story of trees.

C Robinsons Bay Valley Stream - runs from the top of the hills, down the valley and into Robinsons Bay. The waterway is naturally formed, resulting in varying widths and depths with sporadic exotic tree growth along the edge.

D Robinsons Bay - is a mudflat bay greatly effected by the tide. The bay is surrounded by small pockets of residential development, rural land use and a mixture of native and exotic vegetation.



A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP1 - VIEW SOUTHWEST FROM 5080 SUMMIT ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:18 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

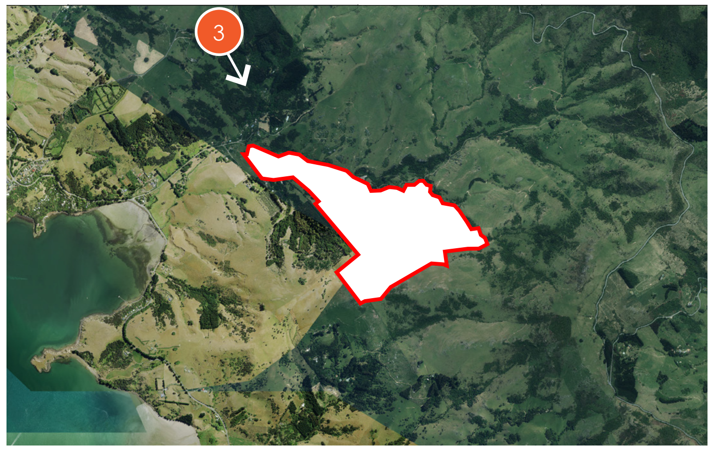
A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP2 - VIEW EAST FROM ŌNAWE PENINSULA TRACK

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:30 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



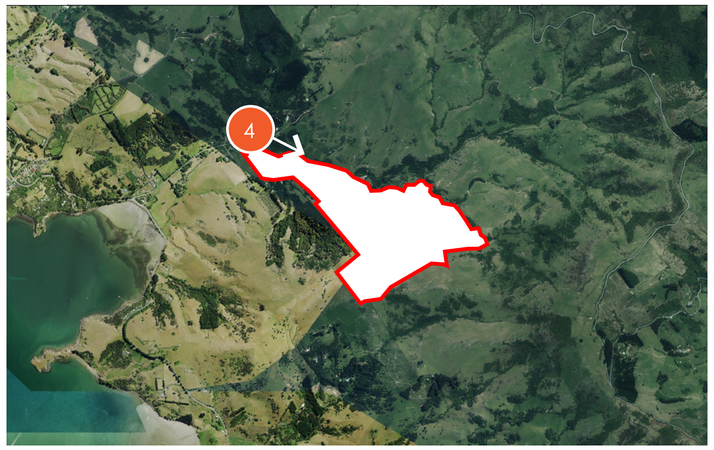
A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

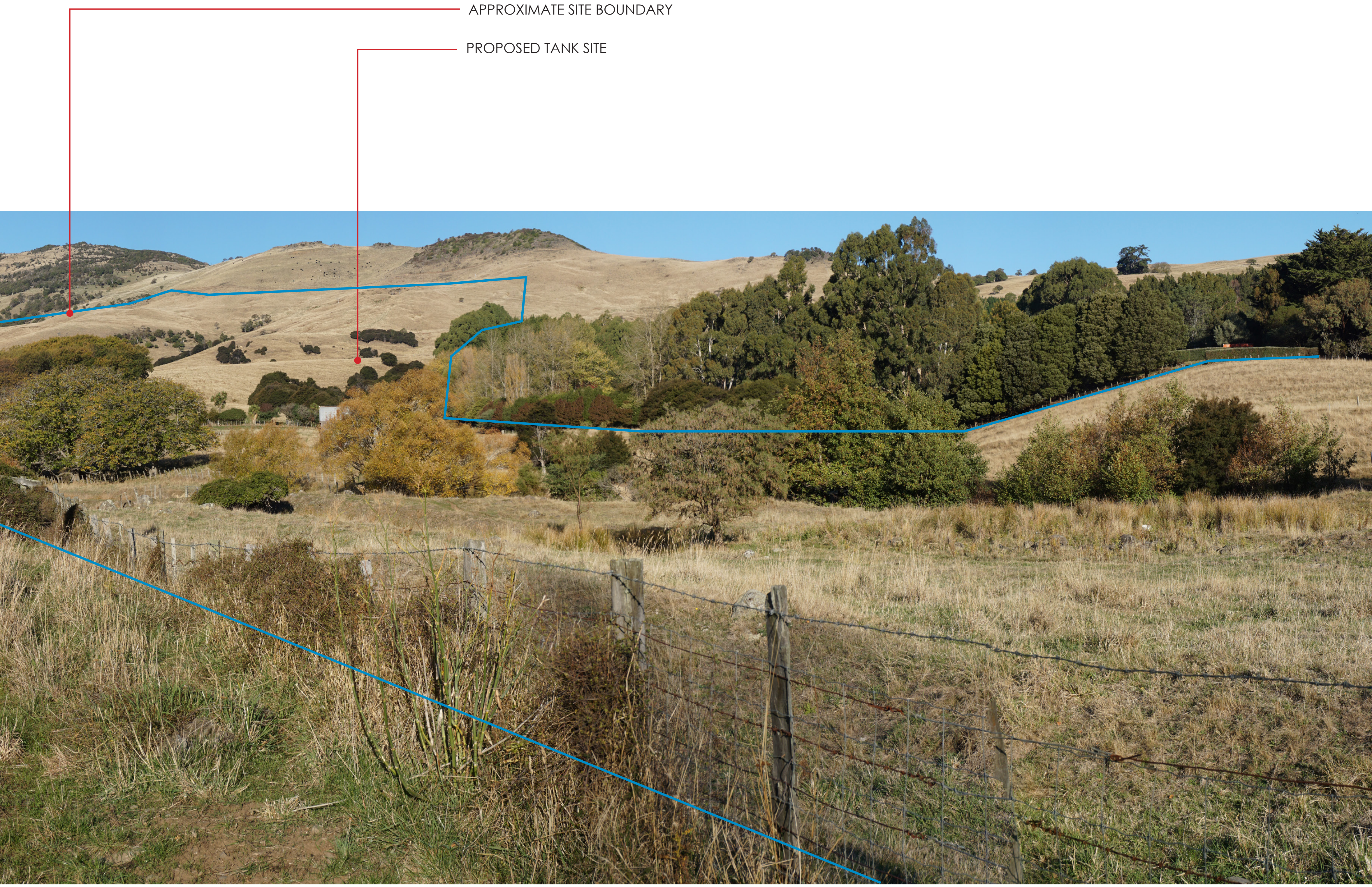
VP3 - VIEW SOUTHEAST FROM 196 OKAINS BAY ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:32 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



A. IMAGE LOCATION

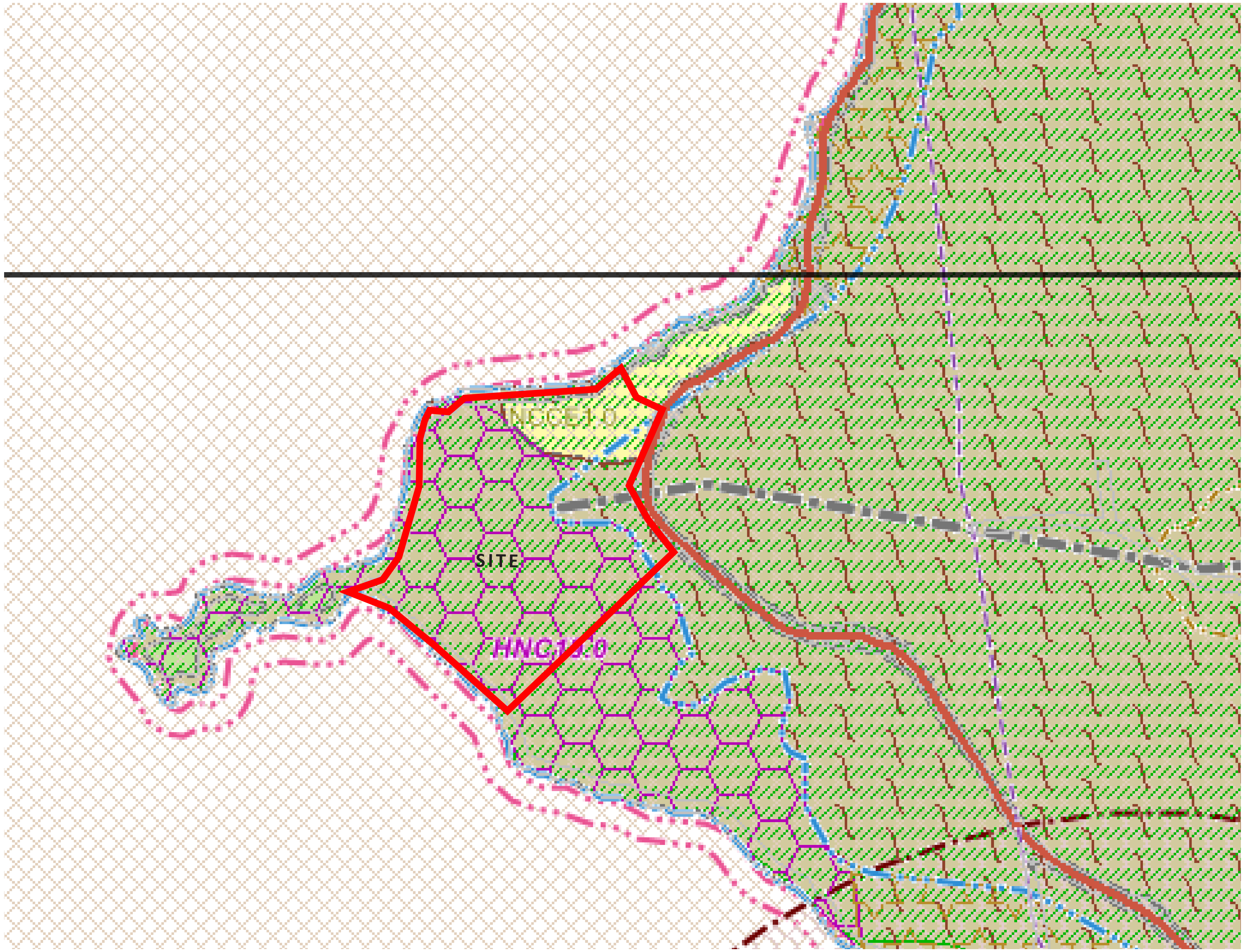


LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP4 - VIEW SOUTH FROM 228 ROBINSONS BAY VALLEY ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:44 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



Land Use Zones

Labels

Zone Labels

Zone

OWM Open Space Water and Margins Zone

RSS Residential Small Settlement Zone

RuBP Rural Banks Peninsula Zone

Transport Zone

Designations and Heritage Orders

Designation

Designation

Other Notations

Contour Line

160m Contour Line (applies only to Rural Banks Peninsula Zone)

Power Line

33kV Electricity Distribution Lines

Road Hierarchy

Collector

Major Arterial

Minor Arterial

Central City Local Distributor

Central City Main Distributor

Waterway

Downstream Waterway (except Mona Vale)

Downstream Waterway (Mona Vale)

Environmental Asset Waterway

Upstream Waterway

Natural and Cultural Heritage

Coastal Environment

Coastal Environment

Coastal Natural Character

Natural Character in the Coastal Environment

Heritage

Heritage Item

Heritage Setting

Natural Landscape

Identified Important Ridgeline

Outstanding Natural Landscape/Feature

Rural Amenity Landscape

Significant Feature

Ngai Tahu Cultural Significance

Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit

Wahi Tapu/Wahi Taonga

Ngā Tūranga Tūpuna

Ngā Wai Coast ID 78

Ngā Wai Coast ID 96

Protected Vegetation

Significant Street Tree

SITE BOUNDARY

map / image source: Christchurch City Council District Plan - not to scale

map / image source: CCC Hammond Point Landscape Plan LP392501_L03

A. LOCATION MAP FOR CHARACTER PHOTOS AND KEY VIEWPOINTS

A Ōnawe Peninsula - is a narrow band of volcanic land jutting out into the harbour from Duvauchelle. The site is a historic fortified pā and is sacred to Ngai Tahu, though it can be accessed by the public when the tide is low .

B Robinsons Bay - is a mudflat bay greatly effected by the tide. The bay is surrounded by small pockets of residential development, rural land use and a mixture of native and exotic vegetation.

C Residential Outlook - from the northern banks of Robinsons Bay look across the bay towards Hammond Point and hills in the background.

D Existing Site - is rural in character with post and wire fencing delineating the site boundaries. The Point is covered in grass with small pockets of native shrub scattered throughout. The northern side of the site is open bank with the southern side covered in native vegetation.

CONTEXT - CHARACTER PHOTOS

A. IMAGE LOCATION

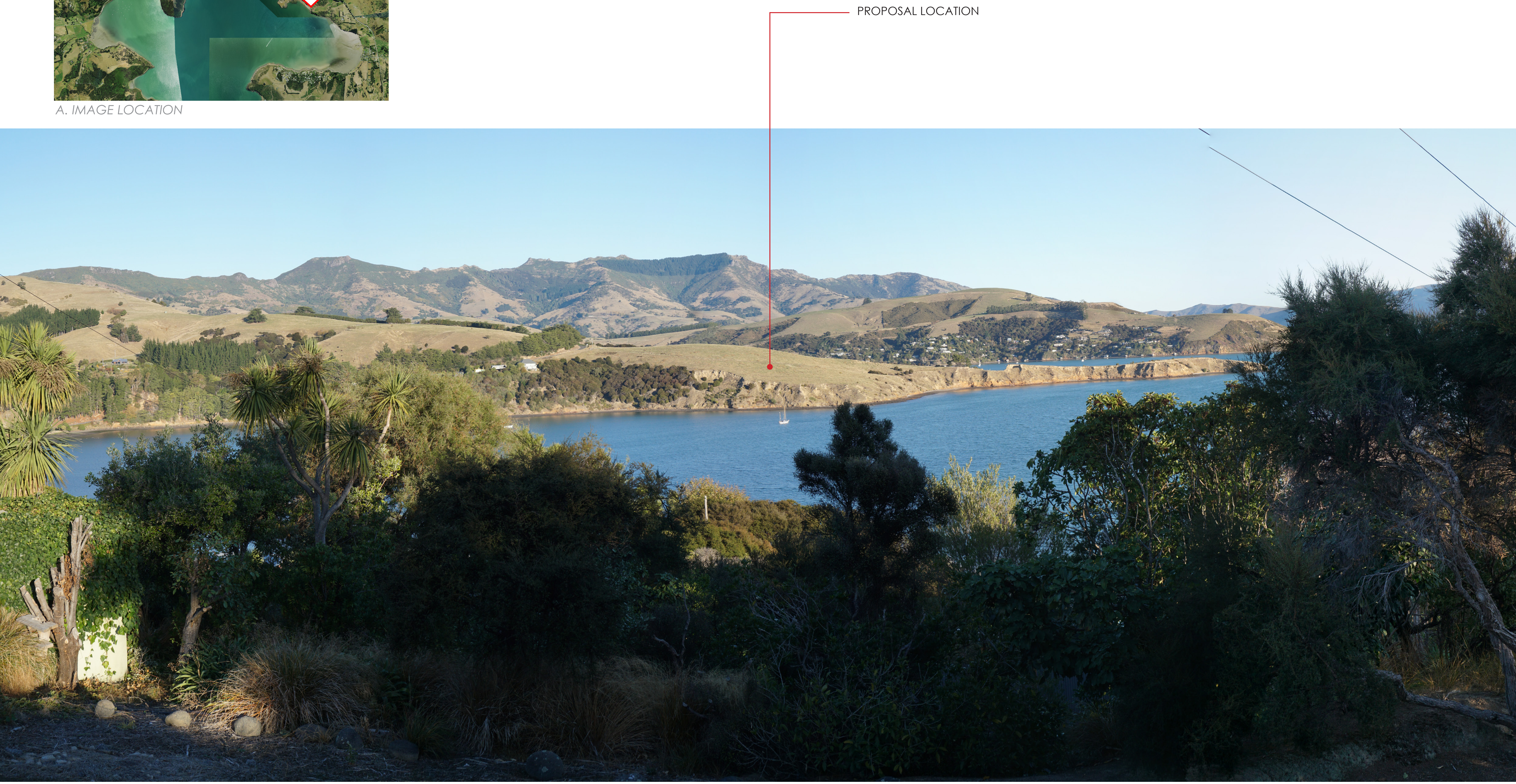
LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP1 - VIEW SOUTHWEST FROM 6648 STATE HIGHWAY 75

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 11:46 am
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION



LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP2 - VIEW SOUTH FROM 1 ARCHDALLS ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:07 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP3 - VIEW SOUTH FROM 6395 STATE HIGHWAY 75

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:05 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP4 - VIEW NORTHEAST FROM 403 WAINUI MAIN ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:59 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

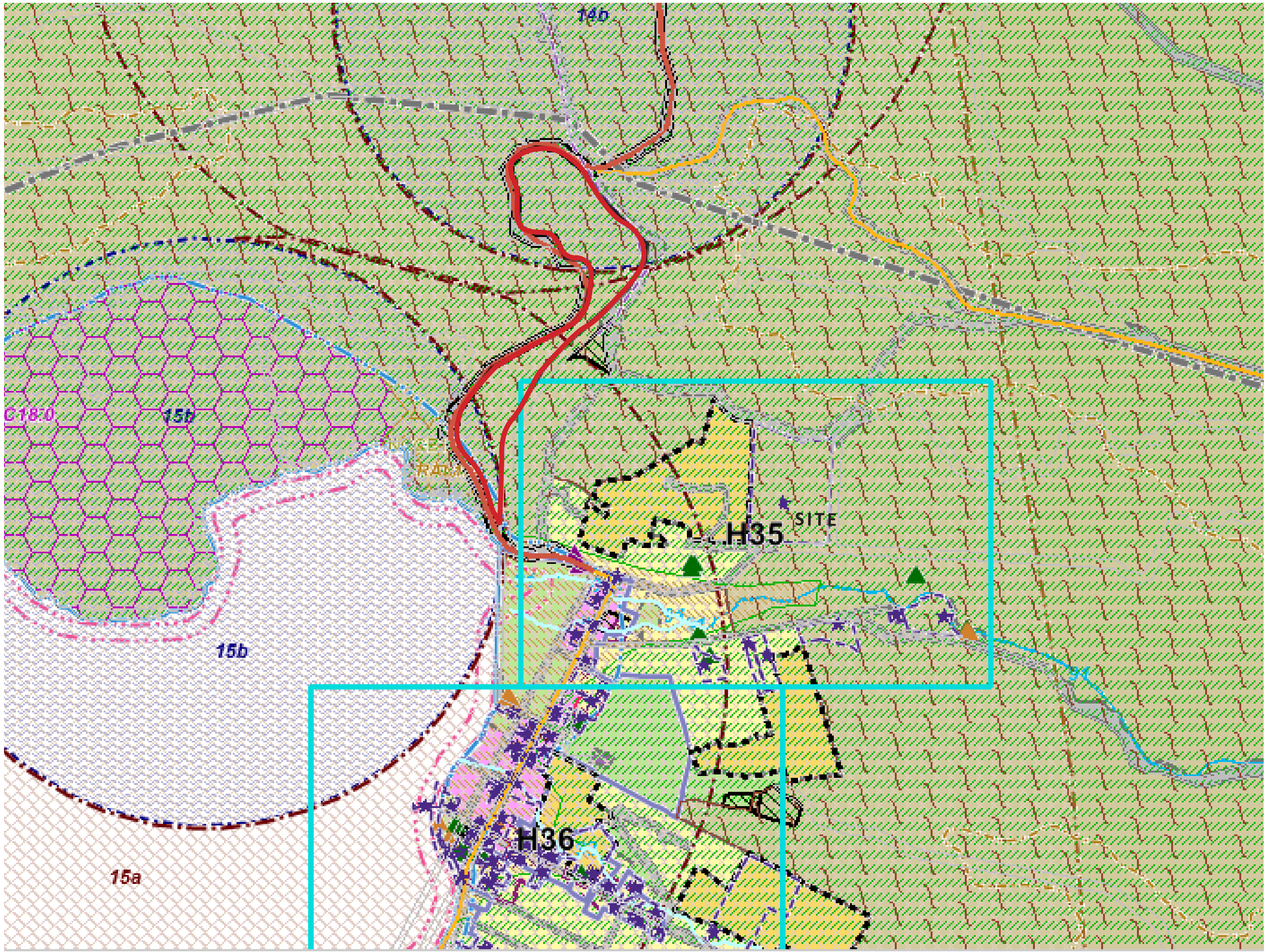
A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP5 - VIEW EAST FROM ŌNAWE PENINSULA TRACK

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:30 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



SITE BOUNDARY

Land Use Zones

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RuBP Rural Banks Peninsula Zone

Transport Zone

Designations and Heritage Orders

Designation

Designation

Other Notations

Contour Line

160m Contour Line (applies only to Rural Banks Peninsula Zone)

Power Line

33kV Electricity Distribution Lines

Road Hierarchy

Collector

Major Arterial

Minor Arterial

Central City Local Distributor

Central City Main Distributor

Waterway

Downstream Waterway (except Mona Vale)

Downstream Waterway (Mona Vale)

Environmental Asset Waterway

Upstream Waterway

Natural and Cultural Heritage

Coastal Environment

Coastal Environment

Coastal Natural Character

Natural Character in the Coastal Environment

Heritage

Heritage Item

Heritage Setting

Natural Landscape

Identified Important Ridgeline

Outstanding Natural Landscape/Feature

Rural Amenity Landscape

Significant Feature

Ngai Tahu Cultural Significance

Mahaanui Iwi Management Plan Silent Files and Kaitorete Spit

Wahi Tapu/Wahi Taonga

Ngā Tūranga Tūpuna

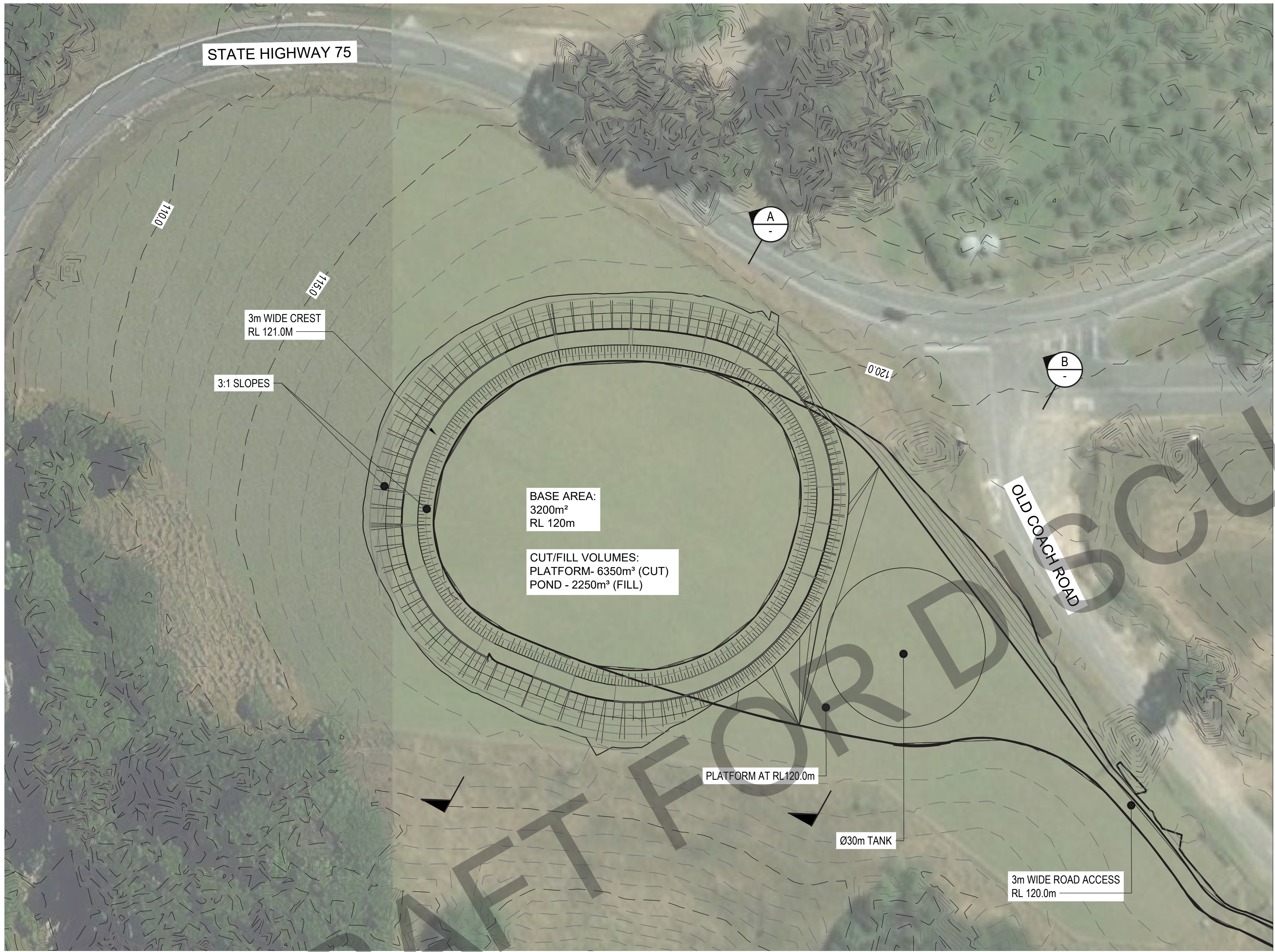
Ngā Wai Coast ID 78

Ngā Wai Coast ID 96

Protected Vegetation

Significant Street Tree

map / image source: Christchurch City Council District Plan - not to scale



PLAN
1:500

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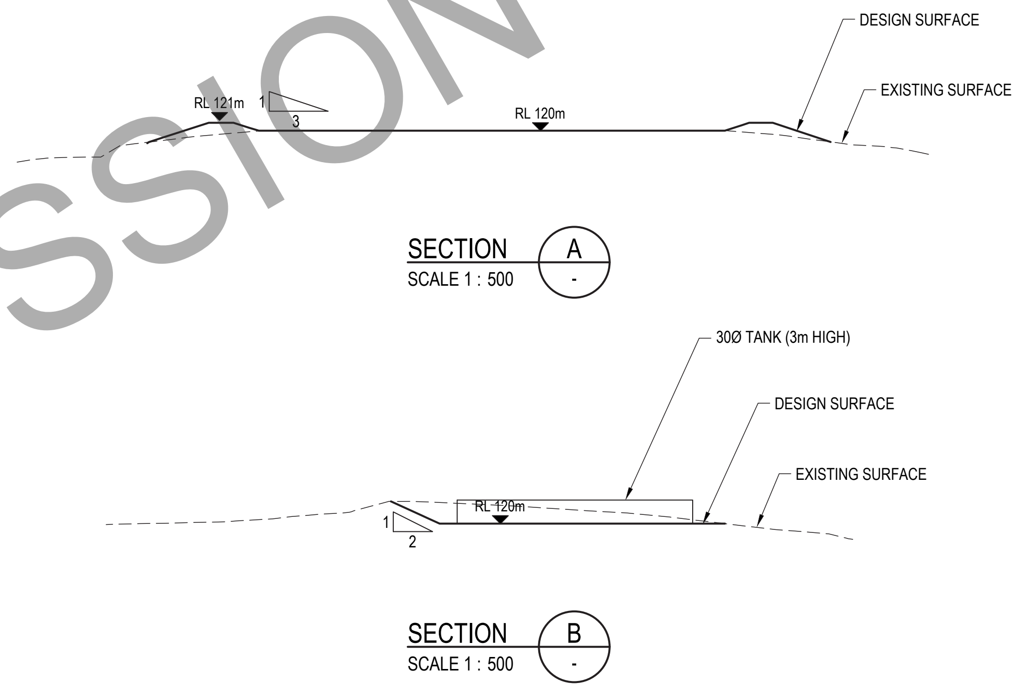
SCALE 1:500



PRELIMINARY
NOT FOR CONSTRUCTION

map / image source: Stantec - Draft Wetland Concept Plan_310103534-01-001-SK10-A

CONTEXT - ENGINEERING DRAWING

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

map / image source: CCC Old Coach Road Landscape Plan LP392501_L04

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

LANDSCAPE CONCEPT PLAN

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

map / image source: Onuku Runanga Old Coach Road Concept Plan

A. LOCATION MAP FOR CHARACTER PHOTOS AND KEY VIEWPOINTS

A Existing Wastewater Treatment Plant across the road from the site. Some pockets of native planting are presence, with pastoral farming as the predominant landuse

B French Bay and Childrens Bay - are highly populated bays of Akaora with multiple wharfs protruding into the harbour and mooring for boats. Settlement is clustered along the habour edge with the hills backing development to the east. Vegetation is scattered where possible among the foothills.

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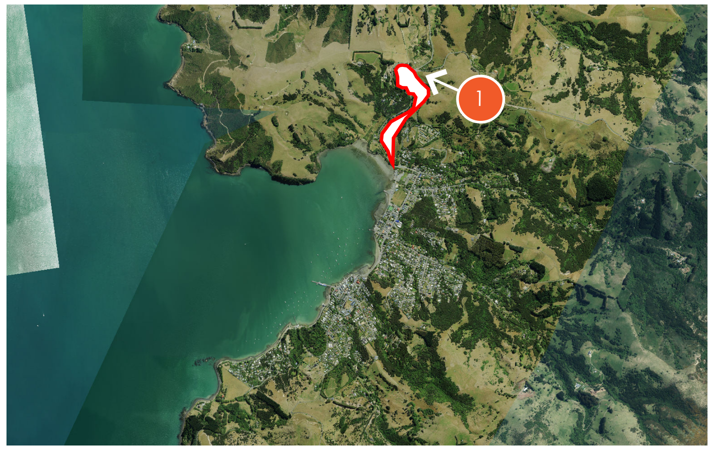

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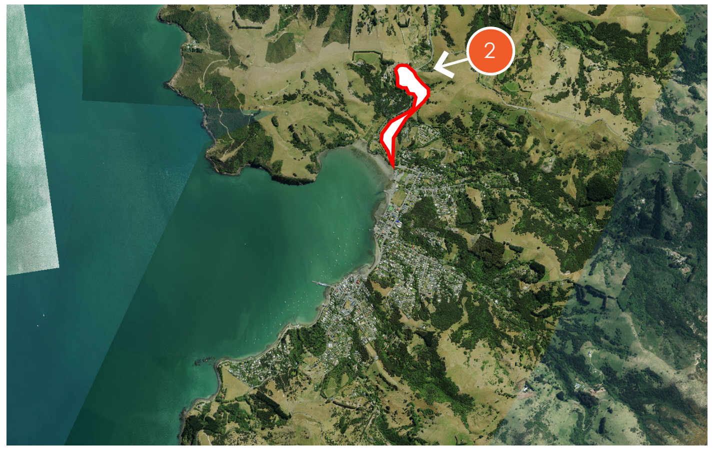

A. IMAGE LOCATION

PROPOSAL LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP2 - VIEW WEST FROM 39 LONG BAY ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

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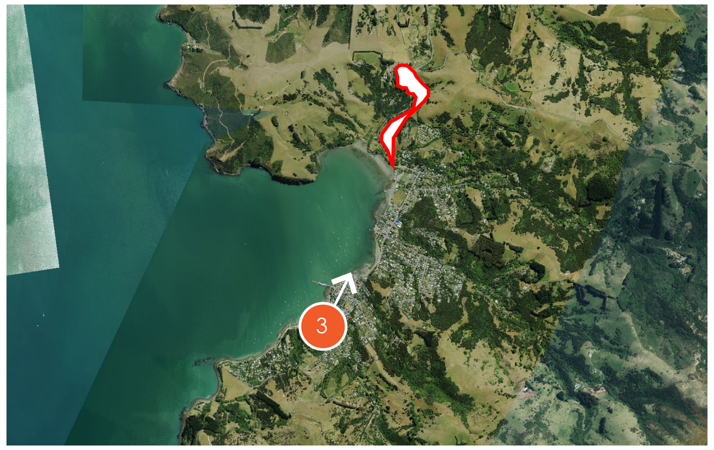

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP3 - VIEW NORTHEAST FROM MAIN WHARF

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
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A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP4 - VIEW NORTH FROM 40 LIGHTHOUSE ROAD

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Image captured on Sony ILCE-6000
Focal length of 50mm
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Photos merged in Photoshop CS to create panorama

APPENDIX TWO - LANDSCAPE AND VISUAL IMPACT ASSESSMENT FIGURES

AKAROA TREATED WASTEWATER IRRIGATION SCHEME,

FOR STANTEC (ON BEHALF OF CHRISTCHURCH CITY COUNCIL)

25 NOVEMBER 2022

REVISION A

dcm URBAN

AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Project no: 2021_034
Document title: LANDSCAPE AND VISUAL IMPACT ASSESSMENT
Revision: A
Date: 25 November 2022
Client name: Stantec

Author: Sophie Beaumont / Chris Greenshields
File name: \\goose\storage\4_DCM - Projects\2021_034 Stantec Akaroa Sewerage Treatment LVIA\3_Working Files\3_InDesign\2021_034 Stantec Akaroa WWTP LVIA figures_A

DOCUMENT HISTORY AND STATUS

REVISION	DATE	DESCRIPTION	BY	REVIEW	APPROVED
A	25/11/2022	LVIA Figures	SB	CG	DCM

DCM URBAN DESIGN LIMITED

10/245 St Asaph Street
Christchurch 8011

CONTENTS

LEGEND
INNER BAYS IRRIGATION SITES

SITE BOUNDARY

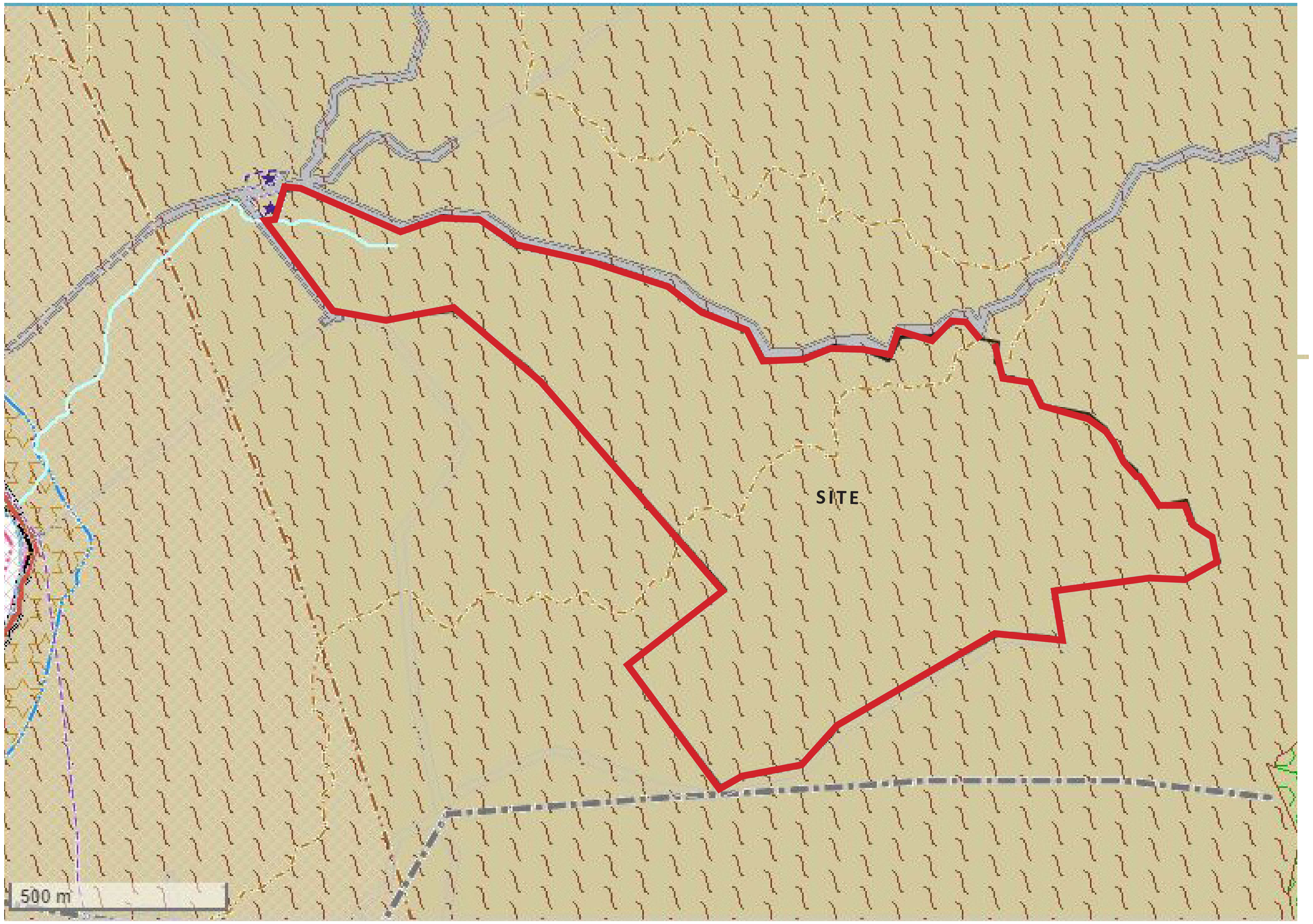
A **ROBINSONS BAY**
(Highly treated wastewater storage tanks, Irrigation & native revegetation)

B **HAMMOND POINT**
(Irrigation & native revegetation)

C **OLD COACH ROAD**
(Wet weather storage tank and subsurface wetland)

map / image source: Canterbury Maps - not to scale

CONTEXT - SCHEME SITE LOCATIONS



Land Use Zones

Labels

Zone Labels

Zone

OWM Open Space Water and Margins Zone

RSS Residential Small Settlement Zone

RuBP Rural Banks Peninsula Zone

Transport Zone

Designations and Heritage Orders

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Ngā Wai Coast ID 78

Ngā Wai Coast ID 96

Protected Vegetation

Significant Street Tree

SITE BOUNDARY

map / image source: Christchurch City Council District Plan - not to scale

SITE OVERVIEW PLAN

SCALE 1 : 2000

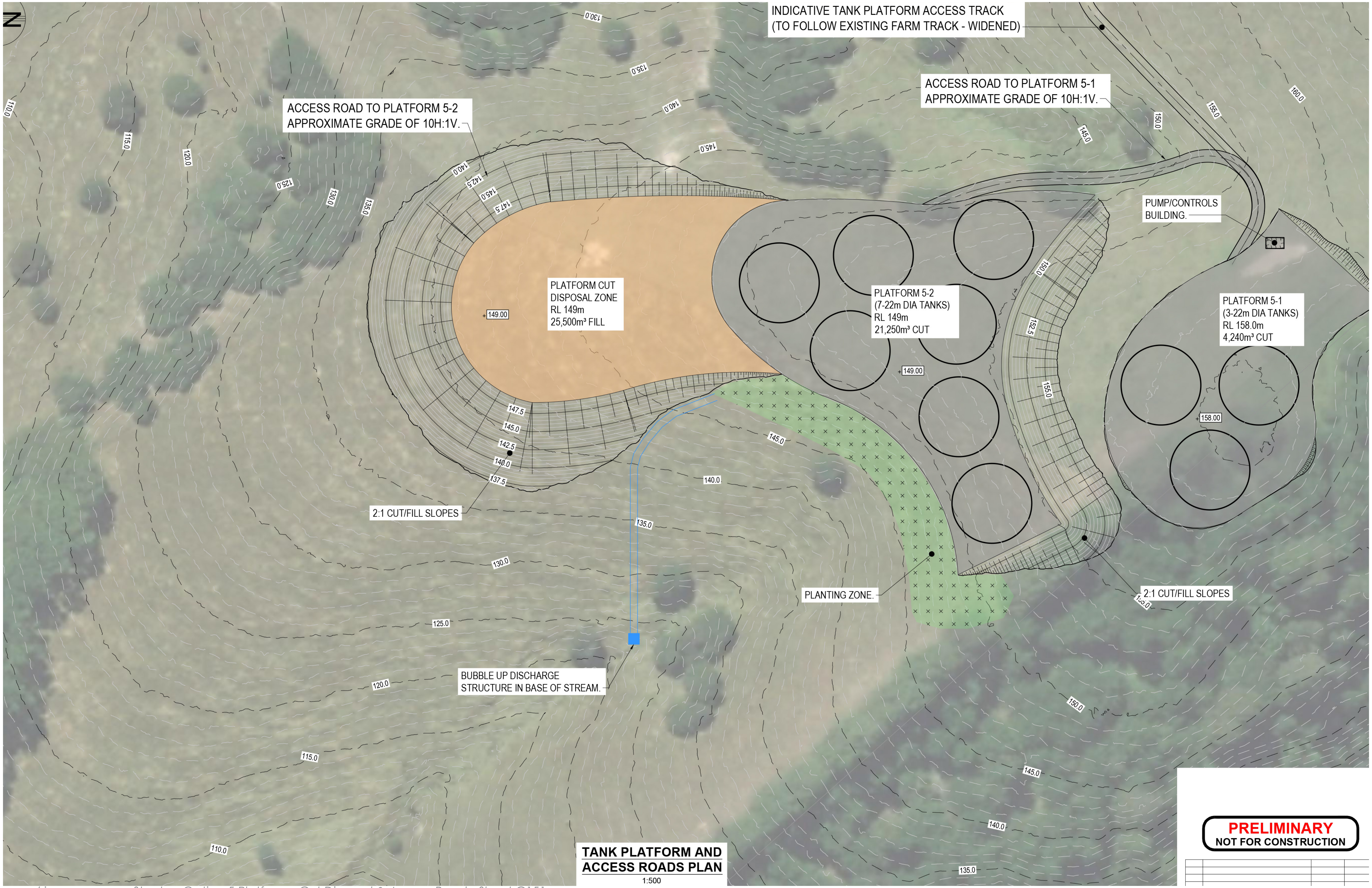
PRELIMINARY
NOT FOR CONSTRUCTION

50 0 50 100m
SCALE 1:2000

ISSUE	AMENDMENTS	SIGNED	DATE
B	ISSUED FOR INFORMATION ONLY	SW	24.02.22
A	ISSUED FOR INFORMATION ONLY	SW	20.11.21

map / image source: Stantec Site Overview Plan Option 5_Sheet C150

CONTEXT - ENGINEERING DRAWING

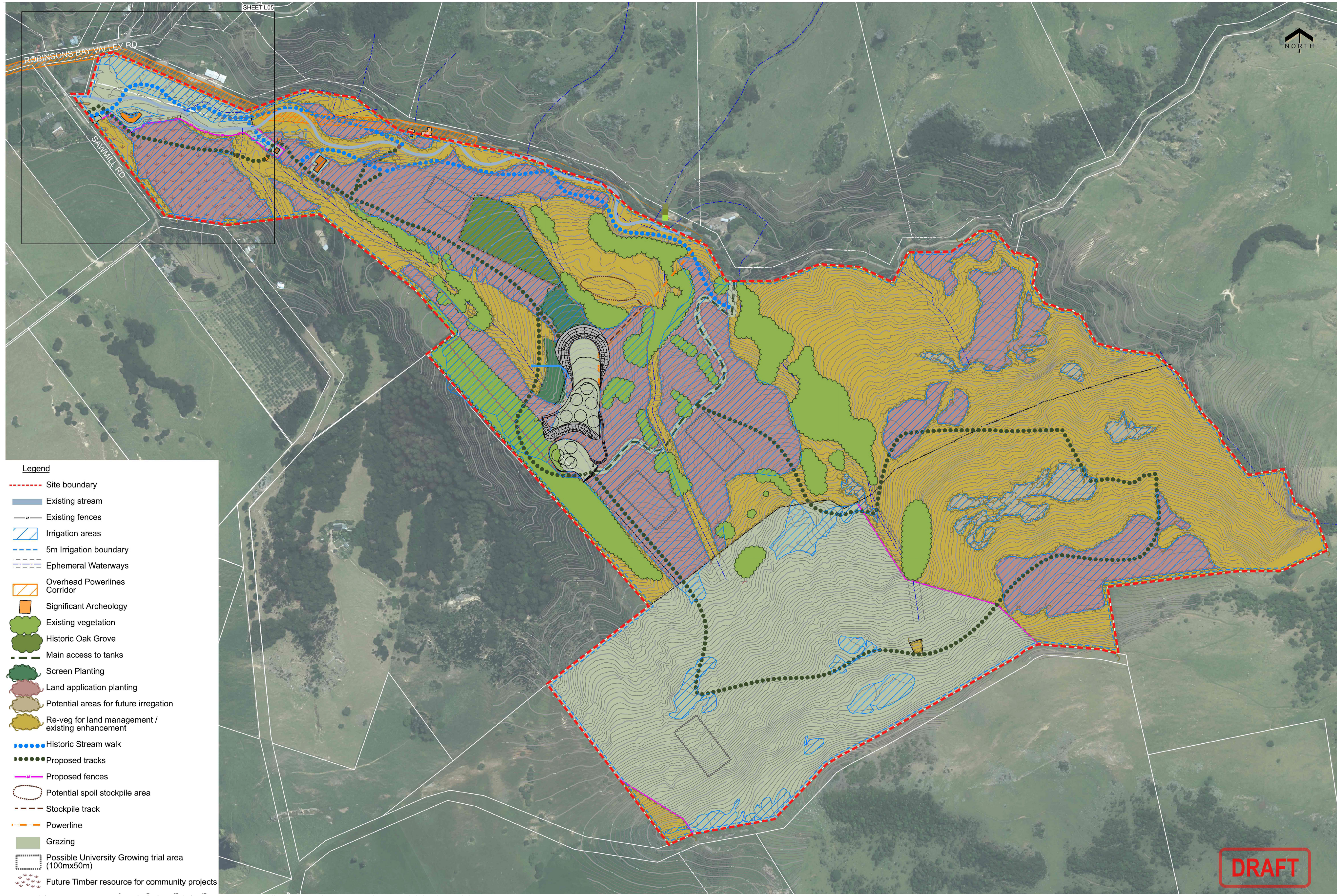


map / image source: Stantec Option 5 Platforms, Cut Disposal & Access Roads_Sheet C151

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

CONTEXT - ENGINEERING DRAWING - PROPOSED TANK SITE

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

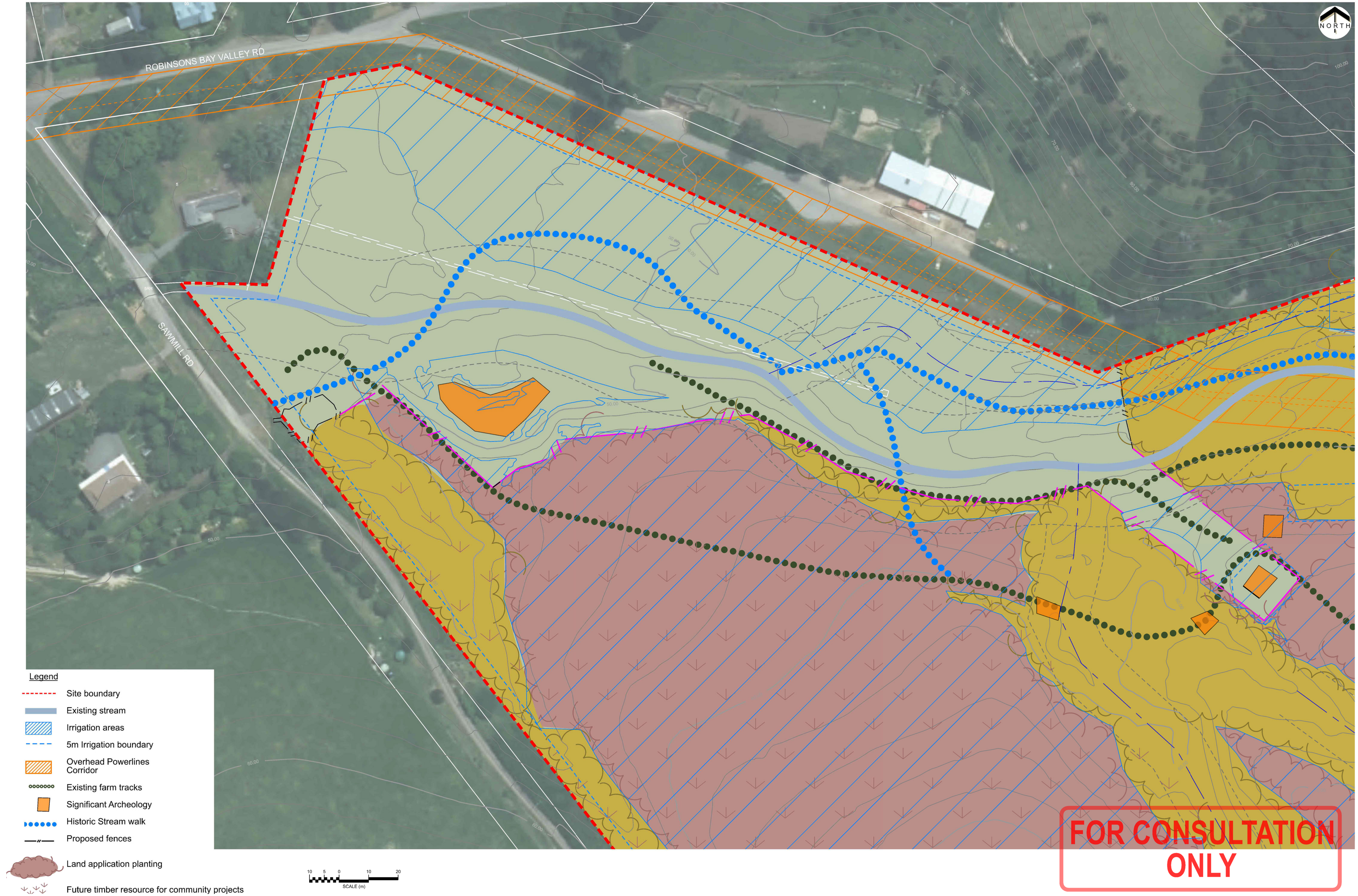


map / image source: CCC Robinsons Bay Valley Landscape Plan LP392501_L02

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

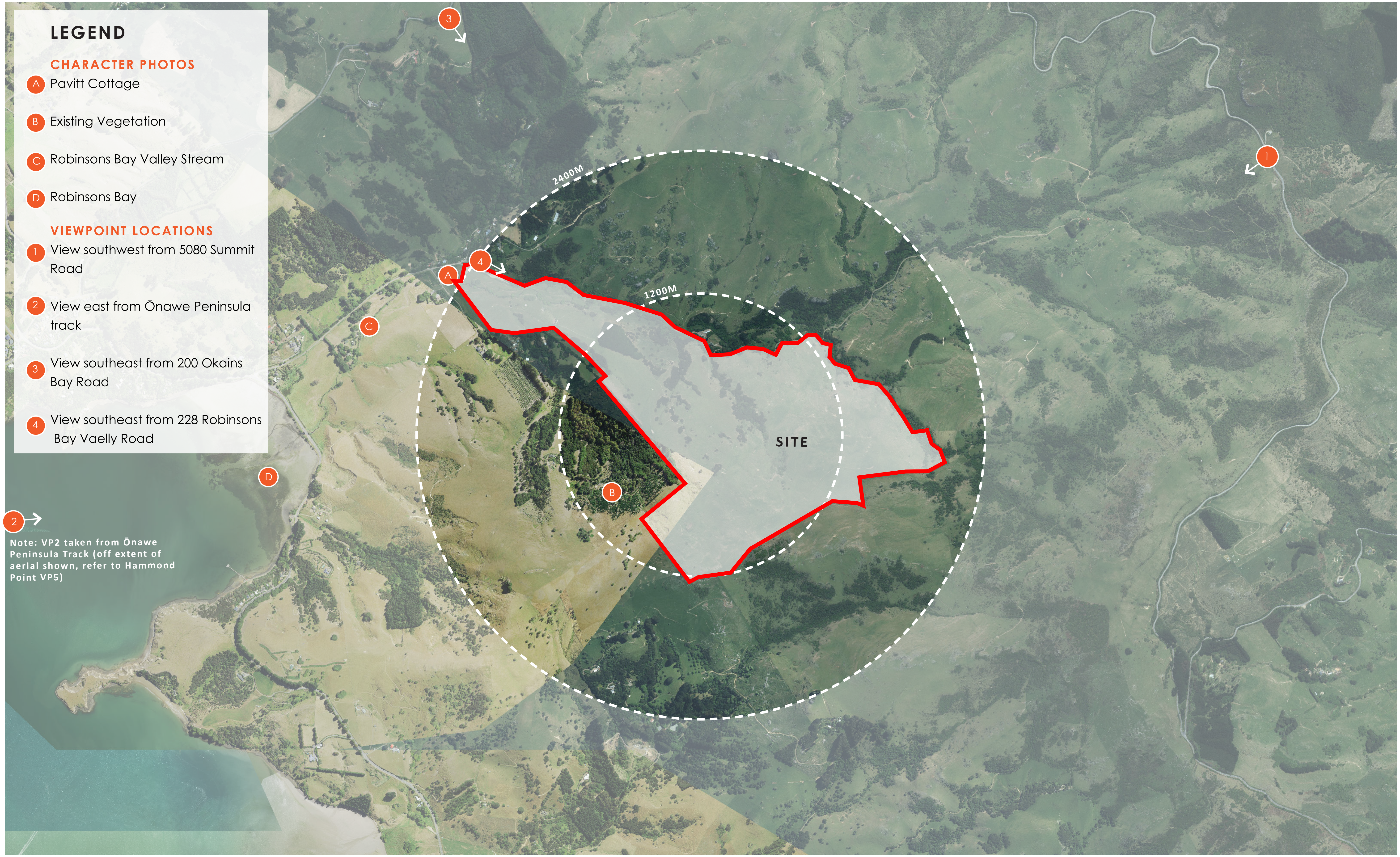
LANDSCAPE CONCEPT PLAN 1

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME



map / image source: CCC Robinsons Bay Valley Landscape Plan LP392501_L05

LANDSCAPE CONCEPT PLAN 2



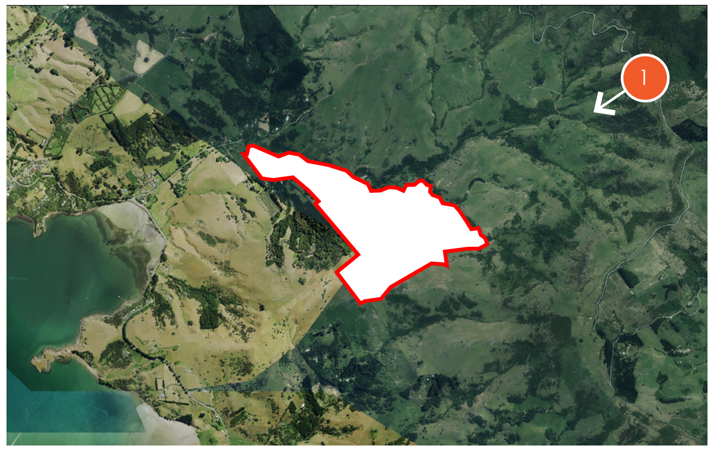
A. LOCATION MAP FOR CHARACTER PHOTOS AND KEY VIEWPOINTS

Ⓐ Existing Site - sits in the valley above Robinsons Bay. The land is undulating and is predominantly grassland used for rural activity. A few residential dwellings are located within the valley and are often supported by sheds.

Ⓑ Existing Vegetation - is typically clustered through the landscape, creating large pockets containing both native and exotics. Naturally regenerating native bush is found in the under story of trees.

Ⓒ Robinsons Bay Valley Stream - runs from the top of the hills, down the valley and into Robinsons Bay. The waterway is naturally formed, resulting in varying widths and depths with sporadic exotic tree growth along the edge.

Ⓓ Robinsons Bay - is a mudflat bay greatly effected by the tide. The bay is surrounded by small pockets of residential development, rural land use and a mixture of native and exotic vegetation.



A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP1 - VIEW SOUTHWEST FROM 5080 SUMMIT ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:18 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP2 - VIEW EAST FROM ŌNAWE PENINSULA TRACK

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:30 pm
Height of 1.7 metres
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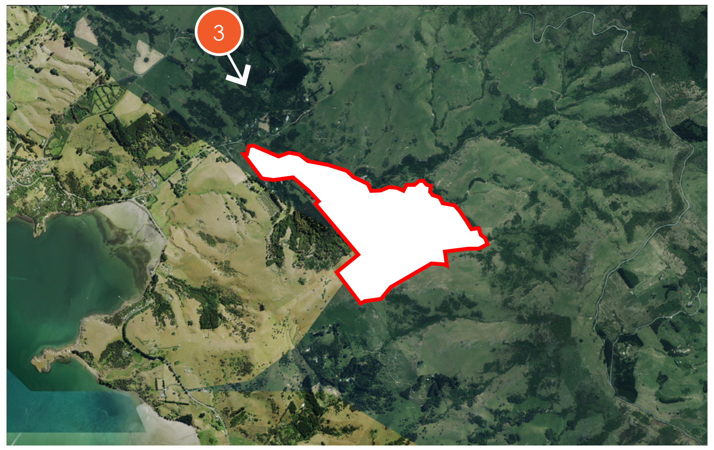


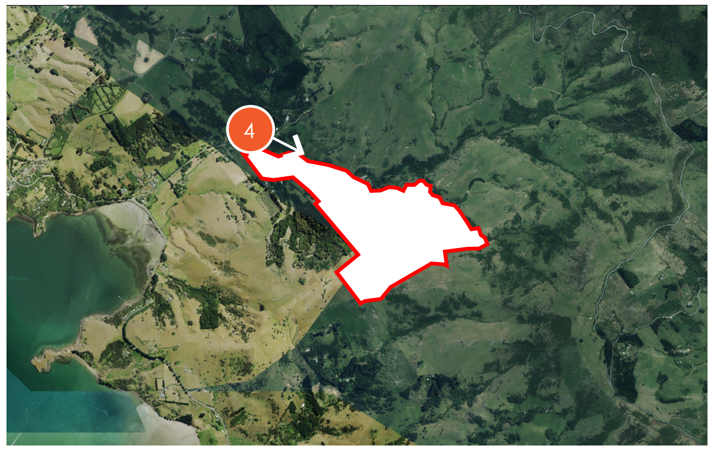
A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP3 - VIEW SOUTHEAST FROM 196 OKAINS BAY ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:32 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



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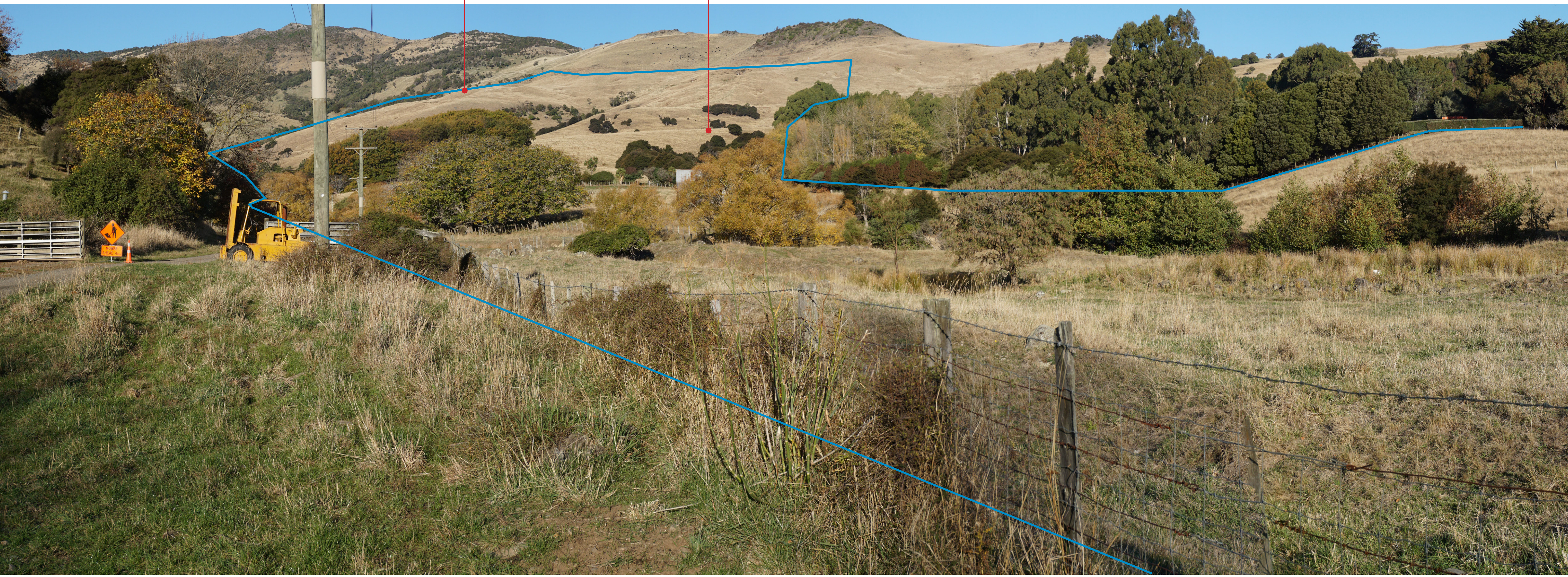
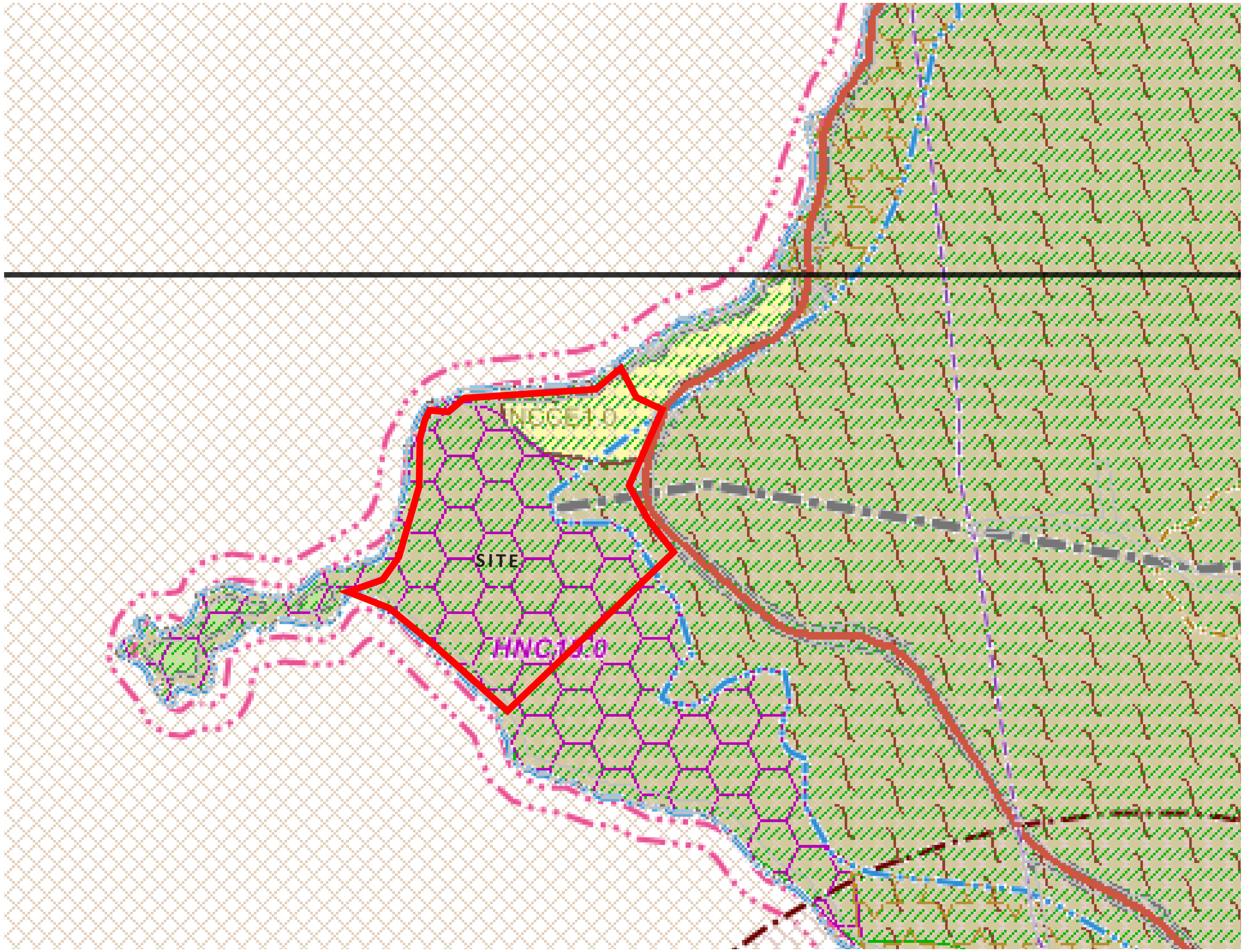


LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP4 - VIEW SOUTH FROM 228 ROBINSONS BAY VALLEY ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 3:44 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama



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Downstream Waterway (Mona Vale)

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Ngā Tūranga Tūpuna

Ngā Wai Coast ID 78

Ngā Wai Coast ID 96

Protected Vegetation

Significant Street Tree

SITE BOUNDARY

map / image source: Christchurch City Council District Plan - not to scale

CONTEXT - DISTRICT PLAN MAP

map / image source: CCC Hammond Point Landscape Plan LP392501_L03

LANDSCAPE CONCEPT PLAN

A. LOCATION MAP FOR CHARACTER PHOTOS AND KEY VIEWPOINTS

A Ōnawe Peninsula - is a narrow band of volcanic land jutting out into the harbour from Duvauchelle. The site is a historic fortified pā and is sacred to Ngai Tahu, though it can be accessed by the public when the tide is low .

B Robinsons Bay - is a mudflat bay greatly effected by the tide. The bay is surrounded by small pockets of residential development, rural land use and a mixture of native and exotic vegetation.

C Residential Outlook - from the northern banks of Robinsons Bay look across the bay towards Hammond Point and hills in the background.

D Existing Site - is rural in character with post and wire fencing delineating the site boundaries. The Point is covered in grass with small pockets of native shrub scattered throughout. The northern side of the site is open bank with the southern side covered in native vegetation.

CONTEXT - CHARACTER PHOTOS

A. IMAGE LOCATION

PROPOSAL LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP1 - VIEW SOUTHWEST FROM 6648 STATE HIGHWAY 75

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 11:46 am
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP2 - VIEW SOUTH FROM 1 ARCHDALLS ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:07 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

VP3 - VIEW SOUTH FROM 6395 STATE HIGHWAY 75

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:05 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP4 - VIEW NORTHEAST FROM 403 WAINUI MAIN ROAD

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

Image captured on Sony ILCE-6000
Focal length of 50mm
Date: 6th May 2021 at 4:59 pm
Height of 1.7 metres
Photos merged in Photoshop CS to create panorama

A. IMAGE LOCATION

PROPOSAL LOCATION

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP5 - VIEW EAST FROM ŌNAWE PENINSULA TRACK

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

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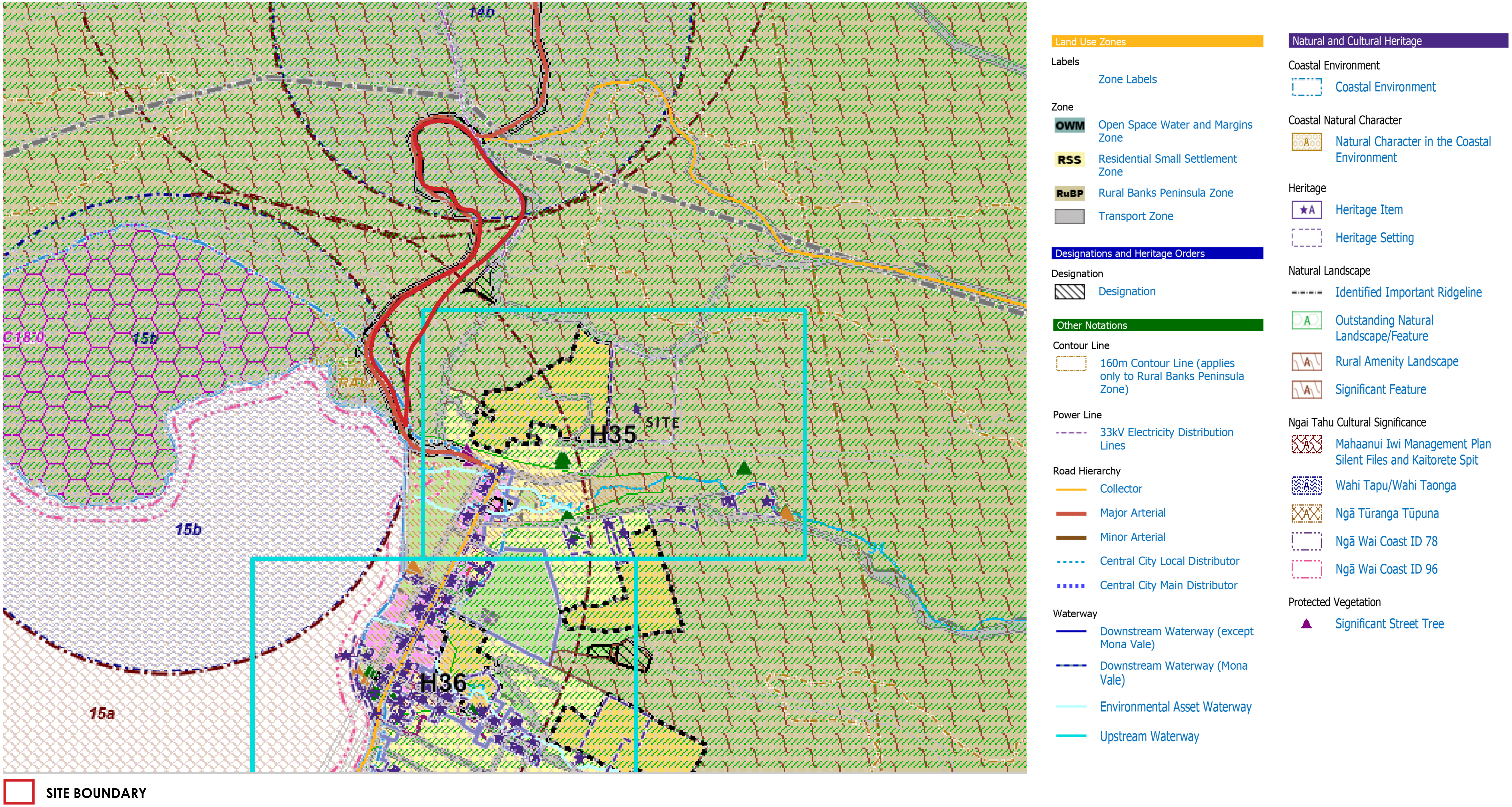

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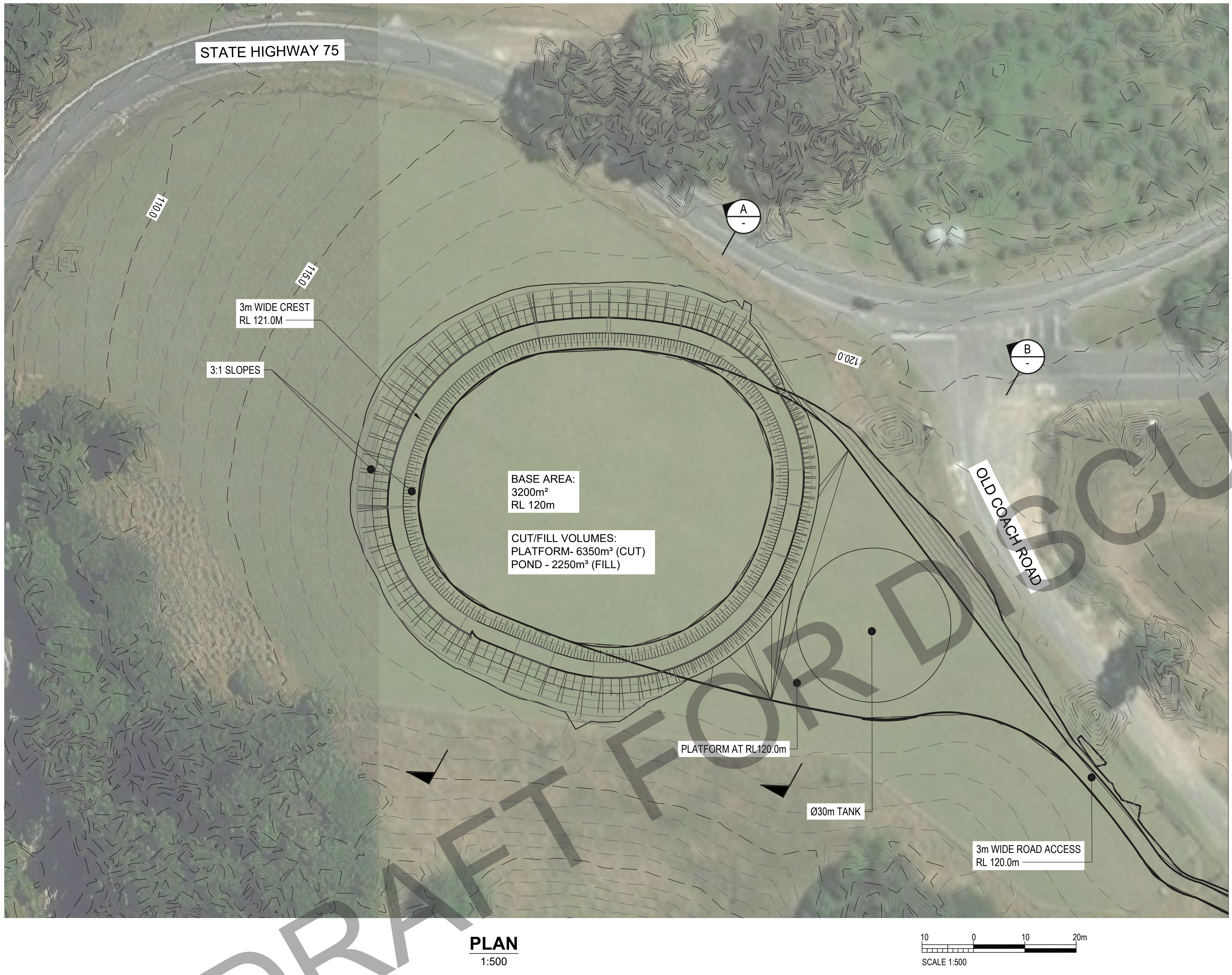

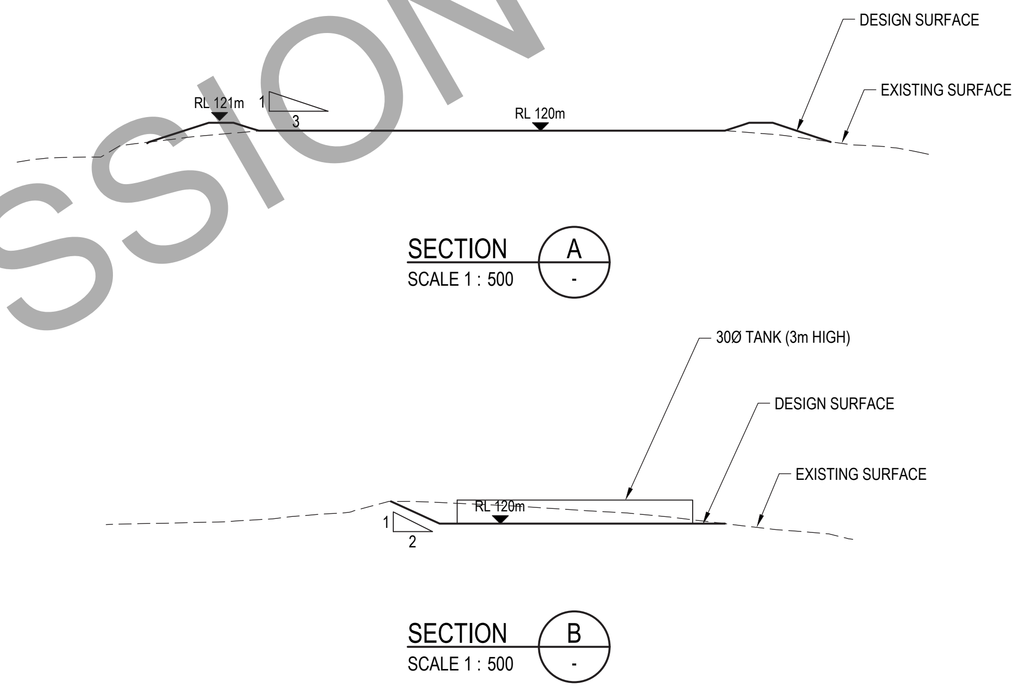

DRAFT FOR DISCUSSION

PRELIMINARY
NOT FOR CONSTRUCTION

map / image source: Stantec - Draft Wetland Concept Plan_310103534-01-001-SK10-A

map / image source: CCC Old Coach Road Landscape Plan LP392501_L04

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

LANDSCAPE CONCEPT PLAN

STANTEC - AKAROA TREATED WASTEWATER IRRIGATION SCHEME

map / image source: Onuku Runanga Old Coach Road Concept Plan

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

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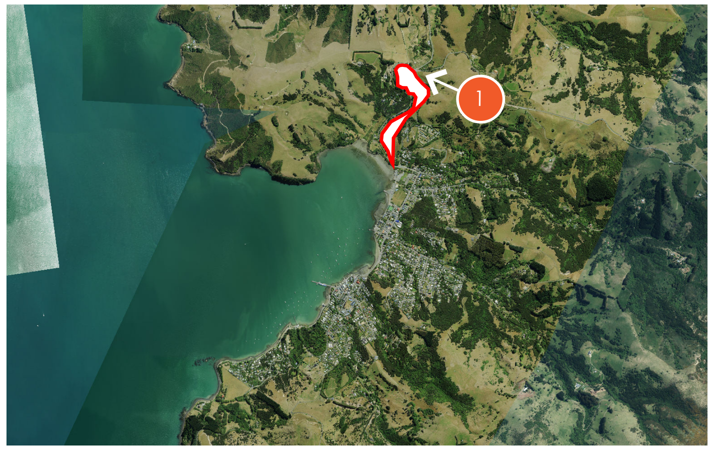

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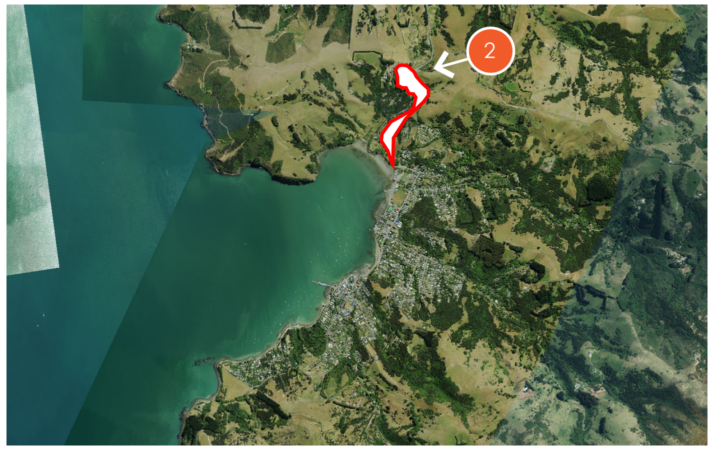

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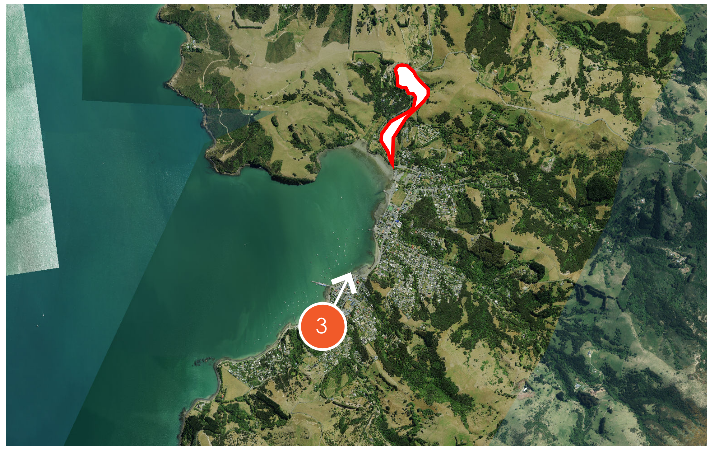

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LANDSCAPE AND VISUAL IMPACT ASSESSMENT

VP3 - VIEW NORTHEAST FROM MAIN WHARF

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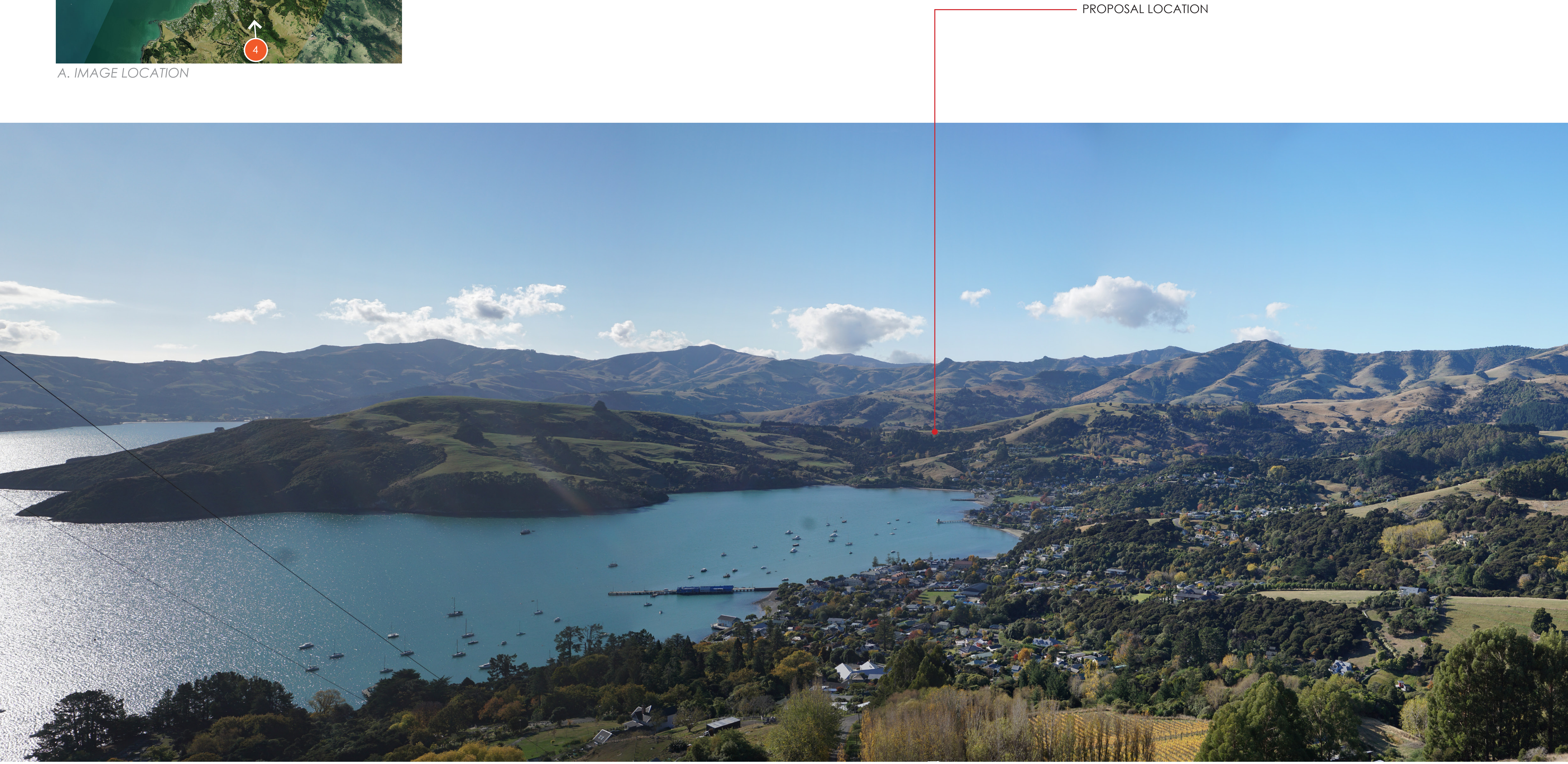

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Appendix N Archaeology Assessment Report

Project Number: 3-C2262.00

Akaroa Wastewater Treatment Scheme – Discharge Consent

ARCHAEOLOGICAL ASSESSMENT

17 December 2021

CONFIDENTIAL

Contact Details

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New Zealand
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Document Details:

Date: 17/12/2021
Reference: 3-C2262.00
Status: Issue 3

Prepared by

Nick Cable
Senior Archaeologist

Reviewed by

Patrick Harsveldt
Senior Archaeologist

Approved for release by

Zoe Burkitt
Work Group Manager – Archaeology & Heritage

Document History and Status

Revision	Date	Author	Reviewed by	Approved by	Status
1	28/09/2021	N. Cable	P. Harsveldt	Z. Burkitt	Draft for Client Review
2	26/11/2021	N. Cable			Draft for Client Review
3	17/12/2021	N. Cable			Final for Release

Revision Details

Revision	Details
2	Incorporates feedback from client in regard to updated schedule works, revised setback areas and mitigation recommendations.
3	Incorporates feedback from CCC and updates following meeting with Heritage New Zealand.

Contents

List of Figures

List of Tables

Disclaimers and Limitations

This report ('**Report**') has been prepared by WSP exclusively for Stantec New Zealand Ltd ('**Client**') in relation to the Akaroa Reclaimed Water Treatment and Reuse Scheme ('**Purpose**'). This is in accordance with the Offer of Service dated 1/03/2021 and the Short Form Agreement between WSP New Zealand Ltd and Stantec New Zealand dated 1/07/2021. The findings in this Report are based on and are subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

1 Introduction

1.1 Purpose of this Report

Christchurch City Council ("CCC") have commissioned Stantec New Zealand, and in turn WSP New Zealand Ltd ("WSP"), to provide an archaeological assessment of proposed treated wastewater storage and drip irrigation at Robinsons Bay, north of Akaroa (Figure 1). This work is being undertaken as part of larger wastewater treatment and irrigation programme.

This report provides an archaeological assessment of the proposed works footprint at the Robinsons Bay irrigation site. It contains an assessment of the archaeological values of the project area and the effects and impacts of proposed works on those values. It is intended to support resource consent applications and an application for an authority to modify or damage archaeological sites.

All recommendations in this report are made in accordance with statutory requirements under the *Heritage New Zealand Pouhere Taonga Act* 2014 (HNZPTA).

Figure 1. Topographic map of Robinsons Bay showing the location of proposed works (outlined in red) (Source: ArchSite).

1.2 Project Background

The Scheme involves construction of a new wastewater treatment plant ("WWTP") north of Akaroa on Old Coach Road. This WWTP will be fed by a new terminal pump station which will be built in the boat park at Children's Bay to pump wastewater from the existing pump stations in Akaroa to the WWTP. Consents for the new WWTP and terminal pump station were granted in 2015.

A covered storage facility for untreated wastewater will be built on council land opposite the treatment plant on Old Coach Road. This pond will provide buffering of in-flows into the treatment plant.

Treated wastewater will be conveyed by a combination of gravity and pumping to a series of ten storage tanks totalling 20,000 m^3 at Robinsons Bay and then distributed via gravity to driplines to irrigate areas of native trees to be planted in Robinsons Bay, Takamātua and Hammond Point. The gravity pipeline will progress from the treatment pond on Old Coach Road along State Highway 75 and then along a revised route up a paper road at the southern end of Robinsons Bay Valley Road to Sawmill Road (Figure 2).

Some of the highly treated wastewater will also be diverted from the WWTP through a 'purple pipe' scheme to be used for irrigating three public parks in Akaroa.

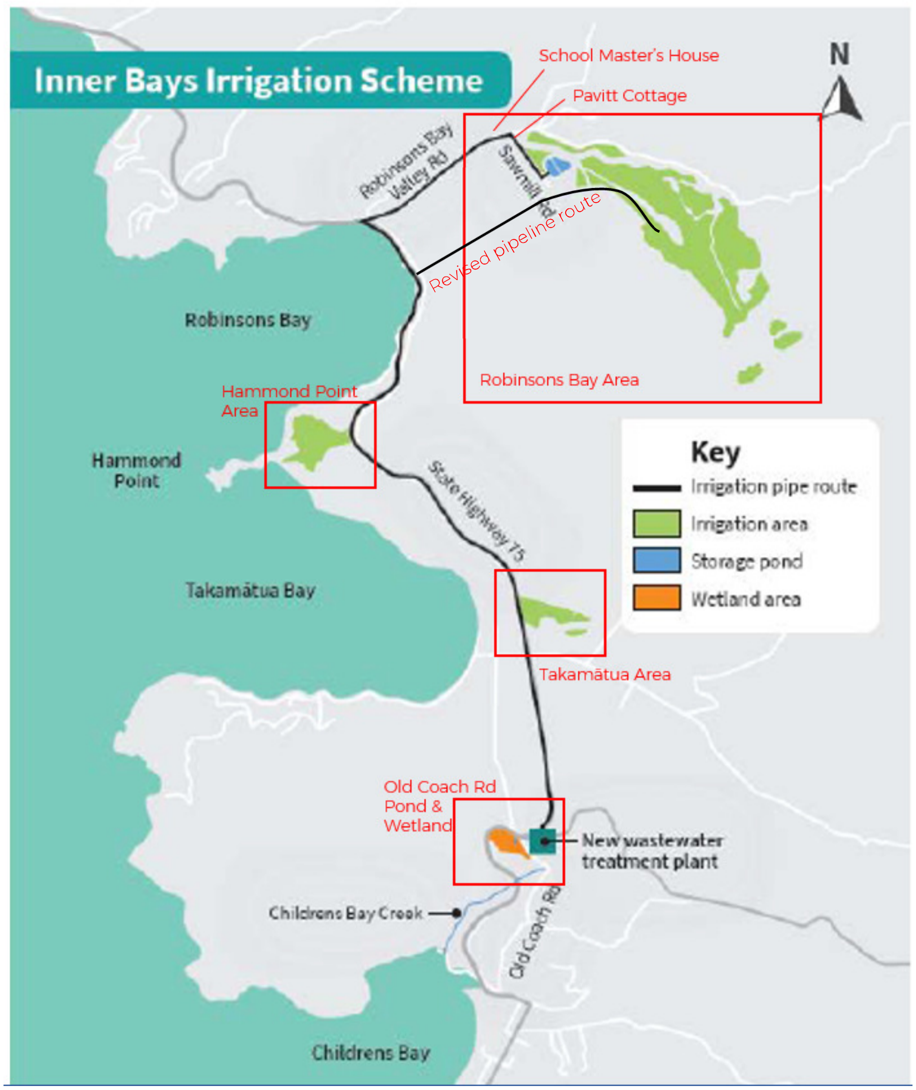

Figure 2. Overview map of the Akaroa reclaimed water reuse scheme (client supplied drawing).

A scoping assessment of the Scheme (CH2m Beca 2020) identified archaeological risks at Robinsons Bay relating to a historic sawmill site at 11 Sawmill Road. Two District Plan listed heritage sites were identified next to the sawmill site – Mill Cottage (no. 1171) (also known as Pavitt Cottage) and the former School Master's House (no. 1173), but these were not considered to be directly affected by proposed works. No archaeological or heritage sites were identified in the areas of proposed works at Takamātua, Hammond Point and the Old Coach Road site.

A review of the scoping assessment by the author confirmed the findings for Takamātua and Hammond Point. However, it was considered that the proposed 'purple pipe' pipeline from the new WWTP on Old Coach Road back into Akaroa had archaeological risks, as did the proposed pipeline north along SH75 and Sawmill Road.

1.3 Disclaimer and Limitations

This report does not present the views of Ngāi Tahu regarding the cultural significance of the project area. Such assessments can only be made by mana whenua, as Māori concerns may encompass a wider range of values than those associated with archaeological sites.

The New Zealand Archaeology Association's (NZAA) digital archaeological site record database (ArchSite) was the primary resource used for identifying recorded archaeological sites in the area. Archaeological site location data in ArchSite should be regarded as a guide only as it is often based on reconnaissance rather than on accurate survey information. In addition to this, the areal extents for many recorded sites are poorly defined. Published archaeological site data should be regarded as a guide only. The coordinates provided are, at best, only accurate to 100 metres. The full extent of recorded sites is often not known, and the single point coordinate is often based on the visible surface expression only. This does not necessarily represent the true subsurface extent of an archaeological site.

2 Statutory Requirements

2.1 Legislative Framework

There are two statutory instruments that control work affecting archaeological sites in New Zealand (see *HNZPT* 2019):

- *Heritage New Zealand Pouhere Taonga Act 2014 (HNZPTA)*
- *Resource Management Act 1991 (RMA)*

2.2 Heritage New Zealand Pouhere Taonga Act 2014

The HNZPTA protects all archaeological sites from damage or modification unless an authority to do so has been issued by HNZPT.

An *archaeological site* is defined in the HNZPTA (s6) as:

(a) Any place in New Zealand, including any building or structure (or part of a building or structure), that –

i. was associated with human activity that occurred before 1900; or is the site of the wreck of any vessel where that wreck occurred before 1900; and

ii. provides or may provide, through investigation by archaeological methods, evidence relating to the history of New Zealand; and

(b) Includes a site for which a declaration is made under Section 43(1).

Any person who intends carrying out work that may modify or destroy an archaeological site, or to investigate an archaeological site using invasive archaeological techniques, must first obtain an authority from Heritage New Zealand Pouhere Taonga (HNZPT). The process applies to sites on land of all tenures, including private, public and designated land. The HNZPTA contains penalties for unauthorised site damage.

The archaeological authority process applies to all archaeological sites regardless of whether:

- the site is recorded in ArchSite or entered on the New Zealand Heritage List / Rārangi Kōrero (The List).
- the site only becomes known about because of ground disturbance.
- the activity is permitted under a district or regional plan, or a resource or building consent has been granted.

2.3 Resource Management Act 1991

The RMA provides for the sustainable management and protection of natural and physical resources, including the cultural environment. It requires territorial authorities to manage the use, development, and protection of natural and physical resources in a way that provides for the wellbeing of today's communities while safeguarding the options of future generations.

Section 6 (f) – *Matters of National Importance* of the RMA provides for "*the protection of historic heritage from inappropriate subdivision, use, and development*" as a matter of national importance.

The definition of "historic heritage" (RMA s2) refers to *"those natural and physical resources that contribute to an understanding and appreciation of New Zealand's history and cultures."*. This includes historic sites, structures, places and areas; archaeological sites; sites of significance to Māori; and surroundings associated with these resources. These categories are not mutually exclusive, and some archaeological sites may include historic sites or may also be places that are of significance to Māori.

3 Methodology

3.1 Identification of Archaeological Sites

ArchSite is a digital database maintained by NZAA which contains details on all recorded archaeological sites throughout New Zealand. Individuals, professional archaeologists, and iwi groups have contributed files in the database over the last sixty years, and the quality and detail on records varies. The database is a useful management tool for understanding the distribution of archaeological sites within an area and past land use patterns. Although some areas of New Zealand have been intensively surveyed and large numbers of archaeological sites recorded, there are still large areas where no archaeological surveying has been carried out and few sites, if any, have been recorded. A lack of recorded sites does not necessarily equate to an absence of sites in some regions.

ArchSite was consulted for information on recorded archaeological sites within the study area.

In addition to ArchSite, a desktop review was made of primary and secondary sources on the study area, including historic aerial photographs, online documentary archives, the HNZPT Digital Archaeological Report Library, and the New Zealand Heritage List/ Rārangi Kōrero.

The results of the documentary review are presented in Sections 4 and 5.

The project area was visited by the author on 21/07/2021 in order to undertake an archaeological survey of the drip irrigation areas. The results of the site visit are presented in Section 6 of this report.

3.2 Criteria for Assessing Archaeological Values

Under the HNZPTA, archaeological assessments are directed to determine whether proposals will directly impact archaeological sites and hence require an authority to modify or damage archaeological sites from HNZPT.

HNZPT regard the following values as important in determining whether an authority can be granted and what mitigation conditions should be attached to the authority's decision (HNZPT 2019:9-10):

I. *The **condition** of the site(s).*

II. ***Rarity**: Is the site(s) unusual, rare or unique, or notable in any other way in comparison with other sites of its kind?*

III. *Does the site possess **contextual value**?*

IV. ***Information Potential**: What current research questions or areas of interest could be addressed with information from the site(s)?*

V. ***Amenity Value**: Does the site(s) have potential for public interpretation and education?*

VI. *Does the site(s) have any special **cultural associations** for any particular communities or groups?*

3.3 Criteria for Assessing Heritage Values

The RMA informs a prescriptive assessment process for determining environmental effects (Schedule 5). As part of an Assessment of Environmental Effects (AEE), an assessment of heritage effects must assess the effects of a proposal on the heritage values of recognised heritage sites and identify appropriate mitigation or avoidance measures for these effects.

An Archaeological Assessment should consider both archaeological values relevant to the HNZPTA authority process and heritage values relevant to RMA decision making in determining effects on heritage values.

The RMA lists a number of qualities for assessing historic heritage in order to provide a robust analysis as part of a resource consent application, and to withstand, for example, Environment Court scrutiny.

There qualities are (RMA s2):

i. Archaeological

ii. Architectural

iii. Cultural

iv. Historic

v. Scientific

vi. Technical

Section 66(3) of the HNZPTA lists criteria that should be used to assess the heritage significance of a historic place:

a) The extent to which the place reflects important or representative aspects of New Zealand history.

b) The association of a place with events, persons, or ideas of importance in New Zealand history.

c) The potential of a place to provide knowledge of New Zealand history.

d) The importance of the place to tangata whenua.

e) The community association with, or public esteem for, the place.

f) The potential of the place for public education.

g) The technical accomplishment or value, or design of the place.

h) The symbolic or commemorative value of the place.

i) The importance of identifying historic places known to date from early periods of New Zealand settlement.

j) The importance of identifying rare types of historic places.

k) The extent to which the place forms part of a wider historic and cultural area.

Section 66(4) and (6) provide that additional criteria may be prescribed by regulation.

For the purposes of this assessment, the HNZPTA assessment criteria relevant to assessing heritage values have been incorporated within a framework of RMA qualities in order to provide a robust form of analysis for RMA purposes (Table 1). This approach is consistent with that used in numerous Regional Policy Statements around the country (e.g. Waikato Regional Policy Statement Section 10A; Bay of Plenty Regional Policy Statement Appendix F).

A twofold assessment has been applied in this report. The archaeological values of sites identified in this report are assessed using the HNZPTA assessment criteria (see Section 3.2). The heritage values of each archaeological site are assessed using the combined assessment criteria (see Section 3.3).

Magnitudes for the value assessments were based on an evaluation of the level of significance at a local, regional or national level, with greatest value placed on those sites with national or greater significance.

Table 1. Combined Assessment Criteria for Heritage Value Assessments.

Archaeological Qualities	a) **Information** – The potential for the place to define or expand knowledge of earlier human occupation, activities, or events through investigation using archaeological methods.
	b) **Research** – The potential of the place to provide evidence to address archaeological research questions.
	c) **Recognition or Protection** – The place is recognised with the HNZPT for it archaeological value either by being entered on the New Zealand Heritage List / Rārangi Korero or as a gazetted post-1900 archaeological site, or recorded by the NZAA Site Recording Scheme, or is an 'archaeological site' as defined by the HNZPTA.
Architectural Qualities	a) **Site or Type** – The style of the building or structure is representative of a significant development period in the region or the nation. The building is associated with a significant activity.
	b) **Design** – The building or structure has distinctive or special attributes of an aesthetic or functional nature. These may include massing, proportion, materials, detail, fenestration, ornamentation, artwork, functional layout, landmark status or symbolic value.

	c) **Construction** – The building uses unique or uncommon building materials, or demonstrates an innovative method of construction, or is an early example of the use of a particular building technique.
	d) **Designer or Builder** – The building's architect, designer, engineer or builder was a notable practitioner or made a significant contribution to the region or nation.
Cultural Qualities	a) **Sentiment** – The place is important as a focus of spiritual, political, national or other cultural sentiment.
	b) **Identity** – The place is a context for community identity or sense of place and provides evidence of cultural or historical continuity. The place is a local landmark or physically prominent.
	c) **Amenity or education** – The place has symbolic or commemorative significance to people who use or have used it, or to the descendants of such people. The interpretative capacity of the place and its potential to increase understanding of past lifeways or events.
Historic Qualities	a) **Associative Value** – The place has a direct association with, or relationship to, a group, institution, event or activity of historical significance.
	b) **Historical Pattern** – The place is associated with broad patterns of local or national history, including development and settlement patterns, early or important transportation routes, social or economic trends and activities.
Scientific Qualities	a) **Information** – The potential for the place or area to contribute further information and the importance of the data involved, its rarity, quality or representativeness.
	b) **Potential for Scientific Research** – The degree to which the place may contribute further information and the importance of the data involved, its rarity, quality or representativeness.
Technological Qualities	a) **Technological Achievement** – The place shows a high degree of creative or technological achievement at a particular time or is associated with scientific or technical innovations or achievements.

4 Environmental Context

4.1 Physical Setting

Akaroa Harbour is formed from the eroded crater of an extinct volcano which once dominated the coastline. The remains of the caldera form the ridgeline around the harbour, with prominent peaks rising to over 600 metres above sea level.

Robinsons Bay is a sheltered inlet on the east side of Akaroa Harbour, approximately 15 km north of Akaroa township. The bay leads to a relatively flat valley which drains a number of waterways from steep slopes to the north and south, including the Kakakaiau Stream/ Robinsons Bay Stream which flows into the bay. The valley narrows as it rises into the steeper slopes to the east. Robinsons Bay Valley Road continues to the head of the valley at Okains Peak.

Prior to human impacts, Banks Peninsula was dominated by podocarp/hardwood forest. Kahikatea dominated the valley floors while the lowers slopes of the ridgeline were covered with lowland totara and matai. The upper slopes contained totara, broadleaf and other shrubby hardwoods and tree ferns, which in turn gave way to non-forest montane species of shrubland and scrub.

As much as three quarters of the land was still covered in old forest growth when Europeans first arrived. Robinsons Bay was no different, however most of the forest growth has since been cleared by milling and converted to pasture. Patches of bush and introduced trees survive throughout the valley.

4.2 Historic Background

The first human settlers in Banks Peninsula were the Waitaha, descendants of the explorer Rākaihautū, who arrived in the waka Uruao. These settlers occupied the sheltered harbours and bays along the eastern coastline, exploiting the abundant marine and terrestrial resources (Challis 1995:1). Ngāti Mamoe and later, Ngāi Tahu, arrived from the north from the late 16th century AD onwards.

The original name for Robinsons Bay was Kakakaiau, the name of the main stream in the bay. The name was thought to refer to the numerous kaka birds that lived there (*Akaroa Mail* 28/04/1882). The southern headland of the bay, separating it from Takamātua, was named Te Umu-te-rehua, likely a reference to flounder fishing in the bay (Anderson 1927:191; Ogilvie 1991:167).

Intertribal warfare culminated in the Kai Huanga feuds from the 1800s, followed by Te Rauparaha's invasions from late 1820 which resulted in the sacking of Ōnawe Pa in 1832 (Ogilvie 1991:13). These events, along with increasing European influence saw significant changes to the way of life for Māori and serious population depletion on Banks Peninsula (Underground Overground Archaeology 2020:16). By the 1830s, the combined impact of these events had led to the abandonment of many of the coastal settlements and consolidation of people at Ōnuku (Wilson & Beaumont 2009:9).

In 1838 the French Captain Jean Langlois purchased around 5000 hectares of land around Port Cooper from Māori (Maxwell & Huebert 2020:6). Some of this land was sold to settlers by the Nanto-Bordelaise Company who were also responsible for the 1840 French settlement in Akaroa (Ogilvie 1991:15, 20-23).

Charles Barrington Robinson and William Watkins Wood purchased a 100 acre section of land at Robinsons Bay from the Nanto-Bordelaise Company on 3 June 1842 (Maxwell & Huebert 2020:11; Hight & Straubel 1957:240). The section encompassed much of the valley flat from the foreshore inland. Robinson built a dwelling near the beach southeast of the stream (Maxwell & Huebert 2020:11).

Under threat of losing their property entitlements following the signing of the Treaty of Waitangi, the Nanto-Bordelaise Company successfully petitioned for land grants to cover their holdings at Akaroa in 1845, although with declining whaling revenues, the company sold their interests to the newly-formed New Zealand Company in 1848 (Maxwell & Huebert 2020:6). The British government were able to extend their protection to some of the existing freehold landowners, but other lands were transferred back to the Crown and then granted to new incoming settlers. This led to uncertainties as to ownership, property boundaries and pasture licenses (Ogilvie 1991:14-15; George 2008; Leach & George 2010a:8-10; Leach & George 2010b:5-8). Robinson and Wood, along with fellow settler Sir Michel le Fleming, were able to retain their land holdings (Maxwell & Huebert 2020:11).

Robinson returned to England in 1850 and brought back immigrants John Pavitt and his extended family as well as Samuel Farr, who married one of Pavitt's daughters (Maxwell & Huebert 2020:11; Mould 1991:10). Farr was an architect and engineer who would go on to help design the Cumberlands Sawmill in Duvauchelle Bay and the Haylock overshot flour mill in Akaroa (Ogilvie 1991:5; Dingwall and Haylock 2018; Leach & George 2012a).

Farr established a sawmill at Robinsons Bay in order to build a dwelling and supply timber to Christchurch and this was said to be the first sawmill in Canterbury (Anderson 1927:191). The mill began with pit sawing but by 1855, Farr had designed and constructed an overshot waterwheel to power the sawmill (Ogilvie 1991:6-7). The sawmill was inspected by Henry Sewell in February 1855 and described as a vertical circular saw powered by an 18 foot (5.4 m) diameter overshot waterwheel made of totara and kowhai, fed by nearly 100 foot (30 m) of timber fluming on trestles (MacIntyre 1980:132 *vide* Maxwell & Huebert 2020:29). Along with the mill were excavations for a reservoir and small dam just above the mill and a 2 and ½ mile (4 km) tramway with fourteen bridges built over the creeks and sawmill workers' huts along the creek banks. Sluice gates would have been needed to control the flow of water into the reservoir and then into the flume, along with an overflow channel and deep wheel pit below the water wheel and a tail race back into the stream (Leach & George 2012a:5)

Wood sold his interests in 1854 and Robinson sold what would become Rural Section 579 to John Pavitt's sons, Frederick, Henry, Francis and Alfred in October 1856 (Maxwell & Huebert 2020:12). At the same time, fire swept through the section destroying the Pavitts' residence and Farr's sawmill (*Lyttelton Times* 1/11/1856:7; Leach & George 2012a:4). The Pavitts lived in a whare in the bush while building a new house (Maxwell & Huebert 2020:14). The sawmill workers camped close to the beach as their own huts along the creeks had also been destroyed. At this time, the land was still largely covered in "black and white pine, totara, manuka, kowahi, koanini" (Farr 1900:56 *vide* Maxwell & Huebert 2020:12).

Following the death of Henry Pavitt and threat of partnership dissolution in 1860, the remaining Pavitt Brothers looked to sell their land holdings, comprising 118 acres of land and including the sawmill, three dwellings, sawyers' huts, gardens and orchards (*Lyttelton Times* 5/12/1860:6). This land included both Rural Section 579 and Rural Section 958 to the north-west (Figure 3). Sixty acres of land were described as cleared and fenced. The dwellings included a homestead of ten rooms and a wash-house, a 4-room house and a 2-room cottage. The homestead, "Woodlands", was named after the original Pavitt home and likely occupied by Frederick Pavitt and his wife, Mary Ann, as well as the remainder of his father's dependants (Leach & George 2010a:2). The 4-room dwelling was likely that of Francis and Annette Pavitt, located on the elevated northwest corner of Rural Section 579 (Leach & George 2010a:3). The 2-room cottage was presumably formerly occupied by Henry Pavitt, identified as a timber merchant and farmer in the 1857 electoral roll (Leach & George 2010a:2). The location of this house is unknown but was likely located near the sawmill, debatably as the antecedent for the current Mill House despite lying outside the boundaries of R.S. 579 (see Leach & George 2010a). The sawmill was described as "nearly new" and capable of cutting ten thousand feet of timber per week, with a large and constant supply of water. The land does not appear to have been sold at this time.

John Pavitt died in 1865 and Rural Section 579 was again offered for sale, this time described as 100 acres subdivided into six paddocks, "together with a ten roomed house, outbuildings, garden, stockyard, milk shed, etc" (*Press* 27/04/1865:3). There is no mention of the sawmill nor other dwellings. The section was leased to George Henry Saxton and Frederick Walter Williams, formerly sawyers in Le Bons Bay. They eventually purchased the land in 1874.

By the late 1850s, the land surrounding the Pavitts' estate began to be purchased by others. In 1857, Rural Section 882, a 20 acre section on the south-eastern boundary of R.S. 579 (Figure 3), along with pasture rights for land to the north-east were secured by Captain John Jenkins Peacock, a Sydney based merchant (Maxwell & Huebert 2020:16; see Leach & George 2010b).

The land parcels to the immediate east of R.S. 579, Rural Sections 1763 (49 acres) and Rural Section 1764 (55 acres), were granted to Richard Jackson Hughes in April 1856 in payment for public works (Leach & George 2012b:3). In 1861 the lands were sold to his father, Thomas Jackson Hughes (D.I.B. C3 *f.*1763, 1764). A 20-acre section of land between R.S. 1763 and R.S. 1764, Rural Section 1248, remained unallocated at this time (Maxwell & Huebert 2020:16).

Thomas Hughes was a pioneer settler who first arrived in Wellington in 1840 before moving to Canterbury in 1849 and working as a foreman under Captain Thomas (*Lyttelton Times*

11/03/1865:4). He was also the first proprietor of the Heathcote Ferry. He operated a sawmill at Robinsons Bay from early 1860, bringing two timber cutting saws which he had purchased in Otago to the valley and stating his intention to put them on the land, then advertising for circular saw benchmen to join his operation (*Lyttelton Times* 23/03/1861:1; Leach & George 2010a:7; Maxwell & Huebert 2020:30). By 1862, he advertised for a further 10 to 12 good sawyers and in 1863, a blacksmith to join the Works (*Lyttelton Times* 19/07/1862, 13/06/1863:5).

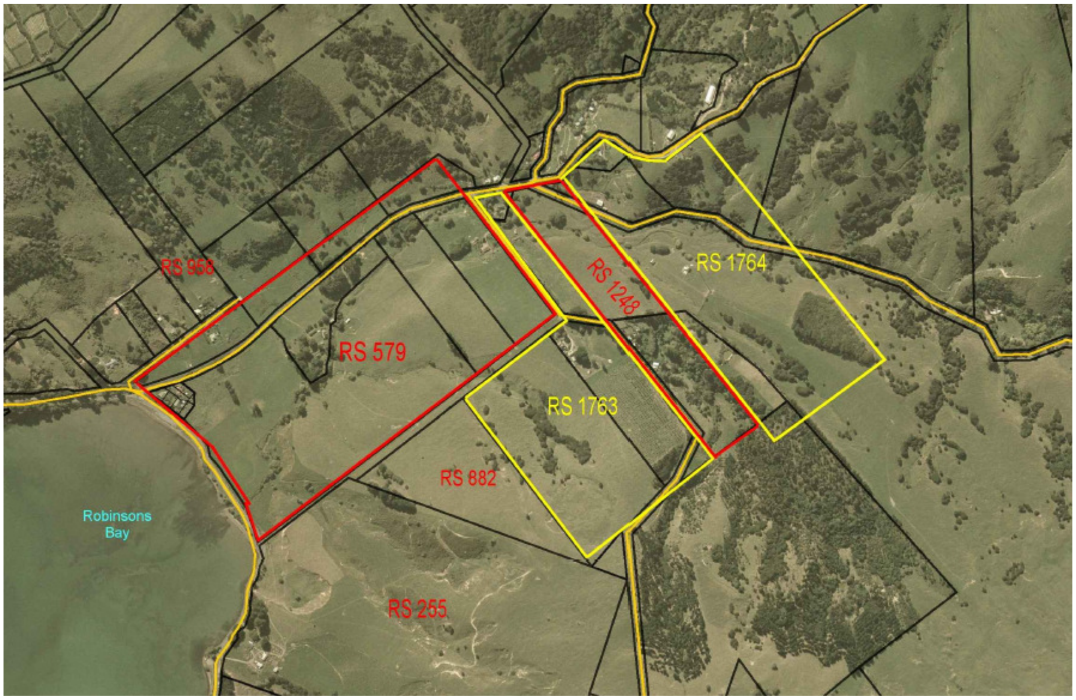

Figure 3. Original land parcels in Robinsons Bay, reproduced from Leach and George 2010a:1 Map 1).

The historical evidence is inconclusive as to whether Hughes set up his own mill or took over the existing Pavitt mill (Jacobson 1914:20, Mould 1991:26 *vide* Maxwell & Huebert 2020:30; Leach & George 2012a). An 1861 newspaper article states that he built his own sawmill on the promise of being able to construct a road from his sawmill down to the beach across the Pavitt property, but the Pavitts initially refused to sell a corridor of their land for road (Leach & George 2010a:10). The Provincial Government cut a line for the road along the north-western boundary of the Pavitt's property in October 1861, but the alignment was criticised by Hughes (*Lyttelton Times* 21/06/1862:4; *Press* 28/12/1861:2, 16/09/1864:2). Leach and George (2010a) argue that this road survey may have led to a reconsideration of the actual boundaries of the Pavitt property and subsequent withdrawal of land and the sawmill site from sale notices after 1861. Maxwell and Huebert argue that both the Pavitts and Hughes may have amalgamated their holdings into one sawmill, on considering references to both parties owning the sawmill at the time of its sale in 1865 (Jacobson & Stack 1940:196; Mould 1991:33 both *vide* Maxwell & Huebert 2020:33).

Hughes' property was offered for sale following his accidental death at the sawmill in 1865 (*Lyttelton Times* 20/06/1865:7). The property was described as comprising two well-built houses, three acres of orchard, and one of the finest saw-mills in the province.

The land was purchased by George Saxton and Frederick Williams in 1865 at the same time as they leased, and eventually purchased, the former Pavitt Estate, consolidating a large land holding encompassing much of Robinsons Bay. By 1874, Williams was living in the Mill Cottage next to the sawmill site, while Saxton lived in the "Woodlands" homestead formerly occupied by the Pavitts. Saxton and Williams purchased additional sections in the valley in the following years and farmed them once they were cleared of timber, eventually holding a total of 2,038 acres (Leach & George 2012b:5). They also claimed ownership of Rural Section 1248 and this was recognised in the Deed Index Books in 1873 (D.I.B. C2 *f*.1248).

In December 1865, Saxton and Williams looked to convert the sawmill to steam power by requesting a 10-12 horsepower steam engine (*Lyttelton Times* 11/12/1865:3). By 1867, they had converted the sawmill to steam power, renaming it the Matlock Mills (*Star* 7/11/1870:3; Ogilvie 1991:169). It became an important supplier of timber to the region, providing in excess of one million feet of timber annually and employing up to 40 workers (Figures 4-5) (Mould 1991:33; Ogilvie 1991:170). A butcher shop and store were added to the Mill Cottage and in the 1870s, a schoolhouse and school master's house were built nearby (Mould 1991:30; Anderson 1927:191)

Figure 4.Robinson's Bay Mill, c.1870 (Ogilvie 1991:169, credited to Orville Williams, reproduced from Maxwell & Heubert 2020:34).

Figure 5. Robinsons Bay sawmill and cottage, c. 1870 (Mould 1991:7, painting in collection of Wynn Williams, reproduced from Maxwell & Heubert 2020:36).

By 1877, the mill was in decline given the distance from timber that needed to be sourced (*Akaroa Mail* 25/05/1877:2; Ogilvie 1991:170). Much of the land had been cleared by this stage and was turned to pasture, with some patches of native bush retained to protect springs and creeks as well as to provide shelter for stock (*Akaroa Mail* 28/04/1882).

Williams eventually sold his interests in 1881 and retired to St Martins in Christchurch, dying in 1888 at the age of 50 after a long and painful illness (*Press* 14/12/1888:4). Saxton took over the entire land holdings and ran a sheep and dairy farm (Mould 1991:36, Jacobson 1914:292). The mill tramway was repurposed to haul cheese to the wharf for export. Saxton also created an oak plantation which survives today (Mould 1991:37).

In March 1898, the farm was offered for sale by Gould, Beaumont & Co, with Saxton as occupier (*Akaroa Mail* 4/03/1898:3). The property was described as comprising about 2000 acres which was being surveyed and subdivided, and that 1000 acres would be sold by public auction in suitable lots in April. A subdivision plan appeared in August 1898 as Deposited Plan 1410 (Figure 6). Many of the smaller farm plots in the subdivision went to former employees (Maxwell & Huebert 2020:45).

Lots 4, 8 and 9 of DP 1410 were purchased by Christopher and John Thacker, farmers of Okains Bay in 1899 (C/T CB183/262). By this time, the sawmill had since disappeared, leaving only a large waterwheel (Figure 7). This land sold in 1910 to Frederick Wynne Williams and Arthur Leslie Williams, sons of the former mill owner (Maxwell & Huebert 2020:50). It was subdivided again in 1952 under Deposited Plan 16571 and Lot 1, encompassing the sawmill site and much of the upper valley, were purchased by Frederick James Williams and Orville Henry Tosswill Williams (C/T CB571/35). The land containing Mill Cottage and the sawmill site was offered up for reserve in the

1980s by Orville Williams, but the proposal did not succeed (Mould 1991:42 vide Maxwell & Huebert 2020:50). Murray and Luis Thacker purchased the wider land holding from the Williams in 1986 (C/T CB 571/35). Mill Cottage was subdivided from the larger land holding and purchased by descendants of the Pavitts in 2000 (C/T CB 47D/511). The dwelling was repaired and restored and is now administered by the Pavitt Cottage Trust.

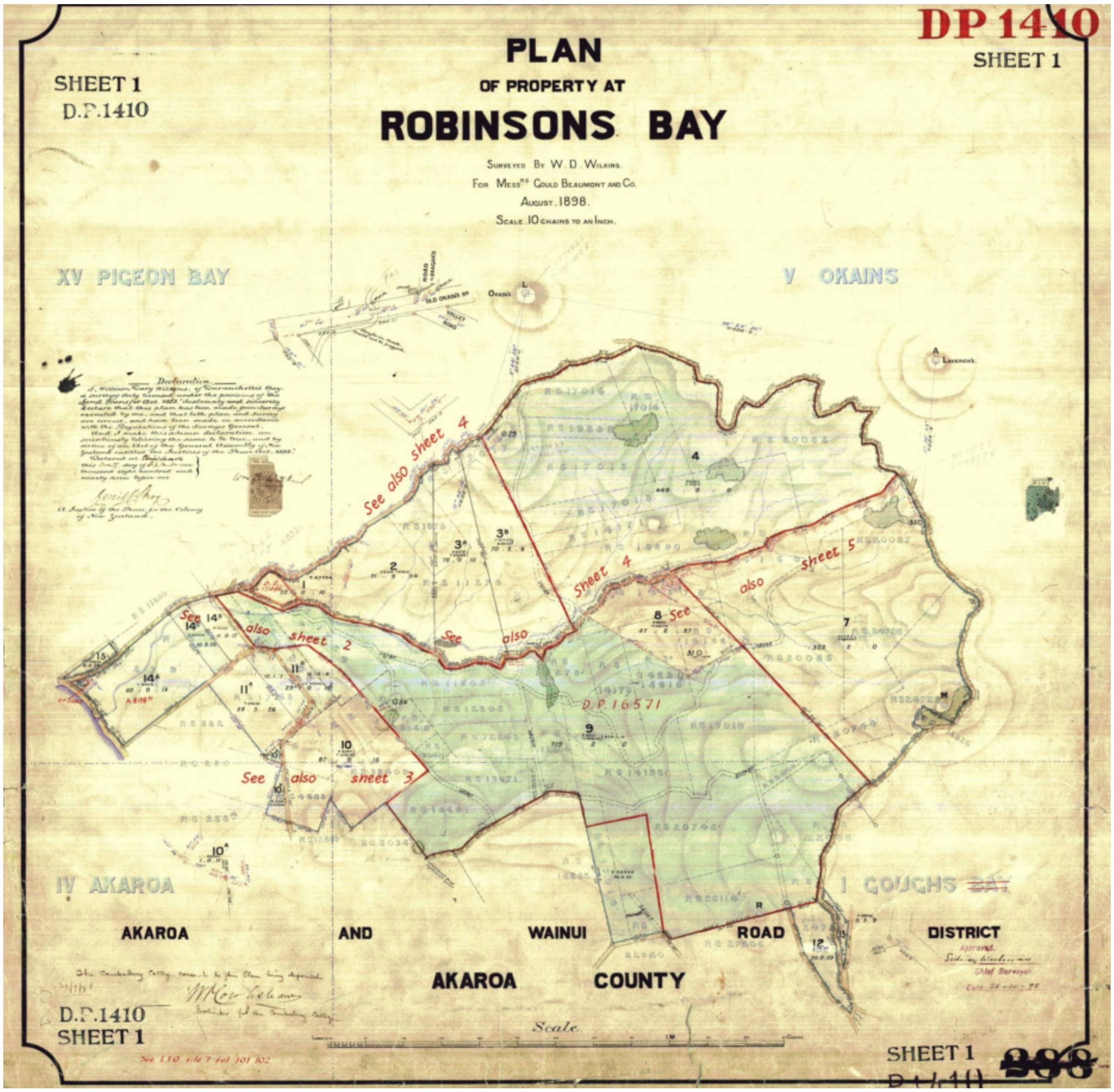

Figure 6. Deposited Plan 1410 (1898) showing land owned by the Canterbury College (Source: Grip.co.nz).

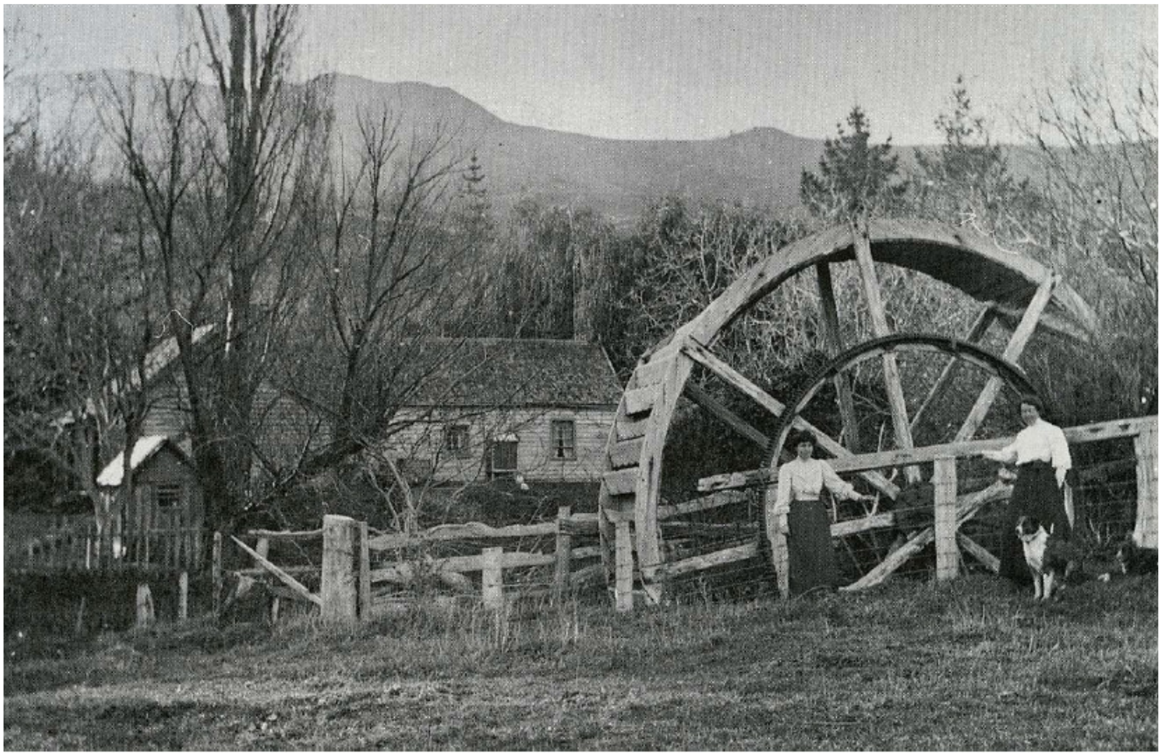

Figure 7. The mill waterwheel c.1906 during the land tenure of the Thackers (Ogilvie 1991:168, credited to Marie Rhodes, reproduced from Maxwell & Huebert 2020:46).

5 Documentary Research

5.1 Recorded Archaeological Sites

The following archaeological sites recorded in ArchSite are considered relevant to the proposed works (Table 2).

Table 2. Details on recorded archaeological sites relevant to the proposed works.

SRF No:	Easting (NZTM)	Northing (NZTM)	Description	Date recorded
N36/155	E1597597	N5155015	Mill Cottage, 5 Sawmill Road – a c. 1860 timber cottage recorded by Katharine Watson in 2015. The history of the cottage is disputed as it is not clear whether it was built by the Pavitt family or Hughes family, although there is general consensus that it was built in c.1860. This site is located adjacent to, but outside of the area of proposed works.	2015
N36/260	E1597780	N5154938	Pavitt/Hughes/Saxton Sawmill – encompassing the Mill Cottage, Waterwheel remains, mill dam, spillway, head race and tramway on Lots 1-2 DP 82749. The features were recorded by Justin Maxwell in 2020 as part of a wider assessment of the archaeological landscape commissioned by the Pavitt Cottage Trust. As land access was not permitted, the features were recorded on the basis of historic documents, aerial photographs and what could be observed from the road. The	2020

			condition of visible features was described as good, given minimal evidence of land modification. This site is located within the area of proposed works.	
N36/105	E1596989	N5154301	Midden - Recorded as burnt basalt stones visible on the south side of the creek mouth at Robinsons Bay in 1969 by Mike Trotter. The burnt stones were interpreted as evidence of an early Māori oven, in turn indicative of pre-European Māori activity in this location. The site has not been seen since its original recording and is assumed destroyed. The site lays outside of the area of proposed works although pipeline installation along State Highway 75 to Sawmill Road would occur in the vicinity of the site.	1969

5.2 Previous Archaeological Investigations

Mill Cottage has been the subject of two unpublished archaeological assessments – one by Katharine Watson (2015) and one more recently by Maxwell and Huebert (2020). There are also a series of research articles by University of Otago Emeritus Professor Helen Leach and surveyor Brent George, both descendants of the Pavitt family, that have been published online by the Pavitt Community Trust (Leach & George 2010a, 2010b, 2012a, 2012b). These articles discuss various aspects of historic research relating to the cottage, sawmill and surrounds.

There are no reports of previous archaeological investigations at Robinson Bay in the HNZPT Archaeological Report Digital Library.

Figure 8. Mill Cottage and Setting from the Christchurch District Plan, reproduced as Figure 5-14 in CH2m Beca 2020.

5.3 Protected Heritage Resources

Both the Mill Cottage at 5 Sawmill Road and the nearby former school master's house on Robinson Bay Valley Road are listed as protected heritage resources in the Christchurch District Plan (CDP).

Mill Cottage and its setting are identified in the CDP as a significant heritage item (No. 1171 - dwelling and no. 145 - setting. The description provided in the CDP indicates that the setting of the dwelling includes the adjacent sawmill site, although the site boundaries in the CDP are limited to the immediate land parcel on which the cottage sits (Figure 8).

The former school master's house, on the other side of Robinsons Bay Valley Road, is also identified in the CDP as a significant heritage item (No. 1173 - dwelling and no. 539 - setting). The location of this item is further north than Pavitt Cottage and well outside of the proposed works area.

6 Field Survey

6.1 Description of Survey

The proposed irrigation area above Sawmill Road was surveyed by the author on 21/07/2021. The survey consisted of a walkover from the sawmill site eastwards along the stream corridor and adjacent land up to Saxton's oak plantation. This area encompassed the extent of historic features previously recognised in the documentary research and the 2020 assessment by Maxwell and Huebert. Beyond this point, the topography changed from low-lying valley floor and moderately steep hillslopes to steep uphill terrain. These steep uphill slopes were not surveyed.

The purpose of the survey was to document surface evidence of archaeological remains relating to the historic sawmilling and pastoral landscape (Figure 9). The section encompassing Mill Cottage was excluded from the survey. The pipeline route along SH75 and up a paper road to the south-east end of Sawmill Road was also excluded.

6.2 Results of Field Survey

The western end of the survey area comprises the valley floor along which two stream channels run, merging at a point just west of Sawmill Road, which itself is a modern road formation running south-eastwards from Robinsons Bay Valley Road (Figure 11). The land rises gently to the south-east, encompassing the historic sawmill site, marked by an interpretation panel along the boundary fence on Sawmill Road, before crossing over another unnamed waterway which runs to the south-west.

The valley floor continues eastwards, marked by the main stream channel which cuts a meandering route through old alluvial terraces (Figure 24). A number of former waterways can be seen in the hummocky ground east of Mill Cottage and a former stream alignment hugs Robinsons Bay Valley Road, which itself runs along the northern side of the valley floor. Most of the proposed irrigation areas are located on the hillslopes above the southern side of the stream channel. These lead to a large oak plantation along the top of the main ridgeline leading down to the sawmill site (Figure 52). East of this point, the valley floor narrows significantly towards the headwaters of the stream, while the land rises sharply to the summit ridgeline (Figure 54).

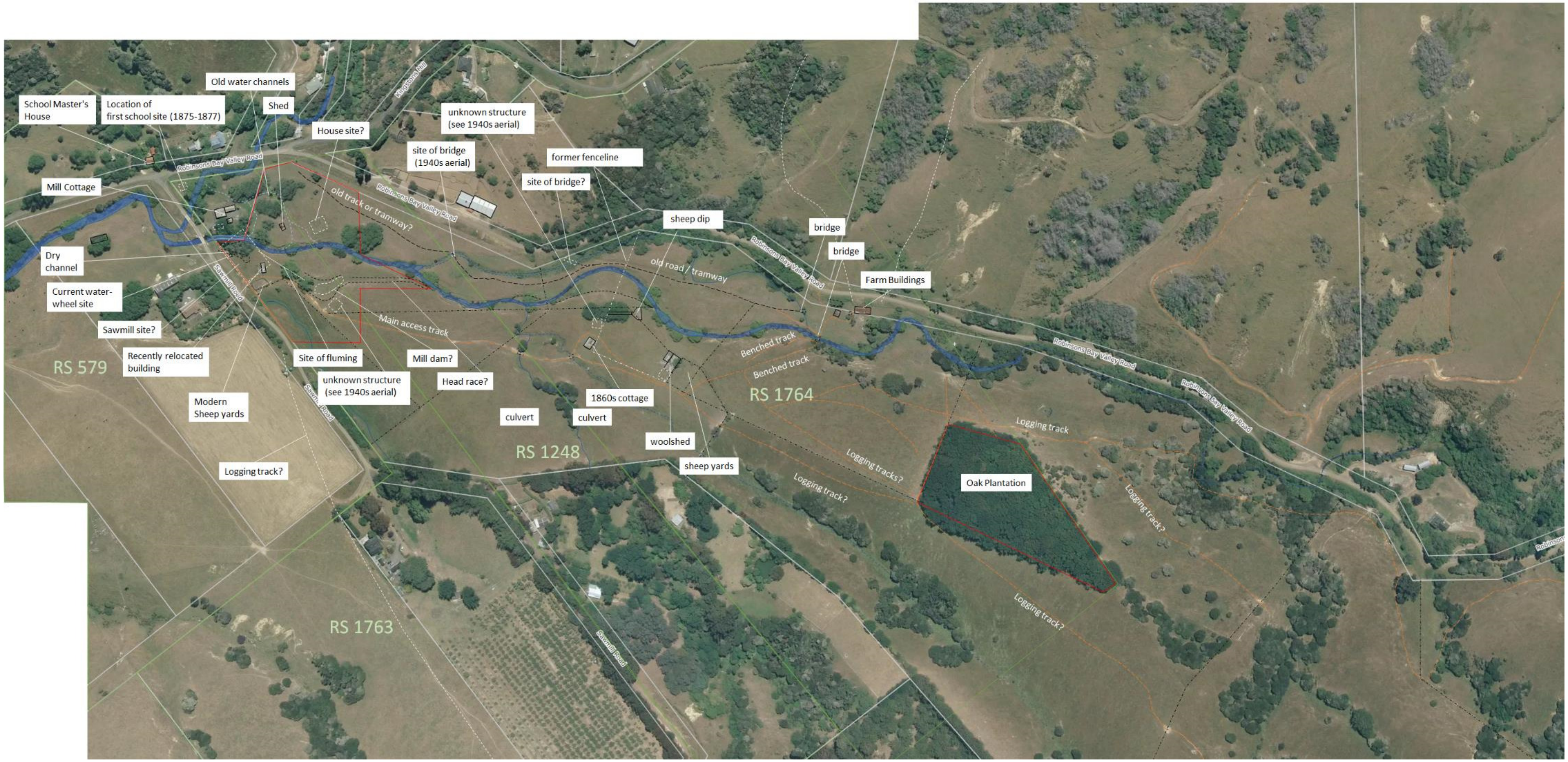

Figure 9. Annotated aerial plan showing historic features noted during the archaeological survey by the author, which are depicted in site plan drawings in Figures 10, 27 and 51 (Source for aerial imagery: Canterbury Maps).

There were 49 features of potential historic origin identified during the field survey. The features related to both historic sawmilling and later pastoral sheep farming activities on the landscape. Each of these features is discussed below in Tables 3-5 and presented in Figures 10, 27 and 51.

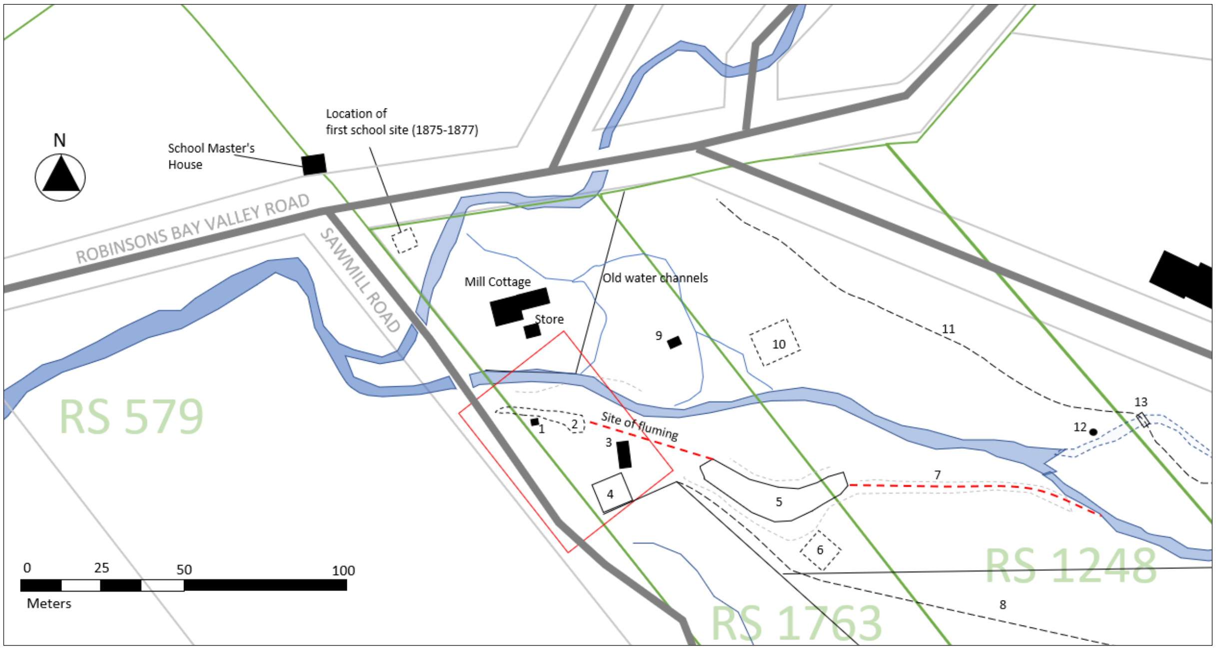

Figure 10. Plan of historic features noted during the survey (as referenced in the text), along with waterways (in blue), property boundaries (grey) and fencelines (black). The original rural section boundaries are highlighted in green and labelled with the Rural Section number.

Table 3. List of historical features (1-13) recorded during the archaeological survey (refer to Figure 10).

Feature No.	Feature	Description	Reference
1	Water wheel	Remnants of waterwheel display (collapsed) including original wheel hub and axle and timber struts reused as boxing on a modern concrete pedestal. A modern interpretation panel lies in front of the roadside boundary fencing next to the display.	Figures 11- 12.
2	Wheel pit & tail race?	Linear infilled depression adjacent to the water wheel display, running east-west under the road boundary fence on a terrace above the stream. Possible truncated by Sawmill Road formation. The boundary fence also featured original split totara posts.	Figures 13-14.
3	Relocated Shed	Rectangular weatherboard clad building with boxed ends and exposed rafters and a corrugated iron low pitched roof indicative of early 20th century construction. In poor condition, tilted on one side, presumably due to collapsed piles, missing half of the timberwork on the north side and a section of the south wall. Relocated to the site in the 1980s by Murray Thacker.	Figure 15.
4	Sheep yards	Modern sheep yards located on a slight rise above the sawmill area. The fencing features modern fencing with some recycled totara fenceposts. Post 1940s as not visible in 1941 aerial photograph (Retrolens.co.nz).	Figure 16.
5	Mill Dam	Sub-circular earthworks on a terrace above the main river flat, defined by two semi-circular raised embankments in front of a	Figures 17-18.

		escarpment. A sub-circular enclosure can be seen between the escarpment and embankment in historic aerial photographs (Canterburymaps.govt.nz)	
6	Unknown Structure	Identified on 1941 aerial photograph as a square enclosure but no surface indication of this building was identified during the survey. The current access track runs through this feature.	N/A
7	Head Race	Benched track leading eastwards from the Mill Dam back towards the stream, featuring two v-shaped channels – possibly due to use of this track for vehicle access rather than specific features. Some isolated split timber posts noted along the track.	Figure 19.
8	Access Track	Vehicle access track from Sawmill Road, starting next to the sheep yards and continuing south-east along a benched track above the Mill Dam area. Possibly part of the original tramway line leading to the sawmill.	Figure 20.
9	Small shed	Small modern corrugated iron shed, set up as inside as a chicken coop. Surrounded on both sites by former waterways – these may be related to the canal indicated on the sawmill interpretation panel as a mechanism for transporting logs from the tramway to the sawmill.	Figures 21-22.
10	Unknown building	Depicted as a former house site in Maxwell & Huebert's 2020 assessment but not visible in historic aerial photographs. Little remaining evidence other than some loose timbers in the low grass and tall posts incorporated into a fenceline.	Figures 24-25.
11	Old road / tramway formation	Indistinct track, marking by wheel ruts leading from Robinsons Bay Valley Road to the first bridge site (13), where the track becomes more defined as a rocky embankment against the surrounding hummocky ground. Thought to be the original formation for Robinsons Bay Valley Road and possibly part of the original tramway leading down to the bay.	Figure 26
12	Well	Stone-lined well marked on Maxwell & Huebert's survey plan in their 2020 assessment, but not relocated/sighted in the current survey. Identified as the clean water source for Mill Cottage, with a recently designated easement leading from this location back to the cottage and therefore assumed to be modern.	N/A
13	Former Bridge	Site of a former bridge over an old waterway, visible in 1941 aerial photograph although no surface remains of this structure were noted during the survey. The location is now an earthen causeway across the dry river channel.	Figure 26

Figure 11. Sawmill Road landscape, looking westwards back towards Robinsons Bay Valley Road from the sawmill site (N. Cable 21/07/21).

Figure 12. Collapsed water wheel display on a concrete platform, looking southwards towards Sawmill Road (N. Cable 21/07/2021).

Figure 13. Linear depression running westwards beside the waterwheel, thought to be the wheel pit and tail race (note the drop in fenceline towards Sawmill Road (N. Cable 21/07/2021).

Figure 14. View north-west across the sawmill site towards Mill Cottage (behind the trees).Note the loose off-cut timbers in the foreground and vehicle track across the middle of the site(N. Cable 21/07/2021).

Figure 15. Relocated shed on the sawmill site, identified as the Blacksmith's Shop on the sawmill interpretation panel (N. Cable 21/07/2021).

Figure 16. Modern sheep yards to the south of the Sawmill site, adjoining Sawmill Road, looking west from the relocated shed (N. Cable 21/07/2021).

Figure 17. Embankments on the terrace above the river flat (to the right) associated with the mill dam site, looking eastwards back towards the Sawmill site (N. Cable 21/07/2021).

Figure 18. View north-east overlooking the mill dam from the top of the escarpment. The red water monitoring bores in the middle of the image (circled) mark the location of the headrace channel (N. Cable 21/07/2021).

Figure 19. Head race from Mill Dam, looking eastwards along the river channel (N. Cable 21/07/2021)..

Figure 20. Benched access track along the top of the embankment above the mill dam area (N. Cable 21/07/2021).

Figure 21. Small corrugated iron chicken coop behind Mill Cottage, looking north (N. Cable 21/07/2021).

Figure 22. Chicken coop, looking eastwards towards Mill Cottage across the former waterways (N. Cable 21/07/2021).

Figure 23. Mill Cottage, looking eastwards from the rear boundary fence (N. Cable 21/07/2021).

Figure 24. View northwards from mill dam across stream towards unknown structure location and Robinsons Bay Valley Road (N. Cable 21/07/21).

Figure 25. Upright totara posts marking location of unknown building (10), looking northwards (N. Cable 21/07/2021).

Figure 26. Old road / tramway formation looking eastwards towards the former bridge crossing (13) and Robinsons Bay Valley Road (N. Cable 21/07/2021).

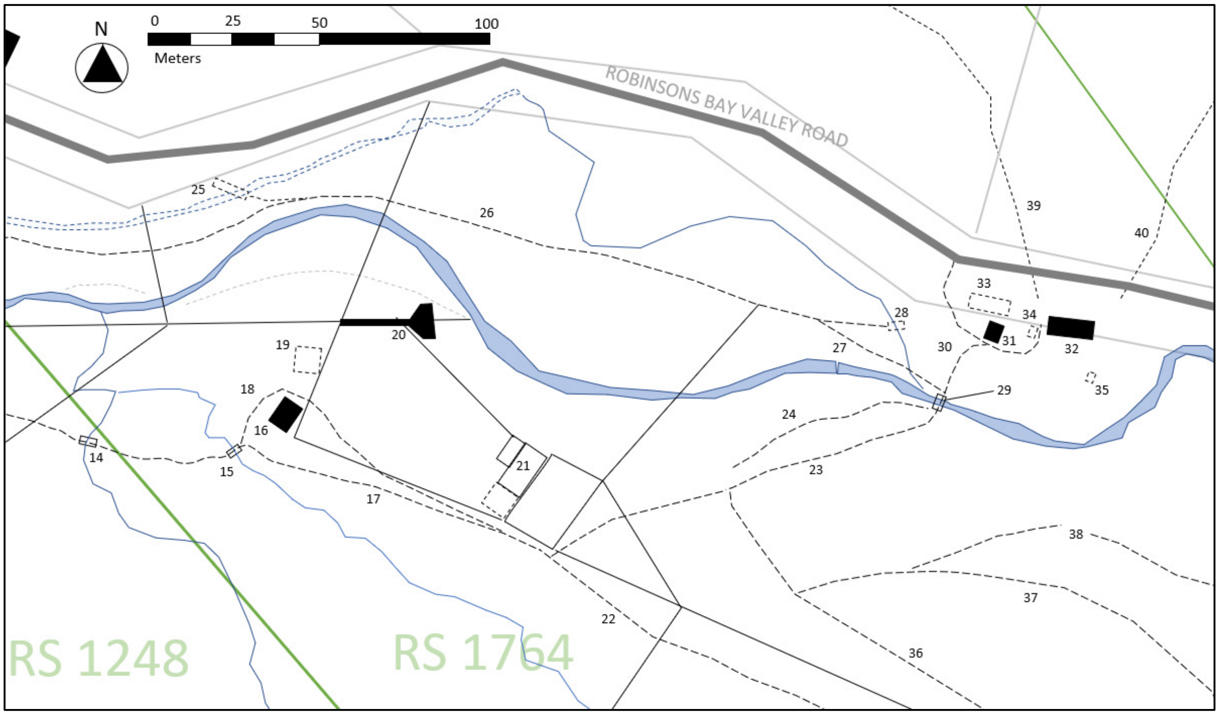

Figure 27. Plan of historic features noted during the survey (as referenced in the text), along with waterways (in blue), property boundaries (grey) and fencelines (black). The original rural section boundaries are highlighted in green and labelled with the Rural Sections.

Table 4.List of historical features (14-40) recorded during the archaeological survey (refer to Figure 27).

Feature No.	Feature	Description	Reference
14	Stone culvert	Stone rubble construction over modern concrete pipe, likely 20th century construction but the location likely marks a former culvert or bridge crossing over the waterway.	Figure. 28
15	Stone culvert	Stone rubble construction over modern concrete pipe, likely 20th century construction but likely location of earlier culvert.	Figure 29.
16	Old Cottage	Rough cut timber weatherboard clad rectangular 1 ½ storey gabled 4-room cottage with rear saltbox lean-to similar to Mill Cottage, brick internal chimney, short-run corrugated iron roof, consistent with 1860s construction and likely associated with the Hughes.	Figure 30-32.
17	Farm track	Continuation of (8), running across culverts (14 & 15) towards the old cottage (18), then continues along edge of collapsed fenceline towards oak plantation as little more than a vehicle track barely discernible on the hillside.	Figure 33.
18	Farm track	Little more than a footpath or stock track running around the perimeter of the old cottage (16).	Figure 34.

19	Unknown structure	Unknown square enclosure identified on 1941 aerial photograph between the cottage (16) and the sheep dip (20). Likely an old sheep pen of some sort associated with the sheep dip. Square timber posts mark the location but there are no other surface indications of this structure. Potential a contaminated site if associated with sheep dip.	Figure 35.
20	Sheep dip	Brick with Portland cement render forming a c.1900s sheep dip on hillside below cottage (16) and above the river flat. Eastern end is a trapezoid concrete platform. Timber remains of additional structures, likely pens or gates are adjacent to the structure. Contaminated site.	Figure 36-37.
21	Woolshed and yards	Timber remains of large rectangular woolshed and adjacent sheep-yards, with scattered equipment. Structure contains modern round posts but also old totara beams, so maybe have been a heavily modified historic structure. Clearly visible in 1941 aerial photographs. Shorter structure with side addition to the west visible in 1980s aerial photographs, indicating that it was partially demolished by this time. Appears to have been demolished to floor level in c.2000s.	Figures 38-39.
22	Farm track	Barely discernible vehicle track continuing across grassed paddock towards oak plantation (42). Likely a modern track rather than historic.	Figure 40.
23	Farm track	Cut track below and parallel to benched track (24), possibly a stock track?	Figure 41.
24	Farm track	Benched track cut into hillside, leading down to bridge (29).	Figure 42.
25	Former bridge site	Projected location of original bridge leading from Robinsons Bay Valley Road to old road alignment (26). No surface evidence for bridge noted.	Figure 43.
26	Old road / tramway formation	Embankment with v-shaped drains on either side marking former road and possible tramway alignment.	Figures 43-45.
27	Farm track	Narrow cut track along north side of stream between two former bridges (28 & 29), possibly a logging track. .	Figure 46.
28	Former bridge	Timber beam and stone rubble abutment construction over former waterway.	Figure 47.
29	Former bridge	Former bridge over stream, comprising timber beams on timber and stone rubble abutments. A concrete pier has been added to the middle of the bridge and now supports three timber beams at a higher height than the original bridge formation, including at least two phases of construction.	Figure 48.

30	Farm track	Indistinct cleared track leading from Robinson Bay Valley Road to the farm buildings. Not surveyed.	N/A
31	Farm building	Corrugated iron clad rectangular structure with pitched roof, likely a pig pen. Not surveyed.	Figure 46, 49.
32	Farm building	Cottage clad in corrugated iron with gabled roof and rear pitched leanto, adjoining another pitched lean-to clad in corrugated iron. Not surveyed.	Figure 46, 49.
33	Former farm building	Collapsed pile of timber and corrugated iron under vegetation. Not surveyed.	Figure 46.
34	Former farm buildings	Identified in aerial photographs but no surface remains visible other than rock rubble. Not surveyed.	N/A
35	Former farm building	Former site of small square structure noted in aerial photographs. Not surveyed.	N/A
36	Logging / stock track	Little more than a worn stock track along gentle sloping land above river flat, visible in modern aerial photographs. Possibly a former logging track?	Figure 49.
37	Logging / stock track	Little more than a worn stock track along gentle sloping land above river flat, visible in modern aerial photographs. Possibly a former logging track?	Figure 49.
38	Logging / stock track	Little more than a worn stock track along gentle sloping land above river flat, visible in modern aerial photographs. Possibly a former logging track?	Figure 49.
39	Logging track	Logging track on north side of valley floor, identified on sawmill interpretation panel.	N/A
40	Logging track	Logging track on north side of valley floor, identified on sawmill interpretation panel.	N/A

Figure 28. Stone rubble and concrete culvert (14) along access track (8) (N. Cable 21/07/2021).

Figure 29. Second stone rubble and concrete culvert (15), partially submerged, under access track (8) (N. Cable 21/07/2021).

Figure 30. West (front) elevation of c. 1860s cottage (16) on hillside above the stream channel (N. Cable 21/07/2021).

Figure 31. East and north elevations of the c.1860s cottage (16) (N. Cable 21/07/2021).

Figure 32.Interior of c.1860s cottage (16), viewed through window on south side and showing largely unmodified interior filled with sheep farming ephemera (N. Cable 21/07/2021).

Figure 33. Farm track (17) (arrowed) leading westwards from fenceline past woolsheds (21) back to old cottage (16) (N. Cable 21/07/2021).

Figure 34. Footpath (18) to the left of the old cottage (16), looking northwards at the south elevation (N. Cable 21/07/2021.

Figure 35. Timber posts marking the location of an unknown enclosure (19) next to the sheep dip (20) (N. Cable 21/07/2021).

Figure 36. Cement-rendered brick sheep dip, located along fenceline above stream flat (N. Cable 21/07/2021).

Figure 37. Concrete platform at the eastern end of the sheep dip (arrowed), situated on the edge of the hillslope above the stream flat (N. Cable 21/09/2021).

Figure 38.Timber remains of the woolshed (21), looking northwards (N. Cable 21/07/2021).

Figure 39. Fencing from the sheep pens on the east side of the woolshed (21), looking west (N. Cable 21/07/2021).

Figure 40. Farm track (22) running eastwards (arrowed) from the fence gate to the oak plantation (42) (N. Cable 21/07/2021).

Figure 41. Upper benched track (23) cut into hillside, leading down from woolsheds (21) to bridge (29), looking north-east (N. Cable 21/07/2021).

Figure 42. Lower benched track (24) leading to stream channel and bridge (29) (N. Cable 21/07/2021).

Figure 43. Former road/tramway alignment (26), running eastwards from the point of the former bridge (25) beside the stream channel (N. Cable 21/07/2021).

Figure 44. Former road/tramway alignment (26), looking westwards from the same point as Figure 43 (N. Cable 21/07/2021).

Figure 45. Former road/tramway embankment running westwards along the hummocky stream flat between the active stream channel to the south and former channel to the north (N. Cable 21/07/2021).

Figure 46. Lower track (27) on north bank of stream leading to bridge (29), looking northwards (N. Cable 21/07/2021). Farm buildings (31 & 32) can be seen in the background.

Figure 47. Former bridge remains (28) along old road/tramway formation, looking eastwards (N. Cable 21/07/2021). A farm building (31) is located on the rise above the stream channel.

Figure 48. Bridge remains (29) over stream channel, looking westwards (N. Cable 21/07/2021).

Figure 49. Farm buildings (31 & 32) alongside Robinsons Bay Valley Road, looking north-east (N. Cable 21/07/2021).

Figure 50. Possible logging tracks, although more likely stock tracks (36-38, arrowed) on grassed slope, looking westwards (N. Cable 21/07/2021).

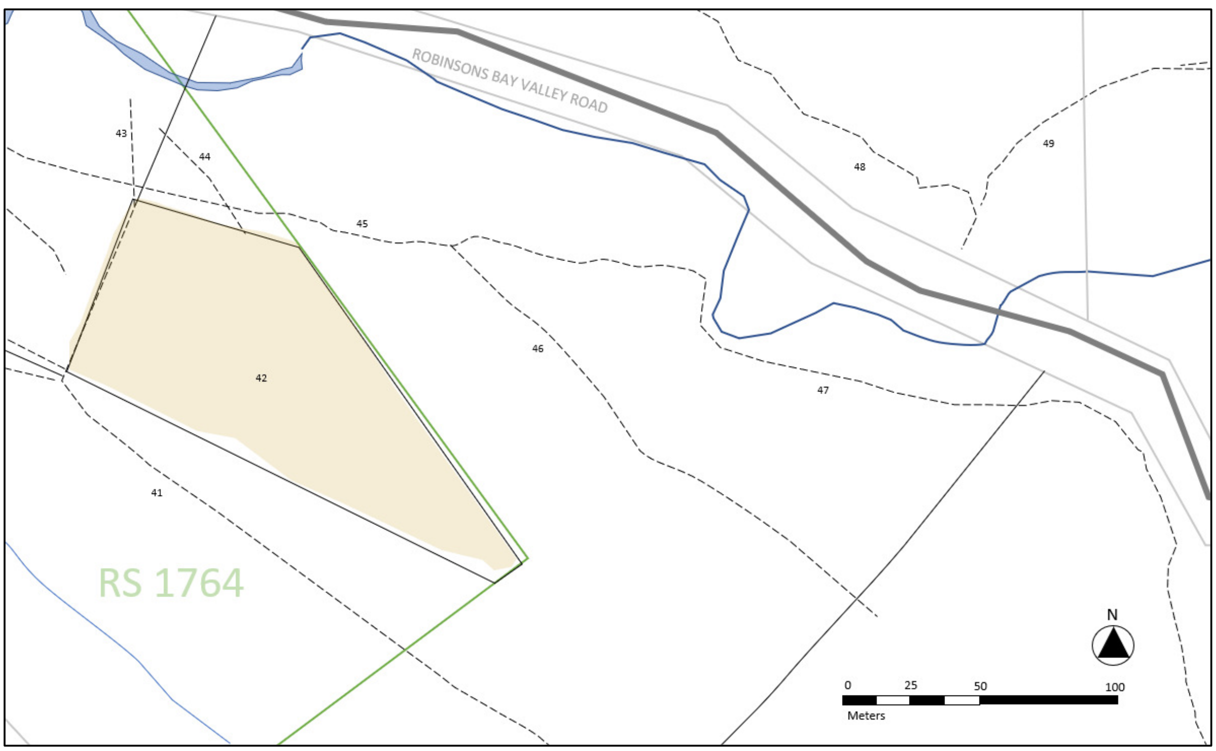

Figure 51. Plan of historic features noted during the survey (as referenced in the text), along with waterways (in blue), property boundaries (grey) and fencelines (black). The original rural section boundaries are highlighted in green and labelled with the Rural Section.

Table 5.List of historical features (41-49) recorded during the archaeological survey (refer to Figure 27).

Feature No.	Feature	Description	Reference
41	Logging / stock track	Little more than a worn stock track along the ridgeline above the oak plantation, visible in modern aerial photographs. Possibly a former logging track? Surveyed to just past the oak plantation.	N/A
42	Oak Plantation	Large fenced off enclosure along top of ridgeline containing mature oak trees planted by George Saxton.	Figure 52.
43	Logging / stock track	Little more than a stock track on the ground but runs from the oak plantation down to the stream. Possibly part of the logging track shown on the sawmill interpretation panel. Visible in aerial photographs.	N/A
44	Logging / stock track	Little more than a stock track on the ground but may have a logging track connecting to the tramway along the valley floor.	Figure 52.
45	Logging / stock track	Little more than a stock track on the ground along the south side of the oak plantation but is visible on aerial photographs as a benched track or tramway. May have been once been a logging track. Surveyed to just past the oak plantation.	Figure 53.
46	Logging / stock track	Little more than a stock track, but visible in aerial photographs, but along the south side of the oak plantation. Not surveyed.	N/A
47	Logging / stock track	Little more than a stock track, visible in aerial photographs but barely visible on the ground. Continuation of 45 but follows the valley floor and is on a similar alignment to the tramway shown on the sawmill interpretation panel. Not surveyed.	N/A
48	Farm track	Benched farm track on north side of Robinsons Bay Valley Road. Possibly had origins as a logging track. Not surveyed.	N/A
49	Farm track	Benched farm track identified as a logging track on the sawmill interpretation panel. Not surveyed.	N/A

Figure 52. Oak plantation (42) and stock track or possible logging track (44) in foreground, looking south-west (N. Cable 21/07/2021).

Figure 53. Detail of oak plantation (42) and cleared track (45) (arrowed) along the southern side of the plantation (N. Cable 21/07/2021).

Figure 54. View looking eastwards up valley from the eastern end of the oak plantation (42) (N. Cable 21/07/2021).

7 Assessment of Values

7.1 Assessment of Archaeological Values

The historic or potential historic features identified during the field survey are captured under the single archaeological site, N36/260, which covers the archaeological landscape of sawmilling activities associated with the historic sawmill site and the late 19th century conversion to pastoralism.

The recorded midden site at the head of the bay, N36/105, also indicates there is potential for evidence of pre-European Māori activity along the foreshore and along the coastal flat on which SH75 is located. The proposed pipeline route north of Hammond Point runs through this location.

The following tables (Tables 6-7) provide statements of archaeological value for the types of archaeological sites found within the project area . The criteria are based on the criteria outlined in Section 3.2.

Table 6. Assessment of HNZPTA archaeological values for evidence of pre-European Māori activity along the coastal flat of Robinsons Bay (N36/105).

Value	Assessment
Condition	Poor – midden recorded at stream mouth in 1960s but has since been destroyed. No other evidence of Māori activity has been recorded in the bay, although the location has traditional significance as a place of food gathering.
Rarity	Uncommon representative evidence of pre-European Māori activity along the inner bays of Akaroa Harbour.

Contextual Value	Associated with pre-European Māori occupation and food gathering activities along the sheltered bay in Akaroa Harbour.
Information Potential	Potential to document evidence of economic activities, including food gathering and processing. Potential to find evidence of temporary or semi-permanent encampments..
Amenity Value	Low – the road corridor along SH75 is a public space, however the nature of proposed works is such that there is limited amenity value and little opportunity for site interpretation or public outreach.
Cultural Associations	Ngāi Tahu whānui
Directly Affected?	Yes
Overall Significance	Low to moderate archaeological values based on potential for encountering archaeological remains.

Table 7. Assessment of HNZPTA archaeological values for N36/260 (historic sawmill and pastoral landscape).

Value	Assessment
Condition	Fair – there are standing buildings, surface structural remains and evidence of associated infrastructure as well as high potential for subsurface archaeological remains.
Rarity	Rare – associated with early to mid-19th century settlement and sawmilling activities, potentially the first sawmill in Canterbury.
Contextual Value	Associated with early settlement of Akaroa Harbour and development of sawmilling activities in the early to mid-19th century and conversion to pastoral farming activities in the late 19th century.
Information Potential	High, potential to document technical aspects of sawmill operation, water control, tramways and transportation links; standing building record of sawmill worker' cottages and sheep farm buildings, potential archaeological remains of other structures and cottages along the stream corridor as well as aspects of early settlement, sawmill workers and farming life.
Amenity Value	High – existing interpretation panel at sawmill site could be added to, and potential to develop walking tracks through the valley system around the irrigation areas.
Cultural Associations	European
Directly Affected?	Yes
Overall Significance	High

7.2 Assessment of Heritage Values

The following tables (Tables 8-9) provide a summary of heritage values for the respective archaeological site types. The assessments are based on the criteria outlined in Section 3.3.

Table 8. Summary of heritage values for evidence of pre-European Maori activity along the coastal flat of Robinsons Bay (N36/105).

Qualities	Comments
Archaeological Qualities	Recorded archaeological site but likely destroyed, indicative of wider activity along the coastal edge so potential for finding similar evidence of temporary occupation and food processing – of low to moderate archaeological significance.

Architectural Qualities	N/A
Cultural Qualities	High – associated with pre-European Māori activity in the general location. Flagged as culturally significant area in consultation with local rūnanga.
Historic Qualities	N/A
Scientific Qualities	N/A
Technical Qualities	N/A
OVERALL SIGNIFICANCE	LOW – general location has local cultural and archaeological significance relating to early Māori activity around the coastal margins of Akaroa Harbour.

Table 9. Summary of heritage values for N36/260 (historic sawmill and pastoral landscape).

Qualities	Comments
Archaeological Qualities	High archaeological significance as a largely unmodified early European sawmilling, and later pastoral, landscape, with standing buildings, surface archaeological remains and high potential for subsurface archaeological remains around the sawmill area and along the valley floor. Potential to archaeologically investigate aspects of early settlers' life, development of sawmilling and transportation technology and later shift to pastoralism.
Architectural Qualities	Standing cottage and nearby farm buildings are representative examples of 1860s to 1900s domestic and farming architecture. The 1860s cottage in particularly is distinctive in being largely unmodified from original construction and has architectural links to the nearby Mill Cottage.
Cultural Qualities	The location provides an important sense of community identity, particularly for descendants of the Pavitt family. Mill Cottage and the nearby school master's house are recognised as significant heritage buildings and an interpretation panel marks the location of the sawmill, which is an important landmark.
Historic Qualities	Associated with early settlement of Akaroa Harbour and the development of the sawmill industry in the region. Recognised as the earliest sawmill site in Canterbury. Associated with a number of notable people and family groups, including Robinson and Wood, the Pavitt family, Samuel Farr, Thomas Hughes, Saxton and Williams, the Thacker family from Le Bons Bay, Frederick Wynne Williams. The location is also recognised in paintings and publications as a sawmilling landscape. There is also representative value in the change from sawmilling to pastoralism as the timber was cleared.
Scientific Qualities	N/A
Technical Qualities	Although the information on the sawmills in this area is sparse, there is merit in the technological achievements needed to construct an overshot powered mill, including construction of a dam and timber fluming in the 1850s, as well as in constructing a timber tramway uphill to feed the mill as well as later conversion to steam. The sawmill interpretation panel also references construction of a canal at the end of the tramway, which is a significant feat although no trace of this structure was noted during the archaeological survey.
OVERALL SIGNIFICANCE	HIGH - The sawmilling landscape has high heritage values, particularly in relation to the sawmill area and associated dam and waterway system, adjacent to the already recognised Mill Cottage. The remains of the tramway system

	along the valley floor along with other building, structures and archaeological remains of sawmill workers residences are also connected with this landscape. The later pastoral landscape, as evidenced by farm buildings, fencing, sheep yard and wool shed remains are of lesser representative heritage value given their association with the tail end of the sawmilling industry and subsequent conversion of cleared land to farming at the end of the 19th century.

8 Assessment of Effects

8.1 Proposed Works

The Robinsons Bay component of the Scheme will require the following works to be undertaken. Final design and optimisation of these activities is currently underway, although the footprint of works is not expected to change.

- A gravity fed pipeline is to be installed along SH75 from the new Wastewater Treatment Plant on Old Coach Road, just north of Akaroa. This pipe will follow the road corridor through Takamātua and Hammond Point before emerging at Robinsons Bay. A 1.4 km section of pipeline will then continue along SH75 before traversing uphill along a paper road on the south-eastern border of Rural Section 379 and then connect with storage tanks at 11 Sawmill Road (Figure 55).
- Ten storage tanks are proposed to be installed on a broad spur on the hillside of 11 Sawmill Road (Figure 55). A pump station will also be required in order to feed the irrigation driplines.
- Up to 34 hectares of native plantings will be established along the hillslopes of Robinsons Bay at 11 and 88 Sawmill Road (Figure 56). Irrigation driplines will be laid throughout these native planting areas in order to irrigate the treated wastewater from the Old Coach Road treatment plant. Setbacks have been provided from active waterways and further setbacks around sites of heritage interest and potential amenities such as walking tracks are being considered as part of the site development. The driplines will be laid along existing contours without ground disturbance, so the only earthworks planned are those related to planting, installation of distribution mains, formation of an internal vehicle access track and tank platform, and incidental small-scale earthworks.

8.2 Potential Effects of Proposed Works

The gravity fed pipeline will run along a c.600 m section of SH75 at the southern end of Robinsons Bay. The route lies over 100 m south of the recorded location of N36/105, but the nature of the site is indicative of wider pre-European Māori activity along the coastal margins of the bay. There is potential for pipeline installation trench works along the road corridor to encounter buried archaeological remains associated with Māori activity. Any such archaeological remains will be destroyed by trench excavations, although the extent of site damage will be limited to the confines of the trench. As this is a potential impact, the works are considered to have minor negative effects on archaeological and cultural values.

The proposed storage tanks are to be located on a broad spur c.200 m south-east of the historic oak plantation and outside the area of surveyed historic features. A modern farm track runs through this area but there no signs of former tracks in the 1941 historic aerial photograph (Figure 57). Works are not expected to have any effects on archaeological and heritage values.

The drip irrigation area encompasses virtually all of the historic features identified in the archaeological survey, with the exception of features located within the setback area along the stream corridor, as well as the 1860s cottage and oak plantation. The specific effect on each feature is discussed in the table below (Table 10). Commentary is also provided on more general effects on the wider sawmilling and pastoral landscape within which these features exist, particularly in regard to the historic sawmill site and the former road/tramway formation along the valley floor.

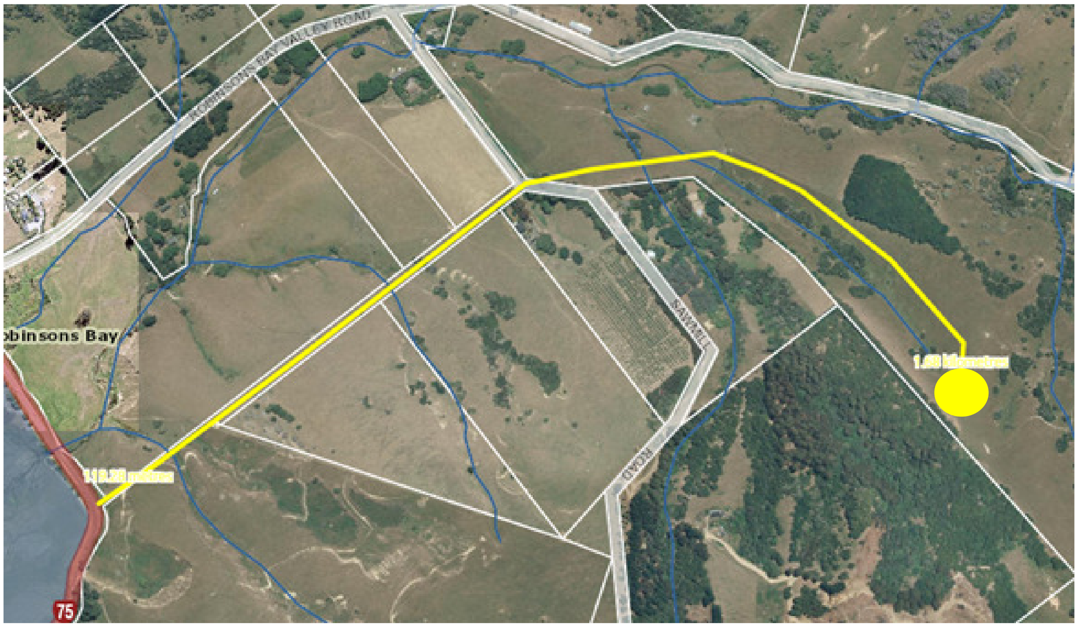

Figure 55. Indicative location of gravity fed pipeline and storage tanks on the hillside at 11 Sawmill Road (Client provided image).

Figure 56. Indicative location of native planting irrigation areas (in green) and gravity pipeline (in yellow) from the CH2m Beca Report (2020: Appendix J). Note the plan shows storage ponds which are no longer proposed, with storage tanks proposed instead.

Figure 57. Aerial photograph SN165/140/28, from 17/01/1941, showing the upper Robinsons Bay valley (Source: Retrolens.co.nz).

Table 10. Table of effects and mitigation recommendations by heritage features identified in the archaeological survey.

Feature No.	Feature	Activity	Description of Effects	Recommended Mitigation
n/a	Historic Sawmill Area	Track formation	Within setback area, with no works planned. Formation of metalled access road may require shallow grading or widening of existing farm track, potentially exposing subsurface remains of earlier track or tramway formation.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
1	Waterwheel	No activity planned.	Within irrigation setback around waterway and low lying ground, outside of the area of proposed works (see Figure 58). Not directly affected by proposed works.	Nil
2	Wheel pit & tail race	No activity planned.	Within irrigation setback around waterway and low lying ground, outside of the area of proposed works (see Figure 58). Not directly affected by proposed works.	Nil
3	Relocated shed (20th C)	No activity planned (as of Nov 21, this building has collapsed).	Not a historic feature, although located within historic sawmill area (see Figure 58). Within irrigation setback.	Nil
4	Sheep yards (20th C)	No activity planned.	Not a historic feature, although located within historic sawmill area (see Figure 58). Within irrigation setback, so outside of the area of proposed works.	Nil
5	Mill Dam	Removal of willow trees	Within irrigation setback along waterway and around this feature (see Figure 58). Not directly affected by irrigation works although proposal to remove dead willow trees from the location as well as along the waterway likely to disturb subsurface archaeological remains.	Minor effects - mitigate willow removal through archaeological monitoring under HNZPT authority.
6	Unknown Structure	Tree planting	No surface evidence, potential for subsurface remains only. Tree planting and tree root growth may disturb these subsurface remains.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
7	Head race	No activity planned	Within irrigation setback along waterway (see Figure 58). Not directly affected by proposed works.	Nil

8	Farm track	Track formation	Upgrading of farm track to metalled access road may require some shallow grading or widening of existing benches along existing track, thereby disturbing the feature and potential exposing subsurface remains of earlier track or tramway formation.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
9	Small shed (Chicken coop)	Removal	A modern structure, which will be removed from site. Within setback for waterway and sawmill (see Figure 58), so location outside of proposed works area.	Nil
10	Unknown building	No activity planned.	Within setback around waterway and sawmill area, so outside of the area of proposed works (see Figure 58). Not directly affected by proposed works	Nil
11	Old road / tramway	Tree planting, track formation	Indistinct track but potentially part earlier alignment of Robinsons Bay Valley Road (as depicted in the Wynne Williams painting).and original bush tramway. Excavations for tree planting and grading for track formation will potentially impact the integrity of subsurface remains.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
12	Well	No activity planned.	Believed to be a modern structure. Within setback along waterway so not directly affected by works.	Nil
13	Former bridge	No activity planned.	Within setback along waterway so not directly affected by works.	Nil
14	Stone culvert	No activity planned.	Within setback along waterway so not directly affected by works.	Nil
15	Stone culvert	No activity planned	Within setback along waterway so not directly affected by works.	Nil
16	Old cottage (1860s)	Tree planting, Visitor Impacts	Cottage to be retained and setback to be established in a 5 m perimeter around house. Interior to be cleared and exterior to be secured against visitor impacts. Visual setting will be modified, so works are expected to have a moderate effect on archaeological and heritage values.	Moderate effects - Mitigate through L.2 standing building record and monitoring of interior and exterior works under HNZPT authority; incorporating into public walking track and adding interpretation panel.

17	Farm track	Tree planting, Track formation	Little more than a farm vehicle track, but still forms the main access way running eastwards. Excavations for tree planting or improvements to access track will potentially impact the integrity of this feature, but works are still only expected to have minor effects on archaeological and heritage values.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
18	Farm track	No activity planned.	Foot track around perimeter of 1860s cottage, so would fall within extent of setback area around cottage. Not directly affected by works.	Nil.
19	Unknown Structure	Tree planting	Excavations for tree planting will potentially impact the integrity of subsurface remains so works are expected to have minor effects on archaeological values.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
20	Sheep dip	No activity planned.	Within contaminated land setback around sheep dip. Not directly affected by works.	Nil
21	Woolshed and yards	Tree planting, Visitor Impacts	Within setback around woolshed structure, although clean-up of sites and clearance of yard area proposed. Visual setting will be modified. Potential for tree planting to impact the integrity of subsurface remains and potential for vandalism of any remaining structure in the future.	Moderate effects – mitigate through L.3 standing building record of extant structural remains and monitoring of clearance under HNZPT authority; incorporating into public walking track and adding interpretation panel.
22	Farm track	Tree planting, Track formation, gravity fed pipeline	Little more than a farm vehicle track, but still forms the main accessway running eastwards. Excavations for tree planting, widening for access road or pipeline construction will potentially impact the integrity of this feature but works are still only expected to have minor effects on archaeological and heritage values.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
23	Farm track	Track formation	Grading for track formation and potentially widening the existing bench by cutting back the scarp will potentially impact the integrity of the track itself and any subsurface remains present.	Minor effects - mitigate through archaeological monitoring under HNZPT authority.
24	Farm track	Tree planting	Excavations for tree planting will potentially impact the integrity of this feature and any subsurface remains present.	Minor effects - mitigate through archaeological recording of track prior to works.
25	Former bridge site	No activity planned.	Within setback along waterway and Robinsons Bay Valley Road. Not directly affected by works.	Nil

26	Old road / tramway	Tree planting, Track formation	Excavations for tree planting or grading and widening of track to improve accessway will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the original tramway or road formation.	Minor effects - mitigate through archaeological monitoring under HNZPT authority during works.
27	Farm Track	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
28	Former bridge	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
29	Former bridge	Vegetation removal	Within setback along waterway. Proposal to remove vegetation will fully expose feature.	Minor effects – mitigate through L3 standing building record under HNZPT authority to ensure preservation by record.
30	Farm track	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
31	Farm building	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
32	Farm building	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
33	Former farm building	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
34	Former farm building	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
35	Former farm building	No activity planned.	Within setback along waterway. Not directly affected by works.	Nil.
36	Farm track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works

37	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works
38	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.
39	Logging track	No activity planned.	Outside of project area.	No action required.
40	Logging track	No activity planned.	Outside of project area.	No action required.
41	Logging / stock track	Tree planting, track formation, gravity-fed pipeline	Excavations for tree planting, widening for access road or pipeline construction will potentially impact the integrity of this feature but works are still only expected to have minor effects on archaeological and heritage values.	Minor effects - mitigate through archaeological recording of track prior to works.
42	Oak Plantation	Dripline irrigation.	Within dripline irrigation area but no planting proposed. Minor visual impact with the addition of driplines through the area, but otherwise no effects.	Minor effects on heritage values – improve amenity value by incorporating into public walking track and adding interpretation panel.
43	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.
44	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.
45	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.

46	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.
47	Logging / stock track	Tree planting	Excavations for tree planting will potentially impact the integrity of the visible earthworks, particularly as the plantings mature as this will reduce the ability to read this feature as part of the sawmill or later pastoral landscape.	Minor effects - mitigate through archaeological recording of track prior to works.
48	Farm track	No activity planned.	Outside of project area.	Nil
49	Farm track	No activity planned.	Outside of project area.	Nil

8.3 Avoidance and Mitigation of Effects

All pre-1900 archaeological sites are protected under the provisions of the Heritage New Zealand Pouhere Taonga Act 2014, whether the sites are recorded or not. It is illegal to destroy, damage or modify archaeological sites without an authority from the HNZPT.

Mitigation for negative impacts to archaeological values typically takes the form of archaeological investigation and recording during works under a HNZPT authority.

Construction of the gravity fed pipeline is expected to impact archaeological values along the coastal margin of Robinsons Bay and in the upper section of pipeline route north-east of Sawmill Road, where the pipeline intersects farm track potentially associated with the historic sawmilling and pastoral landscape. Given the potential for disturbing archaeological remains during works, it is recommended that an Archaeological Authority is sought for the pipeline construction under the HNZPTA. The effects on archaeological and heritage values will be adequately mitigated through archaeological monitoring and recording under this Authority.

Activities in the drip irrigation areas are expected to have minor to moderate effects on the historic sawmilling and pastoral archaeological landscapes. Specific mitigation measures for each identified heritage feature are provided in Table 10 and summarised below in Table 11. Given the potential for disturbing archaeological remains during works, it is recommended that an Archaeological Authority is sought for the proposed works under the HNZPTA. Minor effects on archaeological and heritage values for the specific features will either be avoided by establishing setback areas or mitigated through archaeological monitoring and recording under this Authority. These actions are considered suitable mitigation for the effects of proposed works on the historic sawmilling and pastoral landscape.

Further consideration is given to high heritage values of the historic sawmill area and its immediate supporting infrastructure, including the mill dam location and potential tramway routes which would have fed the mill. It is recommended that an irrigation setback area should be established around the historic sawmill site using the historic viewshaft provided by the c.1870s painting from the Wynne Williams collection (see Figure 5) as a baseline for establishing the boundaries of the historic sawmill (Figure 58). This setback would have the effect of providing a visual buffer for both the sawmill site and the adjacent Mill Cottage against the proposed native plantings, incorporating the former waterways which also fed the mill.

Table 11. Summary table of recommended mitigation measures for features directly affected by proposed activities.

Recommended mitigation	Proposed Activities	Features Affected
Establish irrigation setback areas around key heritage features or areas.	Appropriate plantings to occur in setback area for weed control and public amenity – to be guided by HNZPT.	Historic sawmill area (see Fig. 58), old 1860s cottage (16) and woolshed (21) (see Fig. 59).
Archaeological recording of heritage features under HNZPT authority in advance of works	Tree planting and track formation where surface remains are visible but there is unlikely to be subsurface evidence which warrants monitoring of earthworks under an authority.	GPS Survey of Farm Tracks and Logging / Stock Tracks (36, 37, 38, 41, 43, 44, 45, 46, 47)

	Removal of vegetation or structural remains where there are surviving surface remains of the building or structure	Standing Building Record (Level 3) of former bridges (28, 29), woolshed & yards (21)
	Tree planting (although cottage to be preserved within setback), works to secure cottage from future visitor impacts	Standing Building Record (Level 2) of old 1860s cottage (16)
Archaeological monitoring of ground disturbing activities under HNZPT Authority	Activities where earthworks are likely to disturb subsurface archaeological remains, including tree planting , track formation, willow removal, construction of gravity-fed pipeline	Standover monitoring of any ground disturbance within the historic sawmill area, the mill dam area (5), in the vicinity of the unknown structures (6, 19), along the old road / tramway formation(26), and along farm tracks (8, 17, 23, 24, 26)
Incorporate heritage features into public walking track with interpretation panels	Heritage effects due to tree planting, dripline irrigation, track formation.	Old 1860s cottage (16), woolshed and yards (21), historic oak plantation (42)

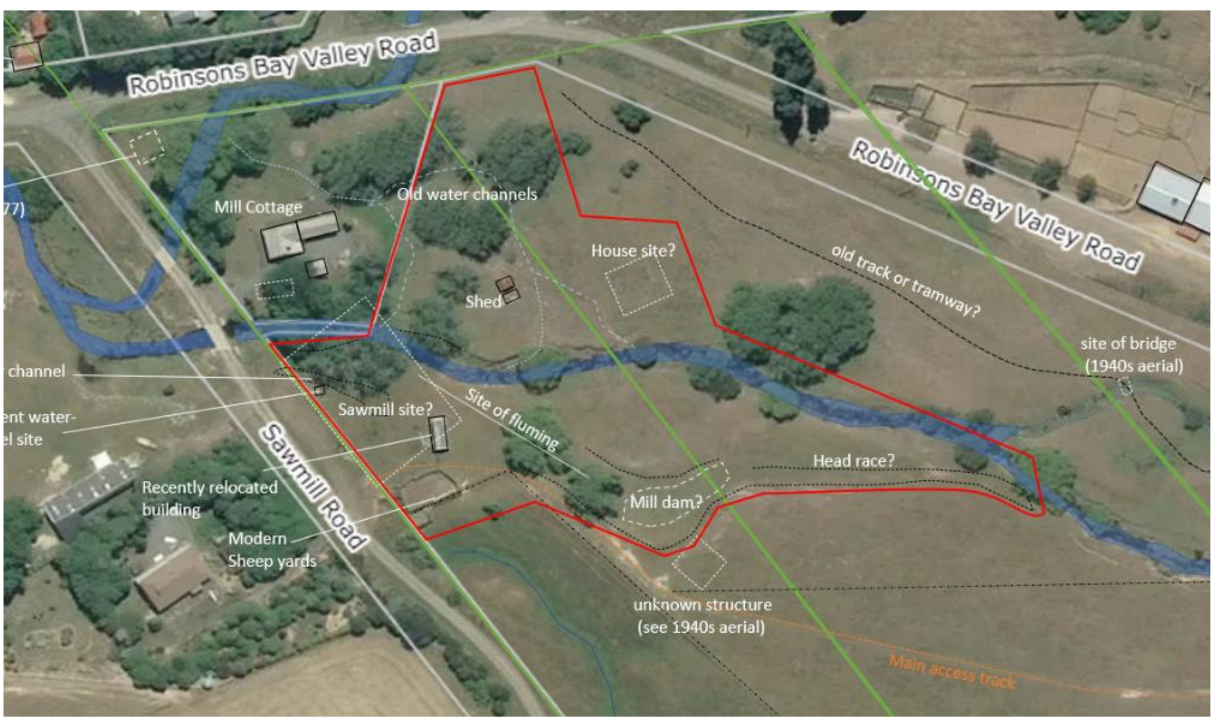

Figure 58. Proposed irrigation setback (outlined in red) for the historic sawmill area, encompassing the mill dam and head race features.

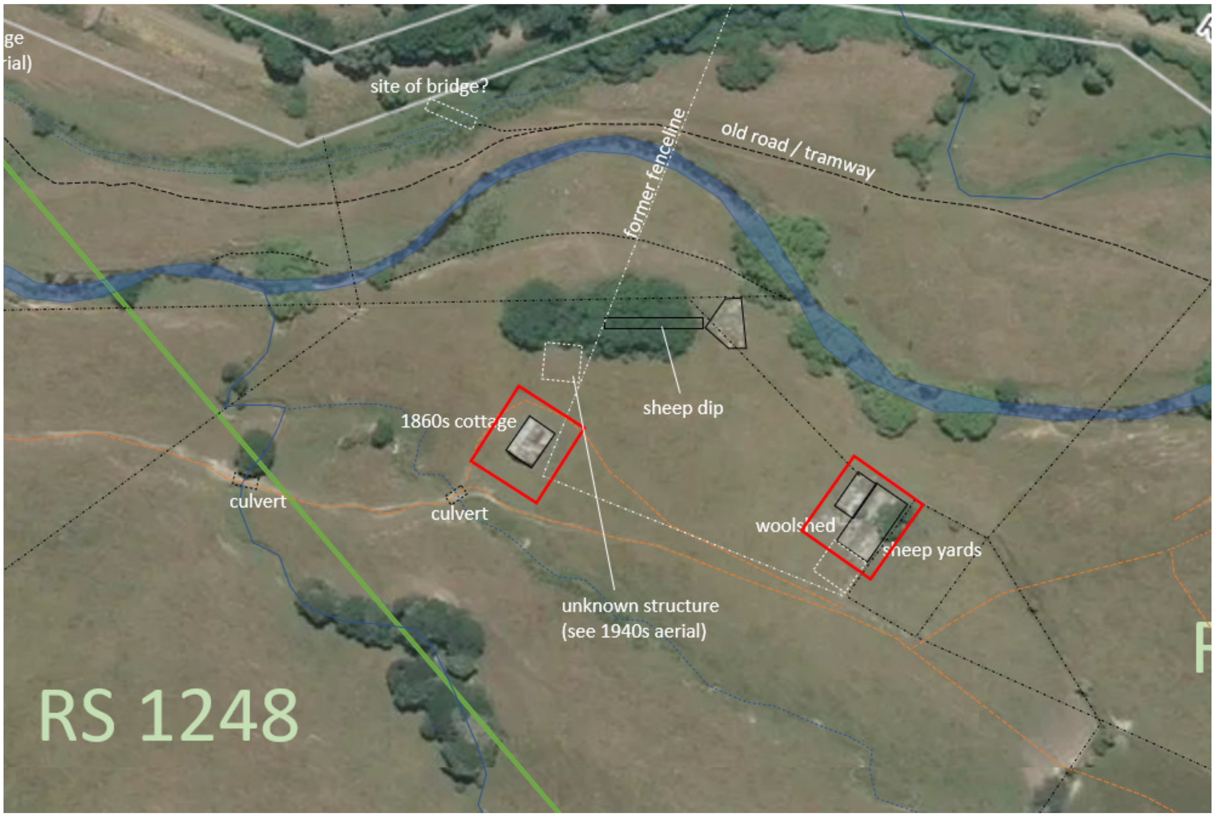

Figure 59. Proposed irrigation setbacks (outlined in red) for the 1860s cottage and woolshed.

9 Recommendations

The following recommendations are made for proposed consent conditions:

- Key heritage features should be avoided by preserving *in situ* and establishing set-back areas for drip irrigation with appropriate plantings for weed control and public amenity, to be guided by HNZPT. These features include:
  - historic sawmill area, including the mill dam and dam head race.
  - Old 1860s cottage on the rise above the sheep dip.
  - Woolshed remains on the rise above the sheep dip and old cottage.
- Key heritage features, including the old 1860s cottage, woolshed and yards and historic oak plantation should be incorporated into a public walking track with interpretation panels.
- An application should be made for an Archaeological Authority under the HNZPTA covering the pipeline along SH75 to Robinsons Bay and proposed works in irrigation areas in the upper Robinsons Bay valley.
- An Archaeological Site Management Plan (ASMP) should be prepared prior to construction activities commencing. The ASMP will guide archaeological work to be undertaken under the auspices of the Archaeological Authority, including, but not limited to, the following activities:

  a) Archaeological recording of heritage features with visible surface remains, including GPS surveys of extant farm tracks, logging and stock tracks (items 36-38, 41, 43, 44-47); and Standing Building Records for extant buildings and structures affected by proposed activities, including the former bridges (28, 29), old 1860s cottage (16), and former woolshed and yards (21).

b) Archaeological monitoring and investigation of heritage features where subsurface remains are likely to be found, including any track formation or plantings through the historic sawmill area, willow removal around the mill dam area (5), any works in the vicinity of the unknown structures (6, 19) and works along the old road / tramway formation (26) or other farm tracks that might be associated with old road or tramway formations (8, 17, 23-24, 26).

c) Protocols for managing unsupervised discoveries of archaeological materials during earthworks in areas not otherwise identified above where there is a low risk of encountering archaeology.

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Appendix O Robinsons Bay Detailed Site Investigation Report

Robinsons Bay Sawmill Road Site – Detailed Site Investigation

PREPARED FOR Christchurch City Council | June 2022

We design with community in mind

Stantec

Revision Schedule

Rev No.	Date	Description	Signature or Typed Name (documentation on file)			
			Prepared by	Checked by	Reviewed by	Approved by
1	5 Oct 2021	Report (draft for client comments)	SF	JD	PH	SV
2	8 June 2022	Updated report to include supplementary testing.	SF	JD	JD	SV
3	22 June 2022	Approval to issue				SV

Quality Statement

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CHECKED BY Janan Dunning		4 / 10 / 2021
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STATUS FINAL | Project No 310103534

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Executive Summary

Christchurch City Council (CCC) has engaged Stantec New Zealand (Stantec) to undertake a Detailed Site Investigation (DSI) to investigate the Robinson Bay Sawmill Road site. This area is to be used for the irrigation of treated wastewater to land, as part of the Akaroa Treated Wastewater Irrigation Scheme.

The Robinsons Bay site is located at 11 Sawmill Road in Robinsons Bay on Banks Peninsula. The site comprises 35 ha of predominantly pastoral land. The site history review and site inspection found the site has been subject to historical HAIL activities. These are listed below:

- HAIL A8 - Livestock dip or spray race operations
- HAIL I - Any land that has been subject to the accidental release of a hazardous substance (in this case, lead paint) in sufficient quantity that it could be a risk to human health or the environment.

There are two historical buildings on the site (Farm Buildings A and B) that were assessed for the use of lead-based paint. Eight samples were collected from the environs of each location. The potential contamination in the sheep dip area was assessed as arising from historical sheep dipping activities using insecticides. A total of 25 samples ("Sheep 1" to "Sheep 25") were collected from this area to investigate the nature and extent of soil contamination.

At Farm Building A, Sample FB A3 recorded a lead concentration of 1,970 mg/kg which exceeds the recreational land use standard of 880 mg/kg; all other soil samples had lead concentrations below the recreational standard. All but one sample (FBA5) recorded lead concentrations above background levels. All lead concentrations were however below the commercial/industrial standard.

As part of works to ready the site Farm Building A was removed by CCC's subcontractors in December 2021, postdating the original investigation. No soil was removed, and any soil disturbance appeared minimal. All samples had lead concentrations below the recreational standard. This indicates that the removal of Farm Building A did not significantly add to lead present in the soils.

At Farm Building B, Sample FB B1 recorded a lead concentration of 900 mg/kg which marginally exceeds the recreational land use standard of 880 mg/kg. All lead concentrations were greater than background levels and below the commercial/industrial standard.

The historical sheep dip area was found to have areas of arsenic concentration that far exceed both recreational and commercial/industrial standards.

At the time of preparing this report, it is unknown if Farm Building A will be removed from the site. Farm Building B is of historical significance however and will likely remain at its present location.

Supplementary testing after Farm Building A was removed showed the removal of the building did not increase lead concentrations significantly. During the demolition soils were not disturbed or removed. At the time of writing this report there is no plan to disturb or remove soils from this location and therefore there is no activity that would invoke the NESCS. Given the current plan to not disturb soil, the NESCS does apply to the "piece of land. This conclusion should be reconsidered if once the proposed site development plan is finalised and soils from this area are proposed to be removed or disturbed. If this occurs a remediation approach should be addressed and implemented through a Remedial Action Plan/Site Management Plan and NESCS consent may be needed.

It is assumed Farm Building B will be left in position and that no disturbance of soil or other activity that would invoke the NESCS will take place; therefore, the NESCS does not apply to the "piece of land." Future requirements based on management of the lead concentrations in this area should be contained in a Site Management Plan.

Historic sheep dip chemicals were found to have contaminated soils at levels above recreational and commercial/industrial standards in and around the sheep dip area. It is assumed that the sheep dip and surrounding land will be identified and left in place as an exclusion zone from any future site irrigation or recreational land use. Therefore, the NESCS does not apply to this "piece of land." Exclusion zones and other requirements for this area should be specified in a Site Management Plan.

If the assumptions of land use for Farm Building B and the sheep dip area change and soil is disturbed or another activity occurs, then the NESCS may well apply. Given this, if there is a change in assumptions and the NESCS is accordingly invoked, Regulation 10(2)(b) of the NESCS identifies the consent status of the site works at Farm Building B and the sheep dip as being a Restricted Discretionary Activity.

Irrigation of treated wastewater should be excluded from areas identified as a “piece of land”, as shown in Appendix E. These areas have been identified as being contaminated and water should not be discharged to contaminated land. If this is not possible then a resource consent will likely be required under the Regional Land and Water Plan.

If the assumptions made around soil disposal change and soil is to be taken off-site for disposal then this soil will need to be deposited to a facility or site that is authorised to accept the material and the assessment under the NESCS will need to be revisited.

In the case of an accidental discovery of contamination the procedures outlined in the Accidental Discovery Protocol in section 15.0 should be followed.

Glossary

Canterbury Maps	Environment Canterbury's Canterbury Maps Viewer
CCC	Christchurch City Council
CLMG No.1	MfE's *Contaminated Land Management Guidelines No.1 (revised June 2021)*
CoC	Chain of Custody
CSM	Conceptual Site Model
DQO	Data Quality Objective
DSI	Detailed Site Investigation
ECan	Environment Canterbury
HAIL	Hazardous Activities and Industries List
LLUR	Environment Canterbury's *Listed Land Use Register*
NESCS	The Ministry for the Environment's *National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Heath*
NZGD	New Zealand Geotechnical Database
OCPs	Organochlorine Pesticides
PSI	Preliminary Site Investigation
SCS	Soil Contaminant Standard
SQEP	Suitable Qualified and Experienced Practitioner
Stantec	Stantec New Zealand

1.0 SUITABLY QUALIFIED ENVIRONMENTAL PRACTITIONER CERTIFICATION OF THE REPORT

I Scott Fellers of Stantec New Zealand certify that:

1. This detailed site investigation meets the requirements of the Resource Management (National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health) Regulations 2011 (the NESCS) because it has been:

   a) prepared by a suitably qualified and experienced practitioner, and

   b) done in accordance with the current edition of Contaminated Land Management Guidelines No 5 – Site investigation and analysis of soils, and

   c) reported on in accordance with the current edition of Contaminated Land Management Guidelines No 1 – Reporting on contaminated sites in New Zealand, and

   d) the report is certified by a suitably qualified and experienced practitioner.

2. This detailed site investigation concludes that:

   a) soil disturbance in relation to Farm Building A is within the permitted volume under Regulation 8(3)(d) of the NESCS Regulations. Locations Farm Building B and the sheep dip area are assessed as not being covered by the NESCS as no activity is proposed within these areas.

Evidence of the qualifications and experience of the suitably qualified and experienced practitioner(s) who have done this investigation and certified this report is appended to this detailed site investigation report in Appendix F.

Signed

Scott Fellers

Environmental Scientist

Dated: 08 June 2022

2.0 SCOPE OF WORK

As part of the Akaroa Treated Wastewater Irrigation Scheme, the Christchurch City Council (CCC) has engaged Stantec New Zealand (Stantec) to undertake a Detailed Site Investigation (DSI) at the Robinsons Bay Sawmill Road site indicated in Section 3.0 of this document.

This DSI fulfils the reporting requirements for the assessment of contaminated land effects against the National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (Ministry for the Environment, 2012) (NESCS) and has been prepared in general accordance with the Ministry for the Environment's *Contaminated Land Management Guideline No 1: Reporting on Contaminated Sites in New Zealand (revised June 2021)*.

3.0 PROJECT LOCATION

The Robinsons Bay Sawmill Road site is located at 11 Sawmill Road in Robinsons Bay on Banks Peninsula and has a legal description of Lot 2 DP 82749. The site comprises 35 ha of predominantly pastoral land and lies approximately 6km due north of Akaroa township. The site is bounded by a residential property to the west, Sawmill Road on the southwest, Robinsons Bay Valley Road to the north and pastoral land to the east. The site is accessed from the south via Sawmill Road.

Refer to Figure 1 and Figure 2 for site locations and details.

Figure 1: Site location shown in relation to Akaroa Harbour

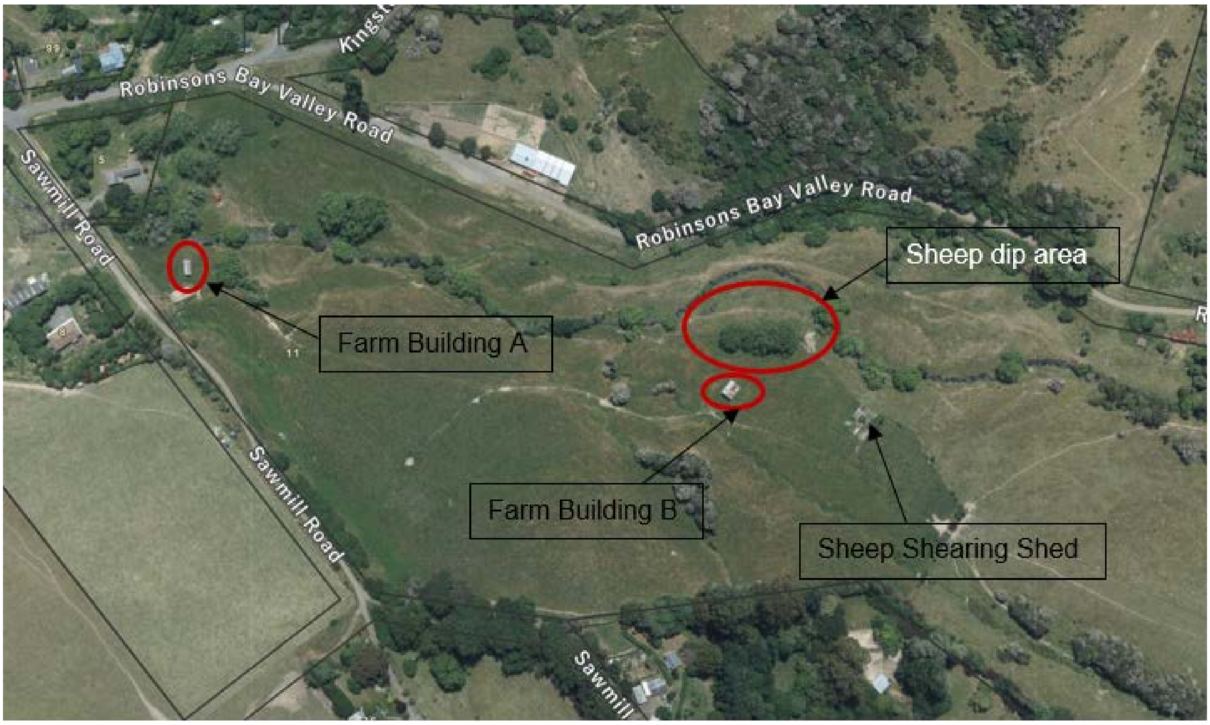

Figure 2: Site details with testing locations

4.0 PROPOSED ACTIVITES AND SUMMARY OF WORKS

The following is an excerpt from the CCC "Statement of Work for the Akaroa Consent Application Document" (Issued for Tender V2):

"The existing Akaroa Wastewater Treatment Plant (WWTP) discharging to Akaroa Harbour is to be replaced with a new WWTP to be built at the intersection of Long Bay Road and Old Coach Road near Akaroa."

In 2020, after five years of robust options analysis[1] The CCC consulted on four options for the disposal / reuse of treated wastewater that will be produced by a proposed new treatment plant to be built at a site on Old Coach Road above Akaroa. The CCC decided on 10 December 2020 to adopt the 'Inner Bays' scheme which will irrigate the highly treated wastewater to plantings of native trees in Robinsons Bay, Takamātua and Hammond Point. The CCC resolution and extensive background information about the project can be found on the project webpage[2]. It is strongly recommended that tenderers review these documents.

The CCC are currently seeking a short-term eight-year discharge permit for the existing WWTP outfall at Redhouse Bay (this is not included in this project scope). The permit is to enable the existing WWTP to continue to operate until the new WWTP and irrigation scheme is operation. The new scheme must therefore be consented, designed, constructed and commissioned before that new discharge permit expires.

This DSI report covers only the Robinsons Bay irrigation and planting areas. A Preliminary Site Investigation completed by Stantec[3] has assessed the remainder of the proposal for contamination potential.

[1] Consultation document Akaroa treated wastewater options: https://ccc.govt.nz/assets/Documents/Consultation/2020/07-July/Akaroa-Wastewater/WEB-Akaroa-treated-wastewater-options.pdf
[2] Akaroa reclaimed water treatment and reuse scheme project webpage: https://ccc.govt.nz/services/water-and-drainage/wastewater/wastewater-projects/akaroa-wastewater-scheme
[3] Akaroa Treated Wastewater Irrigation Scheme Preliminary Site Investigation. June 2022. Stantec. Reference No: 310303534

5.0 SITE CONDITION

The site is currently used for cattle grazing with various stands of trees and shrubs dotted across the site. The site slopes generally upwards to the east with a gain of approximately 300 m by the upper boundary of the site.

Several farm buildings and stock pens are present on the site. A modern cattle pen and historical farm building are located adjacent to the site entrance at Sawmill Road. A historical farmhouse, the remains of a wool shed, and a sheep dip are together located approximately 400 m upslope of the site entrance off Sawmill Road and are accessed by a farm track that traverses the site.

Please refer to Appendix A for site photographs.

6.0 GEOLOGY AND HYDROLOGY

Geology at the site is mapped[4] as being comprised of Yellow- brown windblown silt on Banks Peninsula, greater than 3 m thick and commonly in multiple layers (mQe).

Bore N36/0137 is located approximately 20 m to the south of the site and is used for domestic water supply. The bore logs show “earth” to a depth of 0.30 m bgl, with volcanic cobbles and silt to a depth of 4.8 m bgl and further volcanic cobbles to 18.0 m bgl, with basalt then present to 49.0 m bgl where the bore was terminated. The initial water level was measured at 18.68 m below the measuring point.

Robinsons Bay Stream runs east to west through the northern part of the site. Various ephemeral streams are present on the site, with these generally flowing from south to north until they connect with Robinsons Bay Stream.

7.0 SUMMARY OF SITE HISTORY

7.1 LISTED LAND USE REGISTER

The Listed Land Use Register (LLUR) is a publicly available database of information held by Environment Canterbury (ECan) about sites where hazardous activities and industries have been or are currently being carried out throughout the Canterbury region. It should be noted that the LLUR is not a complete record and that information about properties is added or updated regularly as more information becomes available

No LLUR records are held for this site.

7.2 CHRISTCHURCH CITY COUNCIL INFORMATION

The CCC property file for the site was reviewed on 14 June 2021. The information on that file was transferred to the CCC from the historical Banks Peninsula District Council’s records. The following items were noted in the file records:

- An application to relocate a farm shed to the site. A diagram shows that this relocated building is the one presently adjacent to the entrance to the site. The building was relocated from Duvauchelle School in 1993.
- A resource consent to subdivide the allotment to create a smaller allotment to the northwest of the site that contains the historical farmhouse now located at 5 Sawmill Road. Dated 1999.
- An application for a permit for drainage and plumbing works relating to a septic tank, drainage and effluent lines. Although there is no indication of where the septic tank was installed it is likely to be associated with the farmhouse that is now located at 5 Sawmill Road and thus will not be part of the current site. Dated 1991.
- A Land Information Memorandum (LIM) report from 2005. No information relating to potential contamination was included in this LIM record.

[4] Brown, L.J.; Weeber, JH. 1992: Geology of the Christchurch urban area. Scale 1:25,000. Institute of Geological & Nuclear Sciences geological map 1. Institute of Geological & Nuclear Sciences Limited, Lower Hutt, New Zealand

The property file does not contain any information that indicates a HAIL activity has occurred or is occurring on the site.

7.3 HISTORICAL AERIAL IMAGERY

Historical aerial imagery from Retrolens, ECan's GIS and Google Maps were reviewed for the site from 1941 through to 2019. The findings are presented in Table 1 below. Please refer to Appendix A for a representative sample of historical aerial imagery.

Table 1: Historical Imagery Information

Date	Source	Comments
1941	Retrolens	The land use appears predominantly pastoral. The farm track is faintly established leading from Sawmill Road to the woolshed in the eastern part of the site. The farmhouse near the woolshed is visible. The woolshed appears to be in use and holding pens can be seen to the east of the shed. The sheep dip is not visible due to vegetation in the area although what is probably a tank shed is present immediately to the east of where the concrete foundation at the head of the sheep dip is presently located. A stock pen is situated along the western part of the farm track. No sheep dips or spray race structures are visible. A portion of the western part of the site is fenced, with lines of trees or shrubs. The remainder of the site appears to be predominantly paddocks with sparse trees and shrubs.
1952	Retrolens	The eastern part of the sheep dip is visible beneath the vegetation (HAIL A8) as shown on Figure 2The fenced area on the western part of the site shows vegetation is now mostly no longer present, with only some faint lines of vegetation visible. If the area was planted as an orchard, it appears the establishment was not successful. Not assessed to be a HAIL activity. The remainder of the site appears predominantly unchanged from previous imagery.
1966	Retrolens	Vegetation in the western paddock is now removed. The farm track appears well established and now connects through the site to Robinsons Bay Road on the northeast side of the site. The remainder of the site appears largely unchanged from previous imagery.
1980-1984	ECan	Stock pens can now be seen at the entrance to the site off Sawmill Road. The sheep dip (HAIL A8) is still visible beneath some trees to the north of the woolshed. The concrete foundation east of the dip is visible, although the building has been removed. The remainder of the site appears predominantly unchanged from previous imagery.
1995-1999	ECan	A building can be seen north of the stock pens near the entrance to the site. This is likely to be the building translocated from the Duvauchelle School as noted on the CCC property file. The remainder of the site is relatively unchanged from previous imagery.
2002	Google Earth	The site is relatively unchanged from previous imagery. All buildings are still visible. The stock pens to the west of the woolshed appear unused.
2004-2010	ECan	The farm track is less well defined. The woolshed and the sheep dip appear in disuse. The woolshed is partially dismantled. The majority of the site remains in pastoral use.
2013	Google Maps	The site is relatively unchanged from previous imagery.
2019	Google Maps	The site is relatively unchanged from previous imagery.

7.4 SITE VISIT

A site walkover was completed on 6 May 2021 and identified three areas of potential HAIL activities, as follows:

- A historical farm building (Building A) is located approximately 30 m east of the site entrance. Paint was flaking off this building and accumulating on the ground. The building is in a derelict condition. The building first appeared in aerial imagery from 1995, although the CCC property file indicates that the building was relocated to its current location from the Duvauchelle School. The age of the building is unknown. Given this, and its historical appearance, it was assumed that the paint could contain lead (HAIL I).
- A historic two-story farmhouse (Building B) is located approximately 350 m east of the site entrance. The building is in reasonable condition given its age. While no paint was visible on the building at the time of the site visit, given its obvious age it is assumed that lead paint (HAIL I) could have been used at some point in the building's history.
- A sheep dip (HAIL A8) was identified on the northern part of the site, approximately 400 m east of the site entrance and located beneath a row of trees. The dip itself is approximately 15 m long by 0.5 m wide and 1.5 m deep. A concrete foundation is present immediately to the east of the dip. It is assumed this was the base of a farm shed used to store chemical supplies for the sheep dip. A man-made channel is faintly visible extending from the western end of the sheep dip downslope to the north towards the Robinsons Bay Stream. There is what appears to be a plug in the wall of the sheep dip above the drain that may have been used to drain treatment solution into the man-made channel. A smaller drain is also located approximately 10 m to the north and running in a similar direction. It is unclear what this smaller drain was used for.
- The historical wool shed is dilapidated, with most of it fallen down and removed. The foundations are present along with some piles of timber. Given the use of the building as a wool shed only, it is unlikely that it was ever painted. This is assessed as not being a HAIL activity.
- The cattle yards located at the entrance to the site appear to be generally modern and are not assessed as being a HAIL activity.

Please refer to Appendix A for site photographs.

7.5 SUMMARY OF HAZARDOUS ACTIVITIES

The site history review and site inspection found that the site has been subject to historical HAIL activities. These are listed below:

- HAIL A8 - Livestock dip or spray race operations.
- HAIL I - Any land that has been subject to the accidental release of a hazardous substance (in this case, lead paint) in sufficient quantity that it could be a risk to human health or the environment.

8.0 SAMPLING AND ANALYSIS PLAN

8.1 DATA QUALITY OBJECTIVES

The Data Quality Objectives (DQO) of the soil sampling program were to:

- Quantify concentrations of contaminants of concern relating to the HAIL activities identified in the site history review.
- Assess whether the concentrations of contaminants exceed the relevant regulatory standards and guideline values for the proposed treated wastewater irrigation element of the Akaroa wastewater upgrade project.

8.2 SAMPLING DESCRIPTION: HISTORICAL FARM BUILDINGS

The two historical buildings on the site were assessed for the use of lead-based paint. Please see sections 9.2.1 and 9.2.2 below for a breakdown of details for each location.

8.2.1 Farm Building A

Farm building A is located 30 m east of the site entrance. Flaking paint was visible on the building and paint chips are visibly accumulating in the soil. A total of eight samples (FBA1- FBA8) were collected in the vicinity of the building. Samples FBA1 to FBA4 were collected approximately 0.5 m from each wall of the building. Samples

FBA5 to FBA8 were collected approximately 5 m away from each wall of the building, but in line with the closer samples.

Samples were collected from the top 100 mm of soil as this is the soil horizon likely to be affected by any accumulation of lead-based paint. Each sample was analysed by the laboratory for lead only.

Please refer to Appendix C for test locations.

8.2.2 Farm Building B

Farm Building B (the farmhouse) is located 350 m east of the site entrance. Given the considerable age of the building it was assumed that it is likely to have been painted with lead-based paint. A total of eight samples (FBB1- FBA8) were collected in the vicinity of the building. Samples FBB1 to FBB4 were collected at approximately 0.5 m from each wall of the building. Samples FBB5 to FBB8 were collected approximately 5 m away from each wall of the building, but in line with the closer samples.

Samples were collected from the top 100 mm of soil as this is the soil horizon likely to be affected by lead based paint. Each sample was analysed by the laboratory for lead only.

Please refer to Appendix C for test locations.

8.3 SAMPLING DESCRIPTION: SHEEP DIP AREA

The potential contamination in the sheep dip area was assessed as arising from historical activities to apply insecticide treatments to the sheep. A total of 25 soil samples ("Sheep 1" to "Sheep 25") were collected from this area, with details as follows:

- The concrete foundation east of the sheep dip was assumed to be a remnant of a shed used to store bulk sheep dip solution and materials. Samples "Sheep 1" to "Sheep 4" and "Sheep 10" were collected adjacent to the foundation.
- The sheep dip itself has a concrete base, but it is expected that solution would have been splashed out onto the ground by the sheep moving through the dip. Samples "Sheep 11" to "Sheep 16" were collected from directly adjacent to the sheep dip along its length.
- A wooden sheep run was present immediately to the west of the sheep dip. It is assumed that this funneled sheep from the dip into the adjacent paddock after treatment. Samples "Sheep 17" and "Sheep 18" were collected from within this run.
- The paddock immediately to the west of the sheep run would be likely to have been impacted as drenched sheep would have dripped chemicals onto the ground as they dried off. Samples "Sheep 19" to "Sheep 25" were collected from the paddock area immediately east of the wooden sheep run.
- The man-made channel extending downslope to the north appears to have been used to drain used or excess dip solution out of the sheep dip. Samples "Sheep 5" to Sheep 8" were collected from within the channel area.

Samples were collected in the top 100 mm of soil as this is the soil horizon most likely to have been affected by sheep dip chemicals. Arsenic was selected as being the most appropriate contaminant to represent the general contamination levels relating to sheep dip chemicals as it was the most common component historically of sheep dip insecticide formulations. All samples were therefore analysed for arsenic and, in addition the additional contaminants lead, organochlorine pesticides (OCPs), and dieldrin were also analysed in soil samples from seven locations chosen at random.

Please refer to Appendix C for sampling locations.

8.4 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

The fieldwork and reporting were conducted in general accordance with the Ministry for the Environment's (MfE) Contaminated Land Management Guidelines (CLMG) No. 1 and 5 (both revised in June 2021), and followed a uniform and systematic approach comprising the following procedures:

- Decontamination: By wiping residual soil from the soil sampling equipment after each sample, and then rinsing with 1-molar nitric acid followed by rinsing with deionized water, before collecting any new soil samples.
- Sample ID procedures: Soil samples were immediately transferred to a sealed laboratory supplied glass jar. Each container was labelled with a permanent marker stating sample ID, date, sampling depth and reference number. The samples were then transferred to a 'chilly bin' containing chiller pads. Samples were then delivered to the laboratory on the day of collection.
- Chain of Custody (CoC): A chain of custody form was completed for each batch of samples.

9.0 BASIS FOR GUIDELINE VALUES

The development of the Robinsons Bay Sawmill Road site will result in the irrigation of treated wastewater onto surface soils within a replanted native forest setting. It is possible that, once completely established, the site may be opened for public access, with potential for walking or biking tracks through the revegetated areas. The NESCS Soil Contaminant Standards (SCS) for recreational land use were therefore chosen as the most appropriate standards to apply to the risk assessment of final land use.

To assess the potential for human health impacts during the construction phase of the Project results were compared against the commercial/industrial land use SCSs. This is generally accepted as the appropriate land use scenario to represent worker health.

To assess the potential effects of stormwater runoff from HAIL sites during earthworks, the soil concentrations were compared against the Toxicant Default Guideline Values for Sediment Quality (GV- High).

The western part of the site containing Farm Building A has soils from the Recent Regional soil group[5]. The eastern part of the site where Farm Building B and the sheep dip are located comprises soils from the Intergrade Regional soil group. For simplicity, all results have been compared to the Intergrade Regional soil group as the majority of the tests were completed in this western area and this is a more conservative background scenario. Comparison of laboratory results for the site with expected background concentrations were used to determine NESCS consenting requirements.

10.0 RESULTS

10.1 HISTORIC FARM BUILDINGS

10.1.1 Farm Building A

Eight samples were collected in close proximity to Farm Building A at the site entrance off Sawmill Road. Four samples (FBA1- FBA4) were collected adjacent to the walls of the building and four samples (FB A5- FB A8) were collected 5 m away from each wall. These samples were all analysed for lead only.

Sample FB A3 recorded a lead concentration of 1,970 mg/kg which exceeds the recreational land use standard of 880 mg/kg. All other samples had lead concentrations below the recreational standard. All but one sample (FBA5) recorded lead concentrations above background levels. All lead concentrations were however below the commercial/industrial standard.

To assess the potential effects of stormwater runoff from the HAIL sites during earthworks, the soil concentrations were compared against Toxicant Default Guideline Values for Sediment Quality (GV- High). All concentrations, except for FB A3, were below the relevant guideline value.

Please refer to Table 10-1 in Section 10.2 below for a table of selected results and Appendix D for the full laboratory report.

[5] https://ecan.maps.arcgis.com/home/item.html?id=2f2855396dc54c3ea9f8cd9bdeb3b993. Reviewed December 2020

10.1.2 Farm Building B

Eight samples were collected in close proximity to Farm Building B (the farmhouse). Four samples (FB B1- FB B4) were collected adjacent to the walls of the building and four samples (FB B5- FB B8) were collected 5 m away from each wall. All samples were analysed for lead only.

Sample FB B1 recorded a lead concentration of 900 mg/kg which marginally exceeds the recreational land use standard of 880 mg/kg. All lead concentrations were above background levels but below the commercial/industrial standard.

To assess the potential effects of stormwater runoff from the HAIL sites during earthworks, the soil concentrations were compared against Toxicant Default Guideline Values for Sediment Quality (GV- High). Concentrations were recorded above guideline values at all locations except FB B5 and FB B8.

Please refer to Table 10-2 in Section 10.2 below for a table of selected results and Appendix D for the full laboratory report.

10.2 SHEEP DIP AREA

Twenty-five samples were collected from around the sheep dip area. These samples were broken up into five areas, as now described.

- Five samples (“Sheep 1-4” and “Sheep 10”) were collected from adjacent to the concrete pad. Three of these samples (“Sheep 2- 4”) showed arsenic results that exceeded both recreational and commercial/industrial standards. The highest exceedance of arsenic was 340 mg/kg at the “Sheep 2” location which was collected along the north side of the concrete foundation. All samples had arsenic concentrations the exceeded the expected background level. At the “Sheep 1” and “Sheep 4” locations lead was recorded at below background levels, dieldrin concentrations were marginally above the laboratory limit of detection and OCP concentrations were all below the laboratory limits of detection.
- Five samples (“Sheep 5-9”) were collected from the man-made channels extending north from the sheep dip structure itself. Sample “Sheep 7” was collected from the smaller channel to the north and its arsenic concentration did not exceed the recreational standard but did exceed the expected background level. The remaining samples were collected from the main channel and all samples exceeded both recreational and commercial/industrial standards and background levels for arsenic. The highest exceedance of arsenic was 1,060 mg/kg, compared to the 70 mg/kg commercial/industrial standard, at location “Sheep 9”, 0.5m north of the northwestern edge of the sheep dip. At location “Sheep 8” lead was recorded at below the expected background level, the dieldrin concentration was recorded above the recreational standard and OCP concentrations were all below the laboratory limits of detection.
- Six samples (“Sheep 11-16”) were collected adjacent to the concrete sheep dip itself. All samples showed arsenic results that exceeded recreational and commercial/industrial standards, as well as toxicant default guidelines. The highest exceedance for arsenic was 1,630 mg/kg at the “Sheep 16” location at the northwestern end of the sheep dip structure. At location “Sheep 12” the lead concentration was below the expected background level, and both dieldrin and OCP concentrations were below the laboratory limits of detection.
- Two samples (“Sheep 17” and “Sheep 18”) were collected from the base of the sheep run. Sample “Sheep 17” showed an arsenic concentration of 159 mg/kg which exceeds both recreational and commercial/industrial standards and also the toxicant default guideline value. Sample “Sheep 18” recorded a concentration of 40 mg/kg for arsenic which is below both recreational and commercial/industrial standards but is above the expected background level.
- Six samples (“Sheep 19-25”) were collected from the paddock immediately adjacent to the sheep run. All samples had arsenic concentrations below both recreational and commercial/industrial standards and also the toxicant default guidelines. Four of the samples (“Sheep 19-21”, “Sheep 23” and “Sheep 25”) had arsenic concentrations that exceeded the expected background level. At locations “Sheep 20” and “Sheep 25” lead was recorded in concentrations below background levels, dieldrin concentrations were marginally above the laboratory limit of detection at location “Sheep 20” and below the laboratory limit of detection at “Sheep 25” and OCP concentrations were below the laboratory limit of detection in both of these samples.

Please refer to Table 10-3 in Section 10.4 below for a table of selected results and Appendix D for the full laboratory report.

Samples ("Sheep 5, 6, 8 and 9") collected from the primary constructed channel which extends north downslope from the sheep dip all showed arsenic concentrations that exceeded recreational and commercial/industrial standards. This indicates (as suspected) that the channel was used to drain excess or used dip chemicals from the sheep dip. The total extent of the contamination arising from this historical practice could not be ascertained from the small number of samples collected in the channel area. Therefore, additional sampling from downslope of the sheep dip was proposed, in the form of a supplementary round, to delineate the area affected by sheep dip chemicals. Please refer to Section 10.3 below for more details.

10.3 SUPPLEMENTARY TESTING AT SHEEP DIP SITE

To delineate the extent of the contamination arising from draining sheep dip chemicals into the man-made channel north of the sheep dip an additional 19 test locations were chosen. During the initial sampling at the sheep dip arsenic was found to be the primary contaminant present. For this reason, supplementary samples were analysed for arsenic only. Please see Appendix C for test locations.

Of the 19 samples, five had arsenic concentrations that exceeded recreational and commercial/industrial standards. These were samples from Locations 27, 31, 32, 33 and 44. This pattern of exceedances indicates that sheep dip chemicals flowed down the channel onto a natural terrace above the stream and then flowed west down a shallow historical stream bed which eventually connects with Robinson Bay Stream where chemicals would potentially have flowed into the active stream bed. The flow pattern can be generally seen in the results map shown in Appendix C.

10.4 SUPPLIMENTARY TESTING AT FARM BUILDING A

As part of works to ready the site Farm Building A was removed by CCC's subcontractors in December 2021, postdating the original investigation. No soil was removed, and any soil disturbance appeared minimal. The removal was done without the consultation of Stantec, and it was unknown if any consideration was taken of the potential for lead-based paint to enter the soil as during the demolition process. Therefore, it was deemed that supplementary sampling was required to assess residual lead levels in the soil after the demolition had occurred.

On 29 March 2022 Stantec staff collected four additional samples (Robinson 1 to Robinson 4) from the building footprint of Farm Building A. Samples were collected from the top 100 mm of soil as this is the soil horizon likely to be affected by any accumulation of lead-based paint. Each sample was analysed by the laboratory for lead only.

All samples recorded lead concentrations above background levels. All lead concentrations were however below Recreational as well as commercial/industrial soil contaminant standards.

To assess the potential effects of stormwater runoff from the HAIL sites during earthworks, the soil concentrations were compared against Toxicant Default Guideline Values for Sediment Quality (GV- High). All concentrations were below the relevant guideline value.

Please refer to Appendix C for test locations. Please refer to Table 10-1 in Section 10.2 below for a table of selected results and Appendix D for the full laboratory report.

10.5 RESULTS TABLES

Table 10-1: Analytical Results for Farm Building A

Sample Name	Lead (mg/kg)
FB A1	**68**
FB A2	**220**
FB A3	**1,970**
FB A4	**220**
FB A5	20
FB A6	**46**
FB A7	**31**
FB A8	**35**
Robinson 1	**18**
Robinson 2	**200**
Robinson 3	**52**
Robinson 4	**63**
Background: Intergrade Regional	30.3(135.8)
SCSs(health)for recreational land use	880
SCSs(health)for commercial/industrial land use	3,300
Toxicant Default guideline Values for Sediment Quality (GV-High)	220

*Bold fond indicates contaminant exceeding background levels. Orange shading indicates contaminant exceeding recreational standard.

Table 10-2: Analytical Results for the Farm Building B

Sample Name	Lead (mg/kg)
FB B1	**900**
FB B2	**640**
FB B3	**570**
FB B4	**460**
FB B5	**88**
FB B6	**270**
FB B7	**260**
FB B8	**133**
Background: Intergrade Regional	**30.3(135.8)**
SCSs(health)for recreational land use	880
SCSs(health)for commercial/industrial land use	3,300
Toxicant Default guideline Values for Sediment Quality (GV-High)	220

*Bold fond indicates contaminant exceeding background levels. Orange shading indicates contaminant exceeding recreational standard.

Table 10-3: Analytical Results for the Sheep Dip Area

Sample Name	Arsenic (mg/kg)	Lead (mg/kg)	Sum DDT Isomers (mg/kg)	Dieldrin (mg/kg)
Sheep 1	**50**	14	<0.013	**0.019**
Sheep 2	**340**	-	-	-
Sheep 3	**210**	-	-	-
Sheep 4	**116**	21	<0.08	**0.014**
Sheep 5	**152**	-	-	-
Sheep 6	**780**	-	-	-
Sheep 7	**25**	-	-	-
Sheep 8	**700**	12	<0.09	**12.2**
Sheep 9	**1,060**	-	-	-
Sheep 10	**39**	-	-	-
Sheep 11	**230**	-	-	-
Sheep 12	**109**	26	<0.08	<0.014
Sheep 13	**184**	-	-	-
Sheep 14	**750**	-	-	-
Sheep 15	**340**	-	-	-
Sheep 16	**1,630**	**98**	<0.09	**3.4**
Sheep 17	**159**	-	-	-
Sheep 18	**40**	-	-	-
Sheep 19	**21**	-	-	-

Sheep 20	**16**	18	<0.09	**0.015**
Sheep 21	**13**	-	-	-
Sheep 22	7	-	-	-
Sheep 23	**8**	-	-	-
Sheep 24	7	-	-	-
Sheep 25	**8**	14	<0.08	<0.013
Sheep 26	**23**	-	-	-
Sheep 27	**175**	-	-	-
Sheep 28	**25**	-	-	-
Sheep 29	**10**	-	-	-
Sheep 30	**19**	-	-	-
Sheep 31	**360**	-	-	-
Sheep 32	**154**	-	-	-
Sheep 33	**220**	-	-	-
Sheep 34	3	-	-	-
Sheep 35	7	-	-	-
Sheep 36	5	-	-	-
Sheep 37	3	-	-	-
Sheep 38	2	-	-	-
Sheep 39	2	-	-	-
Sheep 40	<2	-	-	-
Sheep 41	2	-	-	-
Sheep 42	**14**	-	-	-
Sheep 43	**45**	-	-	-
Sheep 44	**159**	-	-	-
Background: Intergrade Regional	**7**	**30.3(135.8)**	**-**	**-**
SCSs(health)for Recreational	80	880	400	70
SCSs (health) for Commercial/industrial	70	3,300	1,000	160
Toxicant Default guideline Values for Sediment Quality (GV-High)	70	220	5.0	7

*Bold fond indicates contaminant exceeding background levels. Red shading indicates contaminant exceeding commercial/industrial standard.

11.0 LABORATORY QUALITY ASSURANCE

All soil samples were analysed by R J Hill Laboratories. This laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation system (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised. The tests reported herein have been performed in accordance with the terms of accreditation.

12.0 DATA EVALUATION QUALITY ASSURANCE

The laboratory results in this report have been examined for consistency with respect to both the site history and field observations, as well as by comparison with tests from each location.

The laboratory results did not show any tests that were significantly out of proportion with expected levels of contamination from the former HAIL activities.

There were no indications of any quality control issues evident from the laboratory results.

13.0 CONCEPTUAL SITE MODEL (CSM)

A Conceptual Site Model (CSM) for a site is based on the environmental setting of the site and assesses contaminant distributions, release mechanisms, exposure pathways, migration routes and potential receptors. The CSM for this site acknowledges that the potential for contamination arises from historical activities that have taken place across three particular areas on the site.

The potential receptors for contaminants on the site are the workers during the construction of the proposed wastewater irrigation system and subsequent native planting, the nearby Robinsons Bay Stream, and ephemeral streams courses from wastewater runoff. Additional receptors are likely to be recreational users if recreational use of the site is established, although this will depend on how the site is developed and configured for recreation in the future. Pathways for human exposure during the construction phase and for recreational land use include dermal contact, inhalation, and ingestion of small amounts of soil.

Farm Building A was assessed as having been painted with lead-based paint. This building was removed during the development of the site subsequent to the initial soil testing program. Initial testing showed the highest concentrations of lead were found immediately adjacent to the building, with significantly lower levels 5 m further out from the building walls. The lead concentration at location FBA3 adjacent to the building exceeded the commercial/industrial Soil Contaminant Standard indicating that workers health during construction phase could potentially be impacted. Supplementary testing after the building was removed did not show any lead concentrations exceeding commercial/industrial standard indicating that the removal of the building was unlikely to have added significantly to previously existing lead concentrations. The building is located 10m south of Robinson Bay Stream but lead concentrations in samples taken 5 m away from the building walls showed results that were below Toxicant Default Guideline Values for Sediment Quality, thus indicating it is unlikely that lead from paint chips will migrate to the stream in concentrations sufficient to affect aquatic life.

Farm Building B was also assessed as having been painted with lead-based paint. Due to the historic significance of this farmhouse, it is assumed that it will not be removed from the site. One lead result at location FBA1 showed a lead concentration at 900 mg/kg, thus marginally exceeding the recreational standard of 880 mg/kg although, on average, the lead concentrations adjacent to the building walls are below the recreational standard. It is assumed that soil disturbance during recreational activities will not be taking place directly adjacent to the farmhouse. With the average lead concentration being below the recreational standard, it is thus unlikely that lead concentrations found close to the farmhouse are relevant to potential future recreational users of this land.

Lead concentrations did exceed the Toxicant Default Guideline Values for Sediment Quality at most test locations but the farmhouse is located approximately 20 m from the nearest ephemeral stream and 50 m from the primary

Robinson Bay Stream. It is unlikely that lead from paint chips will migrate those distances in concentrations that would present any risk to aquatic life.

The historic sheep dip area was found to have areas of arsenic concentrations that far exceed recreational and commercial/industrial standards. Based on conversations with the CCC, it is assumed that the sheep dip and the surrounding area will not be irrigated and will not be accessible to the public. This strategy will eliminate the pathway for contact with soils that may otherwise negatively impact human health. If this assumption is changed in the future, both construction workers and site end users could potentially encounter soil containing lead levels that may negatively affect human health through dermal contact, inhalation, and ingestion.

Additionally, at the historic sheep dip area both arsenic and dieldrin contamination was found at levels in exceedance of the Toxicant Default Guideline Values for Sediment Quality (GV-High). Elevated results across the area indicate that the sheep dip was occasionally drained of solution, and this flowed through a constructed channel downslope where it possibly drained into the stream itself. This indicates that aquatic life in the stream north of the sheep dip is a potential receptor for sediment with significant levels of arsenic and dieldrin. If any earthworks are completed in this area this potential risk could be exacerbated through mobilisation and migration of sediment, and therefore this will need to be accounted for in any future erosion and sediment control plan.

14.0 STATUTORY PROVISIONS

14.1 DETAILED SITE INVESTIGATION

The Detailed Site Investigation (DSI) is subject to the following national and regional statutory provisions:

- National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS 2011).
- Canterbury Land and Water Regional Plan (LWRP), Rules 5.185, 5.186.

14.2 SOIL DISTURBANCE AND REMOVAL

Given the size of the 35 ha site and the scope of expected earthworks all surplus soil disturbed in Project works is expected be reused on the site. Soil from adjacent to Farm Building A showed one sample with lead levels exceeding the recreational standard. If soil is removed and/or disturbed and reused on the site from this area some form of remediation will be required. Soil mixing with clean soil would be appropriate allowing the average level of lead contamination to be diluted to below the appropriate standard.

Any future remediation and ongoing site management should be covered in an appropriate report when the proposed site development plan has been finalised.

No soil removal or disturbance is expected from the surroundings of Farm Building B as the building has historical value and is expected to remain in its current location.

It is expected the sheep dip and the surrounding area will be instituted as an exclusion zone and these locations will be retained as undeveloped areas of the site and will not be irrigated. Therefore, no soil is expected to be removed or disturbed in this area. If this changes then the high levels of arsenic contamination will need to be managed by implementing a Remedial Action Plan.

14.3 NATIONAL ENVIRONMENTAL STANDARD FOR ASSESSING AND MANAGING CONTAMINANTS IN SOIL TO PROTECT HUMAN HEALTH (NESCS)

The NESCS came into effect on 1 January 2012. Its main objective is to ensure that potential ground contamination is identified and assessed at the time of development to make sure the land is safe for the proposed earthworks, any future land uses, and to protect human health.

The NESCS applies when a person wants to do an activity described in subclause 5(2) to 5(6) on a “piece of land” described in subclause 5(9) of the NESCS. Within the large rural Robinsons Bay Sawmill Road site there are three areas that would be considered a “piece of land” under the NESCS: these are the former location of Farm Building A, Farm Building B, and the sheep dip area. Soil sampling is listed as activity 5(3) under the NESCS. Soil sampling from the three locations at the site is a permitted activity under regulation 8(2) of the NESCS. Please refer to Appendix E for the areas of the site that are considered to be “pieces of land” under the NESCS.

Of the three locations shown in Appendix E, only the former Farm Building A location may have soil disturbed in and around its immediate environs, although the fate of this area and surrounding soil is unknown at this time. Depending on the remediation technique used an NESCS consent may be needed. This will be assessed later when the proposed site development plan has been finalised.

It is assumed that no activities described under Regulation 5(2) through 5(6) of the NESCS will be occurring at the locations of Farm Building B or the sheep dip area, as shown in Appendix E. Therefore, it is assessed that the NESCS does not apply to these areas. If this assumption about activities changes at either location, then this assessment under the NESCS will need to be revisited.

It is concluded therefore that the NESCS does not apply to the greater 35 ha Robinsons Bay Sawmill Road site.

15.0 ACCIDENTAL DISCOVERY OF CONTAMINATION

The site has historically been used for grazing and farming activities. There is a risk that these or other activities may have led to contaminated soil that may be discovered during earthworks that was not known or obvious at the time of writing this report. Therefore, if any materials are encountered during any future earthworks, such as:

- Stained or odorous soil (e.g. black, green, grey; or smells of rotting organic material, petroleum hydrocarbons or solvents)
- Slag, ash, charcoal
- Rubbish comprising putrescible waste, or hardfill
- Potential asbestos containing-material (for example fragments from cement fibre sheets, or loose fibres from insulation, etc.)

- then we recommend:

1. Excavation and earthworks cease within 10 m of the accidental discovery, the site is secured to stop people entering the area where potential contamination was encountered, and then:
2. Contact is made with a contaminated land specialist for further advice. If required, Stantec can inspect the area, assess the material to determine if it is contaminated or hazardous, and then recommend a practical course of action.

Note that this report is not intended to relieve contractors and landowners of their responsibilities under the Health and Safety at Work Act 2015.

16.0 CONCLUSIONS AND RECOMMENDATIONS

Land immediately adjacent to the former location of Farm Building A was found to have soils impacted by lead based paint which has resulted in concentrations of lead above the recreational standard.

Supplementary testing after Farm Building A was removed showed the removal of the building did not increase lead concentrations significantly. During the demolition soils were not disturbed or removed. At the time of writing this report there is no plan to disturb or remove soils from this location and therefore there is no activity that would invoke the NESCS. Given the current plan to not disturb soils in this location, the NESCS does apply to the “piece of land. This conclusion should be reconsidered if once the proposed site development plan is finalised and soils from this area are proposed to be removed or disturbed. If this occurs a remediation approach should be addressed and implemented through a Remedial Action Plan/Site Management Plan and NESCS consent may be needed.

Land immediately adjacent to historic Farm Building B was found to have lead concentrations marginally above the recreational standard, with these exceedances also assumed to arise from lead-based paint. Farm Building B is of historical significance and will likely remain in its present location.

Since it is assumed Farm Building B will be left in position and that no disturbance of soil or other activity that would invoke the NESCS will take place; therefore, the NESCS does not apply to the “piece of land.” Future requirements based on management of the lead concentrations in this area should be contained in a Site Management Plan.

Historic sheep dip chemicals were found to have contaminated soils at levels above recreational and commercial/industrial standards in and around the sheep dip area. It is assumed that the sheep dip and surrounding land will be identified and left in place as an exclusion zone from any future site irrigation or recreational land use. Therefore, the NESCS does not apply to this “piece of land.” Exclusion zones and other requirements for this area should be specified in a Site Management Plan.

If the assumptions of land use for Farm Building B and the sheep dip area change and soil is disturbed or another activity occurs, then the NESCS may well apply. Given this, if there is a change in assumptions and the NESCS is accordingly invoked, Regulation 10(2)(b) of the NESCS identifies the consent status of the site works at Farm Building B and the sheep dip as being a Restricted Discretionary Activity.

Irrigation of treated wastewater should be excluded from areas identified as a “piece of land”, as shown in Appendix E. These areas have been identified as being contaminated and water should not be discharged to contaminated land. If this is not possible then a resource consent will likely be required under the Regional Land and Water Plan.

If the assumptions made around soil disposal change and soil is to be taken off-site for disposal then this soil will need to be deposited to a facility or site that is authorised to accept the material and the assessment under the NESCS will need to be revisited.

In the case of an accidental discovery of contamination the procedures outlined in the Accidental Discovery Protocol in section 15.0 should be followed.

17.0 LIMITATIONS

The conclusions contained in this report are based on a desk study, a site walkover inspection of the existing ground surface and a limited number of soil samples. It is possible these may not provide a complete or accurate assessment of the entire site.

All reasonable efforts have been made to ensure the conclusions drawn in this report are correct at the time of its preparation. However, contaminant standards may change in the future as knowledge about potentially hazardous substances develops. Consequently, conclusions drawn from the analyzed concentrations that are below today’s standards might become unacceptable in the future and require re-assessment. Also, some contaminants can be mobile, and concentrations may change over time e.g. due to decomposition, leaching or changes in the environment.

Stantec does not take responsibility for any buried or unidentified substances that may be present but were not observed at the time of our site walkover inspection or site works, were not identified by the laboratory testing, or are known to others but whose presence has not been communicated to Stantec as part of this investigation and report. As a result, Stantec provides this information on the basis that it does not warrant or represent that the information is complete or without error and accepts no liability for any inaccuracy in, or omission from, this information.

Should additional information be identified by the current or previous landowners or land users that could relate to the potential for historic soil contamination at the site then Stantec should be advised immediately.

A copy of this report should be provided to any contractor who is required to undertake earthworks at the site. The Contractor will need to make their own interpretation of the factual data provided. The Contractor shall comply with the recommendations of the report and the Health and Safety at Work Act 2015.

Appendices

We design with community in mind

Appendix A SITE PHOTOGRAPHS

Figure 3: General grassed slopping nature of the site. Farm Building B in the background.

Figure 4: Farm Building A

Figure 5: Area after Farm Building A was removed. Note no soil removal or disturbance.

Figure 6: Farm Building B- historic farmhouse

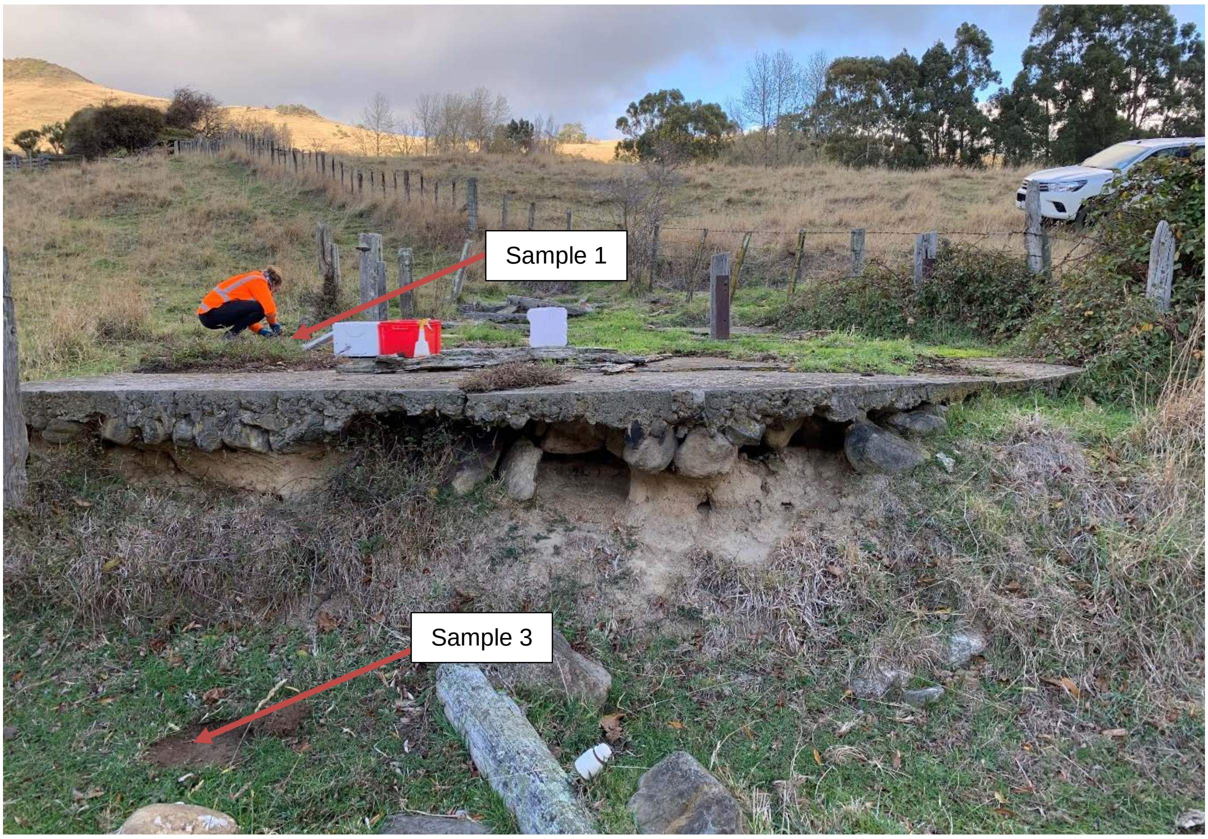

Figure 7: Foundation slab immediately east of the sheep dip.

Figure 8: Sheep dip- approximately 1.5 m deep looking from east to west

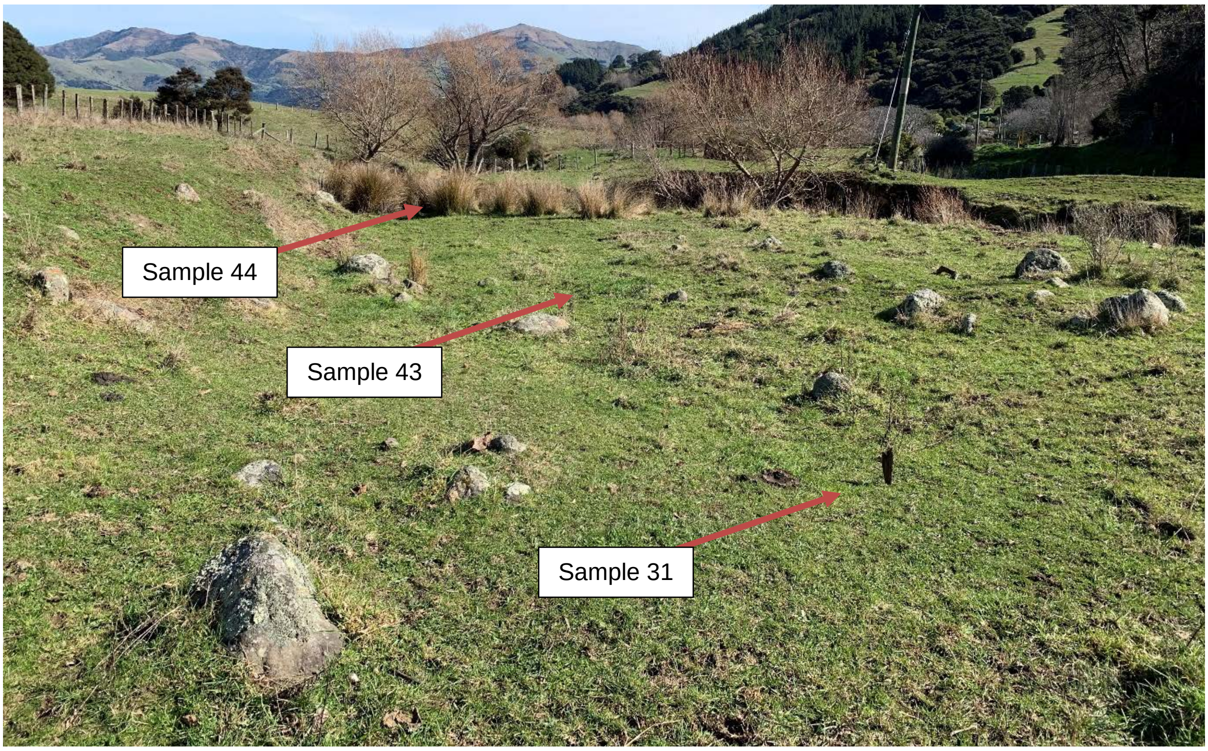

Figure 9: Terraced area above the Robinsons Bay Stream. Note test locations 31, 43 and 44.

Figure 10: **Man-made channel extending from below the northwest end of the sheep dip down to the terrace shown in Figure 8. Notice drain plug in the side of the dip.**

Appendix B SELECT HISTORICAL AERIAL IMAGES

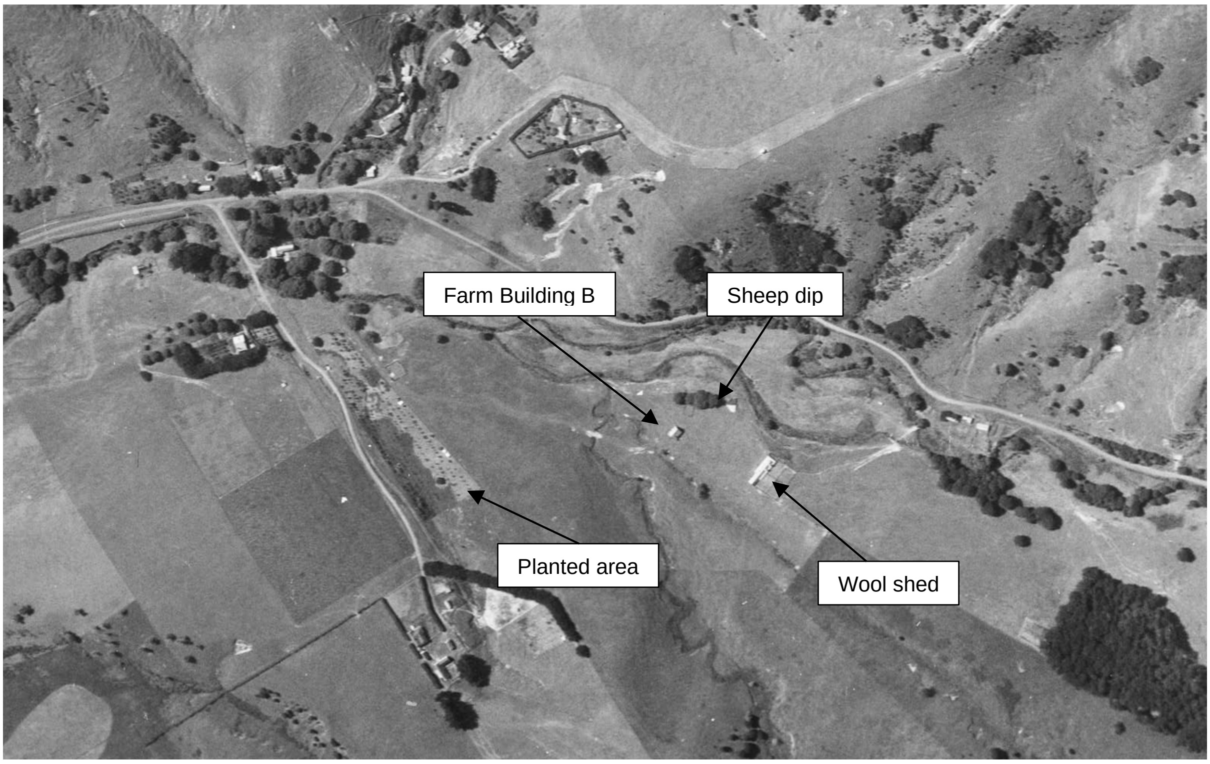

Figure 11: 1941 Image (source: Retrolens)

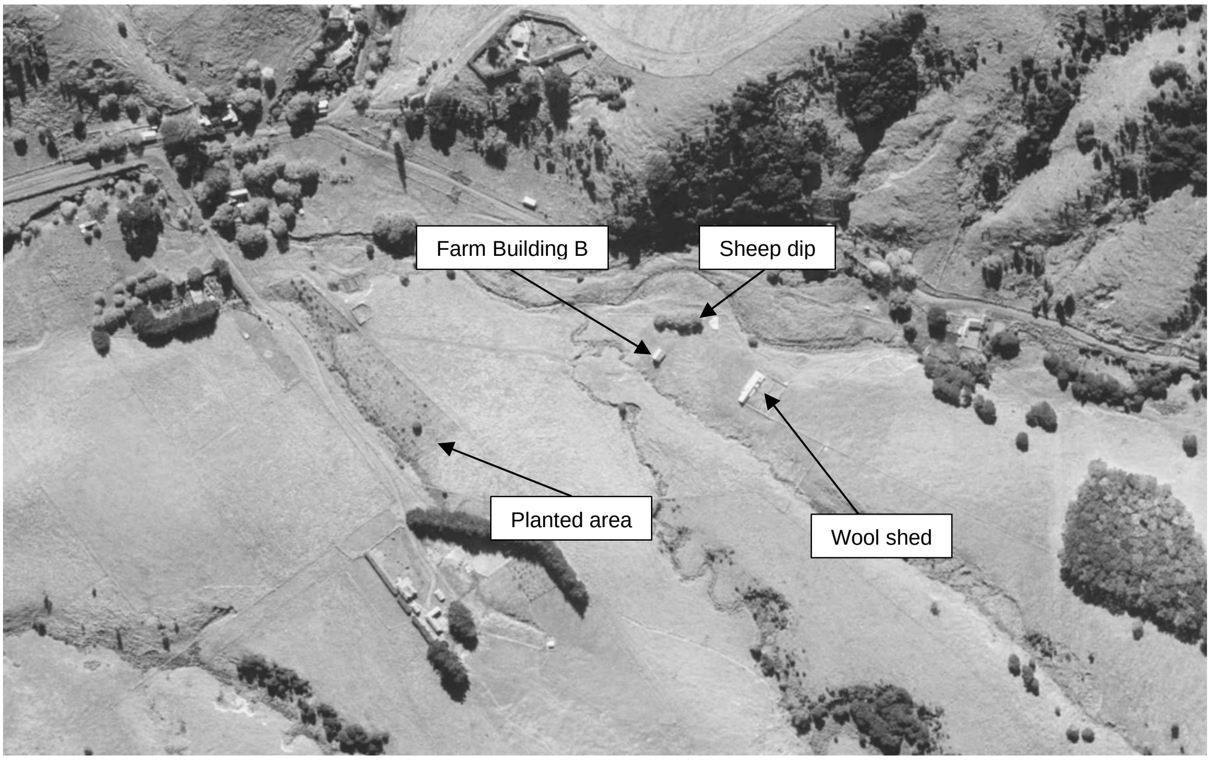

Figure 12: 1952 Image (Source Retrolens)

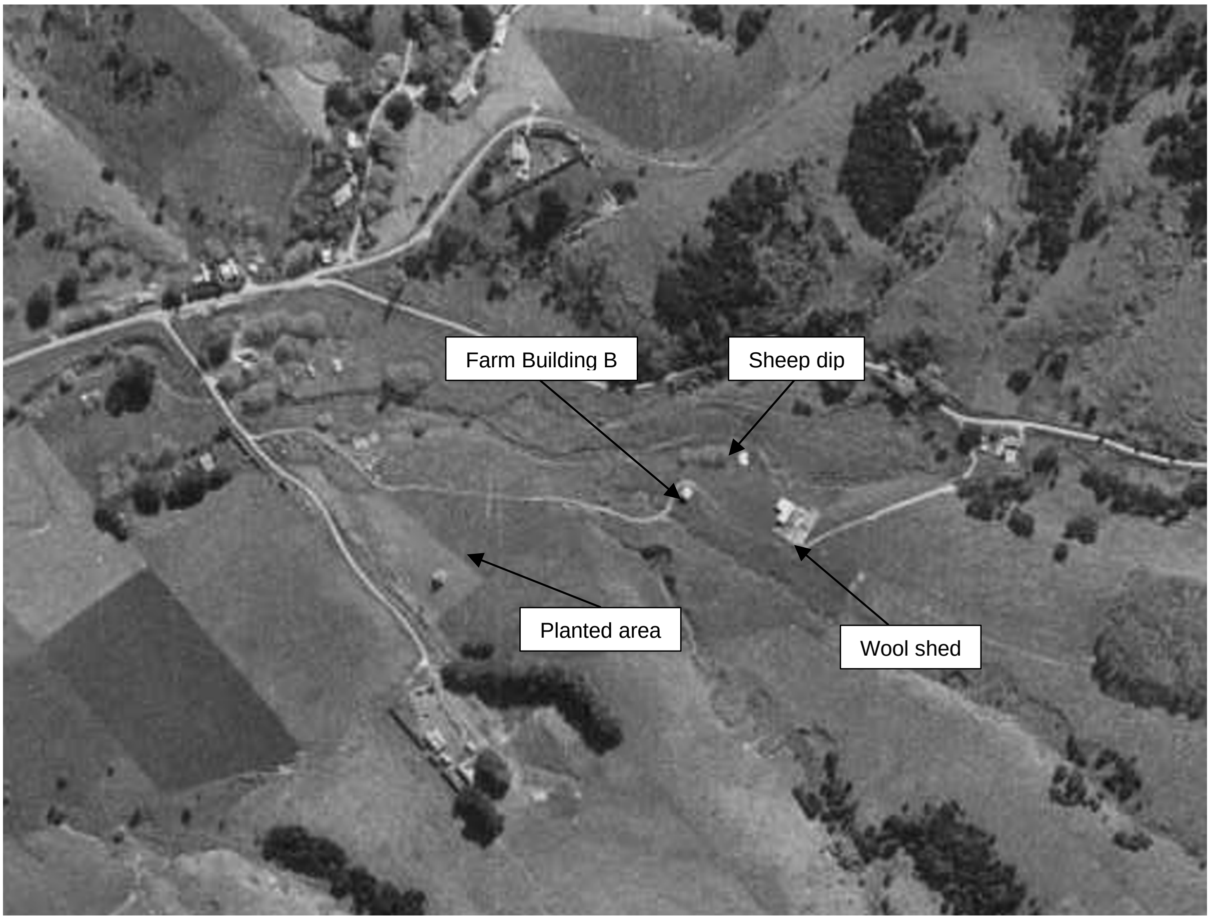

Figure 13: 1966 Image (source: Retrolens)

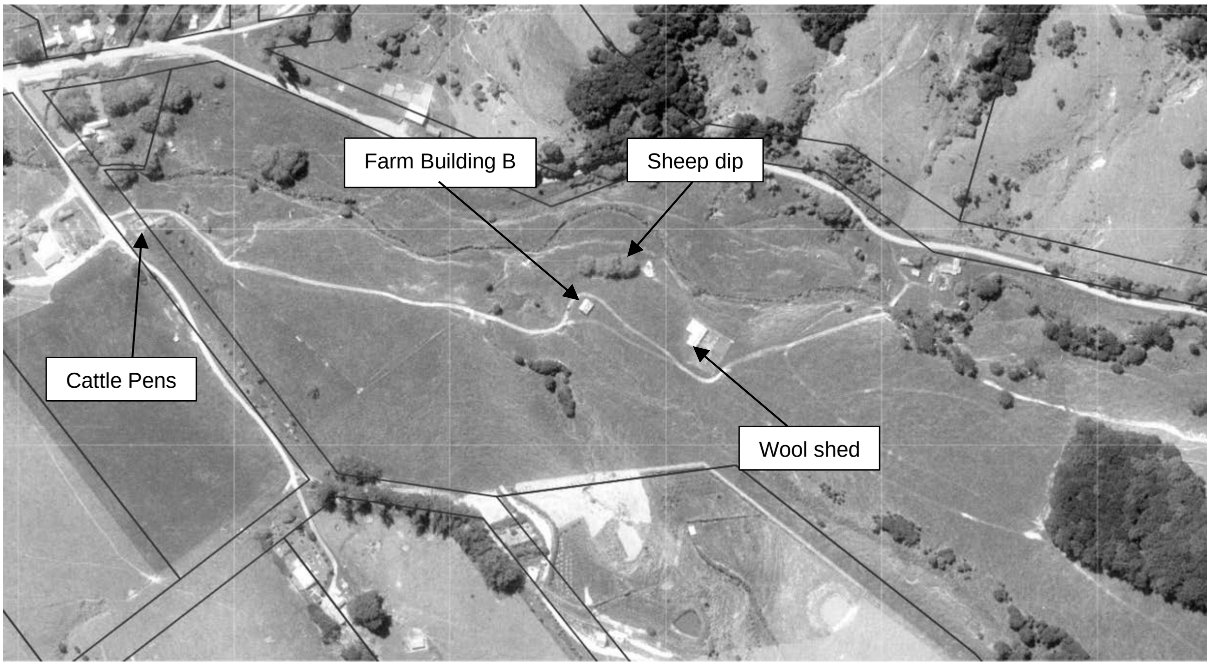

Figure 14: 1980 Image (source: Canterbury Maps)

Figure 15: 2002 Image (source: Google Maps)

Figure 16: 2018 Image (source: Google Maps)

Appendix C TEST LOCATIONS

Figure 17: Farm Building A test locations. Samples FB A5- FB A8 were collected approximately 5m from the wall of the building. Note the stock pens to the south were assessed as being modern cattle pens and not a HAIL site.

Figure 18: Supplementary samples collected after the removal of Farm Building A

Figure 19: Farm building B test locations. Samples FB B5- FB B8 were collected approximately 5m from the wall of the building.

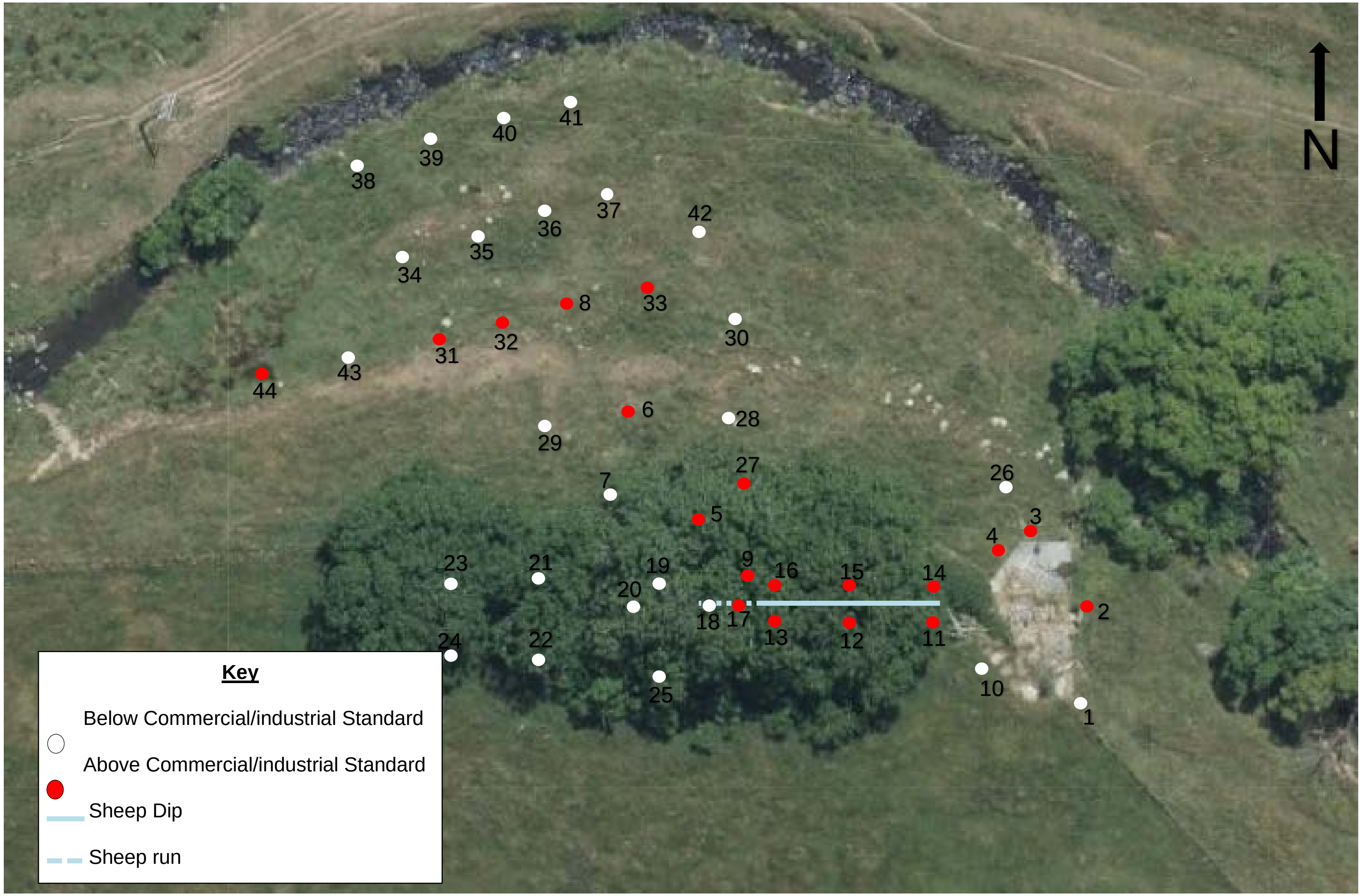

Figure 20: Sheep dip area test locations

Appendix D LABORATORY REPORTS

Hill Laboratories
TRIED, TESTED AND TRUSTED

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Private Bag 3205
Hamilton 3240 New Zealand

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T +64 7 858 2000
E mail@hill-labs.co.nz
W www.hill-laboratories.com

Certificate of Analysis

Client:	Stantec New Zealand	**Lab No:**	2622912	SPv2
Contact:	Scott Fellers	**Date Received:**	27-May-2021	
	C/- Stantec New Zealand	**Date Reported:**	08-Jun-2021	**(Amended)**
	PO Box 13249	**Quote No:**	90394	
	Christchurch 8141	**Order No:**		
		Client Reference:	Ataroa	
		Submitted By:	Scott Fellers	

Sample Type: Soil

Sample Name:		Farm Building A1 27-May-2021	Farm Building A2 27-May-2021	Farm Building A3 27-May-2021	Farm Building A4 27-May-2021	Farm Building A5 27-May-2021
Lab Number:		2622912.1	2622912.2	2622912.3	2622912.4	2622912.5
Individual Tests						
Total Recoverable Lead	mg/kg dry wt	68	220	1,970	220	20

Sample Name:		Farm Building A6 27-May-2021	Farm Building A7 27-May-2021	Farm Building A8 27-May-2021	Farm Building B1 27-May-2021	Farm Building B2 27-May-2021
Lab Number:		2622912.6	2622912.7	2622912.8	2622912.9	2622912.10
Individual Tests						
Total Recoverable Lead	mg/kg dry wt	46	31	35	900	640

Sample Name:		Farm Building B3 27-May-2021	Farm Building B4 27-May-2021	Farm Building B5 27-May-2021	Farm Building B6 27-May-2021	Farm Building B7 27-May-2021
Lab Number:		2622912.11	2622912.12	2622912.13	2622912.14	2622912.15
Individual Tests						
Total Recoverable Lead	mg/kg dry wt	570	460	88	270	260

Sample Name:		Farm Building B8 27-May-2021	Sheep 1 27-May-2021	Sheep 2 27-May-2021	Sheep 3 27-May-2021	Sheep 4 27-May-2021
Lab Number:		2622912.16	2622912.17	2622912.18	2622912.19	2622912.20
Individual Tests						
Dry Matter	g/100g as rcvd	-	77	-	-	77
Total Recoverable Arsenic	mg/kg dry wt	-	50	340	210	116
Total Recoverable Lead	mg/kg dry wt	133	14.1	-	-	21
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	-	< 0.013	-	-	< 0.013
alpha-BHC	mg/kg dry wt	-	< 0.013	-	-	< 0.013
beta-BHC	mg/kg dry wt	-	< 0.013	-	-	< 0.013
delta-BHC	mg/kg dry wt	-	< 0.013	-	-	< 0.013
gamma-BHC (Lindane)	mg/kg dry wt	-	< 0.013	-	-	< 0.013
cis-Chlordane	mg/kg dry wt	-	< 0.013	-	-	< 0.013
trans-Chlordane	mg/kg dry wt	-	< 0.013	-	-	< 0.013
2,4'-DDD	mg/kg dry wt	-	< 0.013	-	-	< 0.013
4,4'-DDD	mg/kg dry wt	-	< 0.013	-	-	< 0.013
2,4'-DDE	mg/kg dry wt	-	< 0.013	-	-	< 0.013
4,4'-DDE	mg/kg dry wt	-	< 0.013	-	-	< 0.013
2,4'-DDT	mg/kg dry wt	-	< 0.013	-	-	< 0.013
4,4'-DDT	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Total DDT Isomers	mg/kg dry wt	-	< 0.08	-	-	< 0.08
Dieldrin	mg/kg dry wt	-	0.019	-	-	0.014
Endosulfan I	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Endosulfan II	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Endosulfan sulphate	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Endrin	mg/kg dry wt	-	< 0.013	-	-	< 0.013

Sample Type: Soil						
	Sample Name:	Farm Building B8 27-May-2021	Sheep 1 27-May-2021	Sheep 2 27-May-2021	Sheep 3 27-May-2021	Sheep 4 27-May-2021
	Lab Number:	2622912.16	2622912.17	2622912.18	2622912.19	2622912.20
Organochlorine Pesticides Screening in Soil						
Endrin aldehyde	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Endrin ketone	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Heptachlor	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Heptachlor epoxide	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Hexachlorobenzene	mg/kg dry wt	-	< 0.013	-	-	< 0.013
Methoxychlor	mg/kg dry wt	-	< 0.013	-	-	< 0.013
	Sample Name:	Sheep 5 27-May-2021	Sheep 6 27-May-2021	Sheep 7 27-May-2021	Sheep 8 27-May-2021	Sheep 9 27-May-2021
	Lab Number:	2622912.21	2622912.22	2622912.23	2622912.24	2622912.25
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	-	71	-
Total Recoverable Arsenic	mg/kg dry wt	152	780	25	700	1,060
Total Recoverable Lead	mg/kg dry wt	-	-	-	12.2	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	-	-	-	< 0.014	-
alpha-BHC	mg/kg dry wt	-	-	-	< 0.014	-
beta-BHC	mg/kg dry wt	-	-	-	< 0.014	-
delta-BHC	mg/kg dry wt	-	-	-	< 0.014	-
gamma-BHC (Lindane)	mg/kg dry wt	-	-	-	< 0.014	-
cis-Chlordane	mg/kg dry wt	-	-	-	< 0.014	-
trans-Chlordane	mg/kg dry wt	-	-	-	< 0.014	-
2,4'-DDD	mg/kg dry wt	-	-	-	< 0.014	-
4,4'-DDD	mg/kg dry wt	-	-	-	< 0.014	-
2,4'-DDE	mg/kg dry wt	-	-	-	< 0.014	-
4,4'-DDE	mg/kg dry wt	-	-	-	< 0.014	-
2,4'-DDT	mg/kg dry wt	-	-	-	< 0.014	-
4,4'-DDT	mg/kg dry wt	-	-	-	< 0.014	-
Total DDT Isomers	mg/kg dry wt	-	-	-	< 0.09	-
Dieldrin	mg/kg dry wt	-	-	-	12.2	-
Endosulfan I	mg/kg dry wt	-	-	-	< 0.014	-
Endosulfan II	mg/kg dry wt	-	-	-	< 0.014	-
Endosulfan sulphate	mg/kg dry wt	-	-	-	< 0.014	-
Endrin	mg/kg dry wt	-	-	-	< 0.014	-
Endrin aldehyde	mg/kg dry wt	-	-	-	< 0.014	-
Endrin ketone	mg/kg dry wt	-	-	-	< 0.014	-
Heptachlor	mg/kg dry wt	-	-	-	< 0.014	-
Heptachlor epoxide	mg/kg dry wt	-	-	-	< 0.014	-
Hexachlorobenzene	mg/kg dry wt	-	-	-	< 0.014	-
Methoxychlor	mg/kg dry wt	-	-	-	< 0.014	-
	Sample Name:	Sheep 10 27-May-2021	Sheep 11 27-May-2021	Sheep 12 27-May-2021	Sheep 13 27-May-2021	Sheep 14 27-May-2021
	Lab Number:	2622912.26	2622912.27	2622912.28	2622912.29	2622912.30
Individual Tests						
Dry Matter	g/100g as rcvd	-	-	74	-	-
Total Recoverable Arsenic	mg/kg dry wt	39	230	109	184	750
Total Recoverable Lead	mg/kg dry wt	-	-	26	-	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	-	-	< 0.014	-	-
alpha-BHC	mg/kg dry wt	-	-	< 0.014	-	-
beta-BHC	mg/kg dry wt	-	-	< 0.014	-	-
delta-BHC	mg/kg dry wt	-	-	< 0.014	-	-
gamma-BHC (Lindane)	mg/kg dry wt	-	-	< 0.014	-	-
cis-Chlordane	mg/kg dry wt	-	-	< 0.014	-	-
trans-Chlordane	mg/kg dry wt	-	-	< 0.014	-	-
2,4'-DDD	mg/kg dry wt	-	-	< 0.014	-	-

Sample Type: Soil

Sample Name:		Sheep 10 27-May-2021	Sheep 11 27-May-2021	Sheep 12 27-May-2021	Sheep 13 27-May-2021	Sheep 14 27-May-2021
Lab Number:		2622912.26	2622912.27	2622912.28	2622912.29	2622912.30
Organochlorine Pesticides Screening in Soil						
4,4'-DDD	mg/kg dry wt	-	-	< 0.014	-	-
2,4'-DDE	mg/kg dry wt	-	-	< 0.014	-	-
4,4'-DDE	mg/kg dry wt	-	-	< 0.014	-	-
2,4'-DDT	mg/kg dry wt	-	-	< 0.014	-	-
4,4'-DDT	mg/kg dry wt	-	-	< 0.014	-	-
Total DDT Isomers	mg/kg dry wt	-	-	< 0.08	-	-
Dieldrin	mg/kg dry wt	-	-	< 0.014	-	-
Endosulfan I	mg/kg dry wt	-	-	< 0.014	-	-
Endosulfan II	mg/kg dry wt	-	-	< 0.014	-	-
Endosulfan sulphate	mg/kg dry wt	-	-	< 0.014	-	-
Endrin	mg/kg dry wt	-	-	< 0.014	-	-
Endrin aldehyde	mg/kg dry wt	-	-	< 0.014	-	-
Endrin ketone	mg/kg dry wt	-	-	< 0.014	-	-
Heptachlor	mg/kg dry wt	-	-	< 0.014	-	-
Heptachlor epoxide	mg/kg dry wt	-	-	< 0.014	-	-
Hexachlorobenzene	mg/kg dry wt	-	-	< 0.014	-	-
Methoxychlor	mg/kg dry wt	-	-	< 0.014	-	-

Sample Name:		Sheep 15 27-May-2021	Sheep 16 27-May-2021	Sheep 17 27-May-2021	Sheep 18 27-May-2021	Sheep 19 27-May-2021
Lab Number:		2622912.31	2622912.32	2622912.33	2622912.34	2622912.35
Individual Tests						
Dry Matter	g/100g as rcvd	-	66	-	-	-
Total Recoverable Arsenic	mg/kg dry wt	340	1,630	159	40	21
Total Recoverable Lead	mg/kg dry wt	-	98	-	-	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	-	< 0.015	-	-	-
alpha-BHC	mg/kg dry wt	-	< 0.015	-	-	-
beta-BHC	mg/kg dry wt	-	< 0.015	-	-	-
delta-BHC	mg/kg dry wt	-	< 0.015	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	-	< 0.015	-	-	-
cis-Chlordane	mg/kg dry wt	-	< 0.015	-	-	-
trans-Chlordane	mg/kg dry wt	-	< 0.015	-	-	-
2,4'-DDD	mg/kg dry wt	-	< 0.015	-	-	-
4,4'-DDD	mg/kg dry wt	-	< 0.015	-	-	-
2,4'-DDE	mg/kg dry wt	-	< 0.015	-	-	-
4,4'-DDE	mg/kg dry wt	-	< 0.015	-	-	-
2,4'-DDT	mg/kg dry wt	-	< 0.015	-	-	-
4,4'-DDT	mg/kg dry wt	-	< 0.015	-	-	-
Total DDT Isomers	mg/kg dry wt	-	< 0.09	-	-	-
Dieldrin	mg/kg dry wt	-	3.1	-	-	-
Endosulfan I	mg/kg dry wt	-	< 0.015	-	-	-
Endosulfan II	mg/kg dry wt	-	< 0.015	-	-	-
Endosulfan sulphate	mg/kg dry wt	-	< 0.015	-	-	-
Endrin	mg/kg dry wt	-	< 0.015	-	-	-
Endrin aldehyde	mg/kg dry wt	-	< 0.015	-	-	-
Endrin ketone	mg/kg dry wt	-	< 0.015	-	-	-
Heptachlor	mg/kg dry wt	-	< 0.015	-	-	-
Heptachlor epoxide	mg/kg dry wt	-	< 0.015	-	-	-
Hexachlorobenzene	mg/kg dry wt	-	< 0.015	-	-	-
Methoxychlor	mg/kg dry wt	-	< 0.015	-	-	-

Sample Name:		Sheep 20 27-May-2021	Sheep 21 27-May-2021	Sheep 22 27-May-2021	Sheep 23 27-May-2021	Sheep 24 27-May-2021
Lab Number:		2622912.36	2622912.37	2622912.38	2622912.39	2622912.40

Sample Type: Soil						
	Sample Name:	Sheep 20 27-May-2021	Sheep 21 27-May-2021	Sheep 22 27-May-2021	Sheep 23 27-May-2021	Sheep 24 27-May-2021
	Lab Number:	2622912.36	2622912.37	2622912.38	2622912.39	2622912.40
Individual Tests						
Dry Matter	g/100g as rcvd	71	-	-	-	-
Total Recoverable Arsenic	mg/kg dry wt	16	13	7	8	7
Total Recoverable Lead	mg/kg dry wt	18.0	-	-	-	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.014	-	-	-	-
alpha-BHC	mg/kg dry wt	< 0.014	-	-	-	-
beta-BHC	mg/kg dry wt	< 0.014	-	-	-	-
delta-BHC	mg/kg dry wt	< 0.014	-	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.014	-	-	-	-
cis-Chlordane	mg/kg dry wt	< 0.014	-	-	-	-
trans-Chlordane	mg/kg dry wt	< 0.014	-	-	-	-
2,4'-DDD	mg/kg dry wt	< 0.014	-	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.014	-	-	-	-
2,4'-DDE	mg/kg dry wt	< 0.014	-	-	-	-
4,4'-DDE	mg/kg dry wt	< 0.014	-	-	-	-
2,4'-DDT	mg/kg dry wt	< 0.014	-	-	-	-
4,4'-DDT	mg/kg dry wt	< 0.014	-	-	-	-
Total DDT Isomers	mg/kg dry wt	< 0.09	-	-	-	-
Dieldrin	mg/kg dry wt	0.015	-	-	-	-
Endosulfan I	mg/kg dry wt	< 0.014	-	-	-	-
Endosulfan II	mg/kg dry wt	< 0.014	-	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.014	-	-	-	-
Endrin	mg/kg dry wt	< 0.014	-	-	-	-
Endrin aldehyde	mg/kg dry wt	< 0.014	-	-	-	-
Endrin ketone	mg/kg dry wt	< 0.014	-	-	-	-
Heptachlor	mg/kg dry wt	< 0.014	-	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.014	-	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.014	-	-	-	-
Methoxychlor	mg/kg dry wt	< 0.014	-	-	-	-

	Sample Name:	Sheep 25 27-May-2021				
	Lab Number:	2622912.41				
Individual Tests						
Dry Matter	g/100g as rcvd	75	-	-	-	-
Total Recoverable Arsenic	mg/kg dry wt	8	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	14.0	-	-	-	-
Organochlorine Pesticides Screening in Soil						
Aldrin	mg/kg dry wt	< 0.013	-	-	-	-
alpha-BHC	mg/kg dry wt	< 0.013	-	-	-	-
beta-BHC	mg/kg dry wt	< 0.013	-	-	-	-
delta-BHC	mg/kg dry wt	< 0.013	-	-	-	-
gamma-BHC (Lindane)	mg/kg dry wt	< 0.013	-	-	-	-
cis-Chlordane	mg/kg dry wt	< 0.013	-	-	-	-
trans-Chlordane	mg/kg dry wt	< 0.013	-	-	-	-
2,4'-DDD	mg/kg dry wt	< 0.013	-	-	-	-
4,4'-DDD	mg/kg dry wt	< 0.013	-	-	-	-
2,4'-DDE	mg/kg dry wt	< 0.013	-	-	-	-
4,4'-DDE	mg/kg dry wt	< 0.013	-	-	-	-
2,4'-DDT	mg/kg dry wt	< 0.013	-	-	-	-
4,4'-DDT	mg/kg dry wt	< 0.013	-	-	-	-
Total DDT Isomers	mg/kg dry wt	< 0.08	-	-	-	-
Dieldrin	mg/kg dry wt	< 0.013	-	-	-	-
Endosulfan I	mg/kg dry wt	< 0.013	-	-	-	-
Endosulfan II	mg/kg dry wt	< 0.013	-	-	-	-
Endosulfan sulphate	mg/kg dry wt	< 0.013	-	-	-	-

Sample Type: Soil						
	Sample Name:	Sheep 25 27-May-2021				
	Lab Number:	2622912.41				
Organochlorine Pesticides Screening in Soil						
Endrin	mg/kg dry wt	< 0.013	-	-	-	-
Endrin aldehyde	mg/kg dry wt	< 0.013	-	-	-	-
Endrin ketone	mg/kg dry wt	< 0.013	-	-	-	-
Heptachlor	mg/kg dry wt	< 0.013	-	-	-	-
Heptachlor epoxide	mg/kg dry wt	< 0.013	-	-	-	-
Hexachlorobenzene	mg/kg dry wt	< 0.013	-	-	-	-
Methoxychlor	mg/kg dry wt	< 0.013	-	-	-	-

Analyst's Comments

Amended Report: This certificate of analysis replaces report '2622912-SPv1' issued on 01-Jun-2021 at 5:31 pm.
Reason for amendment: Additional testing added at the clients request.

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-41
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%.	-	1-41
Organochlorine Pesticides Screening in Soil	Sonication extraction, GC-ECD analysis. Tested on as received sample. In-house based on US EPA 8081.	0.010 - 0.06 mg/kg dry wt	17, 20, 24, 28, 32, 36, 41
Dry Matter (Env)	Dried at 103°C for 4-22hr (removes 3-5% more water than air dry) , gravimetry. (Free water removed before analysis, non-soil objects such as sticks, leaves, grass and stones also removed). US EPA 3550.	0.10 g/100g as rcvd	17, 20, 24, 28, 32, 36, 41
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-41
Total Recoverable Arsenic	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	17-41
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-17, 20, 24, 28, 32, 36, 41

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 31-May-2021 and 08-Jun-2021. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Graham Corban MSc Tech (Hons)
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Stantec New Zealand	**Lab No:**	2678652 SPv1
Contact:	Scott Fellers	**Date Received:**	16-Aug-2021
	C/- Stantec New Zealand	**Date Reported:**	20-Aug-2021
	PO Box 13249	**Quote No:**	90394
	Christchurch 8141	**Order No:**	
		Client Reference:	310103534
		Submitted By:	Scott Fellers

Sample Type: Soil

	Sample Name:	26 16-Aug-2021	27 16-Aug-2021	28 16-Aug-2021	29 16-Aug-2021	30 16-Aug-2021
	Lab Number:	2678652.1	2678652.2	2678652.3	2678652.4	2678652.5
Total Recoverable Arsenic	mg/kg dry wt	23	175	25	10	19

	Sample Name:	31 16-Aug-2021	32 16-Aug-2021	33 16-Aug-2021	34 16-Aug-2021	35 16-Aug-2021
	Lab Number:	2678652.6	2678652.7	2678652.8	2678652.9	2678652.10
Total Recoverable Arsenic	mg/kg dry wt	360	154	220	3	7

	Sample Name:	36 16-Aug-2021	37 16-Aug-2021	38 16-Aug-2021	39 16-Aug-2021	40 16-Aug-2021
	Lab Number:	2678652.11	2678652.12	2678652.13	2678652.14	2678652.15
Total Recoverable Arsenic	mg/kg dry wt	5	3	2	2	< 2

	Sample Name:	41 16-Aug-2021	42 16-Aug-2021	43 16-Aug-2021	44 16-Aug-2021	
	Lab Number:	2678652.16	2678652.17	2678652.18	2678652.19	
Total Recoverable Arsenic	mg/kg dry wt	2	14	45	159	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request.
Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-19
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%.	-	1-19
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-19
Total Recoverable Arsenic	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	2 mg/kg dry wt	1-19

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed between 19-Aug-2021 and 20-Aug-2021. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

Martin Cowell - BSc
Client Services Manager - Environmental

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This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.
The tests reported herein have been performed in accordance with the terms of accreditation, with the exception of tests marked * or any comments and interpretations, which are not accredited.

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Certificate of Analysis

Client:	Stantec New Zealand	**Lab No:**	2936448 SPv1
Contact:	Scott Fellers	**Date Received:**	29-Mar-2022
	C/- Stantec New Zealand	**Date Reported:**	04-Apr-2022
	PO Box 13249	**Quote No:**	90394
	Christchurch 8141	**Order No:**	
		Client Reference:	Robinson Bay
		Submitted By:	Scott Fellers

Sample Type: Soil

	Sample Name:	Robinson 1 0-100 29-Mar-2022	Robinson 2 0-100 29-Mar-2022	Robinson 3 0-100 29-Mar-2022	Robinson 4 29-Mar-2022	
	Lab Number:	2936448.1	2936448.2	2936448.3	2936448.4	
Total Recoverable Lead	mg/kg dry wt	183	200	52	63	-

Summary of Methods

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively simple matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis. A detection limit range indicates the lowest and highest detection limits in the associated suite of analytes. A full listing of compounds and detection limits are available from the laboratory upon request. Unless otherwise indicated, analyses were performed at Hill Laboratories, 28 Duke Street, Frankton, Hamilton 3204.

Sample Type: Soil

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Drying*	Air dried at 35°C Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-4
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation May contain a residual moisture content of 2-5%.	-	1-4
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-4
Total Recoverable Lead	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	0.4 mg/kg dry wt	1-4

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Testing was completed on 04-Apr-2022. For completion dates of individual analyses please contact the laboratory.

Samples are held at the laboratory after reporting for a length of time based on the stability of the samples and analytes being tested (considering any preservation used), and the storage space available. Once the storage period is completed, the samples are discarded unless otherwise agreed with the customer. Extended storage times may incur additional charges.

K Harrison

Kim Harrison MSc
Client Services Manager - Environmental

Appendix E LOCATIONS OF NESCS "PIECES OF LAND"

Figure 21: Areas identified as a "piece of land" as identified by the NESCS

Figure 22: Piece of Land at Farm Building A. Note the 5m buffer shown around the building.

Figure 23: Piece of Land at Farm Building B. Note the 5m buffer shown around the building.

Figure 24: Piece of Land at the sheep dip area

Appendix F EVIDENCE OF THE SQEP QUALIFICATIONS AND EXPERIENCE

Scott has grown his career as an environmental practitioner over the last 7 years working in Christchurch, New Zealand. He is responsible for many different aspects of contaminated land investigations. The most common projects involve reporting to the standard of the Ministry for the Environments Contaminated Land Management Guidelines. These investigations include Preliminary and Detailed Site reporting involving, development of the sampling and analyte testing regimes, analysis of laboratory results and assessment against various guidelines and standards. Consenting requirements under the National Environmental Standard for Assessing and Managing Contaminants in Soil (NESCS) are assessed. His role also includes development of fee proposals, project management duties, Remedial Action Plans, Site Validation reports and Site Management Plans. Scott has also planned and implemented asbestos specific sampling and testing regimes in accordance with BRANZ guidelines including field analysis of asbestos. He is also responsible for collation and preparation of site works health and safety plans along with liaising with colleagues, clients, contractors, and project stakeholders.

Scott has gained experience working on various contaminated land jobs. Some examples of sites Scott has worked on are sheep dips/sprays, landfills- small scale domestic to large scale municipal, lead based paint on weatherboard dwellings, market gardens, burn pads/pits, fire damaged buildings, ACM in soil through both dirty demolition and natural degradation of ACM material, leaking UST/ASTs, vehicle workshops, lumber mills/timber treatment, coal tar assessment and subdivision of rural land.

EDUCATION

Geoscience, California State University, Chico, California, United States, 2005

Teaching Credential- Single Subject Science, California State University, Chico, California, United States, 2008

CERTIFICATIONS & TRAINING

Certified Environmental Practitioner- General, Environmental Institute of Australia and New Zealand, Christchurch, Canterbury, New Zealand, 2021

MEMBERSHIPS

Member, Australasian Land & Groundwater Association

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Appendix P Community Reference Group Statement

Akaroa Reclaimed Water and Reuse Scheme Community Reference Group Commentary

- **A key step in addressing Community concerns and improving the Scheme.**

Contents

Background

The Akaroa Reclaimed Water and Reuse Scheme is the largest Infrastructure project for Akaroa and surrounding areas in the history of the area. It has been a long time in its creation, starting with a council resolution in 2011 to replace the existing sewerage treatment plant at Takapūneke.

Major factors contributing to the decision to replace the treatment plant were its age, the location of the plant on land that is sacred to local iwi, and that Ōnuku Rūnanga had long been advocating for an end to the disposal of human waste into the harbour as it was culturally and spiritually affronting. In 2011 Christchurch City Council resolved to build a new treatment plant at Old Coach Road. Consents were granted in 2015 for the treatment plant and a new terminal pump station in the Childrens Bay boat park. The proposed harbour discharge consents were not granted. Council needed to find another way to dispose of Akaroa's treated wastewater. Complicating the issue was the very limited availability of land suitable for the disposal of Akaroa's wastewater.

In August 2020, Council consulted with the community on four options for the disposal / reuse of treated wastewater. This followed five years of options investigations and consultation. The process included a number of setbacks; after public consultation in 2015 slope stability issues were further investigated which limited some irrigation sites that had been identified, an outcome of this was that irrigation to land options over a wider area around Akaroa were considered. After consultation in 2017 a faulty flowmeter was identified and an outcome of the flowmeter issue was that sewerage flows were greater than previously thought with a significant portion of this volume being inflow and infiltration into the sewerage pipes within the Akaroa township

The issues and concerns of the affected communities of Akaroa, Takamātua and Robinsons Bay were identified through the 2015 and 2017 submission processes, the Akaroa Treated Re-Use Options Wastewater Working Party which met from February 2017 to June 2020, and the submissions made to the 2020 consultation.

The Council resolved on 10 December 2020 to use the highly treated wastewater to irrigate plantings of native trees in Robinsons Bay, Hammond Point and Takamātua (also known as the Inner Bays Irrigation scheme). The option also included a covered raw wastewater storage pond, a wetland, and a treated water storage pond on land opposite the proposed treatment plant on Old Coach Road, with the bulk of the treated water storage in Robinsons Bay. The resolution also reflected many of the concerns raised by the community and requested further investigations and actions on a range of matters.

A major concern of Robinsons Bay residents was the proposed construction of two large wastewater storage ponds that would be close to existing residences in their Valley. The 2020 resolution called for alternative storage options to be explored.

The Council resolved to establish a Community Reference Group to ensure the communities were engaged with Council Staff in the design and development of the project before being submitted for consent. A group was established with Community Members, Community Board members, Ōnuku Rūnanga representatives and Council Wastewater project staff members, and met in the latter half of 2021. The Terms of Reference for this group was to focus on the proposed irrigation and wastewater storage sites at Robinsons Bay, Hammond Point and Takamātua, along with a constructed wetland between Old Coach Road and Christchurch Akaroa Highway.

The Terms of Reference did not extend to consideration of alternative disposal locations.

Terms of Reference Objectives

- To assist the project team to develop the preliminary design of the Akaroa Reclaimed Water and Reuse Scheme in a way that addresses community concerns where possible.

- To suggest ways that the Akaroa Reclaimed Water and Reuse Scheme could be improved so that it can deliver multiple benefits for the community in the geographic areas considered.

The Community Reference Group members are

- Sue Church Community Member
- John Curry Community Member
- Chris McGill Community Member
- Averil Parthonnaud Community Member
- Ad Sintenie Community Member
- Debbie Tikao Rūnanga Representative
- Rik Tainui Rūnanga Representative
- Jamie Stewart Community Board Member
- Nigel Harrison Community Board Member

The five community members were chosen by the Banks Peninsula Community Board from applicants who responded to the Council's advertisement for the voluntary positions.

Process and Meetings

The Community Reference Group was chaired by an independent facilitator, Carl Pascoe of Creative Facilitation Network Ltd. Five meetings were held between the 23rd of September 2021 and the 17th of February 2022. Key CCC project staff, Kylie Hills, Mike Bourke, and the project sponsor John Filsell were fully engaged with the group, providing input to, and including feedback from the Group into the project.

Community Reference Group Principles

The Akaroa Reclaimed Water and Reuse Scheme must be safe, sustainable, resilient, and take into account the risks and uncertainties of climate change.

Each facet of the project must be designed to avoid, or minimise, adverse effects on the environment, historical sites and affected communities, specifically Robinsons Bay and Takamātua.

To provide for public access and enjoyment where appropriate, particularly where this will further aims for a link from Takapūneke through to Robinsons Bay, and to honour and preserve the histories of both Tangata whenua and European settlers through narrative interpretations.

That the community has advocated for wastewater reduction, reuse, and purple pipe initiatives, with the hope that this can become an exemplar for other communities in Aotearoa.

Community Reference Group Members contribution:

The Community Reference Group meetings involved presentations by CCC staff on the design of the scheme, with opportunity for discussion and feedback. A significant change to the initial proposed design was the location of the water storage in Robinsons Bay and the method of storage. Instead of the two large wastewater ponds being located low in the valley near to houses, the reclaimed water would be stored higher up the valley in large water tanks. The group members felt that this was a much preferable design solution that would resolve the risks of storage in open dams for Robinsons Bay residents.

Project staff also updated the group on progress in reducing the problem of inflow and infiltration of the sewage pipes within Akaroa. Over the past year the Council has made good progress in repairing the existing sewage pipes to reduce the amount of additional water entering the sewage system. This in turn reduces the volume of wastewater that needs to be treated, stored, and disposed of. Another significant source of water into the wastewater system that is being addressed is the wastewater from the filtration process at the L'aube Hill water treatment plant. Council staff estimate that flush water from the filtration process can be reduced from around 15% percent down to around 5%.

Response to Objective 1.1 - Concerns expressed by members were:

Impacts on residents and their communities, including the safety and enjoyment of their properties, and on the environment of the valleys and bays.

Impacts of the large storage scheme in Robinsons Bay. Impacts of the disposal scheme on land and water bodies from contaminants, and continuing over decades.

Aspirational recreation goals, while welcome, do not in themselves resolve concerns or mitigate potential impacts for the receiving communities.

The key matters that were discussed and progressed by the Community Reference Group are:

1 Storage in covered tanks, not open dams

It was found that storage in multiple covered tanks away from the Robinsons Valley floor is a feasible option. This option is more acceptable to the community as it mitigates the risks of dam break, odour, insects, and visual impacts. It also prevents rainwater from adding to the water volume to be irrigated.

The tanks should be distributed in a way that provides maximum resilience and connected in a way that allows each tank to be isolated if necessary, and with suitable screening planting to reduce visual impact.

2 Wastewater Quality, Maintenance and Monitoring

All wastewater for irrigation and purple pipe re-use needs to be treated to a standard, including UV treatment, that will avoid environmental impacts, ensure public safety and promote public confidence in re-use initiatives.

Some members requested holding tanks at the treatment site so that the results of testing would be available before the treated water is distributed enabling it to be re-processed if it does not meet the required standards.

Members made a range of monitoring requests, seeking to ensure that:

- Irrigation rates avoid soil saturation, ponding and run-off,
- Nitrogen, phosphates, pharmaceuticals, heavy metals and other contaminants are not building up in soil, streams and shallow bays,
- Stream water quality below the irrigation fields is not degraded compared to that above,
- Wildlife including inanga, flounder and shellfish are not being affected,
- There is effective pest control for possum, rats, mustelids and browsing animals,
- Trees are in good health and canopy growth is assessed against modelled parameters,
- There is no build-up of odour or insect pests,

Consent conditions should ensure that appropriate monitoring is taking place, that any non-compliance is addressed in a timely way, and that all results are made available to the public promptly.

3 Private Water Supplies affected are provided with a safe and adequate new supply

4 Preservation and Protection of the Robinsons Bay Sawmill Heritage Site

Land purchased by the Council for the irrigation scheme includes an area beside and behind the Pavitt Cottage stretching up to the Wynn Williams Cottage which has immense historic and archaeological importance.

The group discussed a range of possible options to achieve this. These included dividing off the area as a Reserve, Council leasing the area to a community group, or gifting the land to a community charitable trust.

5 On-going need to reduce wastewater volume

Council has made good progress over the past year in identifying and repairing the sewer network to reduce Inflow and Infiltration, and in identifying and reducing retentate from the Akaroa water supply. This is essential to reduce the volume of wastewater to meet the scheme's capacity. Continuing efforts to minimise volume in all practicable ways will help to ensure that the scheme remains sustainable in the face of climate uncertainty. Member's suggestions included:

- On-going work to eliminate Inflow and Infiltration into the wastewater system
- Wastewater to be made available to properties along the pipe route.
- Creative, effective promotion of water conservation and waste reduction measures in Akaroa, with on-going budgets for this.

6 Commitment to furthering a purple pipe network in Akaroa

Commitment to furthering re-use and a purple pipe network in Akaroa, including time-lines and budget for this.

7 Plantings must ensure scheme resilience.

Plants selected must be suitable for the soil and conditions of each site as well as for the application of the wastewater, and take into account fire risk. Members also wanted to see mixed planting used to maximise biodiversity benefits.

8 Contingency plans in place as part of the consent to address system failure, or load exceeding design capacity

9 Some members were concerned that Duvauchelle wastewater might be added to the Akaroa Scheme in the future.

Response to Objective 1.2 - Delivery of multiple benefits to affected areas

One concept that evolved during the Community Reference Group meetings was the potential to integrate the Akaroa Reclaimed and Reuse Water Scheme into an overall Harbour development plan. The Scheme will result in new areas of native bush being established at Takamātua, Hammond Point, and Robinsons Bay. The Community Reference Group members supported the establishment of walkways and recreation areas for public access and use. This would contribute toward achieving the CCC Public Open Space Strategy goal for an Akaroa Harbour Coastal Path.

There is potential to link Akaroa with the Old Coach Road site, then Old French Road to Takamātua, and use paper roads to connect with Hammonds Point, the DoC reserve and the area being reforested by students from Akaroa Area School. This could then link with Robinsons Bay walkways.

While recognising that Council ownership of land acquired for the wastewater scheme has the potential to provide new recreational opportunities, some issues were raised:

- The priority for the scheme should be safety and resilience. Funding for recreational development should not divert from these priorities.
- There needs to be a defined budget for recreation
- How recreational infrastructure created through the wastewater project is to be maintained and who will take responsibility for it
- The remit of the wastewater project does not extend beyond the wastewater sites and could therefore only be a very small part of the recreational ideas that have been put forward at the Reference Group meetings.

The aspirations listed below are those that could be achieved on the sites and in conjunction with construction of wastewater infrastructure.

1 Upper Robinsons Bay Site

Sawmill heritage and archaeological features (including the historic Wynn Williams Cottage) subdivided and appropriately fenced from the wastewater scheme and gifted to a community Charitable Trust with provision for public access and appreciation.

Reclaim heritage materials onsite, such as tōtara posts, to be re-used for fencing or donated to the Community Trust for use in the historic area.

Track network to enable public access on the remainder of the site.

Upper part of the property not used for irrigation to be retained for biodiversity and public access.

Keep the remainder of the tramway embankment that runs through the irrigation field clear of trees for walking access.

2 Hammond Point Site

Construct a walking track linking from the Robinsons Bay Wharf over the headland to Sandy Bay at Takamātua. Connect from top of Hammond Point to the DOC Reserve at the tip of the Peninsula.

Create a seating/lookout area looking across the harbour to Ōnawe Peninsula and Harbour bays, with an interpretation panel of the surrounding features and cultural histories and an information QR code.

3 Takamātua Flats

If the seaward side of the road is acquired, retain this as a coastal protection area and develop it to maximise benefits to the waterway and to provide a sea level rise buffer to the main highway. This could include a coastal forest (nikau and ngaio), podocarp forest (kahikatea, tōtara, matai) and Harakeke harvesting area. A boardwalk /track could link with Old French Road and Takamātua Bay through to Hammond Point.

Upper side of the road – ensure acceptable setback from Thurston's property, partially retaining their vista with smaller plantings and the strategic location of maintenance track. Damper part of property near the creek could be set aside for Harakeke harvesting area.

4 Old Coach Road Site

Develop walking tracks accessible from Akaroa, linking with Old French Road and beyond.

Create a community garden and orchard for the Akaroa community, connecting to the purple pipe network.

It is proposed that this area becomes a wetland reserve and acts as both a place of education and amenity for the local community and visitors. It is intended that a small carpark and bus pull in area be included to accommodate school groups. This area would showcase Māori values associated with water and the how the Akaroa Wastewater scheme is protecting and enhancing those values. This area will include walkways, boardwalks, extensive native revegetation planting, shelter structure and interpretation panels. The design will be developed by Onuku Rūnanga to reflect te ao Māori.

5 Akaroa Boat Park

Provide a boat wash/car wash connecting to the purple pipe network, with provision made to re-capture the water to be returned to the treatment plant.

Appendix Q Geotechnical Investigation Report

Akaroa Treated Wastewater Irrigation Scheme

Geotechnical Desktop Study and Preliminary Investigations

PREPARED FOR CHRISTCHURCH CITY COUNCIL | March 2023

Stantec

Revision Schedule

Rev No	Date	Description	Signature of Typed Name (documentation on file)			
			Prepared by	**Checked by**	**Reviewed by**	**Approved by**
1	16 Nov 2021	Draft for Client	S. Jones	A. Mott	S. Woods	S. Velluppillai
2	19 May 2022	Updated to include Takamatua and Hammonds Point	S. Jones	A. Mott	S. Woods	S. Velluppillai
3	9 March 2023	Final	S. Jones	A. Mott	S. Woods	S. Velluppillai

Quality Statement

The conclusions in the Report titled "Akaroa Treated Wastewater Irrigation Scheme Geotechnical Desktop Study and Preliminary Investigations" are Stantec's professional opinion, as of the time of the Report, and concerning the scope described in the Report. The opinions in the document are based on conditions and information existing at the time the scope of work was conducted and do not take into account any subsequent changes. The Report relates solely to the specific project for which Stantec was retained and the stated purpose for which the Report was prepared. The Report is not to be used or relied on for any variation or extension of the project, or for any other project or purpose, and any unauthorized use or reliance is at the recipient's own risk.

Stantec has assumed all information received from Christchurch City Council (the "Client") and third parties in the preparation of the Report to be correct. While Stantec has exercised a customary level of judgment or due diligence in the use of such information, Stantec assumes no responsibility for the consequences of any error or omission contained therein.

This Report is intended solely for use by the Client in accordance with Stantec's contract with the Client. While the Report may be provided to applicable authorities having jurisdiction and others for whom the Client is responsible, Stantec does not warrant the services to any third party. The report may not be relied upon by any other party without the express written consent of Stantec, which may be withheld at Stantec's discretion.

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Contents

List of Figures

1 Introduction

The Christchurch City Council (CCC) has commissioned Stantec New Zealand (Stantec) to assess tank storage, surface wetland, and infiltration options for the management of treated water from a proposed new Wastewater Treatment Plant (WWTP) near Akaroa. We understand that the current proposal is to pump wastewater from Akaroa township to a new wastewater treatment plant at a site known as the Hay Paddock on Old Coach Road, near Takamatua. From there, some of the treated wastewater will be sent across the road to an adjacent wetland, and the remaining treated wastewater will be sent to the following three sites:

- Takamatua
- Hammonds Point
- Sawmill Road, Robinsons Bay, which has been divided into Areas A to D for the purposes of reporting. The treated wastewater will be pumped to proposed storage tanks (located in Area D), and from there it is proposed to gravity feed and infiltrate areas Areas A, B and C.

The scope of works for this project is outlined in a Stantec offer of service dated 5 March 2021. The assessment has comprised a desktop study and walkover inspection of all four sites and limited geotechnical test pitting investigations at the Sawmill Road and Hay Paddock sites. This report assesses all sites and provides high-level geotechnical related comments and recommendations regarding their likely suitability for tank storage and infiltration, and the suitability of the Hay Paddock site for the new WWTP and wetland. It is intended for this this report to be used to inform a resource consent application and additional geotechnical investigation and assessment to be undertaken as part of detailed design.

This report (Rev 2) has been updated following a desktop study and site walkover of the Takamatua and Hammonds Point sites in April 2022. No geotechnical investigations were conducted at these two sites as part of this additional work.

2 Background Information

Background information used in this assessment includes the CH2M Beca report “Akaroa Wastewater Summary of Disposal and Reuse Options” and associated appendices dated 17 July 2020 and the information sources listed below.

2.1 Google Earth

2.1.1 Sawmill Road

The site is located approximately 7 km north of Akaroa township and is shown in Figure 1. The site has been divided into four potential locations – Areas A, B, C, and D. A comprehensive set of aerial images dating back to 1985 is available on Google Earth, and historic aerial images dating to 1941 are available on Retrolens.

There appears to have been little land use change between 1941 and the present day. Aerial photographs from 1941 show Areas A to D as grassed, as they are in the present day.

Figure 1: Sawmill Road Site at Robinsons Bay, north of Akaroa, showing Areas A to D

2.1.2 Hay Paddock

The Hay Paddock site is located on Old Coach Road, approximately 2 km north of Akaroa and is shown in Figure 2. A comprehensive set of aerial images dating back to 1985 is available on Google Earth, and historic aerial images dating back to 1941 are available on Retrolens.

There appears to have been little land use change between 1941 and the present day. Aerial photographs from 1941 show the site as grassed, as they are in the present day. A row of trees was present on the southern boundary of the site from at least 1941 but historic aerial photographs show they were felled sometime between 1984 and 1995.

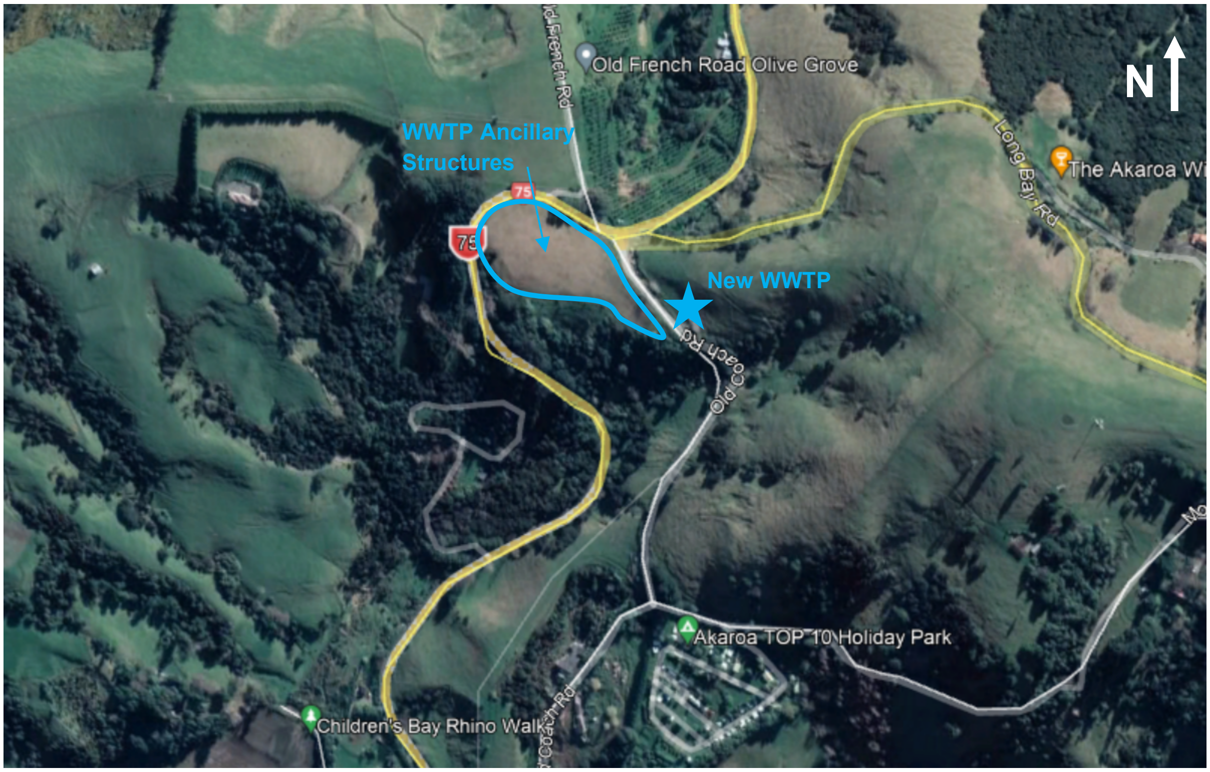


Figure 2: Hay Paddock Site on Old Coach Road, north of Akaroa, showing new WWTP location and associated ancillary structures including wetland, untreated water tank and pump shed.

2.1.3 Takamatua

The Takamatua site is located adjacent to State Highway 75 (SH75) in Takamatua, approximately 3.5 km north of Akaroa, and is shown in Figure 6. A limited set of aerial images dating back to 1985 is available on Google Earth, and a more comprehensive set of historic aerial images dating back to 1941 are available on Retrolens.

There appears to have been little land use change between 1941 and the present day. Aerial photographs from 1941 show the site as a grassed farm paddock, as it is in the present day. Historic stream flow paths crossing the site are visible in many of the images available from 1941 to 1995, particularly in the 1941 image (Figure 4) where flood debris appears to be present over much of the site and crossing SH75. A Retrolens image from 1975 show what appears to be a horse track at the site however imagery from 2019 shows little evidence of the horse track and historic stream flow path, which suggests that areas of fill may be present.

Signs of ongoing shallow instability of the slopes to the north of the site was observed in several of the Retrolens images, however these did not appear to impact the site.

Figure 3: Takamatua site (blue dashed line) adjacent to SH75. Boundaries are indicative. Background image taken from Google Earth Pro.

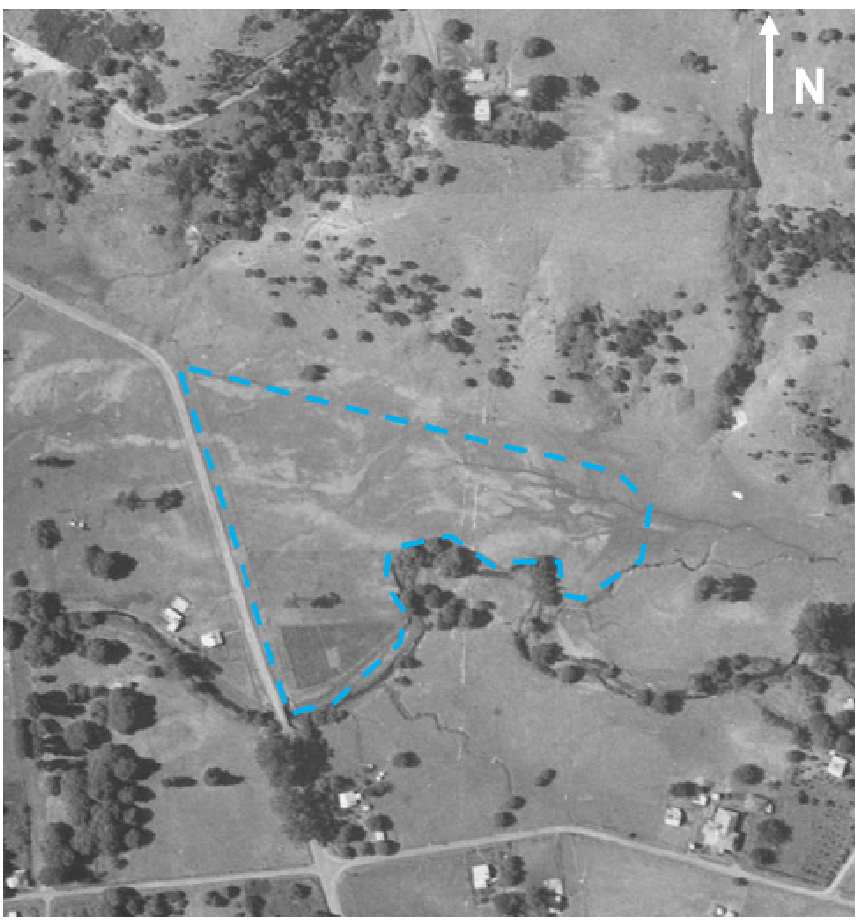


Figure 4: Takamatua site (blue dashed line) in 1941. Note flood debris across site. Boundaries are indicative only. Background image taken from Retrolens.

2.1.4 Hammonds Point

The Hammonds Point site is located approximately 5 km north of Akaroa and is shown in Figure 8. A limited set of aerial images dating back to 1985 is available on Google Earth, and a more comprehensive set of historic aerial images dating back to 1941 are available on Retrolens.

There appears to have been little land use change between 1941 and the present day. Aerial photographs from 1941 show the site as a grassed farm paddock, as it is in the present day. Evidence of ongoing slope instability is visible in Retrolens images from 1941 to the present day, within the sea cliff, private land block, and regenerating native vegetation areas.

Figure 5: Hammonds Point site (blue dashed line). Boundaries are indicative. Background image taken from Google Earth Pro.

2.2 Geological Mapping

Geological and Nuclear Sciences (GNS) published 1:250,000 scale geological mapping indicates the following geological units are present at the Sawmill Road, Hay Paddock, Takamatua, and Hammonds Point sites (Figure 6):

- mQe – Middle Pleistocene loess deposits consisting of windblown silt deposits locally with fine sand or clay. Age, 12,000 – 524,000 years before present. Unit is indicated to overlie the entirety of the Hay Paddock and Sawmill Road sites, and the majority of the Hammonds Point site.
- Mva – Basaltic and Trachytic lava of the Akaroa Basalt Group consisting of basaltic to trachytic lava flows intercalated with tuff, pyroclastic breccia, and agglomerate. Age 8 – 9 million years before present. Unit is mapped as present on the slopes above the Sawmill Road site, nearby the Hay Paddock site, and on the western edges of the Hammonds Point site and is assumed to also underlie the loess unit.
- Q1a – Holocene fan deposits consisting of 'grey to brown alluvium, comprising silty sub-angular gravel and sand forming alluvial fans'. Age approximately 11,500 years to present. Unit is mapped as present beneath the Takamatua site.

Figure 6: Mapped Geology of the proposed Sawmill Road, Hay Paddock, Takamatua, and Hammonds Point Sites (blue stars)

2.3 Active Faults Database

All four sites are located within the eroded cone of an extinct volcanic system. The GNS Active Faults Database shows no active faults in the area of any of these sites, with the nearest mapped active fault being the Greendale Fault more than 50 km to the northwest as shown in Figure 7.

Whilst there are known active faults underlying the Banks Peninsula area – for example the fault that ruptured during the 2011 Christchurch Earthquake – these faults are not mapped as they do not have a surface trace. As far as we are aware, there are no known active faults underlying any of these sites.

Figure 7: Closest mapped active fault (in red) to the proposed sites (blue stars)

2.4 New Zealand Landslide Database

The New Zealand Landslide Database[1] is managed by GNS and contains information on the locations and characteristics of known landslides throughout New Zealand. The database has been consulted as a part of the desktop study for this project and shows no known landslides have been identified at any of the four sites. The database is continually being updated as information becomes available and should continue to be consulted as the project progresses.

[1] https://data.gns.cri.nz/landslides/wms.html

2.5 New Zealand Geotechnical Database

The New Zealand Geotechnical Database (NZGD) has been used to gather information on existing geotechnical investigations that have been conducted in the general vicinity of both the Sawmill Road, Hay Paddock, Takamatua, and Hammonds Point Sites. No information was available near the Sawmill Road or Takamatua sites.

Two boreholes have been conducted within an approximately 100 m radius of the Hay Paddock site, as shown in Figure 8 and summarised as follows:

- Borehole BH_115898: No sample recovery within the first 30 m below ground level (bgl).
- Borehole BH_115896:
    - SILT, silty fine SAND, and sandy SILT, interpreted to be weathered volcanic material, to a depth of 19.5 m bgl
    - Completely weathered, extremely weak to weak TUFF to a depth of 29.5m bgl
    - Slightly to moderately weathered, extremely weak to weak TUFF and TUFF BRECCIA to approximately 61 m bgl.
    - Unweathered, extremely strong BASALT below approximately 61 m bgl.

Figure 8: Existing geotechnical investigations available on the NZGD near the Hay Paddock site

One borehole and four hand augers have been conducted within an approximately 250 m radius of the Takamatua site. The hand augers are likely in a different geological unit (Q1b – beach deposits) to the Takamatua site (Q1a – fan deposits). The positions of the investigations are shown in Figure 9 and summarised as follows:

- Borehole INST_88655: Alluvial deposits. Groundwater at 0.2 m bgl. Material encountered:
  - Gravelly SILT to a depth of 0.95 m bgl
  - Clayey SILT to 2.15 m bgl
  - Medium to coarse GRAVEL to 3.00 m bgl
  - Gravelly SILT to 4.56 m bgl, end of borehole.
- Hand Augers HA-DCP_157932, _157930, _157931, and HA_157934:
  - Interbedded SILT, sandy SILT, and silty SAND to target depths of 3.0 m bgl.
  - Gravelly SAND encountered at 1.5 m bgl in HA-DCP_157932.

Figure 9: Existing geotechnical investigations available on the NZGD near the Takamatua site

3 Geotechnical Walkover Assessment

A geotechnical walkover of both the Sawmill Road and Hay Paddock sites and surrounding area was undertaken by Sarah Jones and Steven Woods (Stantec) and Kylie Hills (CCC) on 4 August 2021. The walkover focused on high level engineering geology (engineering properties of materials), geomorphology (landforms) hydrology (surface water) features and likely hydrogeological (groundwater) considerations.

Conditions underfoot were wet at the time of the walkover with the last significant rainfall event being 54.6 mm recorded at the Akaroa EWS (approximately 2 km from the Hay Paddock site and 5.5 km from Sawmill Road) the previous day. Locations of the Sawmill Road and Hay Paddock sites are shown in Figure 1 to Figure 7.

An additional geotechnical walkover was undertaken of the Takamatua and Hammonds Point sites by Sarah Jones on 5 April 2022. The walkover again focused on high level engineering geology, geomorphology, and hydrology features and likely hydrogeological considerations. Conditions underfoot were relatively dry at the time of the walkover with the last significant rainfall event being 48.8 mm recorded at the Akaroa EWS (approximately 3 km from Takamatua and 4 km from Hammonds Point) on 22 March.

3.1 Sawmill Road

The locations of Areas A to D are shown in Figure 1 and discussed in further detail below. Photographs taken during the site walkover are presented in Appendix A.

3.1.1 Area A

Area A is situated on a gently sloping (<5°) area at the base of the property. The site is currently grassed farmland. No signs of tunnel gullying or slope instability were observed during the site walkover. The site is bordered by a stream to the north, and an ephemeral stream to the east.

3.1.2 Area B

Area B is located on a ridge, gently sloping (<10°) towards the northwest. The area is currently grassed farmland, and no signs of tunnel gullying or slope instability were observed during the site walkover. A plantation of oak trees is present to the southeast of the site, and a gully with an ephemeral stream runs to the west of the site, the walls of which slope in the order of 25°. The stream was relatively dry at the time of inspection. Signs of past shallow slope instability were observed within the gully walls; however, these did not appear to extend into the ridge above. It is understood that this gully is proposed to be planted out during the course of these works.

3.1.3 Area C

Area C is a sloping area adjacent to a plantation of oak trees. The site is currently grassed with low vegetation. The surface of the site is hummocky, sloping in the order of 15°, with an obvious headscarp and outcropping loess material near the top of the slope, indicative of past slope instability. The site slopes moderately to the north, running down to the base of the valley and is bordered by Robinsons Bay Valley Road at its base.

3.1.4 Area D

Area D is located within a gently sloping (<10°) area on a ridge. Gullies with ephemeral and/or intermittent streams run immediately east and west of this Area and show signs of previous shallow instability however the ridge itself appears unaffected. A saddle is present within the ridge to the southeast of this Area and appears to be part of a lineation that continues through adjacent ridges, possibly indicating the presence of a fault or volcanic dyke.

The steeper slopes above the site are hummocky which is suggestive of past slope instability. The failures appear shallow and are likely limited to within the overlying loess formation, however this area was not walked over during the site inspection to confirm. These areas of historic instability to not appear to continue into Area D.

A stand of pine trees is located to the southwest of this Area, extending down the southwestern slope below the ridge. Some of these trees displayed curved trunks which can be an indication of past slope instability.

3.2 Hay Paddock – WWTP and Ancillary Structures

The proposed wetland site at the Hay Paddock site is located at the top of a hill and is bordered by State Highway 75 (SH75) and Old Coach Road. Photographs from the site walkover are included in Appendix B. The wetland site itself is within a relatively flat, grassed farm paddock that slopes gently (<5°) in all directions, with a notable slump in the southeast corner suggestive of historic slope instability (see Figure 7). The gradient of the site becomes steeper at the southern boundary where it borders a gully, the walls of which slope in the order of 45° based on LiDAR information, and western boundary (in the order of 25°) where the slope has been truncated by road cuttings for SH75. Loess outcrops are visible within the road cutting, underlain in areas by boulders and rock. This area was difficult to inspect due to its proximity to SH75 however it appears the loess cover at the site is in the order of 3 – 5 m thick based on visual observations undertaken from a vehicle.

The proposed WWTP location at the Hay Paddock site is a grassed farm paddock that is bordered by Old Coach Road and an existing CCC water tank. The proposed WWTP site is at the base of a relatively steep slope (in the order of 2H:1V) which appears to be the headscarp of the historic slope instability that extends into the proposed wetland area. Retrolens and Google Earth imagery show no discernible change in the historic slope instability over the period that aerial imagery is available for (1940s to present) and it is considered likely that it is currently inactive.

3.3 Takamatua

The Takamatua site consists of a generally flat farm paddock adjacent to SH75, approximately 3.5 km north of Akaroa township. Photographs from the site walkover are included in Appendix C. At the time of the inspection the site was in arable use with a crop cover in place. The site is bordered by a stream on the southern boundary, SH75 on the western boundary, slopes on the northern boundary, and paddocks and a residence on the eastern boundary.

Signs of previous slope instability were observed on the northern boundary. Debris fans were observed encroaching into the paddock by up to 5 m, however these fans appeared to pre-date construction of the current farm fence which was estimated to be at least 20 years old.

Active stream erosion was observed in several places along the stream bank and at one location the boundary fence had been undermined by several metres over an approximately 20 m length of the boundary, as shown in the photographs in Appendix C. The stream level was approximately 2 m below the level of the paddock at the time of inspection, however there had been little rainfall in the weeks leading up to the inspection and this level is likely to fluctuate throughout the year. Material within the stream banks and base appeared to be variable reworked loess and subrounded to rounded gravel and boulders. This material is consistent with the mapped geology of the area (Q1a).

3.4 Hammonds Point

The Hammonds Point site consists of a farm paddock approximately 5 km north of Akaroa township. Photographs from the site walkover are included in Appendix D. The site is bordered by SH75 in the east, slopes covered in regenerating native vegetation to the south, a private block of land and cliffs to the southwest, and sea cliffs to the west and north. The site slopes downwards in all directions from the eastern road boundary – approximately 20-25° to the south in the area of the native vegetation, approximately 10-15° to the southwest, and approximately 15-20° to the northwest.

Material exposed on site appeared to be loess, which is consistent with the mapped geology of the area (mQe).

Evidence of ongoing slope instability was observed throughout the sea cliffs to the north and west of the site. Both historic landslides and ongoing shallow slope instability were observed along the cliff edges, with limited smaller erosion and slump features (<5 m width/length) observed further back within the site itself. A small number of tunnel gully exit holes (piping) were observed in the loess at the top of the sea cliffs. The holes observed were in the order of <200 mm diameter and in the top 1 m of the sea cliffs. No tunnel gullies were observed further up the hill within the site itself, however the presence of exit holes at the sea cliffs suggests they are likely present.

A near-vertical cliff is present on the southwest boundary the site, located along the private property boundary. This cliff appears to be an historic slip scarp, with fresh loess visible in the top 2 – 3 m. The top of the scarp dips at approximately 50° – 80°, while a shallower dip at the base of the slope appears to be a debris fan. A large portion of this area is covered in regenerating native vegetation; however, a section is covered in gorse which is suggestive of more recent movement.

4 LiDAR Assessment

LiDAR data from 2019 has been provided by CCC and reviewed as a part of this assessment. Hillshade models have been produced using this LiDAR data for all four sites and are discussed in the following sections. These models illustrate topographic features at the sites, with steeper slopes highlighted in red.

4.1 Sawmill Road

A hillshade model for the Sawmill Road site is presented in Figure 10. Both the area of historic hummocky landsliding in Area C and the saddle adjacent to Area D are clearly visible, as annotated in Figure 10. Some slope instability was noted in the gullies below and to the northeast and south of Area D.

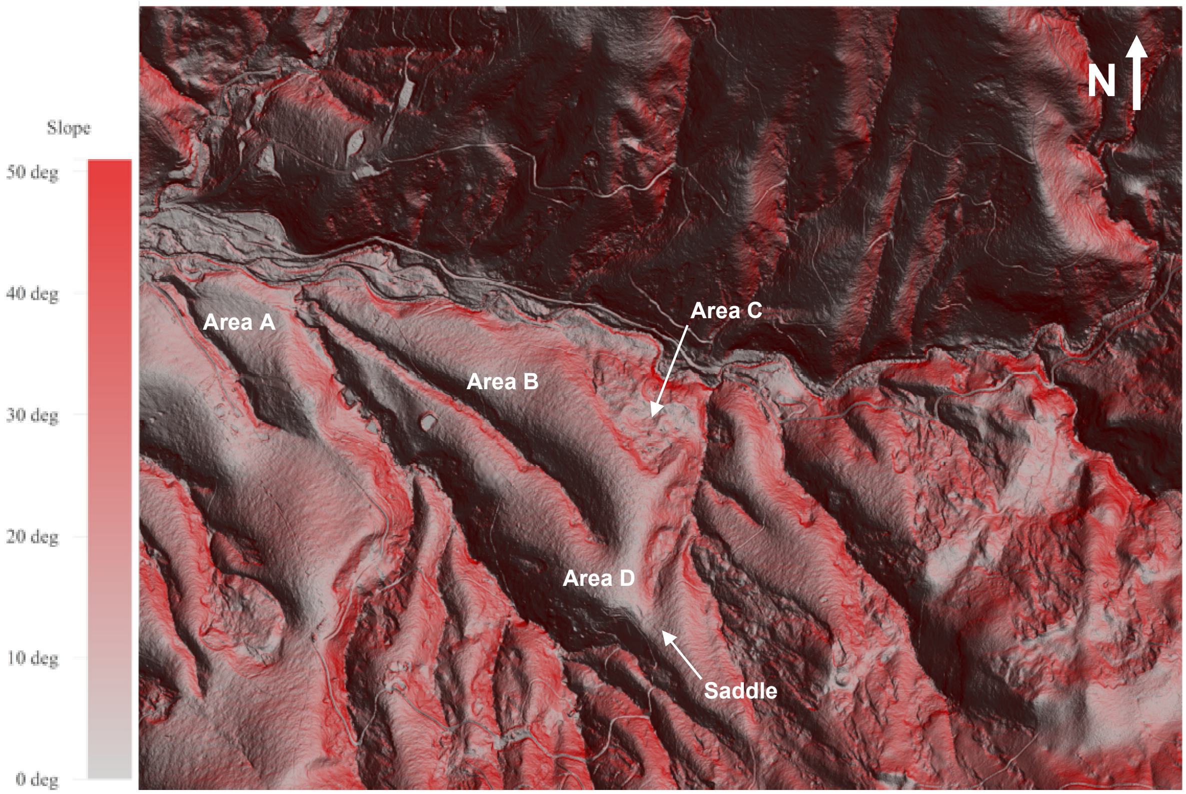


Figure 10: Hillshade model of Sawmill Road site highlighting topographical features

4.2 Hay Paddock

A hillshade model for the Hay Paddock site is presented in Figure 11. The area of probable historic landslide encompassing the existing CCC water tank and progressing into the Ancillary Structures paddock is clearly visible, as annotated in Figure 11. The slope between the paddock and SH75 also indicates several instability features.

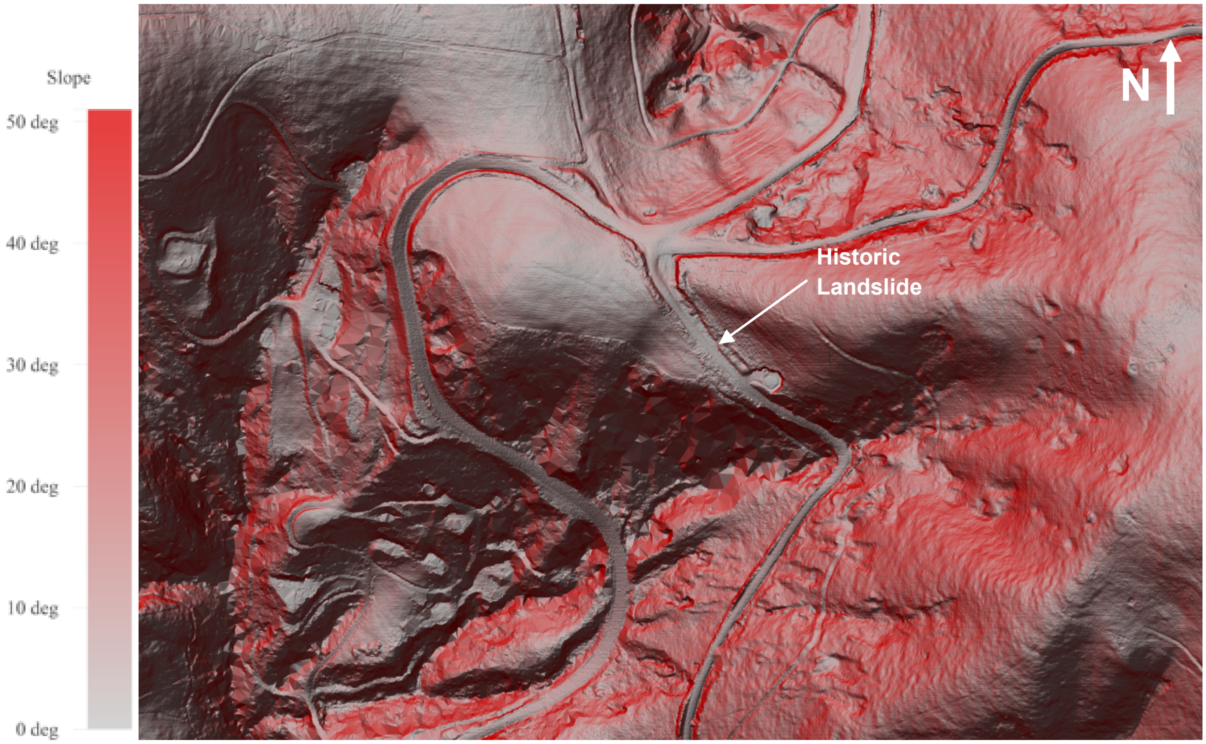


Figure 11: Hillshade image from LiDAR data for the Hay Paddock site

4.3 Takamatua

A hillshade model for the Takamatua site is presented in Figure 12. The areas of slope instability on the northern boundary of the site are clearly visible, along with areas of erosion along the stream banks running through the site. The westernmost debris fan appears to be truncated at its base, likely by stream movement across the site area over time.

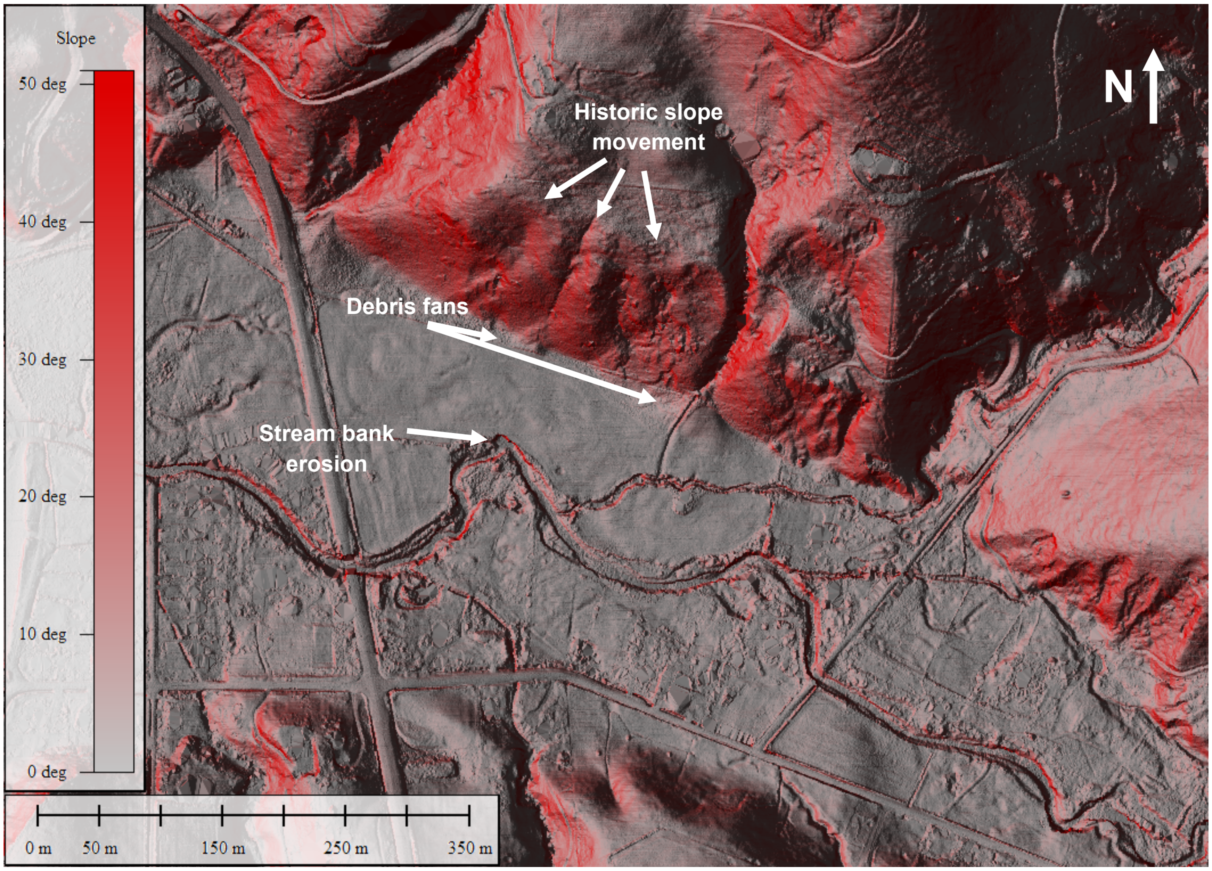


Figure 12: Hillshade model from LiDAR data for the Takamatua site

4.4 Hammonds Point

Hillshade models for the Hammonds Point site are presented in Figure 13 and Figure 14. Figure 13, illuminated from the southwest, clearly shows the historic landslide on the private property on the southwest boundary and evidence of historic movement in the area of native vegetation cover on the southern boundary. Figure 14, illuminated from the northwest, highlights the ongoing slope instability along the sea cliffs on the northwestern boundary of the site. Figure 15 presents 3D views of the site from different angles and further highlights the various areas of slope instability.

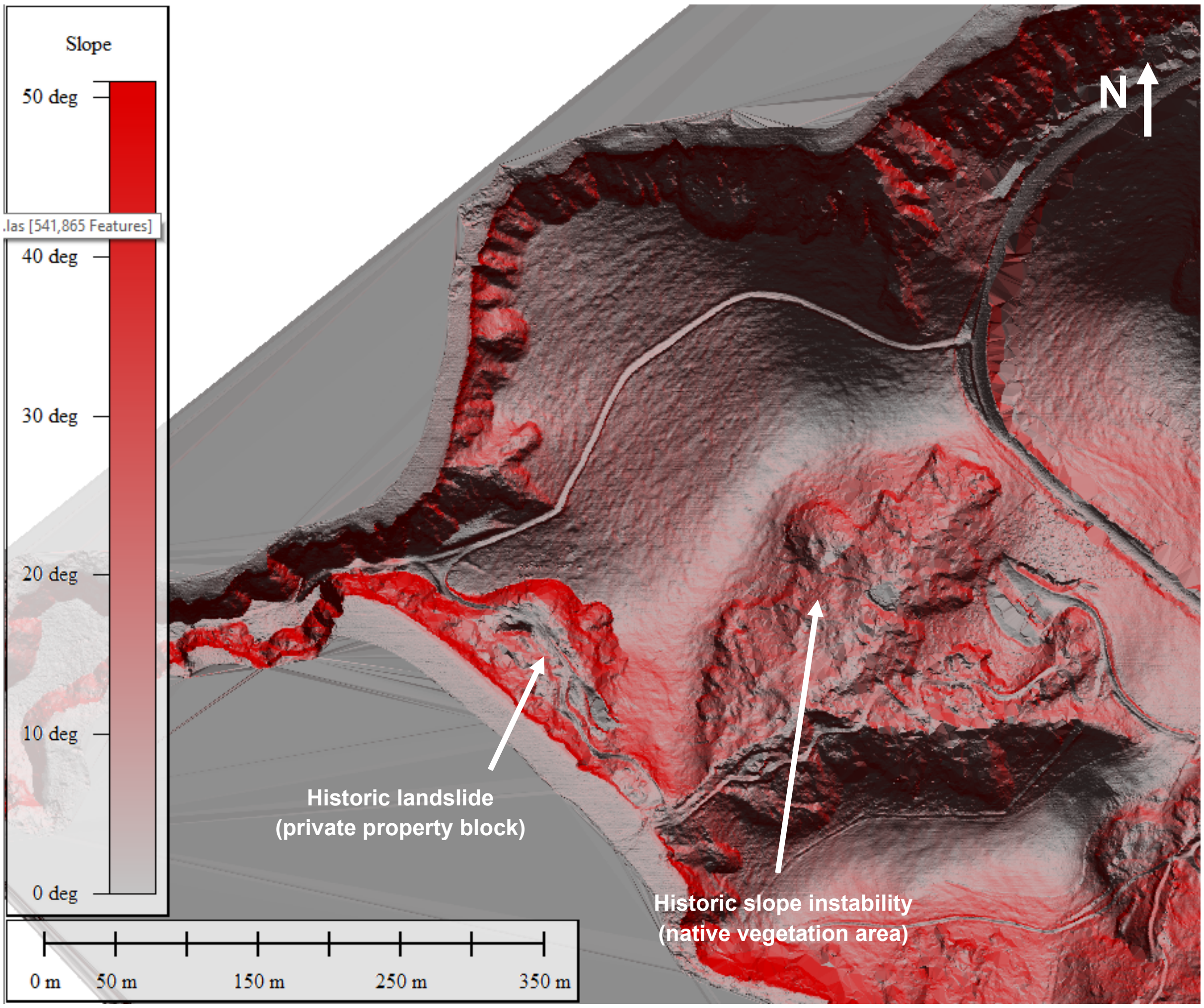


Figure 13: Hillshade model from LiDAR data for the Hammonds Point site

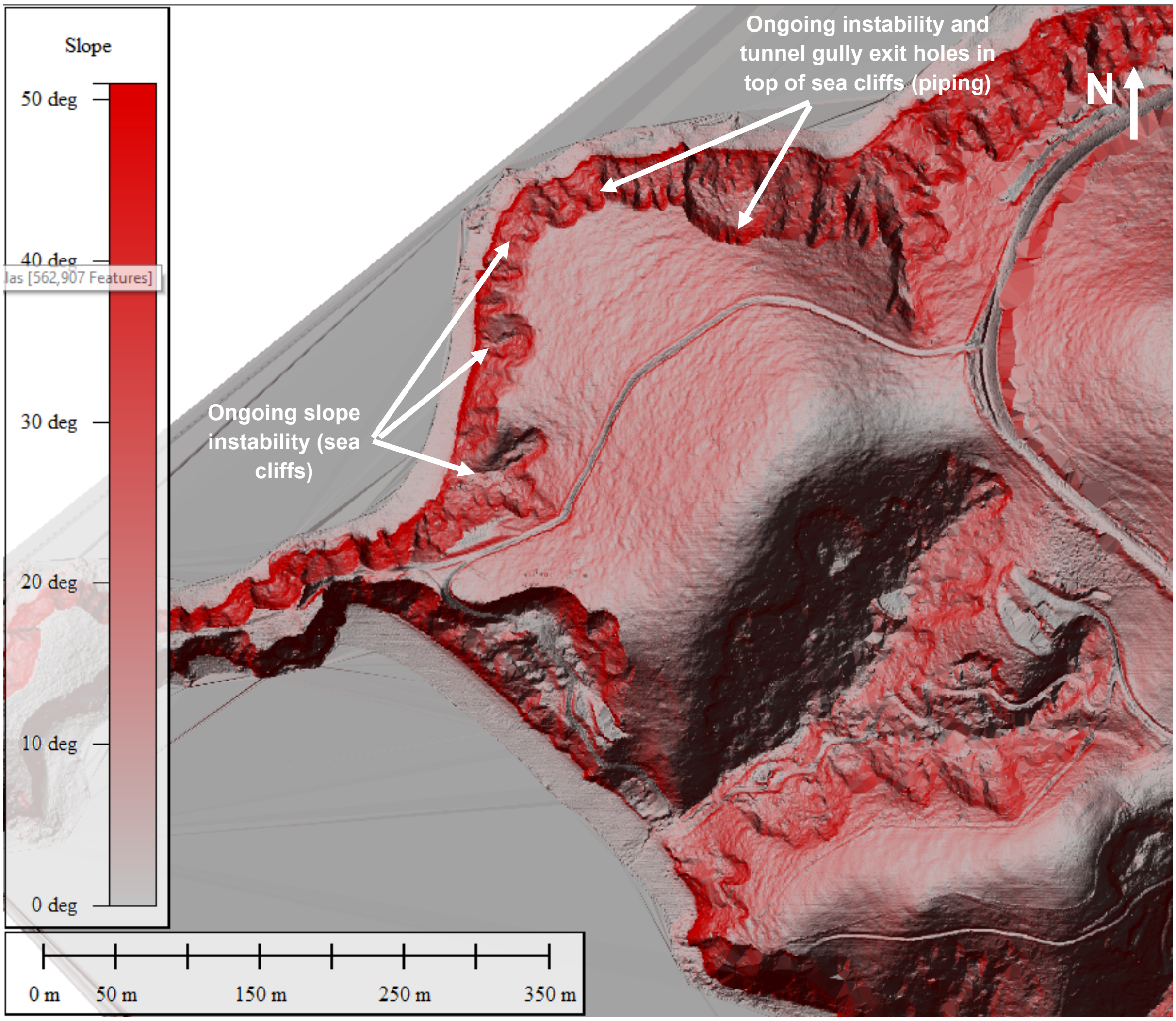


Figure 14: Hillshade model from LiDAR data for the Hammonds Point site

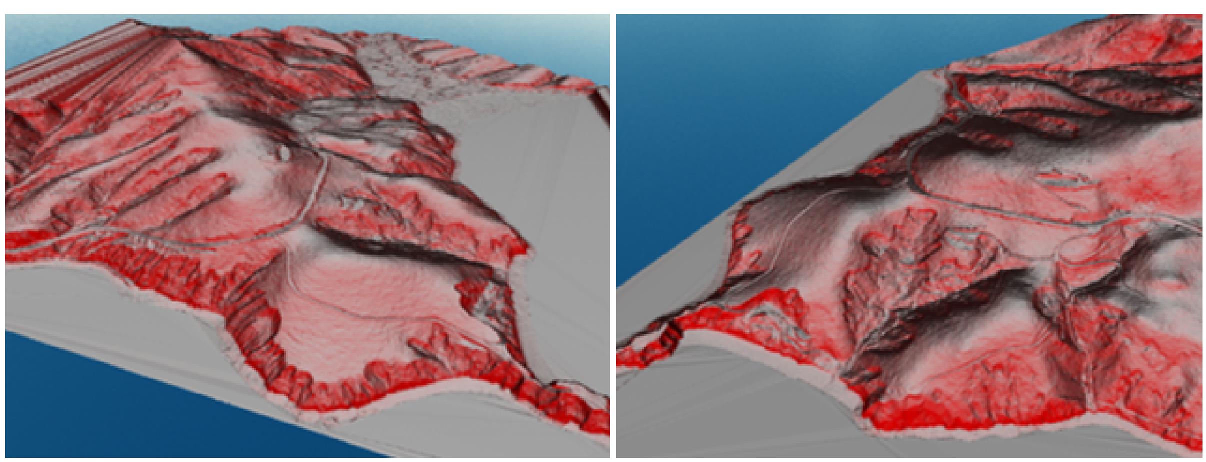


Figure 15: 3D hillshade model views of Hammond Point, looking south (left image) and north (right image)

5 Geotechnical Investigation

A geotechnical investigation consisting of a total of 13 test pits was conducted at both the Hay Paddock and Sawmill Road sites on the 22nd and 23rd of September 2021. The purpose of the investigation was to provide a high-level overview of material types immediately beneath the proposed tank, ancillary structures, and WWTP locations. Further geotechnical investigations, including in-situ testing, is recommended once the final location of these structures is known.

The test pits were excavated using a 2.2 tonne excavator with a bucket attachment until the maximum practical depth was reached, usually in the order of 1.5 m below ground level (bgl), after which a 600mm diameter auger attachment was used to excavate to at least the target depth of 3.0 m bgl. The test pits were backfilled with arisings and tamped with the excavator bucket. The backfilled hole was then rolled several times with the excavator.

No geotechnical investigations have been conducted for the Takamatua or Hammonds Point sites as no structures are proposed for these sites.

5.1 Hay Paddock

Six test pits were excavated at the Hay Paddock site on 22 September 2021 at the locations shown in Figure 16 below. TP01-05 were undertaken within a paddock that is proposed to contain the ancillary structures to the new WWTP, including a wetland. TP06 was undertaken on the opposite side of the road, at the proposed location of the new WWTP. The test pits were terminated between 3.10 and 3.40 m bgl. A bag sample was taken from within each test pit, the depths of which are shown on the test pit logs in Appendix E Photographs of the test pits are included in Appendix F.

TP02 to TP05 encountered up to 300mm of topsoil, underlain by loess and weathered loess throughout the remainder of the excavated depth. TP01 and TP06 also encountered in the order of 300mm of topsoil, however small amounts of angular gravel and cobbles were encountered within the underlying loess material indicating that the material is likely to be loess colluvium. Both pits TP01 and TP06 are located within a probable historic landslide area shown by the red dashed line in Figure 16. TP01 also encountered highly plastic, grey clay within the base of the pit which is inferred to be residual soil overlying the buried volcanics.

Figure 16: Hay Paddock Site Test Pit Locations. Red dashed line indicates potential historic landslide.

5.2 Sawmill Road

Seven test pits were excavated at Sawmill Road on 22 and 23 September 2021 at the locations shown in Figure 17 below. The test pits were terminated between 3.10 m and 3.20 m bgl. A bag sample was taken from within each test pit, the depths of which are shown on the test pit logs in Appendix G. Photographs of the test pits are included in Appendix H.

TP01-03 were undertaken within Area B, and TP04-07 were undertaken within Area D as during the initial scoping phase of this investigation both Areas B and D were being considered as potential tank locations. Area D has subsequently been nominated as the single tank storage site, and Area B will remain an infiltration area.

The material encountered within the test pits was largely similar in both Area B and Area D, and generally encountered up to 150mm of topsoil, underlain by weathered loess for the remainder of the excavated depth. TP01 (within Area B) encountered small amounts of gravel from 2.5 m bgl, and it is possible that the base of this test pit is close to the top of the underlying rock formation. Further, deeper geotechnical investigations are recommended if the intended use of this area changes and depth to rock needs to be determined.

Figure 17: Sawmill Road Test Pit Locations

6 Assessment

6.1 Engineering Properties of Loess

Yates et al. (2017)[2] has been reviewed to gather information on the characteristics of loess in the Canterbury region, with particular regard to the characteristics of deposits in the Banks Peninsula area. A summary of the paper is included below:

Loess deposits in the Canterbury region generally consist of low plasticity silts with variable clay contents. These deposits are divided into in-situ loess and loess colluvium, each exhibiting different engineering properties. In-situ loess can be further split into three pedogenic units which generally consist of:

- Surface (S) layer – moderately weathered, firm silt layer
- Compact (C) layer – fragipan, moderately weathered, stiff clayey silt layer generally displaying vertical fissures and mottling zones
- Parent (P) layer – stiff, sandy silt layer

In Canterbury, in-situ loess cohesion (c') ranges from 0 to 200 kPa and phi ranges from 30° to 65°, however the shear strength properties in loess colluvium deposits are significantly lower, with c' ranging from 0 to 12 kPa and phi ranging from 7° to 23°. **Both types of loess are extremely susceptible to changes in moisture content, with minimal increases sufficient to significantly reduce shear strength properties**. An example of this reduction is the re-activation of an existing deep-seated loess landslide in Akaroa in the 1970s. The construction of a road embankment across this landslide blocked several ephemeral springs, resulting in moisture content within the loess deposit increasing from 8-18% to 30%. When combined with the increased loading from embankment construction, the increased moisture content is believed to have re-initiated movement in the area.

There are many forms of slope instability exhibited by loess deposits, however in Banks Peninsula these are primarily tunnel gullying and mass movement which often occur following periods of high rainfall or other increases in soil moisture. Seasonal desiccation fracturing of the soil and the stratification of in-situ deposits (S, C, and P layers) can lead to increases in permeability and affect slope stability.

6.2 Geotechnical Considerations

6.2.1 Sawmill Road

Geotechnical considerations at the Sawmill Road site include slope stability, cut face stability, and foundation conditions for the storage tanks.

6.2.2 Area A

There were no main geotechnical concerns noted in this area for its proposed use as an infiltration area, however the potential for tunnel gullying and erosion should be considered during detailed design due to the presence of underlying loess material which is prone to erosion. Care should be taken to avoid concentrating water flows in this area.

The potential for overflow into the gullies and intermittent and ephemeral streams will need to be considered should the soil become saturated. To prevent runoff and surface ponding, irrigation application rates will need to be controlled. The infiltration area should be monitored for any adverse effects and infiltration rates adjusted appropriately as required.

6.2.3 Area B

The potential for tunnel gullying, erosion, and slope instability is a concern in this area.

[2] Yates, K., Fenton, C.H., Bell, D.H., 2017. A review of the geotechnical characteristics of loess and loess-derived soils from Canterbury, South Island, New Zealand. Engineering Geology 236 (2018), 11-21.

The potential for overflow into the gullies and ephemeral streams will need to be considered should the soil become saturated. Limited topsoil was encountered on the site during the test pitting investigations and the underlying loess likely has relatively low permeability therefore runoff is more likely. To prevent surface ponding, runoff and associated erosion and tunnel gullying, irrigation application rates should be controlled. The infiltration area should be monitored for any adverse effects and infiltration rates adjusted appropriately as required. It is understood that this gully would be planted out as a part of site works, and water applied via drip irrigation, which will assist in reducing runoff and erosion.

Slope stability within the gully on the southern border of Area B would need to be considered during detailed design to ensure any runoff does not adversely affect the stability of the gully walls or encourage the formation of tunnel gullies. Care should also be taken to avoid the concentration of water flows. The loess encountered in test pits in this area were fractured and mottled, which is indicative of the ‘C’ layer. These fractures may provide higher permeability flow paths for water and lead to the formation of tunnel gullying. Groundwater was observed seeping into TP03 (within Area B) at a depth of 2.8 m bgl, and appeared to originate from one of these fractures. TP01 (within Area B) was also moist to wet from 2.5m bgl. This water is inferred to be a perched water table within higher permeability areas of the loess or could be close to lower permeability basalt rock head as the site is located on a ridgeline.

TP01 encountered small amounts of gravel at depth. Due to its location on top of a ridge and lack of other signs of slope instability this gravel is considered likely to be indicative of proximity to the interface with the underlying rock formation rather than of loess colluvium.

6.2.4 Area C

Slope stability is a significant concern at Area C as this location appears to be an historic landslide. Use of this Area for infiltration or storage is not recommended as excess water infiltration has the potential to increase moisture content within the loess deposit and re-activate the landslide.

6.2.5 Area D

Area D is proposed to be used for storage tanks founded on a series of cut platforms. Stability of cut slopes would need to be considered at Area D during detailed design, however this is not anticipated to be a significant concern based on the limited test pitting undertaken to date. Further geotechnical investigations and assessment are recommended during detailed design to confirm stability and to assess foundation conditions once the exact locations of the storage tanks are known.

Slope stability should be considered for the tanks that are placed closest to the forested slopes on the southern border of Area D. Curved tree trunks indicate the possibility of past slope movement, and care should be taken not to load the slope in this area. Figure 6 Lidar also indicates slope instability within the gully to the northeast of Area D.

Further investigation is recommended to assess foundation conditions during detailed design once the exact location and loadings from tanks is known. Infiltration is not recommended for this site unless lined due to adjacent steep slopes and potential existing slope movement.

Loess encountered within the test pits here was also highly fractured and mottled. The potential for preferential flow paths within these fractures and possible formation of tunnel gullies should be taken into account should this area be considered for infiltration purposes in the future.

6.2.6 Hay Paddock

Geotechnical considerations for the Hay Paddock site include slope stability and infiltration.

Groundwater was not observed at the ground surface or within any of the test pits at the Hay Paddock site. Groundwater was recorded at approximately 22 m bgl in BH_115896, and approximately 57 m bgl in BH_115898 (see Figure 8). If any infiltration areas are proposed at the Hay Paddock site careful consideration should be given to the potential impacts of groundwater on the probable historic landslide and the overlying loess material throughout the site.

Detailed ground investigation and slope stability assessment will need to be undertaken if structures are proposed to be placed within the potential historic landslide shown in Figure 7. Loess overlies volcanic rock in the area and is visible in road cuttings surrounding the site. While these cuts currently appear stable, consideration will need to be given to the effects on slope stability if any structures are placed nearby any potential water infiltration from the wetlands. Water infiltration is likely to significantly reduce the stability of the loess cover.

Stability of the historic landslide identified in the vicinity of the proposed WWTP and south-eastern corner of the ancillary structures area will need to be considered during detailed design. This landslide does not appear to have moved during the period for which aerial photographs are available (i.e. approximately 75 years), however movement may be re-initiated by water infiltration or loading/earthworks. The proposed wetland in the ancillary structures area should be lined, preventing water from infiltrating into the surrounding soil and landslide. As a precautionary measure it is recommended that any significant ancillary infrastructure (ie infrastructure other than access tracks) is located away from the historic landslide area. Any pipework that crosses between the landslide boundary should be detailed to accommodate movement by utilising either welded pipe segments or movement tolerate jointing systems.

Slope stability will also need to be considered in the area behind the proposed WWTP. A steep slope, likely the headscarp of the historic landslide, is present behind the existing CCC water tank and currently appears stable. The material at the base of this slope was identified as loess colluvium in TP06 and is likely to have decreased strength properties compared to in-situ loess. This will need to be taken into consideration during detailed foundation design and the design of any required retaining structures. Any required retaining structures are likely to be similar in nature to the retaining wall which is present behind the existing CCC water tanks and appears to be performing adequately.

6.2.7 Takamatua

Geotechnical considerations for the Takamatua site include infiltration and stream erosion.

Groundwater has been recorded at 0.2 m bgl in a nearby borehole. Although the borehole was 125 m south of the site, high groundwater levels may be encountered within the site boundary. Consideration should be given to the impacts on infiltration of this shallow groundwater table, such as the possibility of surface runoff of treated wastewater. The presence of the stream on the southern boundary also presents a potential flood risk to the property and consideration should be given to the impacts on the infiltration site in the event of a flood.

Erosion of the stream banks was observed in several locations at this site. Consideration should be given to the impacts of this on the infiltration site should erosion further encroach onto the property, such as the potential for treated wastewater to enter the stream. Streambank protection may be required should irrigation infrastructure be located near the stream.

Imagery also indicates the site has been levelled and overflow channels infilled possibly with imported fill. Combined with the alluvial and colluvial nature of the geology this may lead to variations in permeability or preferential flow paths.

6.2.8 Hammonds Point

Geotechnical considerations for the Hammonds Point site include slope stability and infiltration / tunnel gully (piping) formation.

The stability of the several areas of previous slope movement should be considered during detailed design. Infiltration and runoff have the potential to adversely affect these areas, including the private property and residence to the southwest. It is recommended that any infiltration is limited to the flatter area at the top of the site, and that infiltration is monitored, and any runoff is strictly controlled to prevent reactivation of areas of slope instability and reduce the likelihood of tunnel gully (piping) formation.

The potential for infiltration overflow into the ocean or onto private property will need to be considered. To prevent surface ponding, runoff and associated erosion and tunnel gullying, irrigation application rates should be controlled. The infiltration area should be monitored for any adverse effects and irrigation application rates adjusted appropriately as required.

6.3 Hydrogeological Considerations

Aqualinc have undertaken hydrogeological investigations at the Robinsons Bay, Hammonds Point, and Takamatua sites. No investigations have been undertaken at the Hay Paddock site. The investigations undertaken included the installation and monitoring of a number of piezometers at the sites and the production of a May 2022 report entitled ‘Akaroa Treated Wastewater Irrigation Scheme’. We understand that the soil properties used in Aqualinc’s report are not site specific, and it is recommended that site specific soil properties be adopted for detailed design.

The information in this report includes:

- Baseline environmental conditions,
- An irrigation design concept, and
- Estimation of the potential effects of the design concept on the local environment.

Stantec’s assessment in Section 6.1 is based only on visual observations from the site walkover and test pits, and it is recommended that Aqualinc’s May 2022 report is consulted for hydrogeological information, in particular sections 5.2.3 ‘Ponding and runoff’ and 7.3.4 ‘Surface ponding and runoff’.

Aqualinc recommend visual inspections of the irrigation systems for signs of ponding and runoff so that the irrigation system can be fine-tuned to minimise runoff. This is consistent with and complementary to our recommendation to visually monitor the impacts of irrigation on slope stability of the sites.

7 Conclusions and Recommendations

A high-level geotechnical assessment of the proposed Sawmill Road and Hay Paddock sites has been undertaken within the areas shown in Figure 1 and Figure 2. Our conclusions and recommendations for each site based on findings in this report are discussed in Sections 7.1 and 7.2.

7.1 Sawmill Road

- Areas A and B are considered appropriate for further development as infiltration sites based on the site walkover and initial shallow geotechnical investigations undertaken in Area B, as long as controls are in place.
- Dosage rates on all infiltration areas should be carefully controlled to minimise surface ponding and runoff. Excessive dosage rates have the potential to result in runoff, erosion, tunnel gullying and landsliding.
- All infiltration areas should be monitored for signs of erosion and slope instability and irrigation application rates adjusted appropriately as required. Although loess is of generally low permeability, the potential for fractures or higher permeability zones within the loess exists and water may flow more freely in these areas, resulting in erosion and/or tunnel gullying and slope instability.
- Care should be taken to avoid concentrating water flows in all infiltration areas due to the presence of erodible loess material immediately below the topsoil.
- Infiltration areas should be planted with trees capable of establishing deep root systems to assist in reducing runoff.
- Area C is not recommended for further development as an infiltration or storage tank area due to the presence of an historic landslide.
- Area D is considered appropriate for use as a storage tank site based on the initial shallow geotechnical investigations that have been undertaken
- Further geotechnical investigation should be undertaken within Area D to confirm foundation and slope stability conditions once the location of the storage tanks has been finalised.
- Within Area D, care should be taken not to place the tanks close to the edges of gullies or to the top of the southern forested slope to avoid loading the heads of potentially unstable slopes. Further assessment is required to determine safe infrastructure offset from the edge of slopes and engineering control measures where appropriate.
- The loess deposits should be considered of generally low permeability, although there are likely to be fractures or more permeable zones within the loess that water will be able to flow more freely along. These zones are difficult to identify and treat, however potential for this flow should be considered during detailed design as it has the potential to result in tunnel gullying, erosion or landsliding.

7.2 Hay Paddock

- The main paddock is considered appropriate for use for ancillary structures for the new Wastewater Treatment Plant (WWTP).
- The proposed wetland should be lined to prevent water from infiltrating into the soil and into the historic landslide to the southeast and west of the site.
- Further geotechnical investigations are recommended to assess slope stability and foundation conditions below the WWTP once the final location and dimensions are known.
- Retaining structures are likely to be required behind the new WWTP, similar to those in use behind the existing CCC water tank.
- Foundations and retaining structures for the WWTP will need to account for the presence of loess colluvium rather than intact loess.
- Loess deposits generally have a low permeability, although there are likely to be fractures or more permeable zones within the loess that water will be able to flow more freely along. These zones are difficult to identify and

treat, however potential for this flow should be considered during detailed design as it has the potential to result in tunnel gullying and erosion.

7.3 Takamatua

- This site is considered appropriate for further development as an infiltration site based on the desktop study and walkover.
- Consideration should be given to the potential impacts on infiltration rates of a shallow groundwater table.
- Consideration should be given to the potential impacts on any infiltration field of ongoing stream erosion and flood potential. Flood protection measures may be required.
- Ground investigation is recommended to be undertaken to confirm the nature and variation of alluvial soils shown from published geological mapping to underlie the site, their permeability and potential for preferential flow paths to develop.

7.4 Hammonds Point

- The site is not considered appropriate for use as an infiltration area without significant care and mitigation measures to combat the potential effects of infiltration on the areas of slope instability surrounding the site and piping.
- If this site is developed dosage rates on all infiltration areas should be carefully controlled to minimise surface ponding and runoff. Excessive dosage rates have the potential to result in runoff, erosion, tunnel gullying and landsliding.
- All infiltration areas should be monitored for signs of erosion and slope instability and irrigation application rates adjusted appropriately as required. Although loess generally has low permeability, the potential for fractures or higher permeability zones within the loess exists and water may flow more freely in these areas, resulting in erosion and/or tunnel gullying and slope instability.
- Care should be taken to avoid concentrating water flows in all infiltration areas due to the presence of erodible loess material immediately below the topsoil. Tunnel gullying (piping) is already present adjacent to the site and is a significant concern for site development as an infiltration area. There is potential for piping to worsen resulting in additional erosion and treated water flowing out of the sea cliff face.
- Infiltration areas should be planted with trees capable of establishing deep root systems to assist in reducing runoff.
- Loess deposits are generally of a low permeability, although there are likely to be fractures or more permeable zones within the loess that water will be able to flow more freely along. These zones are difficult to identify and treat, however potential for this flow should be considered if this site is carried through to detailed design as it has the potential increase tunnel gullying and erosion observed on cliff faces.
- Consideration should be given to the use of protection measures such as bunding to prevent runoff into the private property in the southwest corner.
- Ground investigation prior to detailed design is recommended to confirm the nature and variation of soils on the site, their permeability and potential for piping.

8 Limitations

This report has been prepared for Christchurch City Council in accordance with the generally accepted practices and standards in use at the time it was prepared. Stantec accepts no liability to any third party who relies on this report.

The information contained in this report is accurate to the best of our knowledge at the time of issue. Stantec has made no independent verification of this information beyond the agreed scope set out in the report.

The interpretations as to the likely subsurface conditions contained in this report are based on the information obtained from desk study and limited ground investigation on two of the four sites including walkover site inspection, as described in this report. Stantec accepts no liability for any unknown or adverse ground conditions that would have been identified had more comprehensive ground investigations, sampling, and testingbeen undertaken.

Actual ground conditions encountered may vary from the predicted subsurface conditions. For example, subsurface groundwater conditions often change seasonally and over time. No warranty is expressed or implied that the actual conditions encountered will conform to the conditions described herein.

Where conditions encountered at the site differ from those inferred in this report Stantec should be notified of such changes and should be given an opportunity to review the report recommendations made in this report in light of any further information.

Appendix A Sawmill Road Site Photos

Stantec **Photographic Log**

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Sawmill Road**	**Site Location:**	**Sawmill Road**

Photograph ID: 1

Photo Location:
Area A

Direction:
Northwest

Survey Date:
04-Aug-21

Comments:
Old building adjacent to Area A (left of image).

Photograph ID: 2

Photo Location:
Area A

Direction:
North

Survey Date:
04-Aug-21

Comments:
Stream running to north of Area A.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 3

Photo Location:
Sawmill Road

Direction:
South

Survey Date:
04-Aug-21

Comments:
Overview of site.

Photograph ID: 4

Photo Location:
Area B

Direction:
North

Survey Date:
04-Aug-21

Comments:
Looking northwards from Area B.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 5 **Photo Location:** Area B **Direction:** East **Survey Date:** 04-Aug-21 **Comments:** Looking towards Area D from Area B. Area C is adjacent to the oak tree plantation in the left of the image.	
Photograph ID: 6 **Photo Location:** Area B **Direction:** West **Survey Date:** 04-Aug-21 **Comments:** Looking West from Area B.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 7 **Photo Location:** Area C **Direction:** Northeast **Survey Date:** 04-Aug-21 **Comments:** Oak tree plantation adjacent to Areas B and C, looking over hummocky terrain of Area C.	
Photograph ID: 8 **Photo Location:** Area C **Direction:** Northwest **Survey Date:** 04-Aug-21 **Comments:** Hummocky terrain within Area C.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 9 **Photo Location:** Area C **Direction:** South **Survey Date:** 04-Aug-21 **Comments:** Headscarp of historic landslide within Area C. Exposed material appears to be loess.	
Photograph ID: 10 **Photo Location:** Area C **Direction:** North **Survey Date:** 04-Aug-21 **Comments:** Hummocky Terrain within Area C.	

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Sawmill Road**	**Site Location:**	**Sawmill Road**

Photograph ID: 11

Photo Location: Area C

Direction: Southeast

Survey Date: 04-Aug-21

Comments: Hummocky Terrain within Area C.

Photograph ID: 12

Photo Location: Area D

Direction: South

Survey Date: 04-Aug-21

Comments: Looking south from Area D. Note hummocky terrain in the steeper slopes in the background of the image.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 13 **Photo Location:** Area D **Direction:** North **Survey Date:** 04-Aug-21 **Comments:** Looking north from Area D.	
Photograph ID: 14 **Photo Location:** Area D **Direction:** Northwest **Survey Date:** 04-Aug-21 **Comments:** Taken within vegetated area on the southern slopes of Area D. Note fallen over/curved trees, suggestive of past slope movement.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 15

Photo Location:
Area D

Direction:
West

Survey Date:
04-Aug-21

Comments:
Taken within vegetated area on the southern slopes of Area D. Note fallen over/curved trees, suggestive of past slope movement.

Photograph ID: 16

Photo Location:
Area D

Direction:
Southeast

Survey Date:
04-Aug-21

Comments:
Taken within vegetated area on the southern slopes of Area D. Note fallen over/curved trees, suggestive of past slope movement.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 17 **Photo Location:** Area D **Direction:** East **Survey Date:** 04-Aug-21 **Comments:** Saddle adjacent to Area D.	
Photograph ID: 18 **Photo Location:** Area D **Direction:** Northwest **Survey Date:** 04-Aug-21 **Comments:** Gully with ephemeral stream adjacent to Areas B and D.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Sawmill Road	Site Location:	Sawmill Road

Photograph ID: 19	
Photo Location: Area D	
Direction: North	
Survey Date: 04-Aug-21	
Comments: Heady of gully with ephemeral stream adjacent to Areas B and D.	

Appendix B   Hay Paddock Site Photos

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Hay Paddock**	**Site Location:**	**Hay Paddock**

Photograph ID: 1

Photo Location:
Hay Paddock

Direction:
Southeast

Survey Date:
04-Aug-21

Comments:
Existing CCC water tank, with scarp of historic landslide behind.

Photograph ID: 2

Photo Location:
Hay Paddock

Direction:
East

Survey Date:
04-Aug-21

Comments:
Scarp of historic landslide, adjacent to/behind existing CCC water tank.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hay Paddock	Site Location:	Hay Paddock

Photograph ID: 3 **Photo Location:** Hay Paddock **Direction:** Southeast **Survey Date:** 04-Aug-21 **Comments:** Old Coach Road and existing CCC water tank.	
Photograph ID: 4 **Photo Location:** Hay Paddock **Direction:** Northwest **Survey Date:** 04-Aug-21 **Comments:** Proposed Ancillary Structures paddock.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hay Paddock	Site Location:	Hay Paddock

Photograph ID: 5

Photo Location:
Hay Paddock

Direction:
Southwest

Survey Date:
04-Aug-21

Comments:
Proposed Ancillary Structures paddock.

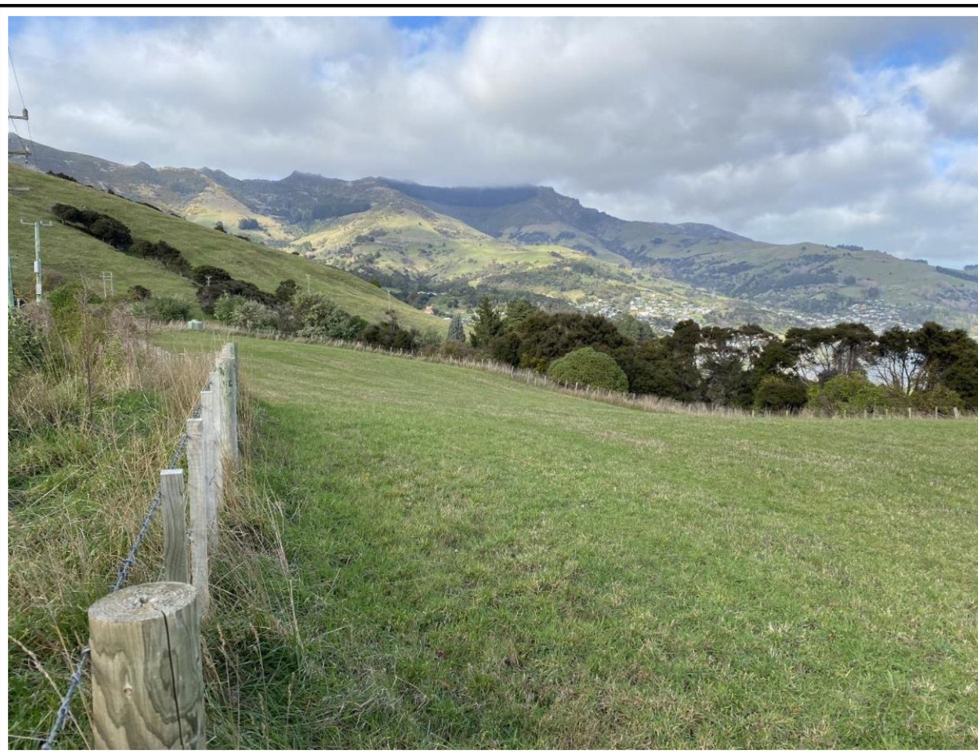
Photograph ID: 6

Photo Location:
Hay Paddock

Direction:
Southeast

Survey Date:
04-Aug-21

Comments:
Proposed Ancillary Structures paddock, looking towards historic landslide.



Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Hay Paddock**	**Site Location:**	**Hay Paddock**

Photograph ID: 7

Photo Location:
Hay Paddock

Direction:
Southeast

Survey Date:
04-Aug-21

Comments:
Scarp of historic landslide behind/adjacent to existing CCC water tank.

Appendix C Takamatua Site Photos

Client:	Christchurch City Council	Project:	310103534
Site Name:	Takamatua	Site Location:	Takamatua

Photograph ID: 1 **Photo Location:** Takamatua site **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Looking southeast from western boundary.	
Photograph ID: 2 **Photo Location:** Takamatua site **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Looking east from western boundary.	

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Takamatua**	**Site Location:**	**Takamatua**

Photograph ID: 3

Photo Location:
Takamatua site

Direction:
North

Survey Date:
05-Apr-22

Comments:
Looking north from western boundary.

Photograph ID: 4

Photo Location:
Takamatua site

Direction:
East

Survey Date:
05-Apr-22

Comments:
Looking east towards slopes on northern boundary. Note gullies and evidence of historic landslide.

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Takamatua**	**Site Location:**	**Takamatua**

Photograph ID: 5

Photo Location:
Takamatua site

Direction:
West

Survey Date:
05-Apr-22

Comments:
Bridge adjacent to southwest corner of site.

Photograph ID: 6

Photo Location:
Takamatua site

Direction:
North

Survey Date:
05-Apr-22

Comments:
Looking north over site.

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Takamatua**	**Site Location:**	**Takamatua**

Photograph ID: 7

Photo Location:
Takamatua site

Direction:
South

Survey Date:
05-Apr-22

Comments:
Material present in stream banks - appears to be reworked loess, gravel, cobbles, and boulders.

Photograph ID: 8

Photo Location:
Takamatua site

Direction:
North

Survey Date:
05-Apr-22

Comments:
Stream erosion on southern boundary. Note gravel and cobbles present in stream banks.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Takamatua	Site Location:	Takamatua

Photograph ID: 9 **Photo Location:** Takamatua site **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Looking east over site.	
Photograph ID: 10 **Photo Location:** Takamatua site **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Stream erosion on southern boundary.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Takamatua	Site Location:	Takamatua

Photograph ID: 11 **Photo Location:** Takamatua site **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Stream erosion on southern boundary.	
Photograph ID: 12 **Photo Location:** Takamatua site **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Stream erosion on southern boundary.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Takamatua	Site Location:	Takamatua

Photograph ID: 13 **Photo Location:** Takamatua site **Direction:** North **Survey Date:** 05-Apr-22 **Comments:** Gully with debris fan at base on northern boundary. Historic slope movement.	
Photograph ID: 14 **Photo Location:** Takamatua site **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Looking west over the northern boundary of the site. Note slopes on northern boundary with debris fans at base.	

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Takamatua**	**Site Location:**	**Takamatua**

Photograph ID: 15	
Photo Location: Takamatua site	
Direction: West	
Survey Date: 05-Apr-22	
Comments: Looking west over the site. Note slopes on northern boundary.	
Photograph ID: 16	
Photo Location: Takamatua site	
Direction: East	
Survey Date: 05-Apr-22	
Comments: Gullies with debris fans at base.	

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Takamatua**	**Site Location:**	**Takamatua**

Photograph ID: 17

Photo Location:
Takamatua site

Direction:
North

Survey Date:
05-Apr-22

Comments:
Historic landslide on northern boundary.

Photograph ID: 18

Photo Location:
Takamatua site

Direction:
West

Survey Date:
05-Apr-22

Comments:
Gully and debris fan at base on northern boundary, note fence rising up over debris fan.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Takamatua	Site Location:	Takamatua

Photograph ID: 19	
Photo Location: Takamatua site	
Direction: West	
Survey Date: 05-Apr-22	
Comments: Condition of fence crossing debris fan, estimate at least 20 years old.	

Appendix D Hammonds Point Site Photos

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 1 **Photo Location:** Hammonds Point **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Looking west from top of site. SH75 out of shot to bottom of image.	
Photograph ID: 2 **Photo Location:** Hammonds Point **Direction:** South **Survey Date:** 05-Apr-22 **Comments:** Top of site. SH75 out of shot to left of image.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 3 **Photo Location:** Hammonds Point **Direction:** North **Survey Date:** 05-Apr-22 **Comments:** Top of site. SH75 out of shot to right of image.	
Photograph ID: 4 **Photo Location:** Hammonds Point **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Top of site, slopes with regenerating native vegetation on southern boundary shown on left of image.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 5 **Photo Location:** Hammonds Point **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Slopes and regenerating native vegetation on southern boundary of site.	
Photograph ID: 6 **Photo Location:** Hammonds Point **Direction:** Southwest **Survey Date:** 05-Apr-22 **Comments:** Slopes and regenerating native vegetation on southern boundary of site.	

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Hammonds Point**	**Site Location:**	**Hammonds Point**

Photograph ID: 7

Photo Location:
Hammonds Point

Direction:
Southwest

Survey Date:
05-Apr-22

Comments:
Looking southwest from the top of the site.

Photograph ID: 8

Photo Location:
Hammonds Point

Direction:
Northeast

Survey Date:
05-Apr-22

Comments:
Slopes and regenerating native vegetation on southern boundary of site.

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Hammonds Point**	**Site Location:**	**Hammonds Point**

Photograph ID: 9 **Photo Location:** Hammonds Point **Direction:** North **Survey Date:** 05-Apr-22 **Comments:** Regenerating native vegetation on southern boundary of site.	
Photograph ID: 10 **Photo Location:** Hammonds Point **Direction:** South **Survey Date:** 05-Apr-22 **Comments:** Gully with regenerating native vegetation on southern boundary of site.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 11 **Photo Location:** Hammonds Point **Direction:** Northwest **Survey Date:** 05-Apr-22 **Comments:** Looking northwest along headscarp above private property block in southwest corner.	
Photograph ID: 12 **Photo Location:** Hammonds Point **Direction:** Southeast **Survey Date:** 05-Apr-22 **Comments:** Looking southeast along headscarp above private property block in southwest corner. Note gorse and exposed loess suggestive of recent movement.	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 13

Photo Location:
Hammonds Point

Direction:
Southeast

Survey Date:
05-Apr-22

Comments:
Looking southeast along headscarp above private property block in southwest corner.

Photograph ID: 14

Photo Location:
Hammonds Point

Direction:
Northeast

Survey Date:
05-Apr-22

Comments:
Looking northeast near base of site.

Client:	**Christchurch City Council**	**Project:**	**310103534**
Site Name:	**Hammonds Point**	**Site Location:**	**Hammonds Point**

Photograph ID: 15

Photo Location:
Hammonds Point

Direction:
Northeast

Survey Date:
05-Apr-22

Comments:
Looking northeast up access track. Note gullies and areas of slope instability in left of image.

Photograph ID: 16

Photo Location:
Hammonds Point

Direction:
Southeast

Survey Date:
05-Apr-22

Comments:
Northern sea cliffs. Loess visible overlying basalt. Note ongoing instability.

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 17 **Photo Location:** Hammonds Point **Direction:** Northeast **Survey Date:** 05-Apr-22 **Comments:** Gullies through northern sea cliffs	
Photograph ID: 18 **Photo Location:** Hammonds Point **Direction:** Northeast **Survey Date:** 05-Apr-22 **Comments:** Ongoing slope instability on northern sea cliffs	

Photographic Log

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 19 **Photo Location:** Hammonds Point **Direction:** Northeast **Survey Date:** 05-Apr-22 **Comments:** Ongoing slope instability on northern sea cliffs	
Photograph ID: 20 **Photo Location:** Hammonds Point **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Looking west across slopes	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 21 **Photo Location:** Hammonds Point **Direction:** East **Survey Date:** 05-Apr-22 **Comments:** Large historic landslide on northern sea cliffs	
Photograph ID: 22 **Photo Location:** Hammonds Point **Direction:** West **Survey Date:** 05-Apr-22 **Comments:** Access track	

Client:	Christchurch City Council	Project:	310103534
Site Name:	Hammonds Point	Site Location:	Hammonds Point

Photograph ID: 23

Photo Location:
Hammonds Point

Direction:
Northwest

Survey Date:
05-Apr-22

Comments:
Looking over slopes and access track to the northwest

Appendix E Hay Paddock Test Pit Logs

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP01**

Sheet 1 of 1

Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1597606 E 5151137 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 119.00 mRL	Logged By: SJ
Description: Hay Paddock, Old Coach Road Test Pits		Date: 22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Scala Penetration (Blows/100mm): 2 4 6 8 10 12 14 16 18 20

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend depth	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages
	0.0–0.30	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.30)	F	M			
	0.30–1.10	Loess Colluvium	SILT with minor clay; light yellowish brown. Moist; stiff; slightly plastic. [LOESS COLLUVIUM?]	(1.10)	St	M			
	1.10–1.60	Loess Colluvium	SILT with minor fine sand, tending to some sand in areas; light brown mottled orange and grey. Moist; firm; non-plastic. [LOESS COLLUVIUM?]	(1.60)	F	M		Bulk	
	1.60–3.00	Loess Colluvium	SILT with trace clay; light yellowish brown. Moist; firm; slightly plastic. [LOESS COLLUVIUM?] *- 2.50m - Minor clay. Firm to stiff. Orange mottling.* *- 2.90m - Cobble (100mm diameter). Angular, basalt.*	(3.00)	F	M			
	3.00–3.10	Inferred Weathered Volcanic	CLAY; greyish brown. Moist; stiff; highly plastic. [INFEREED WEATHERED VOLCANICS]	(3.10)	St	M			

Test Pit terminated at 3.10m BGL due to Machine Limit

Elevation scale: 118 (at 1.0 m), 117 (at 2.0 m), 116 (at 3.0 m). Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket.

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP02**

Sheet 1 of 1

Project Name:	Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1597578 E 5151171 N (NZTM)
Pit Dimensions:	1m x 2m		
Client:	Christchurch City Council	Elevation:	120.00 mRL
Logged By:	SJ		
Description:	Hay Paddock, Old Coach Road Test Pits	Date:	22-09-2021 (Start) 22-09-2021 (End)
Checked By	AM		

Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
	0.0–0.20	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non-plastic. [TOPSOIL]	(0.20)	F	M		Bulk		
	0.20–1.20	Loess	SILT with trace clay and sand; light brown mottled orange and grey. Moist; firm; non-plastic; sand, fine. [LOESS]	(1.20)	F	M		Bulk		
	1.20–3.10	Loess	SILT with trace sand; light brown. Moist; stiff; non to slightly plastic; sand, fine. [LOESS] *- 2.50m - Wet. Dilatant. Slightly plastic.*	(3.10)	St	M				
			Test Pit terminated at 3.10m BGL due to Machine Limit							

Elevation scale: 119 (1.0 m), 118 (2.0 m), 117 (3.0 m). Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP03**

Sheet 1 of 1

Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1597553 E 5151201 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 120.00 mRL	Logged By: SJ
Description: Hay Paddock, Old Coach Road Test Pits		Date: 22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

Elevation (m)	Depth (m)	Geologic Unit	Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
	0.00–0.25	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non-plastic. [TOPSOIL]	(0.25)						
119 (1.0)	0.25–1.30	Loess	SILT with trace clay; light brown mottled orange and grey. Moist; firm; non to slightly plastic. [LOESS] *- 0.50m - Trace sand. Non plastic.*	(1.30)						
118 (2.0), 117 (3.0)	1.30–3.30	Loess	SILT with trace sand; light brown. Moist; firm; non to slightly plastic; sand, fine. [LOESS] *- 2.80m - Soft, wet, dilatant, slightly plastic.*	(3.30)	F	M		Bulk		
	3.30		Test Pit terminated at 3.30m BGL due to Machine Limit							

Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

Equipment: 2 Tonne Excavator	Contractor: Alan Hemsley	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP04**

Sheet 1 of 1

Project Name:	Akaroa WWTP Investigations	Project No. 310103534	Coordinates:	1597532 E 5151167 N (NZTM)	Pit Dimensions: 1m x 2m
Client:	Christchurch City Council		Elevation:	120.00 mRL	Logged By: SJ
Description:	Hay Paddock, Old Coach Road Test Pits		Date:	22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

(Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
	0.00–0.20	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non-plastic. [TOPSOIL]	(0.20)						
	0.20–1.30	Loess	SILT with trace sand; light brown mottled orange and grey. Moist; firm; non to slightly plastic. [LOESS]	(1.30)				Bulk		
	1.30–3.30	Loess	SILT with trace sand; light brown. Moist; firm; non plastic; sand, fine. [LOESS] *- 2.00m - Wet. Minor sand.*	(3.30)	F	M				
			Test Pit terminated at 3.30m BGL due to Machine Limit							

Elevation scale: 119 (1.0), 118 (2.0), 117 (3.0). Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5.

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

TEST PIT LOG

Stantec	Hazeldean Business Park, Level 3, 6 Hazeldean Road Addington, Christchurch, New Zealand, 8024		Test Pit ID: **TP05** Sheet 1 of 1
Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1597516 E 5151196 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 120.00 mRL	Logged By: SJ
Description: Hay Paddock, Old Coach Road Test Pits		Date: 22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

(Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm)
	0.00–0.15	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non-plastic. [TOPSOIL]	(0.15)		M				
	0.15–1.00	Loess	SILT with trace sand and clay; light brown mottled orange and grey. Moist; firm; slightly plastic; sand, fine. [LOESS]	(1.00)	F	M				
119–116.7	1.00–3.30	Loess	SILT with trace sand; light brown. Moist; stiff; non-plastic; sand, fine. [LOESS] *- 2.50m - Wet. Dilatant. Firm to stiff.*	(3.30)	St	M		Bulk		
			Test Pit terminated at 3.30m BGL due to Machine Limit							

Elevation scale: 119 (1.0 m), 118 (2.0 m), 117 (3.0 m). Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5. Scala scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20.

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket..

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP06**

Sheet 1 of 1

Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1597663 E 5151141 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 121.00 mRL	Logged By: SJ
Description: Hay Paddock, Old Coach Road Test Pits		Date: 22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm)
		Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non-plastic. [TOPSOIL]	(0.25)						
	0.5	Loess Colluvium	SILT with trace sand; light brown. Moist; firm; slightly plastic. [LOESS COLLUVIUM?] *- 0.50m - Cobble, basalt, subrounded. Rare orange mottling.*		F	M				
120	1.0									
	1.5									
119	2.0									
	2.5		*- 2.50m - Wet. Soft. Dilatant.*							
118	3.0			(3.40)						
	3.5		Test Pit terminated at 3.40m BGL due to Machine Limit							

Scala Penetration scale: 2 4 6 8 10 12 14 16 18 20

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket.

Appendix F Hay Paddock Test Pit Photographs

Stantec

TEST PIT PHOTOGRAPHS: TP01

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103524

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597606 E 5151137 N
(NZTM)
LOGGED: SJ DATE: 22/09/2021

TP01 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP01

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103524

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597606 E 5151137 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP01 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP01

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103524

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597606 E 5151137 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Gravel within loess colluvium at 2.90 m bgl in TP01.

TEST PIT PHOTOGRAPHS: TP01

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103524

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597606 E 5151137 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Clay found at 3.0 m bgl in TP01.

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597578 E 5151171 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP02 at approximately 1.5m bgl.

Stantec

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597578 E 5151171 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP02 (3.1m bgl)

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597578 E 5151171 N (NZTM)
LOGGED: SJ   DATE: 22/09/2021

TP02 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597578 E 5151171 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP02 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP03

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597553 E 5151201 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP03 at approximately 0.80m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597553 E 5151201 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP03 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597553 E 5151201 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP03 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597553 E 5151201 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP03 at 3.30m bgl

TEST PIT PHOTOGRAPHS: TP04

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597532 E 5151167 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP04 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP04

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597532 E 5151167 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP04 at 3.30m bgl

TEST PIT PHOTOGRAPHS: TP04

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597532 E 5151167 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP04 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP04

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597532 E 5151167 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP04 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP05

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597516 E 5151196 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP05 at 3.30m bgl

TEST PIT PHOTOGRAPHS: TP05

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597516 E 5151196 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP05 at 3.30m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP05

0.0-3.3 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597516 E 5151196 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from TP05 at 3.30m bgl

TEST PIT PHOTOGRAHPS: TP06
0.0-3.4

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597663 E 5151141 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP06 at approximately 1.50m bgl

TEST PIT PHOTOGRAHPS: TP06
0.0-3.4

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597663 E 5151141 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from approximately 1.50m bgl in TP06

TEST PIT PHOTOGRAHPS: TP06 0.0-3.4

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597663 E 5151141 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP06 at 3.40m bgl

Stantec

TEST PIT PHOTOGRAHPS: TP06 0.0-3.4

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Hay Paddock, Old Coach Road
COORDS: 1597663 E 5151141 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP06 at 3.40m bgl

Appendix G Sawmill Road Test Pit Logs

TEST PIT LOG

Stantec	Hazeldean Business Park, Level 3, 6 Hazeldean Road Addington, Christchurch, New Zealand, 8024	TEST PIT LOG	Test Pit ID: **TP01 Sawmill Road** Sheet 1 of 1
Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1598207 E 5154755 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 90.00 mRL	Logged By: SJ
Description: Sawmill Road Test Pits		Date: 22-09-2021 (Start) 22-09-2021 (End)	Checked By AM

Elevation (m)	Depth (m)	Geologic Unit	Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
	0.00–0.20	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.20)	F	M				
89 (at 1.0)	0.20–2.50	Loess	SILT with trace clay and sand; light brown mottled orange brown. Moist; firm; slightly plastic; sand, fine. [LOESS] *- 1.40m - Mottling absent.*	(2.50)	F	M		Bulk		
88 (at 2.0), 87 (at 3.0)	2.50–3.20	Loess?	SILT with minor clay and trace sand and gravel; light brown with rare light greyish brown mottling. Moist to wet; firm; slightly plastic; sand, fine; gravel, coarse, angular, basalt. [LOESS?]	(3.20)	F	M - W				

Test Pit terminated at 3.20m BGL due to Machine Limit

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket.

TEST PIT LOG

Stantec — Hazeldean Business Park, Level 3, 6 Hazeldean Road, Addington, Christchurch, New Zealand, 8024

Test Pit ID: **TP02 Sawmill Road**

Sheet 1 of 1

Project Name:	Akaroa WWTP Investigations	Project No.	310103534
Coordinates:	1598240 E 5154754 N (NZTM)	Pit Dimensions:	1m x 2m
Client:	Christchurch City Council	Elevation:	90.00 mRL
Logged By:	SJ	Description:	Sawmill Road Test Pits
Date:	22-09-2021 (Start) 22-09-2021 (End)	Checked By	AM

(Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm)
	0.0–0.20	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.20)						
	0.20–0.50	Loess	SILT with trace clay and fine sand; light brown mottled orange. Moist; firm; non-slightly plastic. [LOESS]	(0.50)	F	M				
	0.50–0.80		*- 0.50m - Wet; soft.*	(0.80)	S	W				
89	1.0		*- 0.80m - Moist; stiff to very stiff.*					Bulk		
88	2.0				St	M				
			- 2.30m - Mottling decreasing with depth.							
87	3.0			(3.10)						
	3.10		Test Pit terminated at 3.10m BGL due to Machine Limit							

Scala scale: 2 4 6 8 10 12 14 16 18 20

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket.

Stantec	Hazeldean Business Park, Level 3, 6 Hazeldean Road Addington, Christchurch, New Zealand, 8024	# TEST PIT LOG	Test Pit ID: **TP03 Sawmill Road** Sheet 1 of 1
Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1598255 E 5154722 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 90.00 mRL	Logged By: SJ
Description: Sawmill Road Test Pits		Date: 23-09-2021 (Start) 23-09-2021 (End)	Checked By AM

Material Description

(Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
		Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL] (0.10)			M				
	0.5	Loess	SILT with trace clay and sand; light brown mottled orange brown. Moist to wet; firm; slightly plastic; sand, fine. [LOESS]		F	M - W				
89	1.0									
	1.5									
88	2.0									
			- 2.30m - Mottling decreasing.							
	2.5									
			- 2.80m - Groundwater trickling into base of hole						2.8m 23-10	
87	3.0		(3.10)							
			Test Pit terminated at 3.10m BGL due to Machine Limit							
	3.5									

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. Water encountered at 2.8m bgl during excavation. Minor ponding in base of pit, inflow estimated at 0.1L/minute. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

Stantec — Hazeldean Business Park, Level 3, 6 Hazeldean Road, Addington, Christchurch, New Zealand, 8024	**TEST PIT LOG**		Test Pit ID: **TP04 Sawmill Road** Sheet 1 of 1
Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1598506 E 5154483 N (NZTM)	Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 147.00 mRL	Logged By: SJ
Description: Sawmill Road Test Pits		Date: 23-09-2021 (Start) 23-09-2021 (End)	Checked By AM

Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
	0.00–0.10	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.10)						
	0.10–0.60	Loess	SILT with trace clay and sand; light brown mottled orange brown. Moist; firm; slightly plastic; sand, fine. [LOESS]	(0.60)	F	M				
146	0.60–1.40	Loess	- 1.30m - Mottling decreases.	(1.40)	St	M		Bulk		
145	1.40–2.00	Loess		(2.00)	VSt	M				
144	2.00–3.20	Loess		(3.20)	F	M				
	3.20		Test Pit terminated at 3.20m BGL due to Machine Limit							

Depth scale (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5

Equipment: 2 Tonne Excavator

Contractor: Alan Hemsley

Remarks:
Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation.
No ponding water during duration of excavation.
Test pit backfilled with arisings and tamped with excavator bucket.

Stantec

Hazeldean Business Park, Level 3, 6 Hazeldean Road
Addington, Christchurch, New Zealand, 8024

TEST PIT LOG

Test Pit ID: **TP05 Sawmill Road**

Sheet 1 of 1

Project Name:	Akaroa WWTP Investigations	Project No. 310103534	Coordinates:	1598495 E 5154424 N (NZTM)	Pit Dimensions: 1m x 2m
Client:	Christchurch City Council		Elevation:	151.00 mRL	Logged By: SJ
Description:	Sawmill Road Test Pits		Date:	23-09-2021 (Start) 23-09-2021 (End)	Checked By AM

Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm)
	0.00–0.15	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.15)	F	M				
	0.15–1.50	Loess	SILT with trace clay and sand; light brown mottled orange brown and grey. Moist; stiff; slightly plastic. [LOESS]	(1.50)	St	M		Bulk (1.5)		
	1.50–2.50	Loess	- 1.60m - Mottling grey only.	(2.50)	VSt	M				
	2.50–3.10	Loess	- 2.50m - Mottling absent.	(3.10)	F	W				
	3.10		Test Pit terminated at 3.10m BGL due to Machine Limit							

Elevation scale: 150 at 1.0 m; 149 at 2.0 m; 148 at 3.0 m. Depth scale: 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5. Scala scale: 2, 4, 6, 8, 10, 12, 14, 16, 18, 20.

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

TEST PIT LOG

Stantec — Hazeldean Business Park, Level 3, 6 Hazeldean Road, Addington, Christchurch, New Zealand, 8024

Test Pit ID: **TP06 Sawmill Road**

Sheet 1 of 1

Project Name:	Akaroa WWTP Investigations	Project No. 310103534	Coordinates:	1598476 E 5154377 N (NZTM)	Pit Dimensions: 1m x 2m
Client:	Christchurch City Council		Elevation:	157.00 mRL	Logged By: SJ
Description:	Sawmill Road Test Pits		Date:	23-09-2021 Start, 23-09-2021 End	Checked By AM

(Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)

Elevation (m)	Depth (m)	Geologic Unit	Material Description	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm)
	0.00–0.10	Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL]	(0.10)	F	M				
	0.10–3.10	Loess	SILT with trace sand; light brown. Dry to moist; stiff; non plastic. [LOESS]		St					
	0.5		*- 0.50m - Dark brown, grey, and orange brown mottling. Stiff to very stiff.*	(0.50)		M				
156	1.0							Bulk		
	1.5		*- 1.50m - Mottling absent. Dry to moist.*	(1.50)		D - M				
155	2.0									
	2.5									
	2.8			(2.80)		M				
154	3.0			(3.10)						
			Test Pit terminated at 3.10m BGL due to Machine Limit							
	3.5									

Scala Penetration scale: 2 4 6 8 10 12 14 16 18 20

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

Stantec — Hazeldean Business Park, Level 3, 6 Hazeldean Road, Addington, Christchurch, New Zealand, 8024	# TEST PIT LOG	Test Pit ID: **TP07 Sawmill Road** Sheet 1 of 1

Project Name: Akaroa WWTP Investigations	Project No. 310103534	Coordinates: 1598510 E 5154321 N (NZTM)		Pit Dimensions: 1m x 2m
Client: Christchurch City Council		Elevation: 159.00 mRL		Logged By: SJ
Description: Sawmill Road Test Pits		Date: 23-09-2021 (Start) 23-09-2021 (End)		Checked By AM

Elevation (m)	Depth (m)	Geologic Unit	Material Description (Logging carried out in accordance with Guidelines for the Field Classification of Soil and Rock for Engineering Purposes, New Zealand Geotechnical Society, 2005)	Legend	Consistency/ Relative Density	Moisture Condition	Shear Vane Reading (kPa)	Samples	Groundwater/ Seepages	Scala Penetration (Blows/100mm) 2 4 6 8 10 12 14 16 18 20
		Topsoil	SILT with trace rootlets; dark brown. Moist; firm; non plastic. [TOPSOIL] (0.10)							
		Loess	SILT with trace clay and sand; light brown mottled orange and grey. Moist; firm; slightly plastic. [LOESS]							
	0.5									
158	1.0									
			- 1.10m - Pockets of SILT up to 100mm diameter; light grey. Wet to saturated; firm; non plastic. Possibly related to vertical fissuring, appear to be higher permeability than surrounding loess.					Bulk		
	1.5				F	M				
			- 1.80m - Mottling decreasing.							
157	2.0									
	2.5									
156	3.0		(3.10)							
			Test Pit terminated at 3.10m BGL due to Machine Limit							
	3.5									

Equipment:	2 Tonne Excavator	Remarks: Open pit excavation to approximately 1.5m bgl, followed by 600mm machine mounted auger to base of excavation. No ponding water during duration of excavation. Test pit backfilled with arisings and tamped with excavator bucket.
Contractor:	Alan Hemsley	

Appendix H Sawmill Road Test Pit Photographs

TEST PIT PHOTOGRAPHS: TP01

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598207 E 5154755 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP01 at approximately 0.70m bgl

TEST PIT PHOTOGRAPHS: TP01

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598207 E 5154755 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP01 at 3.20m bgl

TEST PIT PHOTOGRAPHS: TP01

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598207 E 5154755 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP01 at 3.20m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP01

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598207 E 5154755 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP01 at 3.20m bgl.

Stantec

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598240 E 5154754 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Base of TP02 at approximately 0.8m bgl.

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598240 E 5154754 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Wall of TP02 at approximately 0.8m bgl

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598240 E 5154754 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

TP02 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP02

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598240 E 5154754 N (NZTM)
LOGGED: SJ DATE: 22/09/2021

Material from base of TP02 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP03

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598255 E 5154722 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP03 at approximately 0.80m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598255 E 5154722 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP03 at approximately 0.80m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598255 E 5154722 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Water trickling into base of TP03 from approximately 2.80m bgl

TEST PIT PHOTOGRAPHS: TP03

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598255 E 5154722 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP03 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP03

0.0-3.1 m

CLIENT: Christchurch City Council

PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road

COORDS: 1598255 E 5154722 N (NZTM)

LOGGED: SJ

DATE: 23/09/2021

Material from base of TP03 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP04

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598506 E 5154483 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP04 at 3.20m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP04

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598506 E 5154483 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP04 at 3.20m bgl

TEST PIT PHOTOGRAPHS: TP04

0.0-3.2 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598506 E 5154483 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Material from base of TP04 at 3.30m bgl

TEST PIT PHOTOGRAPHS: TP05

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598495 E 5154424 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP05 at approximately 0.70m bgl

TEST PIT PHOTOGRAPHS: TP05

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598495 E 5154424 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP05 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP05

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598495 E 5154424 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP05 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP05

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598495 E 5154424 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Material from TP05 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP06 at approximately 0.70m bgl

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Base of TP06 at approximately 0.70m bgl

Stantec

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP06 at approximately 1.2m bgl

Stantec

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP06 at 3.10m bgl

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP06 at 3.10m bgl

Stantec

TEST PIT PHOTOGRAHPS: TP06
0.0-3.1

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Road
COORDS: 1598476 E 5154377 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Material from base of TP06 at 3.10m bgl

TEST PIT PHOTOGRAPHS: TP07

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598510 E 5154321 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP07 at approximately 0.70m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP07

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598510 E 5154321 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Material from TP07 at approximately 0.70m bgl

TEST PIT PHOTOGRAPHS: TP07

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations
JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598510 E 5154321 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

TP07 at approximately 1.50m bgl

Stantec

TEST PIT PHOTOGRAPHS: TP07

0.0-3.1 m

CLIENT: Christchurch City Council
PROJECT: Akaroa WWTP Investigations

JOB NO: 310103534

LOCATION: Sawmill Rd
COORDS: 1598510 E 5154321 N (NZTM)
LOGGED: SJ DATE: 23/09/2021

Material from base of TP07 at 3.10m bgl

Appendix R B Robinson – Field Trials of Treated Wastewater Irrigation to Native Trees

A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula

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Executive Summary

- The application of Treated Municipal Wastewater (TMW) on NZ-native vegetation is a management option under consideration for towns on Banks Peninsula and elsewhere. There is little information on the effect of TMW on the growth of NZ-native plants or the fluxes of nutrients or contaminants in the underlying soil.

- In July 2015, 1350 native species were planted onto a 20 m x 55 m plot on Piper's Valley Road, Duvauchelle, Banks Peninsula. The plants were arranged into 27 blocks (4.5 m x 4 m), with 12 of the blocks receiving TMW. There were three NZ-native vegetation types tested: Type 1 (*Phormium tenax, Phormium colensoi, Cordyline australis, Griselinia littoralis, Pittosporum eugenioides),* Type 2 (*Leptospermum scoparium*, *Kunzea robusta*) and Type 3 (*Coprosma robusta, Pseudopanax arboreus, Podocarpus laetus, Olearia paniculata*). Irrigation with TMW at a rate of 1000 mm/yr started in January 2016.

- In October/November 2018 forty soil pits were opened and samples taken from five depths (0-5, 15, 30, 45 and 60 cm). From January 2016 to the time of sampling, the soils received a total of 3400 mm of TMW. Soils were analysed for pH, total elements, and soluble ('phytoavailable') fractions of key nutrients and contaminants (ammonium, nitrate, Olsen phosphorus, heavy metals).

- There was no visible evidence of changes in soil structure as a result of TMW application that have been reported to occur in other soils receiving TMW due to the accumulation of sodium. Nor was there any visible evidence of runoff.

- On average the Na concentrations in the topsoil (0-5 cm) was significantly higher in the TMW-irrigated plots compared to the control plots. This is only a 25% increase, despite a disproportionately large mass of Na that was added with the effluent. This indicates that Na is moving down the soil profile and not accumulating in the root-zone, where it may cause degradation of the soil structure.

- There was a significant (6%) increase in the total nitrogen concentration in the topsoil (0-5 cm) but at greater soil depths, the total nitrogen in the TMW-treated plots was not significantly greater than the control plots. There were no significant differences in ammonium in any of the soils. Nitrate was significantly higher in the surface soil but not deeper in the soil profiles. It is likely that most excess nitrogen added to the soil (200 kg/ha/yr) is either taken up into the vegetation, denitrified into N_2 and N_2O or leached.

- There was no evidence of phosphorus accumulation in the soil, probably because the amount of phosphorus added in the TMW (110 kg/ha/yr, total of 312 kg/ha) was small compared to the mass of P in the soil profile (7606 kg/ha). This is consistent with the findings of our previous report, modelling the accumulation of P in these soils. Available phosphorus (Olsen-P) was within the range (10 - 30 mg/kg) typically found on extensive farming systems, and well below concentrations reported on soils irrigated with high-P effluent.

- Soil concentrations of potentially toxic heavy metals, including copper, cadmium, lead, and zinc, were not affected by TMW application. The concentrations of these elements were similar to background values reported for Canterbury Soils.

- Plant survival and growth was monitored throughout the trial. Growth (biomass) was assessed initially by canopy volume, and following canopy closure, by plant height. Harvested biomass will be determined at the conclusion of the trial. Plant suitability for effluent application on Banks Peninsula was determined by survival and growth.

- The effluent had a negligible effect on the concentrations of nutrients and contaminants in the plant tissues. While the growth of all species was accelerated by the effluent, there was no indication of luxury uptake of plant nutrients or increased concentrations of elements that may be harmful. This indicates that TMW is unlikely to affect ecological food chains.

- This trial demonstrated the feasibility of establishing NZ-native vegetation using TMW. We recommend irrigation rates of 500 - 800 mm/yr. Further experimental plantings should be conducted with these species to explore the possibility of using TMW to re-establish rare or endangered plants that may significantly enhance the ecological value of the area. A critical success factor for the establishment of New Zealand native vegetation on Banks Peninsula that are to receive TMW is the control of exotic weeds. It is likely that some weeds will have a greater growth response to TMW than the native species. It is therefore critical that these weeds be suppressed as the native vegetation becomes established.

Contents

Introduction

In 2014, the Christchurch City Council (CCC) commissioned an investigation to determine whether Treated Municipal Wastewater (TMW) from the township of Duvauchelle could be irrigated onto the local golf course or surrounding grazed pasture. Subsequent engagement with the community during public open days in 2015 and 2016, this brief was expanded to include cut-and-carry pasture as well as New Zealand (NZ) native vegetation. The feasibility of irrigating TMW onto pasture was demonstrated for two soil types, Barry's soil and the Pawson Silt Loam, from Duvauchelle and the Takamatua Peninsula in lysimeter experiments (Gutierrez-Gines et al., 2017, 2020).

Potentially, TMW from the town of Akaroa, Banks Peninsula, could be irrigated onto NZ-native vegetation, instead of being discharged into Akaroa harbour. Such an approach is consistent with land application being the preferred option over discharge into waterways or the ocean (Sparling et al., 2006), where it can exacerbate eutrophication and/or toxic algal blooms (Sonune and Ghate, 2004). The Irrigation of TMW onto land reduces the contaminants that enter waterways and therefore has positive effects on the water quality (Herath, 1997). While there is significant interspecific variation, the root-zones of plants remove nutrients contained in the TMW, mitigate pathogens (Mandal et al., 2007), and break down or immobilise contaminants (Chaudhry et al., 2005) that would otherwise degrade water bodies. The application of TMW can accelerate the growth of some plants by providing water and nutrients (Overman and Nguy, 1975).

The rate that TMW can be applied to soil depends on the soil type and quality of the TMW (Gutiérrez-Ginés et al., 2020). There are numerous examples of where land application of TMW has been discontinued because of excessive nutrient leaching (Houlbrooke et al., 2003), or degradation of soil quality to the point TMW runoff degraded surface waters (Cameron et al., 1997). Elevated concentrations of monovalent cations, especially sodium and potassium, can degrade soil structure through the dispersion of clays (Mojid and Wyseure, 2013), and reduce plant growth through salinity and sodicity (Bernstein, 1975). The successful application of TMW to land on Banks Peninsula requires particular attention to soil quality. Soils of the lowland areas of the peninsula where TMW could potentially be applied are mostly derived from loess with a relatively high clay content (Griffiths, 1973). They are often imperfectly drained and may contain a fragipan (a layer of impermeable soil). These soils present a higher risk of infiltration problems compared to free-draining soils and consequently an improperly designed TMW application system may be susceptible to surface runoff and erosion. Gutierrez-Gines et al. (2017) demonstrated the feasibility of irrigating TMW at rates up to 1500 mm/yr onto Barry's soil and the Pawson Silt Loam, with a recommended irrigation rate of 500-800 mm/yr. An infiltration study on the Pawson Silt Loam showed that infiltration of up to 1500 mm of TMW irrigation was unimpeded, even when the TMW was spiked with additional Na up to 325 mg/L (McIntyre, 2018).

The irrigation of TMW from the towns of Duvauchelle or Akaroa onto NZ-native vegetation could potentially increase the production of valuable native products and create zones of ecological value (Meurk, 2008; Franklin et al., 2015). *Leptospermum scoparium* (mānuka) is an obvious candidate species because of its associated high-value honey and essential oils (Seyedalikhani et al., 2019). Moreover, *L. scoparium* has been shown to kill soil-borne pathogens (Prosser et al., 2016) and reduce nitrate leaching (Esperschuetz et al., 2017b). Other potential valuable native species are *Kunzea robusta* (kānuka) for essential oil production, P*hormium tenax* (harakeke) for fibre production, and a whole suite of species, including *Griselinia littoralis* (kapuka) that may be a nutritious supplement due to tannins and trace elements (Dickinson et al., 2015).

In many countries, including NZ, TMW is used to irrigate forestry (Capra and Scicolone, 2004; Barton et al., 2005), however, there is as yet a lacuna of data on the effects of TMW irrigation onto soils supporting NZ-native vegetation. There is demonstrable evidence that some NZ-native species, such as *L. scoparium*, *K. robusta*, *P. tenax*, *Cordyline australis* (tī kouka), *Myoporum laetum* (ngaio) and *Austroderia australi*s (toetoe) thrive in high-nutrient environments, even if some of these species (*L. scoparium* and *K. robusta*) are adapted to low-fertility soils (Gutiérrez-Ginés et al., 2017; Esperschuetz et al., 2017a). However, Gutierrez-Gines et al. (2017) showed that some other species, such as *Hebe salicifolia* (koromiko) and *Coprosma acerosa* (sand coprosma) had a limited or negative response to increased nutrients. Therefore, selection of NZ-native species that will tolerate TMW irrigation is critical for a successful operation.

When establishing an ecosystem of NZ-native plants that is receiving TMW, the response of exotic weeds to the TMW also needs to be considered. Species such as *Rubus fruticosus* (blackberry), *Solanum mauritianum* (wooly nightshade), *Solanum dulcamara* (woody nightshade), *Phytolacca octandra (*inkweed), and C*lematis vitalba* (old-man's beard) may have a greater growth response to TMW than the NZ-native species, thereby making their control more difficult.

Transitioning grazed pasture to TMW irrigated native plants will eliminate the application of mineral fertilisers such as superphosphate, which contain elevated concentrations of toxic cadmium, fluorine and uranium that can accumulate in soil (Kim and Robinson, 2015). Irrigation with UV-sterilized TMW, such as that resulting from treatment at Duvauchelle or Akaroa, will also result in a lower environmental pathogen load than grazed pasture. A native ecosystem receiving TMW would likely remain unharvested or have only a small fraction of the biomass removed. Therefore, unlike a cut-and-carry pasture receiving TMW, there would lower-rates of nutrient removal from the system. Therefore, it is likely that nitrate leaching and phosphorus accumulation in the soil would be greater than in a grazed pasture.

Aims

We aimed to determine whether NZ-native vegetation on Banks Peninsula could be established while receiving TMW irrigation at a rate of 1000 mm per year. Specifically, we sought to determine, whether this rate of irrigation would result in ponding, excess nitrate leaching, accumulation or depletion of elements in soil, changes in the survival and growth of individual NZ-native plant species.

Methods

Field trial

In June 2015 a field trial was established at Piper's Valley Road, Duvauchelle, Banks Peninsula (Figure 1). The area of ca. 20 m x 55 m was fenced off from an adjacent paddock under sheep grazing. The soil was a Pawson Silt Loam (Table 1) supporting a pasture dominated by *Dactylis spp.* (cocksfoot) with some *Holcus lanatus* (Yorkshire fog).

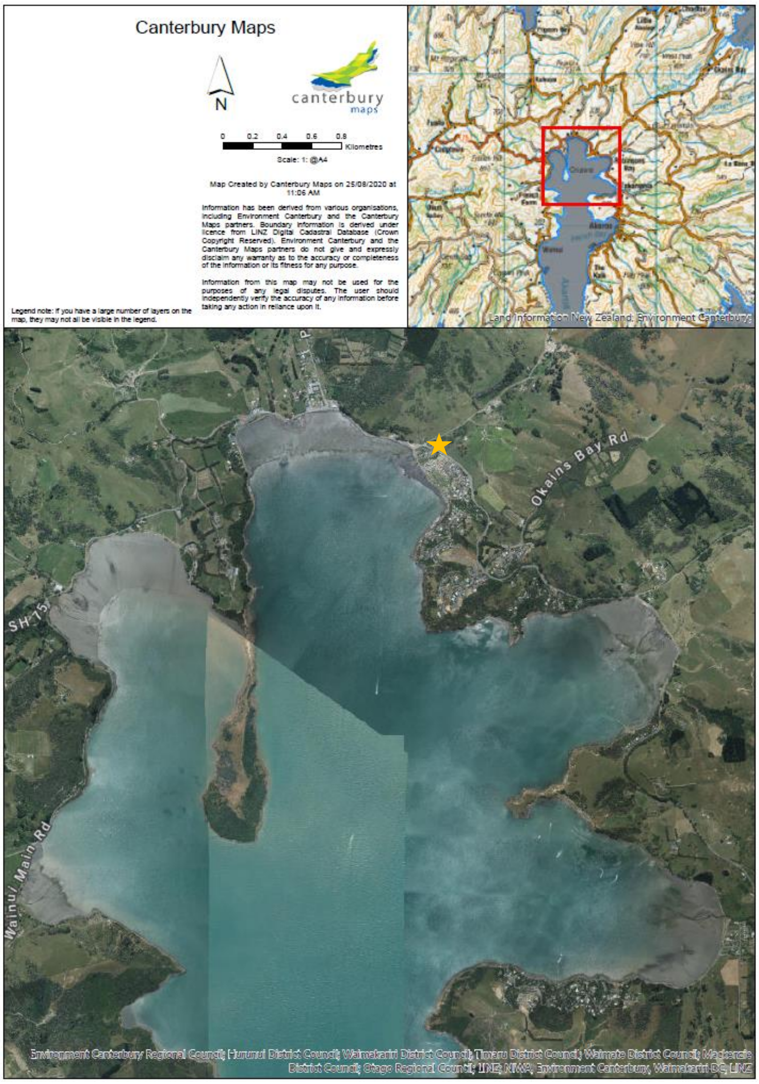

Figure 1: Location of the field site in Duvauchelle (yellow star).

Table 1: Physical properties of the Pawson Silt Loam from the field site at Duvauchelle. Values in brackets represent the standard error of the mean, n=5. (Griffiths 1973; McIntyre 2018).

Horizon	A	Bw	Bg
Depth (m)	0.20-0.28	0.28-0.39	0.39-0.60
Clay (%)	8 (1.3)	9.8 (0.9)	8.3 (0.7)
Silt (%)	22.5 (2.5)	25.4 (1.8)	23.5 (1.6)
Sand (%)	68.5 (3.5)	64.8 (2.8)	68.3 (2.2)

In July 2015, 1350 native trees were planted. The trees were divided into 27 blocks of 4 m x 4.5 m (Figure 2). Eleven native New Zealand species were split into three different vegetation types: monocot dominated, Myrtaceae and broadleaves (Table 2). Twelve of the 27 blocks received TMW irrigation at a rate of 1000 mm per annum (Table 3). Irrigation started in January 2016. Weed control was conducted by lawnmower from 2015 to 2017. In June 2017, all areas within the plot that were not under native vegetation were planted with silver tussock (*Poa cita*) to minimise the need for further weed control. Thereafter, weeds were occasionally removed using a weedeater.

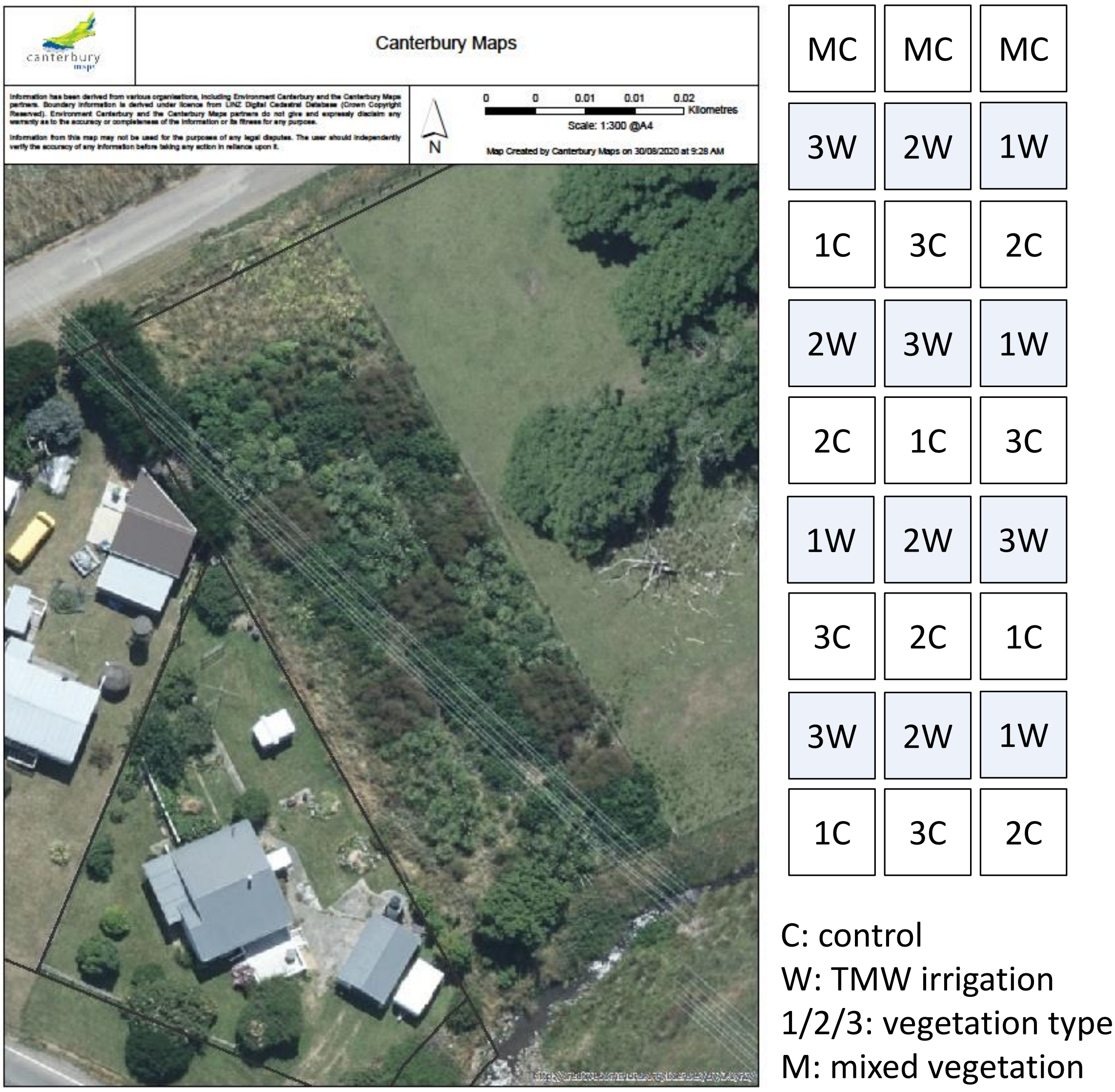

Figure 2: Recent satellite photo of the field site with visible treatment blocks (left) and schematic overview of the trial (right).

Table 2: Vegetation types at the field site.

Vegetation	Species	Botanical reference	Māori name	Common name
Type 1 (Myrtaceae)	*Leptospermum scoparium*	J.R. Forst. & G. Forst.	mānuka	tea tree
	Kunzea robusta	De Lange & Toelken	kānuka	tea tree
Type 2 (Broadleaves)	*Coprosma robusta*	Raoul	karamu	-
	Olearia paniculata	Druce	akiraho	-
	Pseudopanax arboreus	Philipson	puahou	five finger
	*Podocarpus laetus**	Hooibr. ex. Endl.	tōtara	Hall's tōtara
Type 3 (Monocot dominated)	*Phormium tenax*	J.R. Forst. & G. Forst.	harakeke	flax
	Phormium colensoi	Hook.f.	wharariki	mountain flax
	Cordyline australis	Hook.f.	tī kōuka	cabbage tree
	Pittosporum eugenioides	A.Cunn.	tarata	lemonwood
	Griselinia littoralis	Raoul	kapuka	broadleaf

* Referred to as *Podocarpus cunninghamii* in previous reports.

Table 3: Characteristics of irrigated TMW from the Duvauchelle wastewater treatment plant. Mean and standard deviation, n=54. Total applied refers to a 34-month period from the start of the irrigation in January 2016 to soil sampling in October/November 2018.

Compound	TMW		Amount applied kg/ha/yr	Total applied kg/ha
pH	7.5			
Electric Conductivity	423 (40)	uS/cm		
Total suspended solids	32	g/m^3		
Ammonium-nitrogen	0.49 (0.15 – 0.80)*	mg/L	4.9	13.9
Nitrate-nitrogen	18 (7.5)	mg/L	180	510
Nitrite-nitrogen	0.86 (0.09)	mg/L	8.6	24.4
Total nitrogen	<25	mg/L	<250	<708
Aluminium	0.43 (0.11 – 1.7)*	mg/L	4.3	12.2
Boron	0.10 (0.04)	mg/L	1	2.8
Calcium	59 (12)	mg/L	59	1672
Cadmium	<0.001	mg/L	<0.01	0.03
Copper	0.04 (0.03)	mg/L	0.4	1.13
Iron	0.96 (0.25 – 3.6)*	mg/L	9.6	26.9
Potassium	22 (5.0)	mg/L	220	623
Magnesium	19 (5.5)	mg/L	190	538
Manganese	0.06 (0.03)	mg/L	0.6	2.7
Sodium	95 (21)	mg/L	950	2692
Phosphorus	11 (5.0)	mg/L	110	312
Sulphur	25 (11)	mg/L	250	708
Zinc	0.17 (0.11)	mg/L	1.7	4.8
Sodium Accumulation Ratio	15 (2.6)			

*Geometric mean and standard error range.

Sample collection

Soil samples were collected between 25.10.2018 and 08.11.2018. The soil was sampled under 5 species; *Phormium tenax*, *Cordyline australis*, *Leptospermum scoparium*, *Kunzea robusta* and *Coprosma robusta*. Four soil pits were opened per species and treatment (TMW/control) combination, resulting in a total of forty pits. A spade was used to open soil pits of 0.6 m x 0.6 m x 0.6 m next to the plant base. This ensured that the collected soil sample originated from the root zone of the plant. Following removal of the surface litter, a trowel was used to sample soil at 0-5 (referred to as 0 in Figures), 15, 30, 45, and 60 cm, resulting in a total of 200 samples (Figure 3).

Figure 3: Sample collection from a soil pit.

Plant growth was assessed in July 2019. At that time plant canopy had closed and the estimation of the biomass was made by measuring plant height. Each of the 1350 plants at the site was measured with a measurement tape. Plant samples were taken from the forty plants that had soil pits dug at their base in 2018. For each plant, 10 branches/leaves from different heights were cut by secateurs and combined to generate a representative sample.

Chemical analyses

Soil nitrate and exchangeable ammonium were extracted from the soil with 2 M KCl (Blakemore, 1987). 40 mL of 2M KCl was added to 4 g of fresh soil, shaken for 1 hour at 120 cycles/min in a horizontal shaker, and filtered through Whatman No. 42 filter paper. Colorimetric methods were used to determine nitrate (Miranda et al., 2011) and ammonium (Mulvaney, 1996) in the extract, using a Cary 100 Bio (Agilent Technologies) UV-visible spectrophotometer.

Soils were spread on aluminium trays, dried at 40 °C for 4 days and sieved to <2mm. Plants were washed with deionised water before being dried at 60 °C for 4 days. Leaves were separated from the stems. Plant leaves and subsamples of soils were ground with a Rocklabs ring mill.

Soil moisture content was determined by drying 10-20 g of moist soil at 105 °C for 24 hours. Soil weight was recorded before and after drying and the difference used to determine the moisture factor (Blakemore et al., 1987).

A Vario-Max CN Elemental Analyser (Elementar, Germany) was used to determine total carbon and nitrogen contents in the ground soil samples. A LECO CN828 Carbon/Nitrogen analyser (LECO, U.S.) was used to determine total carbon and nitrogen contents in the ground plant samples.

Soil pH was determined in deionised water using a 1: 2.5 g soil: water ratio. The extracts were shaken vigorously and left to equilibrate overnight. The pH was determined using a HQ 440d Multi-Parameter Meter (HACH, U.S.) with pH probe PHC735 (HACH, U.S.).

Soil and plant samples were digested to determine total element concentrations. 1.0 g of ground soil was digested with 4 mL HNO_3 and 10 mL HCl. Samples were left to pre-digest overnight and were then digested on an aluminium heating block at 90 °C for 1 hr. Samples were left to cool down, diluted to 20 mL with ultrapure water (18.2 MΩ cm) and filtered through Whatman No. 42 filter paper. 0.2 g of ground plant sample was digested with 15 mL ultrapure conc. HNO_3 on an aluminium block at 120 °C for 1 hr. Digests were diluted to 25 mL with ultrapure water. Certified reference material was included for soil and plant digestions (SRM 2710a – Montana I Soil and SRM1573a – Tomato Leaves, National Institute of Standards and Technology, U.S. Department of Commerce). Element concentrations in the digests were determined by Microwave Plasma-Atomic Emission Spectrometer (MP-AES) Agilent 4200 (Agilent Technologies, U.S.)

$Ca(NO_3)_2$ was used to extract phytoavailable metals from the soil (Gray et al., 1999). 5.0 g of soil (air-dried, sieved to <2mm) was shaken with 30 mL of 0.05 M $Ca(NO_3)_2$ for 120 min at 15 rpm in an end-over-end shaker, followed by centrifugation at 10,000 rpm for 10 min. Extracts were filtered through Whatman No. 42 filter paper. Extracts were diluted 21 times with 2% ultrapure HNO_3 and element concentrations analysed by Inductively coupled plasma mass spectrometry (ICP-MS) Agilent 7500 CX (Agilent Technologies, U.S.)

To determine plant-available phosphorus (Olsen P), 1.0 g of soil (air dried, <2mm) was extracted with 20 mL 0.5 M $NaHCO_3$ extractant (Blakemore et al., 1987). Samples were shaken for 30 min in an end-over-end shaker at 50 rpm and centrifuged at 2,000 rpm for 10 min. The extract was filtered through Whatman No. 42 filter paper. The P concentration in the extract was determined colorimetric (Olsen, 1954), using a Cary 100 Bio UV-visible spectrophotometer (Agilent Technologies, U.S.).

Calculation of nitrate leaching

Nitrate leaching was calculated using the drainage and the concentration of nitrate measured at 60 cm depth, a zone that is depauperate in organic matter and NZ-native plant roots (Franklin, 2014). Assuming an average annual precipitation is 1000 mm (ClimateData.org, 2020) and the average annual evapotranspiration is 500 mm (Stats, 2020), the drainage from the site will be:

Drainage = 1000 mm irrigation + 1000 mm rainfall - 500 mm = 1500 mm (15000 m^3/ ha)

Nitrate leaching (kg/ha) was calculated using nitrate-nitrogen concentrations at 0.6 m depth, which was below all but the deepest roots. Nitrate at this depth is assumed to leach into groundwater.

Statistical analysis

Data was analysed, graphed and tabulated in Microsoft Excel 2016. A one-way t-test was used to compare treatments at different soil depths. The significance level was $p<0.05$.

Results and discussion

Infiltration and accumulation of sodium and other basic cations

No evidence of ponding or runoff throughout the trial indicating that infiltration was adequate and not significantly perturbed by the application of TMW. This is consistent with the findings of other studies investigating infiltration of similar rates of TMW into Banks Peninsula soils (McIntyre, 2018; Gutiérrez-Ginés et al., 2020). The effluent in Duvauchelle has Sodium Accumulation Ratio (SAR) of 15 (Table 3), below this threshold. In some of the plots, irrigation with TMW significantly increased soil sodium concentrations. While sodium in the topsoil increased by 25% (Table 4), we have strong evidence that sodium is not continuing to accumulate in this system. Over the three-year irrigation period, some 2700 kg/ha sodium equivalent was added to the soil. However, the measured increase in sodium in the soil profile was only 735 kg/hg. This indicates that excess sodium was leaching through the soil profile and not accumulating in the top 0.6 m. These findings are consistent with (Gutiérrez-Ginés et al., 2020), who demonstrated that while TMW increased soil Na concentrations in Barry Silt Loam (Duvauchelle), there was no long-term accumulation of sodium in a lysimeter trial.

Figure 4 shows the concentrations of sodium in the soil profile[1]. Accumulation of sodium can also change soil pH (Figure 5). Our results indicate soil pH was significantly increased on the *L. scoparium* and *K. robusta* plots. This pH value of the TMW soils and the magnitude of change is similar to what may be achieved in agriculture by adding lime to the soils (McLaren and Cameron, 1996). The pH of all the plots was within the optimal range for most plants (Rengel, 2002).

Total sodium was not significantly increased on average (all species). However, some species showed significant increases. Using e.g. *P. tenax* as an example, the topsoil (0-5 cm) contained 174 mg/kg more sodium in the treatment compared to the control (a 25% increase). On a per-hectare basis, this equates to 120 kg extra sodium per ha. In contrast, some 2700 kg of sodium were added - indicating that 2580 kg have leached to deeper horizons. This indicates that sodium is only accumulating to a certain level in the topsoil - consistent with the findings of Gutiérrez-Ginés et al. (2020).

Continual application of sodium can result in the increased leaching of other basic cations, especially potassium, magnesium and calcium (K^+, Mg^{2+} and Ca^{2+}) (FAO, 2020). The results at Duvauchelle indicate that all three of these elements significantly increased in the topsoil (Table 4). Calcium and magnesium increased by 7% and 37% respectively, thereby offsetting the increase in sodium. Unlike sodium, the increase in soil calcium was proportional to the calcium added in the effluent, indicating that there will be a long-term accumulation of calcium. This is beneficial for the system, because calcium improves soil structure (McLaren and Cameron, 1996) and plants can thrive in soils containing several percent calcium (Valentinuzzi et al., 2015).

[1] Provisional results. These results are precise (i.e. relatively correct. Relative Standard Error <4%), however, accuracy (i.e. absolute value) to be revised.

Table 4: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 0-5 cm. Mean and standard error of the mean in brackets (n=20). The chemical parameters of the deeper profiles are given in Tables A-1 to A-4 (Appendix 1).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.54 (0.04)	5.66 (0.05)*	na	na
Carbon (%)	3.32 (0.10)	3.48 (0.10)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.33 (0.01) 17.6 (1.70) 5.9 (0.86)	0.35 (0.01)* 19.2 (1.69) 11.5 (1.51)*	na	na
Phosphorus (mg/kg) Olsen-P	1133 (36.3) 14.0 (1.17)	1261 (58.0)* 17.3 (2.71)	na	na
Potassium (mg/kg)	2340 (138)	2410 (124)	nd	nd
Sulphur (mg/kg)	<816 (75.7)	947 (66.5)	nd	nd
Calcium (mg/kg)	7145 (257)	7653 (355)	nd	nd
Magnesium (mg/kg)	7232 (910)	9941 (1577)	nd	nd
Copper (mg/kg)	16.0 (0.55)	19.3 (2.13)	<0.012 (0.004)	<0.046 (0.019)*
Manganese (mg/kg)	1159 (53.2)	1322 (115)	1.91 (0.16)	1.86 (0.41)
Zinc (mg/kg)	88.9 (3.30)	89.0 (3.37)	0.096 (0.012)	0.106 (0.017)
Contaminants				
Sodium (mg/kg)	705 (34.2)	>879 (52.6)*	nd	nd
Cadmium (ug/kg)	nd	nd	0.67 (0.05)	0.50 (0.05)*
Lead (ug/kg)	nd	nd	0.57 (0.17)	<1.21 (0.43)

na=not applicable

nd=not determined

* significant difference between treatments (p<0.05)

< actual mean is lower due to sample concentrations being below detection limit

> actual mean is higher due to samples concentrations being above measurement range

Sodium

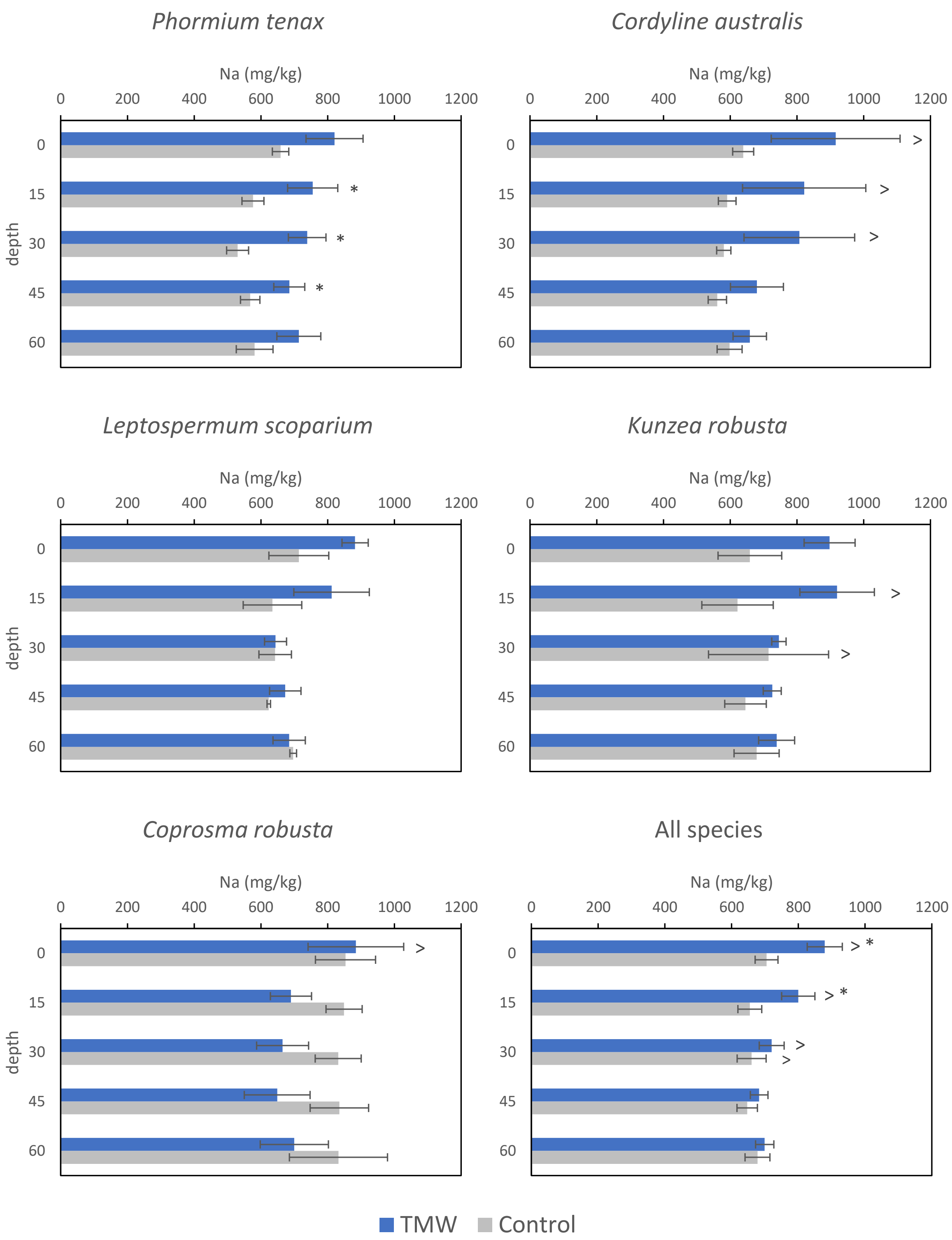

Figure 4: Soil sodium concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

pH

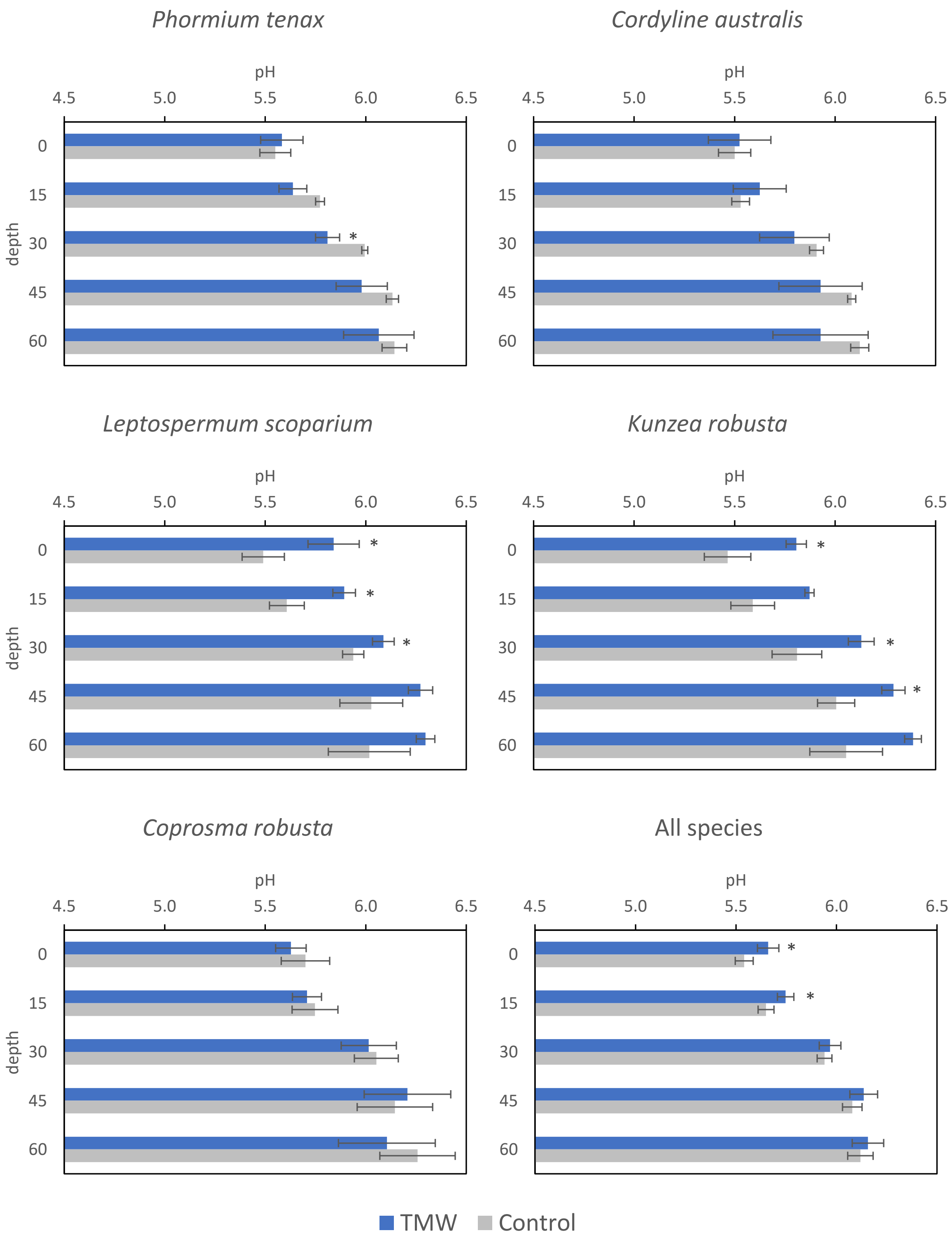

Figure 5: Soil pH under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Carbon and Nitrogen

Across all the plots, the application of TMW did not significantly change soil carbon (Table 4). In the *P. tenax* and *K. robusta* plots, there was a significant increase in soil carbon in the topsoil (Figure 6). This indicates that TMW application is not reducing soil organic matter, despite the potential for elevated nitrogen and phosphorus, applied with the TMW, to increase the oxidation of soil organic matter (McLaren and Cameron, 1996). We would expect there to be a decrease of soil carbon as grazed pasture is converted into forest (Scott et al., 2006). Such a decrease would occur with or without TMW application.

Irrigation with TMW increased soil nitrogen by just 6%, despite an application rate of 250 kg N/ha/yr equivalent (Figure 7). This may be due to increased plant uptake, and increased leaching, and increased denitrification due to increased soil moisture content (Clough et al., 2004) and high pH (SImek and Cooper, 2002) in the TMW irrigated plots. Overseas studies have shown that 25 - 150 kg/ha of applied nitrogen can be lost through denitrification (Paul and Zebarth, 1997; Mahmood et al., 1998). In New Zealand, studies with Dairy Shed Effluent reported that some 60 kg/ha/yr were lost through denitrification (Di and Cameron, 2000).

Soil ammonium concentrations were not significantly different in the TMW and control plots (Figure 8). However, TMW significantly increased soil nitrate concentrations (Table 4, Figure 9) in many of the soils. Higher nitrate is consistent with higher application rates of nitrogen through TMW and higher rates of nitrification caused by higher pH (Ste-Marie and Paré, 1999; Sahrawat, 2008). Nitrate concentration in the irrigated plots is highest in *K. robusta*, followed by *L. scoparium*. Any nitrogen that is added to the soil in the TMW will either be taken up by plants, denitrified into nitrogen gas or nitrous oxide (N_2O), or leached down through the soil profile as nitrate (Figure 10 and Appendix 2).

Just 1% of the applied nitrogen is expected to be emitted as nitrous oxide following TMW irrigation, indicating that 2.5 kg N_2O-N/ha/yr is emitted from the irrigated plots in Duvauchelle (van der Weerden et al., 2016). This is lower than nitrous oxide emissions from grazed pasture, which can be as high as 11.7 kg N_2O-N/ha/yr (Saggar et al., 2007).

Total Carbon

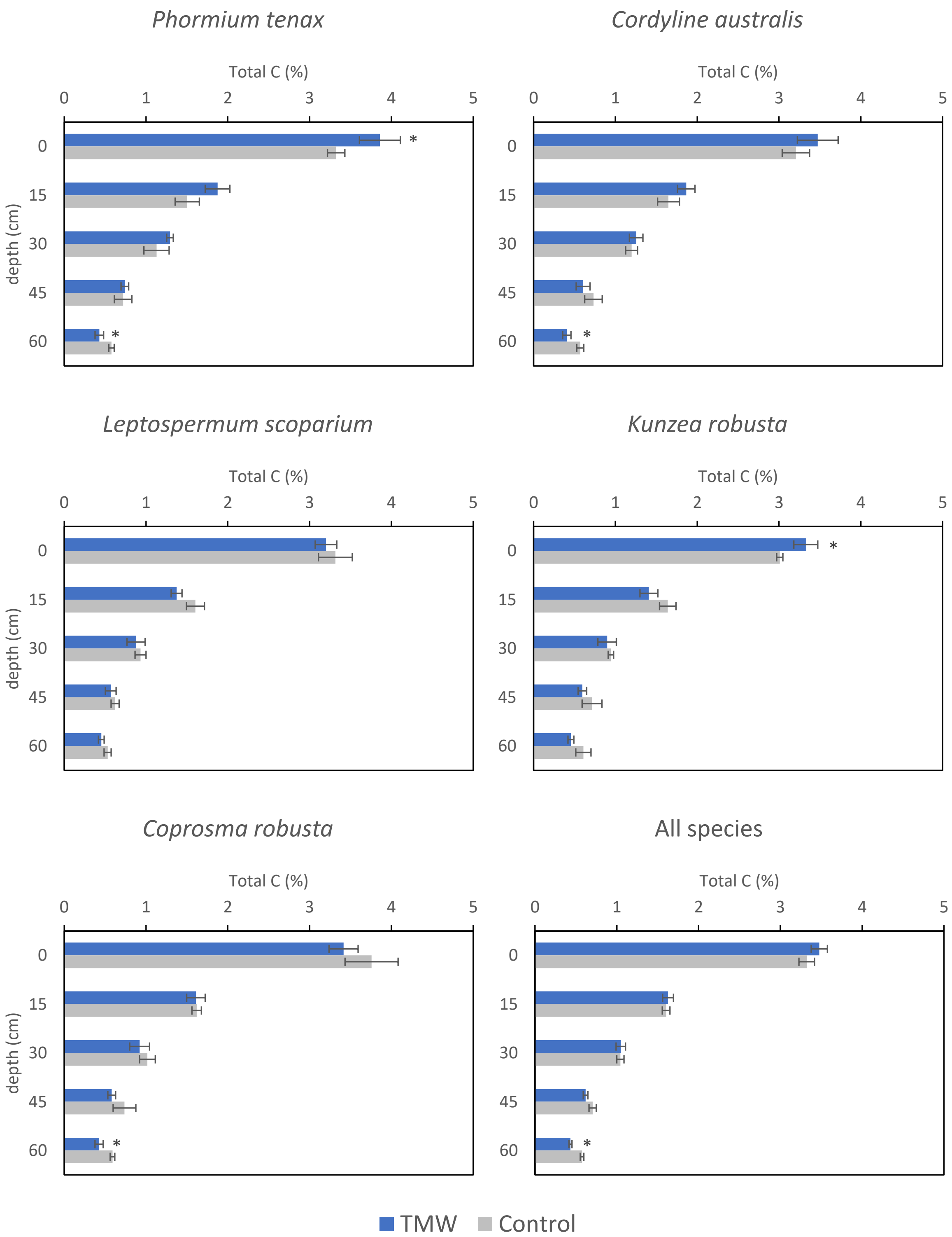

Figure 6: Soil total carbon concentration (%) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

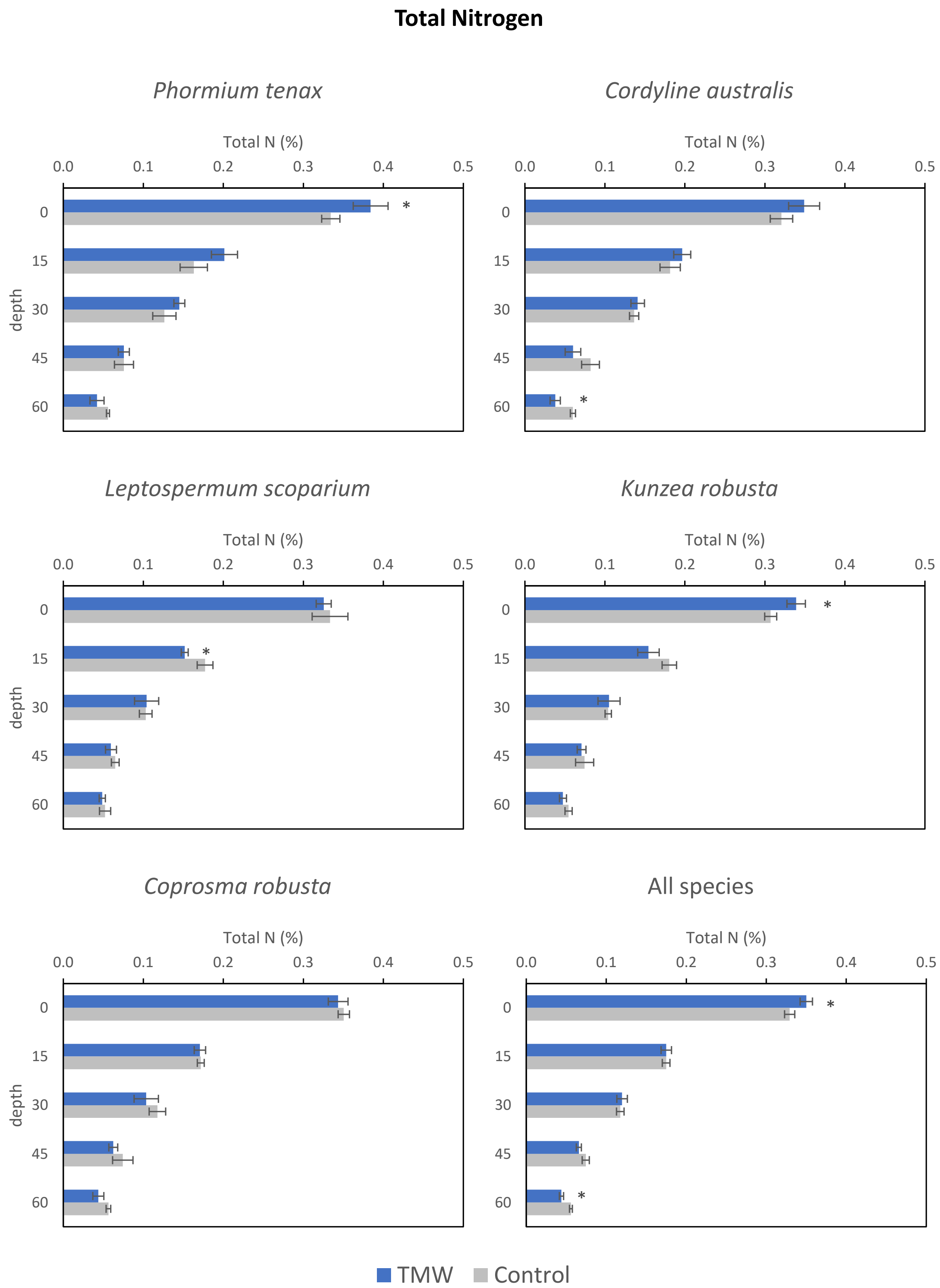

Figure 7: Soil total nitrogen concentration (%) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at $p<0.05$ indicated by (*).

Ammonium

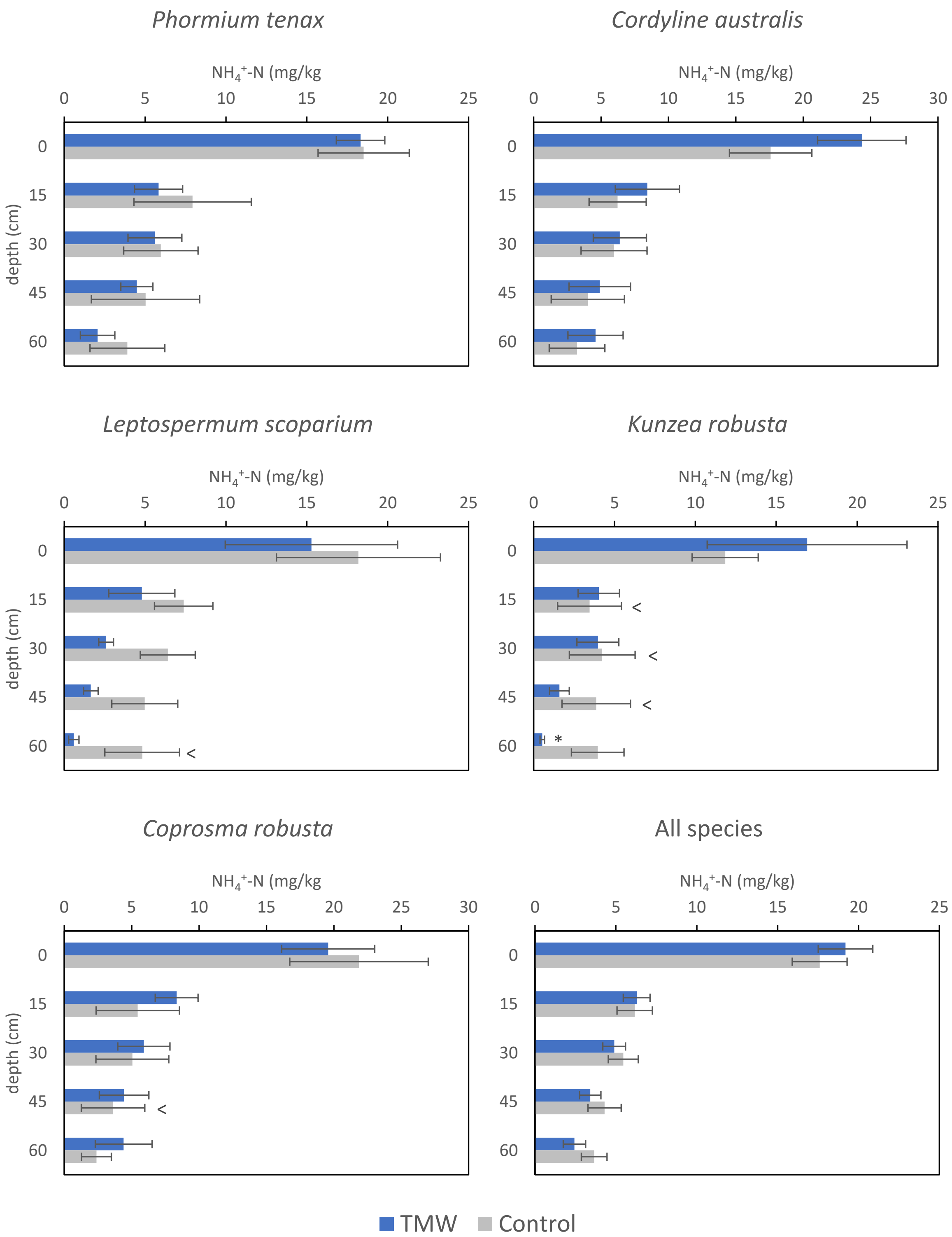

Figure 8: Soil ammonium concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Nitrate

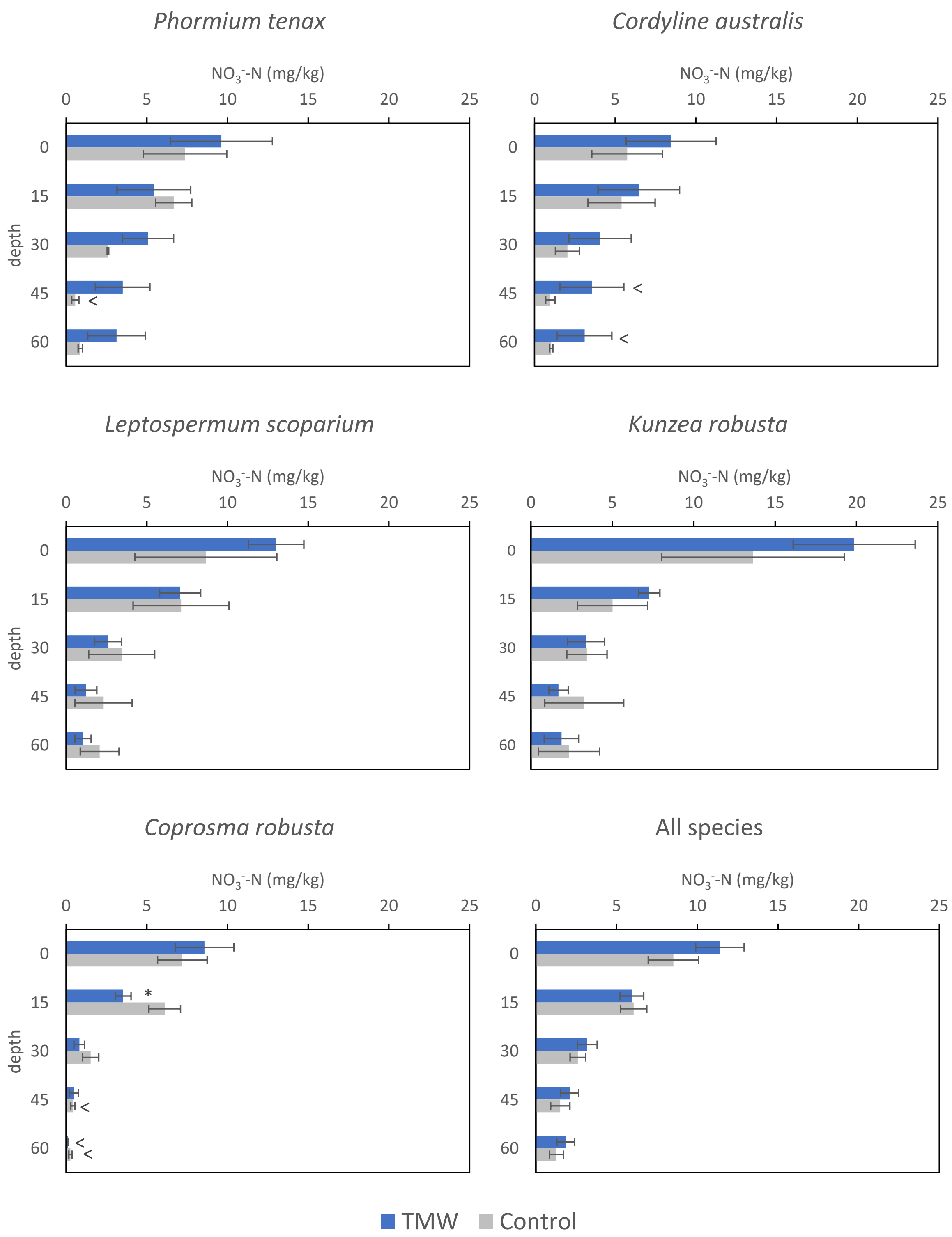

Figure 9: Soil nitrate concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

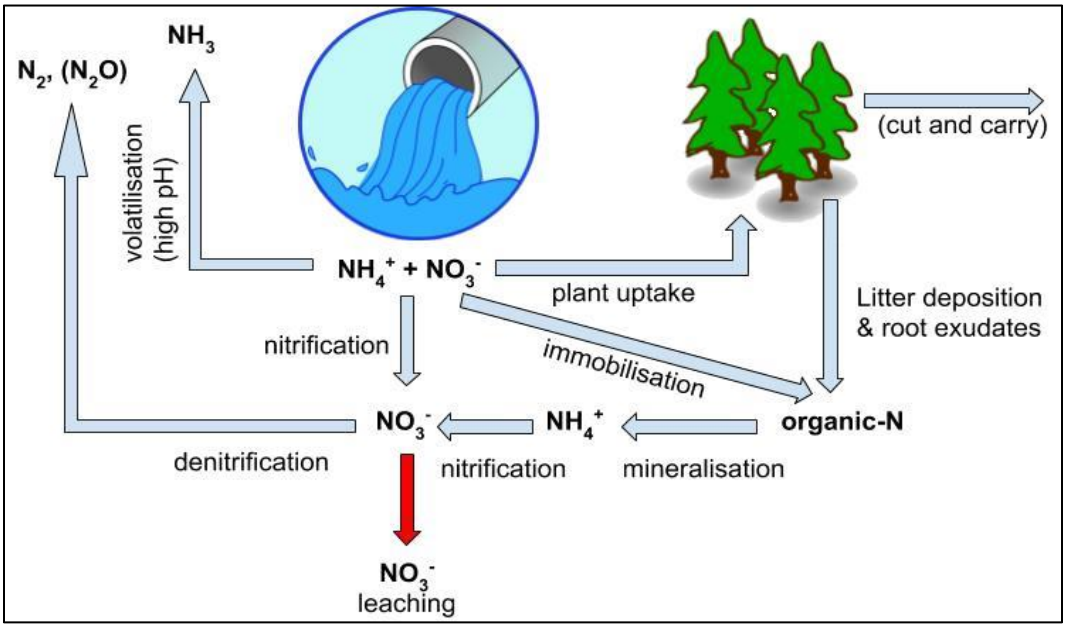

Figure 10: Nitrogen fluxes in irrigated systems (Meister et al. 2019, Appendix 2).

Nitrate leaching

Table 5 shows the calculated nitrate-nitrogen concentrations under the five species with and without TMW irrigation. These results (2 - 47 kg/ha) are lower than those estimated in our preliminary report (15 - 60 kg/kg). Overall, there was a 44% increase in nitrate leaching under the effluent-irrigated vegetation. These values are significantly greater than nitrate leaching that would occur under TMW irrigated cut-and-carry pasture (Gutiérrez-Ginés et al., 2020) and are similar to nitrate leaching rates that occur under grazed-pasture in conventional farming systems (Stats, 2019). There were significant differences between C. robusta and the other species: NO3- leaching was negligible (<4 kg/ha/yr). This may, in part, be due to the greatly accelerated growth of C. robusta under TMW irrigation (see section plant development). These results indicate that under a TMW irrigation rate of 500 - 800 mm/yr, nitrate leaching will be similar to grazed pasture.

Table 5: Mass of nitrate-nitrogen leached (kg/ha/yr equivalent) calculated from measurements taken in October/November 2018.

	Control	TMW irrigated
Phormium tenax	13.2	46.8
Cordyline australis	15.6	46.5
Leptospermum scoparium	31.1	15.7
Kunzea robusta	35.0	28.2
Coprosma robusta	4.04	1.59
All species	19.2	27.8

Phosphorus[2]

Irrigation with TMW caused a significant (11%) increase in the total phosphorus concentration in the topsoil (Table 4), although there was no significant difference when considering the whole soil profile (0-60 cm). This is because the amount of phosphorus added over the entire experimental period (312 kg) was small compared to the total phosphorus in the soil profile (7606 kg). The rate of accumulation is similar to that calculated using a model system for the potential Akaroa wastewater system (Appendix 3).

The strong adsorption of phosphorus in soil means that only a small part of the applied phosphorus is taken up by plants or leached (McLaren and Cameron, 1996). Therefore, in a TMW irrigated soil, phosphorus will accumulate, just as it does in all NZ soils that receive fertilizers. Under flax, where we observed higher levels of P down to 45 cm depth (Figure 11), preferential flow might lead to the percolation of TMW through the soil profile, and accumulation of phosphorus at greater depths (Gupta et al., 1999). Phosphorus can cause serious environmental issues when it enters waterways (Tilman et al., 2001). This could occur via runoff from a TMW-irrigated area, particularly if it was accompanied by soil erosion. However, no signs of runoff and increased erosion were observed in Duvauchelle. Phosphorus losses will be higher from grazed pasture (irrigated or otherwise) than TMW irrigated NZ-native vegetation due to the mechanical disturbance of soil by the animals (McDowell et al., 2009).

Only a small fraction of phosphorus in soil is available for plants, this is commonly measured by an extraction to give so-called 'Olsen-P' (Olsen, 1954). There were no significant differences in the concentrations of Olsen-P between the TMW-irrigated plots and the controls (Figure 12). This may be because the available P was being accumulated by the vegetation. Available phosphorus (Olsen-P) was within the range (10 - 30 mg/kg) typically found on extensive farming systems (Moir et al., 1997), and well below concentrations reported on soils irrigated with high-phosphorus effluent (Bickers 2005).

[2] Provisional results. These results are precise (i.e. relatively correct. Relative Standard Error <4%), however, accuracy (i.e. absolute value) to be revised.

Phosphorus

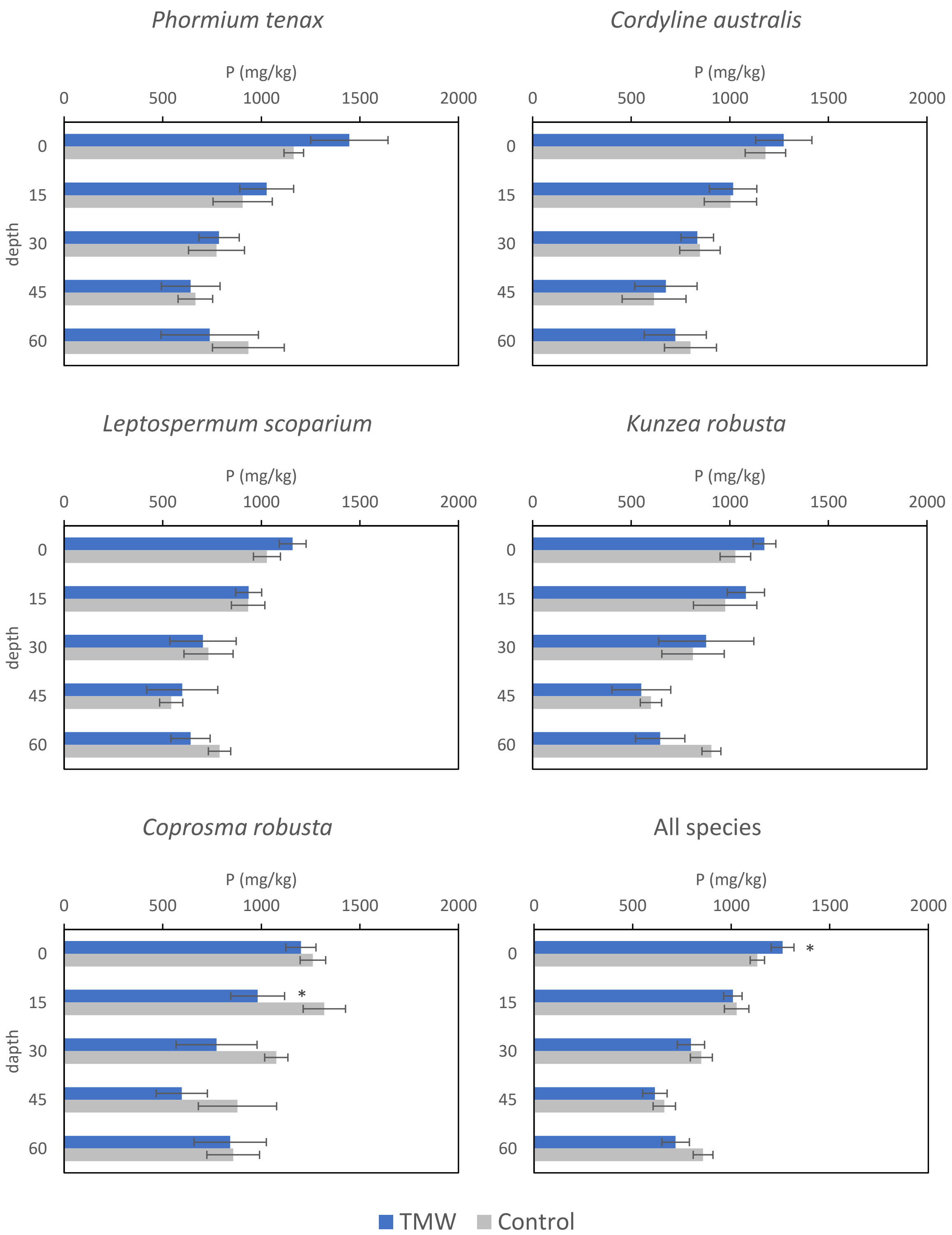

Figure 11: Soil phosphorus concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

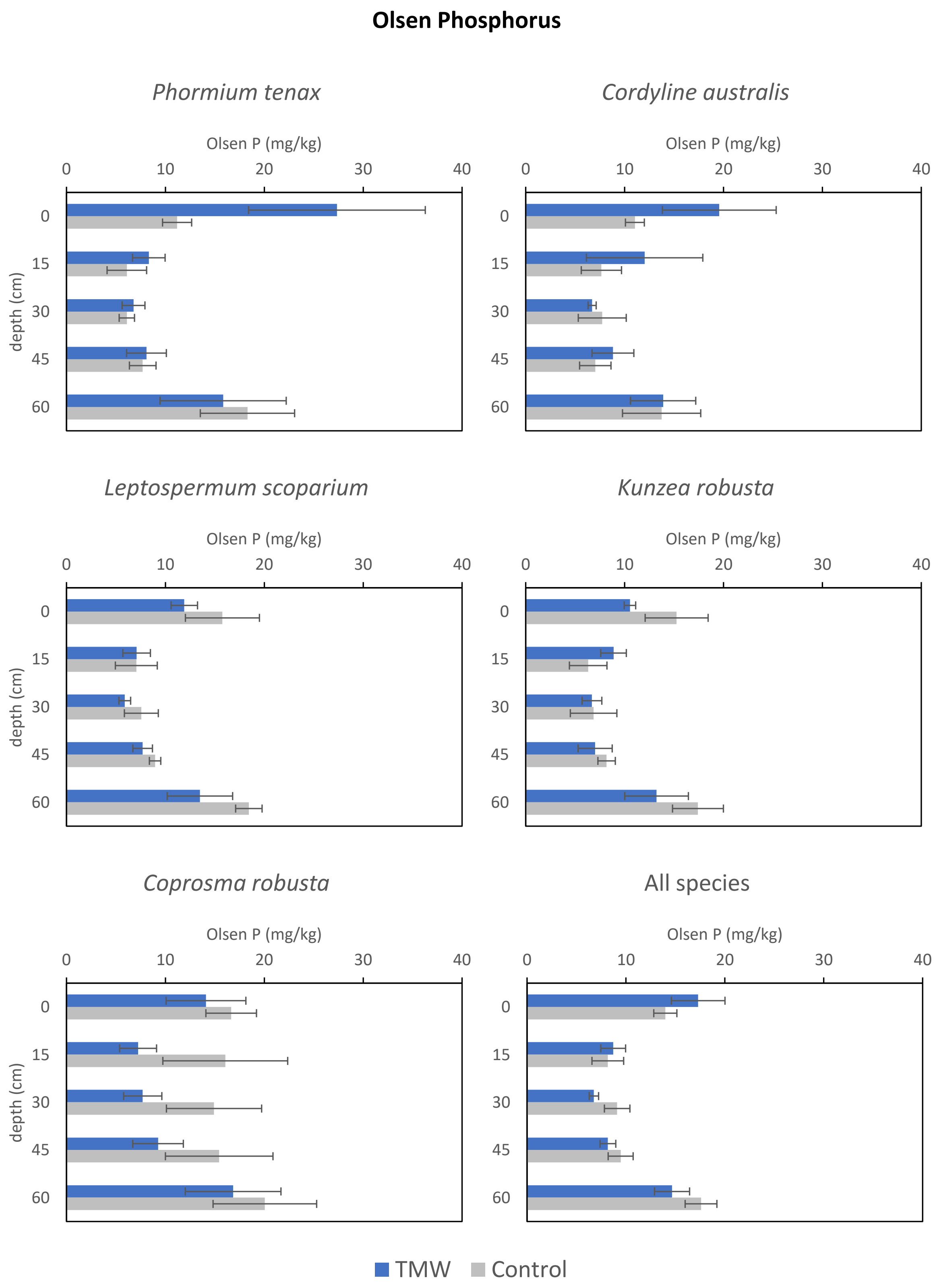

Figure 12: Olsen Phosphorus concentration (mg/kg) under different species. Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*)

Other elements

None of the other elements were significantly affected by the TMW application. Soil concentrations of copper, manganese and zinc were similar to the background concentrations reported for Canterbury soils (Percival et al., 1996). Similarly, with the soluble trace elements, there were few significant differences between the TMW irrigated plots and the controls. Only aluminium and chromium were significantly reduced by TMW application in the topsoil (0-5 cm, Table A-5, Appendix 1). Neither of these elements are essential for plant growth, and a reduction in soluble aluminium can benefit plant growth in acid soils (Jones, 1960). These results indicate that the accumulation of toxic heavy metals in soils receiving TMW as a nutrient source is likely to be less than soils receiving nutrients through mineral fertilizers (Taylor et al., 2016).

Plant development

Most of the plant deaths occurred shortly after planting and before the onset of TMW irrigation: the spring of 2015 was extraordinarily dry. During the first two years of growth (measured in May 2017), the application of effluent either had no effect on growth (*K. robusta, O. paniculata*, *G. littoralis, P. cookianum, P. eugenioides)* or significantly increased growth *(L. scoparium, C. robusta, P. arboreus, P. hallii, P. tenax, C. australis* (Figure 15).

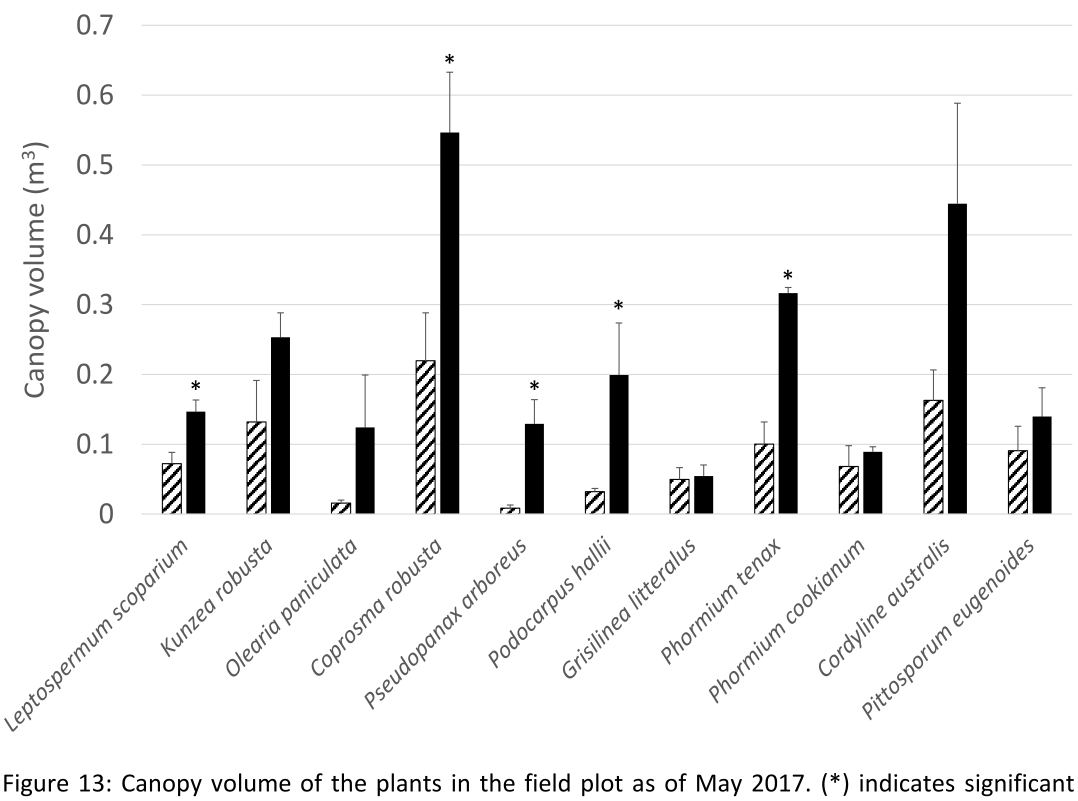

Figure 13: Canopy volume of the plants in the field plot as of May 2017. (*) indicates significant differences between the control (striped bars) and TMW (black bars), Gutierrez-Gines et al. 2017.

By autumn 2018, the canopy of the plants had closed (Appendix 4), eliminating the need to weed between the plants, although weeding occurred on the plot margins. The establishment of *Poa cita* in 2017, reduced the need to remove weeds between the plots and at the margins of the site. This species did not receive TMW. As of 2020, there was no indication of invasive weeds such as *R. fruticosus, S. mauritianum*, *S. dulcamara, P. octandra* or *C. vitalba* that may threaten the site. The weed burden may have been reduced by establishing the native trees into pasture, rather than into bare ground (for example if the site were sprayed-out before planting). In a full-scale planting operation, the plant spacing would likely be 5000 stems per hectare compared to the 20000 stems per hectare equivalent that was planted in the trial plot (to enable results to be obtained in a shorter time frame). At a lower planting density, weeding is likely required for at least another year.

In July 2019, there were 857 surviving plants on the site. The plants have begun to self-thin, i.e. smaller specimens are succumbing to competition from their larger neighbours. Across all species average height of the native vegetation receiving TMW (2.1 m) was significantly greater than the controls (1.9 m). Figure 14 shows the heights of the individual species. While all native species tolerated TMW irrigation (i.e. there were no significant decreases in height), there were significant differences between species.

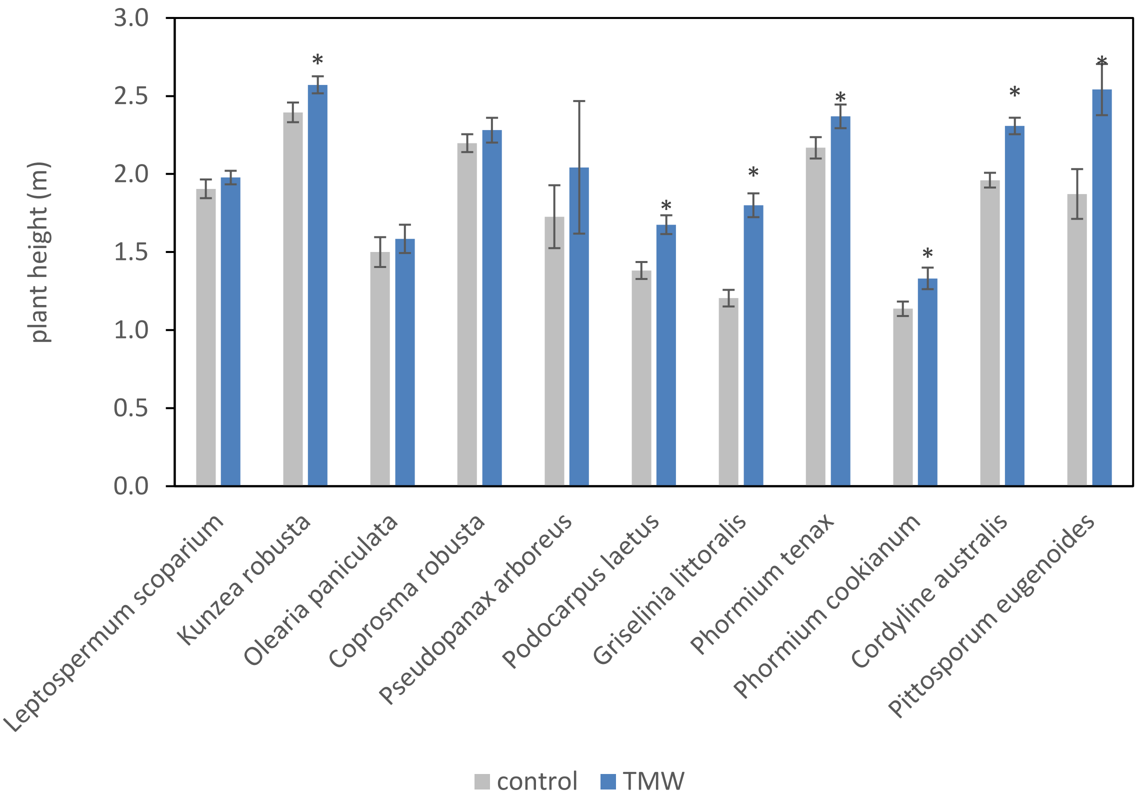

Figure 14: Plant height in July 2019 by species and treatment. Mean and standard errors of the mean.

Observations of individual species, however, indicate that *C. robusta, C. australis*, and *G. littoralis* performed particularly well at the site (Figure 15). In contrast, *L. scoparium*, *P. arboreus,* and *O. paniculata* were not well adapted to the site, with evidence of stress (chlorosis) or disease on trees in both the control and TMW-irrigated plots. In particular, *L. scoparium* has become infected with the common manuka-scale insect (*Eriococcus orariensis*) resulting in sooty-mould growth on the leaves (Figure 15). The survival of *L. scoparium* at this site is uncertain.

Figure 15: *C. robusta* (left), *C. australis* and *P. tenax* (middle) performed well at the site. *L. scoparium* (right) became infected with *E. orariensis,* resulting in the growth of sooty mould.

Plant elemental composition

There were no significant differences in plant-N concentration between the TMW-irrigated plots and the control plots, although there were significant differences between species (Figure 17). This indicates that nitrogen was the limiting factor for plant growth (Marschner, 1995). If nitrogen levels were sufficient, the plant nitrogen concentration would have increased due to luxury uptake (McLaren and Cameron, 1996). This is consistent with previous findings in a lysimeter study by Gutiérrez-Ginés et al. (2020) who measured pasture growth. This indicates that there will be no negative effects on the ecosystem by increased plant nitrogen, such as the biological food chain.

The phosphorus concentration increased in all plants following TMW application. This indicates that P was not limiting plant growth and that plants took up higher amounts of P following TMW application (luxury uptake). This is also consistent with findings by Gutiérrez-Ginés et al. (2020).

There were few other differences in the elemental compositions of the other plants (Table A-6, Appendix 1). Even sodium, which was significantly elevated in the soil, was unchanged by TMW irrigation. These results indicate that irrigating TMW onto NZ-native vegetation will not perturb nutrient status of the plants, nor introduce toxic elements into local ecosystems.

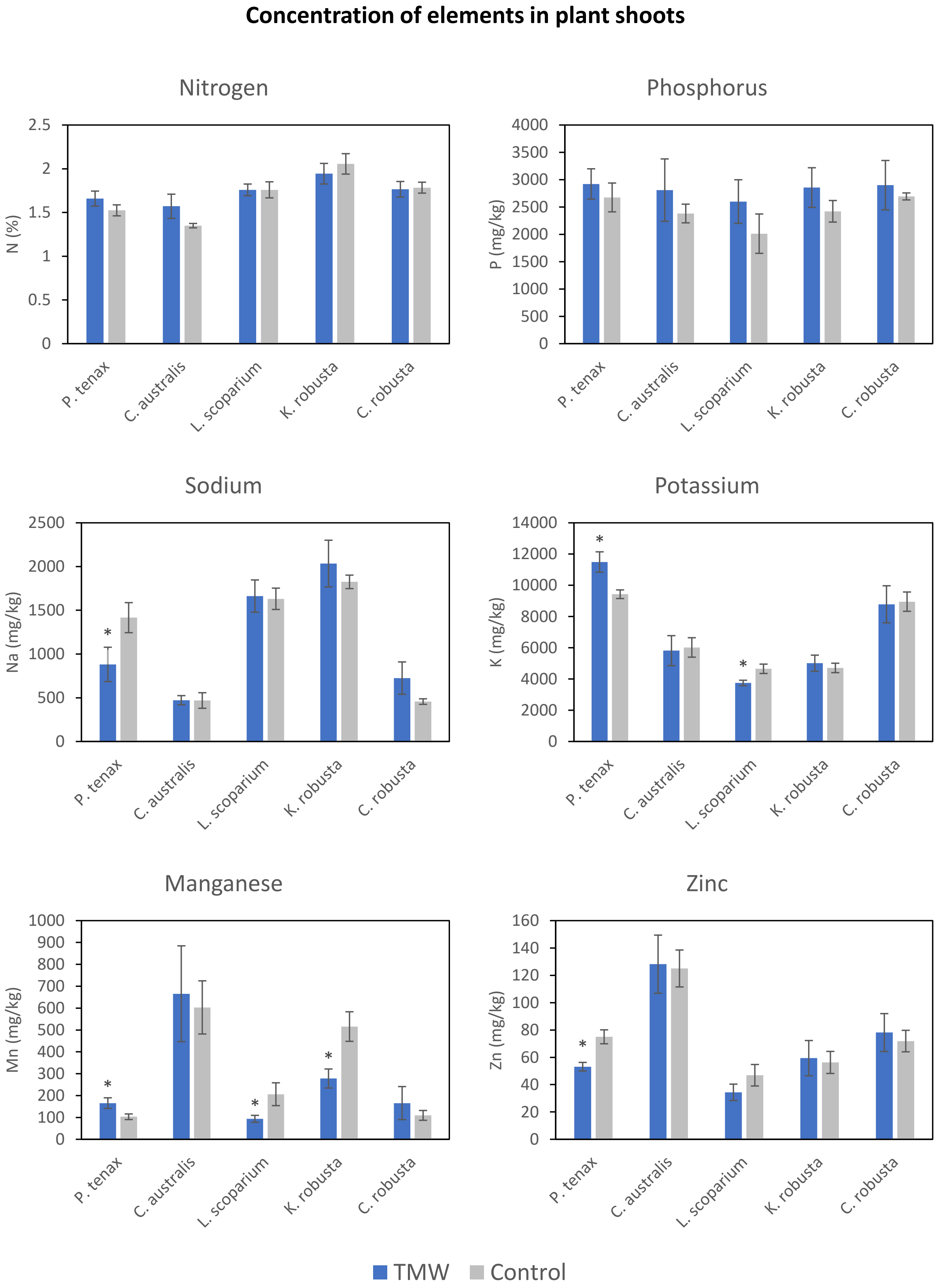

Figure 17: Concentration of elements in the plant shoot dry matter (mg/kg). Mean and standard error of the mean (n=4). Significant difference between treatments at p<0.05 indicated by (*).

Conclusions

The application of TMW to the Pawson Silt Loam on Banks Peninsula can occur at rates of at least 1000 mm/yr without significant soil degradation, accumulation of toxic elements, or induction of nutrient imbalances. However, we recommend a rate of 500 - 800 mm/yr, at least initially. The continual application of sodium may eventually result in depletion of soil calcium, which could be replaced by the occasional application of gypsum ($CaSO_4$). While there was a small increase in the total nitrogen concentration in the topsoil (0-5 cm), the total nitrogen in the TMW-treated plots was not significantly greater than the control plots. There was no evidence of phosphorus accumulation in the soil, probably because the amount of phosphorus added in the TMW was small compared to the mass of P in the soil profile. Available phosphorus (Olsen-P) was within the range typically found on extensive farming systems, and well below concentrations reported on soils irrigated with high-P effluent. Soil concentrations of potentially toxic heavy metals were not affected by TMW application. The concentrations of these elements were similar to background values reported for Canterbury Soils.

The effluent had a negligible effect on the concentrations of nutrients and contaminants in the plant tissues. While the growth of all species was accelerated by the effluent, there was no indication of luxury uptake of plant nutrients or increased concentrations of elements that may be harmful. This indicates that TMW is unlikely to affect ecological food chains.

None of the tested species showed reduced growth following TMW irrigation. However, some species were not well adapted to the site, including *L. scoparium*, *P. arboreus* and *O. paniculata*. In contrast, *C. robusta*, *C. australis* and *G. littoralis* performed particularly well at the site and showed accelerated growth under TMW irrigation compared to the control.

The critical success factor for establishing NZ-native vegetation are **species selection** and **weed control**. The trial at Pipers Valley Road has indicated the NZ-native species that respond well to TMW. These species should be selected for the majority of plantings on Banks Peninsula. Weed control should form part of the planting plan and include the contractors who will do the weeding. Planting into grass such as *Holcus lanthus* (Yorkshire Fog), has better outcomes than blanket spraying and planting into bare soil. Spot spraying may be appropriate. Close (1 m x 1 m, 10,000 stems/ha) plant spacing reduces the time that the site needs to be weeded but can reduce weeding options. Close planting is also more expensive. Compared to close planting, Lower density planting (e.g. 4000 stems per hectare) is less expensive to plant and to remove weeds, but weed control will be required for a longer period, adding to costs. A critical success factor is the appointment of a site manager who can monitor weeding and intervene as appropriate.

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Appendix 1: Supplementary data

Soil properties at 15, 30, 45 and 60 cm

Table A-1: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 15 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.65 (0.04)	5.75 (0.04)*	na	na
Carbon (%)	1.60 (0.05)	1.63 (0.07)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.17 (0.02) <6.16 (1.09) 6.06 (0.81)	0.17 (0.03) 6.29 (0.83) 5.95 (0.73)	na	na
Phosphorus (mg/kg) Olsen-P	1028 (62) 8.17 (1.60)	1009 (47) 8.71 (1.25)	na	na
Potassium (mg/kg)	2363 (131)	2475 (139)	nd	nd
Sulphur (mg/kg)	462 (58)	549 (52)	nd	nd
Calcium (mg/kg)	6787 (264)	7220 (411)	nd	nd
Magnesium (mg/kg)	7241 (959)	9378 (1443)	nd	nd
Copper (mg/kg)	15.1 (0.55)	17.7 (1.40)*	0.023 (0.007)	<0.011 (0.003)
Manganese (mg/kg)	1678 (120)	1821 (162)	1.06 (0.12)	1.18 (0.14)
Zinc (mg/kg)	81.5 (4.29)	72.8 (1.68)*	0.074 (0.013)	0.047 (0.005)*
Contaminants				
Sodium (mg/kg)	655 (36)	>800 (47)*	nd	nd
Cadmium (ug/kg)	nd	nd	0.53 (0.06)	0.49 (0.03)
Lead (ug/kg)	nd	nd	<0.90 (0.29)	1.11 (0.74)

na=not applicable
nd=not determined
* significant difference between treatments ($p<0.05$)
< mean is lower than reported value due to some sample concentrations being below detection limit
> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-2: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 30 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	5.94 (0.04)	5.97 (0.05)	na	na
Carbon (%)	0.20 (0.04)	0.26 (0.06)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.12 (0.00) <5.46 (0.93) 2.60 (0.49)	0.12 (0.01) 4.89 (0.70) 3.19 (0.61)	na	na
Phosphorus (mg/kg) Olsen-P	849 (56) 9.11 (1.29)	796 (42) 6.76 (0.47)	na	na
Potassium (mg/kg)	2386 (135)	2603 (173)	nd	nd
Sulphur (mg/kg)	258 (28)	388 (42)*	nd	nd
Calcium (mg/kg)	6790 (312)	6792 (287)	nd	nd
Magnesium (mg/kg)	7114 (897)	10103 (1600)	nd	nd
Copper (mg/kg)	13.0 (0.75)	14.0 (1.28)	<0.012 (0.004)	<0.009 (0.003)
Manganese (mg/kg)	1902 (172)	2027 (181)	0.52 (0.09)	0.68 (0.09)
Zinc (mg/kg)	70.1 (2.03)	69.6 (2.08)	0.066 (0.041)	0.024 (0.003)
Contaminants				
Sodium (mg/kg)	>660 (43.4)	>720 (37.3)	nd	nd
Cadmium (ug/kg)	nd	nd	0.32 (0.06)	0.30 (0.04)
Lead (ug/kg)	nd	nd	<0.51 (0.16)	<0.40 (0.11)

na=not applicable

nd=not determined

* significant difference between treatments ($p<0.05$)

< mean is lower than reported value due to some sample concentrations being below detection limit

> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-3: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 45 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	6.08 (0.22)	6.14 (0.31)	na	na
Carbon (%)	0.70 (0.04)	0.62 (0.03)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.07 (0.02) <4.30 (1.03) <1.51 (0.60)	0.07 (0.01) 3.41 (0.66) <2.09 (0.57)	na	na
Phosphorus (mg/kg) Olsen-P	661 (57) 9.46 (1.26)	613 (62) 8.18 (0.80)	na	na
Potassium (mg/kg)	2116 (109)	2505 (183)*	nd	nd
Sulphur (mg/kg)	166 (27)	254 (39)*	nd	nd
Calcium (mg/kg)	6178 (169)	6434 (303)	nd	nd
Magnesium (mg/kg)	7036 (712)	10833 (1709)*	nd	nd
Copper (mg/kg)	13.5 (0.79)	13.9 (0.91)	<0.016 (0.008)	<0.012 (0.003)
Manganese (mg/kg)	911 (93)	1177 (168)	0.14 (0.02)	0.24 (0.05)
Zinc (mg/kg)	63.6 (8.35)	52.7 (3.34)	<0.032 (0.015)	0.022 (0.009)
Contaminants				
Sodium (mg/kg)	647 (31)	683 (26)	nd	nd
Cadmium (ug/kg)	nd	nd	<0.10 (0.02)	0.11 (0.02)
Lead (ug/kg)	nd	nd	<0.66 (0.28)	<0.63 (0.21)

na=not applicable

nd=not determined

* significant difference between treatments (p<0.05)

< mean is lower than reported value due to some sample concentrations being below detection limit

> mean is higher than reported value due to some sample concentrations being above the measurement range

Table A-4: Soil properties of the irrigated and non-irrigated plots for the Duvauchelle field trial at 60 cm. Mean and standard error of the mean in brackets (n=20).

	Total		$Ca(NO_3)_2$-extractable	
	Control	TMW application	Control	TMW application
pH	6.12 (0.06)	6.16 (0.08)	na	na
Carbon (%)	0.58 (0.02)	0.43 (0.02)	na	na
Plant nutrients				
Nitrogen (%) Ammonium (mg/kg) Nitrate (mg/kg)	0.06 (0.00) 3.66 (0.79) 1.28 (0.43)	0.04 (0.00)* <2.44 (0.69) <1.85 (0.55)	na	na
Phosphorus (mg/kg) Olsen-P	857 (50) 17.6 (1.61)	718 (70) 14.7 (1.77)	na	na
Potassium (mg/kg)	1992 (100)	2225 (187)	nd	nd
Sulphur (mg/kg)	<125 (33)	181 (38)	nd	nd
Calcium (mg/kg)	5967 (164)	6217 (308)	nd	nd
Magnesium (mg/kg)	7618 (817)	11699 (1828)*	nd	nd
Copper (mg/kg)	15.1 (0.71)	15.1 (0.92)	<0.011 (0.003)	<0.023 (0.007)
Manganese (mg/kg)	731 (60)	849 (115)	<0.11 (0.02)	0.16 (0.04)
Zinc (mg/kg)	44.4 (4.40)	40.3 (3.25)	<0.016 (0.003)	<0.019 (0.005)
Contaminants				
Sodium (mg/kg)	678 (37)	699 (27.4)	nd	nd
Cadmium (ug/kg)	nd	nd	<0.06 (0.01)	<0.04 (0.01)
Lead (ug/kg)	nd	nd	<0.55 (0.15)	<1.03 (0.31)

na=not applicable

nd=not determined

* significant difference between treatments (p<0.05)

< mean is lower than reported value due to some sample concentrations being below detection limit

> mean is higher than reported value due to some sample concentrations being above the measurement range

Available elements in the topsoil (0-5 cm)

Table A-5: Concentration of $Ca(NO_3)_2$-extractable metals in topsoil (0-5 cm) under different species. Mean and standard error of the mean in brackets, n=4. Significant differences between treatments are expressed in %.

		P. tenax		*C. australis*		*L. scoparium*		*K. robusta*		*C. robusta*	
Al	W	495	(220)	742	(257)	146	(91.5)	137	(88.8)	452	(113)
	C	660	(213)	800	(145)	1085	(292)*	1076	(365)*	462	(142)
	%					-87%		-87%			
Cr	W	0.58	(0.39)	0.12	(0.02)	0.05	(0.01)	< 0.10	(0.06)	0.14	(0.03)
	C	0.10	(0.01)	0.16	(0.06)	0.16	(0.09)	0.25	(0.04)*	0.32	(0.20)
	%							-59%			
Mn	W	2150	(260)	2236	(412)	1203	(533)	1061	(414)	2300	(343)
	C	1612	(291)	1765	(262)	2329	(342)	1983	(437)	1949	(505)
	%										
Fe	W	32.1	(6.55)	26.3	(6.72)	16.8	(6.22)	15.3	(6.94)	24.8	(7.50)
	C	32.2	(4.43)	40.3	(2.51)	30.6	(7.52)	35.9	(8.34)	31.0	(11.9)
	%										
Co	W	4.84	(1.00)	5.51	(0.61)	3.11	(0.94)	2.78	(0.73)	5.23	(1.07)
	C	7.51	(2.30)	7.61	(1.23)	7.10	(1.10)	6.25	(1.48)	7.80	(2.84)
	%										
Ni	W	6.54	(1.48)	8.14	(0.93)	4.36	(2.17)	3.93	(2.21)	8.56	(1.31)
	C	7.63	(1.52)	9.00	(1.02)	9.75	(0.96)	8.73	(1.85)	6.96	(1.69)
	%										
Cu	W	91.8	(70.9)	< 14.8	(13.5)	92.7	(59.5)	< 25.7	(14.3)	9.60	(3.33)
	C	< 18.3	(12.5)	< 13.1	(5.97)	18.0	(14.2)	7.01	(3.55)	< 4.25	(2.62)
	%										
Zn	W	150	(46.1)	91.9	(9.15)	94.0	(29.7)	108	(83.4)	82.3	(12.8)
	C	117	(51.1)	83.7	(18.4)	107	(16.3)	85.9	(14.8)	90.5	(24.4)
	%										
As	W	0.48	(0.13)	0.38	(0.09)	0.41	(0.12)	0.31	(0.02)	0.33	(0.05)
	C	0.40	(0.07)	0.45	(0.09)	0.48	(0.04)	0.44	(0.12)	0.36	(0.07)
	%										
Cd	W	0.54	(0.12)	0.52	(0.12)	0.38	(0.13)	0.36	(0.13)	0.63	(0.13)
	C	0.62	(0.06)	0.68	(0.10)	0.71	(0.11)	0.67	(0.18)	0.67	(0.17)
	%										
Pb	W	0.77	(0.41)	< 0.69	(0.46)	3.53	(2.17)	< 1.04	(0.76)	0.55	(0.23)
	C	0.76	(0.61)	0.42	(0.28)	0.99	(0.61)	0.33	(0.13)	< 0.46	(0.20)
	%										

* significant difference between treatments ($p<0.05$)

< mean is lower than reported value due to some sample concentrations being below detection limit

Plant elemental composition

Table A-6: Element concentrations in plant shoots (mg/kg, unless stated otherwise). Mean and standard error of the mean in brackets, n=4.

	P. tenax		*C. australis*		*L. scoparium*		*K. robusta*		*C. robusta*	
	Control	TMW	Control	TMW	Control	TMW	Control	TMW	Control	TMW
Carbon (%)	46.5 (0.16)	45.9 (0.65)	47.0 (2.44)	45.6 (0.48)	52.0 (0.34)	40.4 (1.71)	50.3 (0.12)	50.4 (0.43)	46.1 (1.42)	43.5 (0.09)
Nitrogen (%)	1.52 (0.06)	1.66 (0.09)	1.35 (0.03)	1.57 (0.14)	1.76 (0.09)	1.76 (0.07)	2.06 (0.12)	1.94 (0.12)	1.78 (0.06)	1.77 (0.09)
Calcium	3038 (153)	6322 (3410)	12934 (1635)	12850 (1212)	5781 (581)	5878 (480)	4281 (652)	3403 296)	15391 (889)	12263 (4177)
Copper	13 (0)	21 (8)	17 (4)	17 (4)	17 (4)	19 (4)	17 (4)	19 (4)	13 (0)	16 (3)
Potassium	9428 (278)	9031 (652)*	6022 (622)	5816 (960)	4653 (300)	3747 (174)*	4709 (302)	5013 (516)	8953 (618)	8784 (1186)
Magnesium	7875 (255)	8575 (1089)	8391 (481)	8297 (801)	8794 (453)	8156 (407)	8366 (287)	7538 (688)	9009 (369)	8209 (682)
Manganese	103 (13)	166 (24)*	603 (122)	666 (219)	206 (52)	94 (16)*	516 (68)	278 (43)*	109 (22)	166 (76)
Sodium	1416 (172)	881 (196)*	469 (89)	472 (53)	1631 (122)	1663 (185)	1825 (77)	2034 (267)	456 (32)	725 (185)
Phosphorus	2675 (263)	2922 (277)	2381 (171)	2809 (570)	2013 (360)	2600 (399)	2422 (197)	2856 (362)	2694 (64)	2900 (451)
Sulphur	5441 (1359)	6169 (1989)	5591 (1230)	6231 (1654)	6053 (988)	4391 (1346)	6113 (1024)	4678 (1280)	5747 (836)	5878 (1352)
Zinc	75 (5)	53* (3)	125 (14)	128 (21)	47 (8)	34 (6)	56 (8)	59 (13)	72 (8)	78 (14)

* significant difference between treatments ($p<0.05$)

Appendix 2: Nitrogen report

Impacts of nitrogen application to Pasture and Native Plantings on Banks Peninsula

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Executive summary

- Based on effluent flow-rate data, effluent chemistry, and the land available for irrigation, the nitrogen (N) application rate in Robinsons Bay would be 125 - 172 kg N/ha/yr, which is below the threshold of 200 kg/ha/yr set by many jurisdictions in New Zealand and overseas.
- Applied N will either accumulate in the soil (which is environmentally benign), be removed in the vegetation, be denitrified into nitrogen gas or nitrous oxide, or leach into groundwater.
- Irrigation of the Treated Municipal Effluent (TMW) onto cut-and-carry pasture is likely to result in negligible (<2 kg/ha/yr) nitrate leaching. Experiments have demonstrated that the pasture will remove nearly all of the N that is applied.
- Irrigation of TMW onto grazed pasture will have similar nitrate leaching to a regular grazed pasture where fertiliser has been applied.
- Preliminary data indicate that Irrigation of TMW onto NZ native vegetation will result in nitrate leaching of 15 - 60 kg/ha/yr, similar to grazed pastures. These figures will change as data from experiments in Pipers Valley come to hand. This is expected in early 2020.
- Species selection and weed control are the critical success factors for establishing NZ native vegetation under TMW irrigation.

Introduction

Nitrogen (N), in the form of ammonium (NH_4^+) or nitrate (NO_3^-), is the most important plant macronutrient in soil. Other forms of N, such as nitrogen gas (N_2) and organic N are not available to plants and must be converted to available forms by biological processes (McLaren and Cameron, 1996). New Zealand agriculture relies on N supplementation to soil, via fertilisers (mainly urea), soil conditioners (such as compost), or N-fixation from legumes such as clovers.

While N addition usually improves plant growth, excessive N application can lead to NO_3^- leaching through the soil profile where it may contaminante surface waters or groundwater (Martin et al., 2017). Elevated N application may also result in increased emissions of nitrous oxide (N_2O), a greenhouse gas with a global warming potential some 300 times greater than carbon dioxide (Taghizadeh-Toosi et al., 2011). High concentrations of NO_3^- in drinking water can be harmful to human health, particularly infants (Knobeloch et al., 2000), while elevated NO_3^- concentrations in aquatic or marine ecosystems can exacerbate eutrophication (de Jonge et al., 2002). The New Zealand Drinking Water Standard for NO_3^- is 11.3 mg/L NO_3-N (Di and Cameron, 2000). The Australian and New Zealand Guidelines (NIWA, 2013) for NO_3^- in freshwater range from 1 mg/L NO_3^--N for pristine environments with high biodiversity and conservation values (99% species protection) through to 6.9 mg/L NO_3^--N for environments which are measurable degraded (80% species protection).

Treated Municipal Wastewater (TMW) contains agronomically significant concentrations of N, making it a potential fertiliser replacement but also a potential source of groundwater or surface water contamination. When irrigated onto soil, this N undergoes biologically and chemically-mediated cycling (Fig. 1). Ultimately, the applied N leaves the soil via plant uptake (and removal of the harvested or grazed biomass), volatilisation as N_2 or N_2O, or leaching (as NO_3^-). The amount of NO_3^- leaching or N_2O emissions from an area irrigated with TMW depends on the irrigation rate, the N-concentration in the TMW, the climatic conditions, and the land use.

This report aims to determine the likely effect of TMW irrigation on growth of NZ-native vegetation, grazed pasture, and cut-and-carry pasture on 35 hectares of irrigable land from the Thacker farm, Banks Peninsula. The production rate and chemistry of the TMW was provided by the Christchurch City Council. The soil properties, pasture uptake rates were assessed in a previous report (Robinson et al., 2017) as well as data from an ongoing field trial in Pipers Valley, Duvauchelle. At the time of writing (August 2019), we are awaiting the final results of N-fluxes from the field trial, which is due to conclude in December 2019. As such, we will amend this report with the results of the field trial as they come to hand.

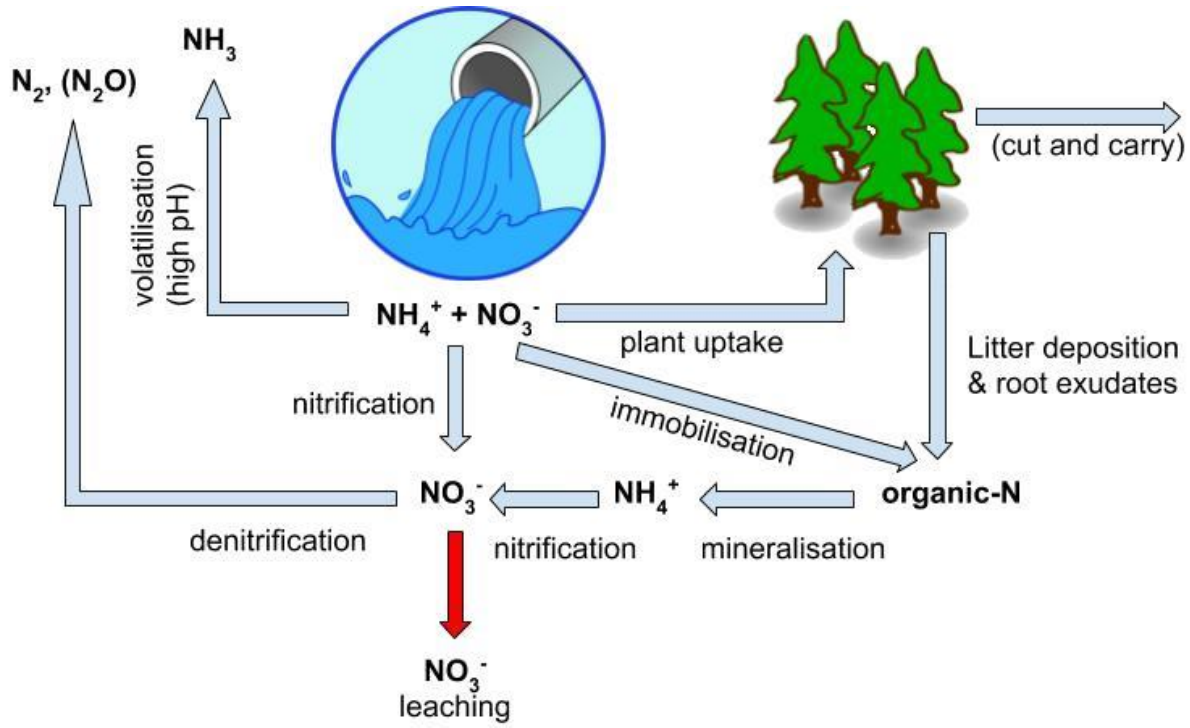

Fig. 1. Nitrogen fluxes following the application of Treated Municipal Wastewater to soil. This diagram assumes that the Wastewater has been treated to a high standard (such as is the case on Banks Peninsula) and the concentration of dissolved organic matter (and organic N) is low.

Nitrogen in the Treated Municipal Wastewater and nitrogen application rates

TMW from Duvauchelle and Akaroa (Feb 2017 - Feb 2019) had average total N concentrations of 18.5 and 25.4 mg N/L, with standard deviations of ca 7.5 mg/L in both cases. At the time of measurement, some 50% of the N was present as NH_4^+, with the remainder mostly comprising NO_3^-. However, the NH_4^+ is rapidly oxidised to NO_3^- in the environment or when the effluent is stored. (Clough et al., 2001). Once irrigated onto soil, any N added that is not taken up by plants will either oxidise to NO_3^- thence be denitrified back to N_2 (or N_2O) gas, become immobilised into soil organic matter, or leach into groundwater (Fig. 1). The rate of application affects the fate of N, with higher application rates resulting in increased N-leaching and potentially increased N_2O emissions. The likely N application rates on Banks Peninsula are 125 - 172 kg N/ha/yr shown in Table 1. These values are below the 200 kg/ha/yr threshold, which is set by many jurisdictions (Clark and Harris, 1996).

Table 1. Annual nitrogen Application (kg N/ha/yr) as a function of irrigation rate and effluent N concentration, given the area of potentially irrigable land in Robinsons Bay is some 35 ha (Barton, 2017). The likely irrigation rate is 678 mm/yr, resulting from an effluent flow rate of 650 m^3/day.

	TMW @ 18.5 mg N/L	TMW @ 25.4 mg N/L
Irrigation 500 mm	92.5	127
Irrigation 678 mm	**125**	**172**
Irrigation 1000 mm	185	254

Nitrate leaching under cut-and-carry pasture, grazed pasture and NZ - native vegetation

Previous research using lysimeter experiments on Banks Peninsula soil (Robinson et al., 2017) has shown that under cut-and-carry pasture, these irrigation rates resulted in negligible NO_3^- leaching (<1 kg N/ha/yr), even at application rates of 207 kg N/hr/yr equivalent. Compared to the previous lysimeter experiments, the groundwater at Robinsons Bay is deeper (at least 4 m (Barton, 2017), which will result in more denitrification of the applied N, thereby reducing N-leaching. However, this effect may be offset by the greater precipitation (ca. 1000 mm/yr) on the peninsula compared to the 660 mm/yr that fall at the Lincoln University lysimeter facility. Even with a small increase in drainage caused by high rainfall events on Banks Peninsula, it is likely that cut-and-carry pasture on the Thacker Farm receiving TMW will have negligible N-leaching.

In contrast to TMW-irrigated cut-and-carry systems, grazed pastures over much of the Canterbury Plains and small parts of Banks Peninsula typically leach >45 kg N/ha/yr (Stats, 2019). If the TMW-irrigated pasture were used for grazing, it is likely that the N-leaching rates would be similar to those of a non-TMW-irrigated pasture where N-fertiliser had been applied.

New Zealand native plant species have an N concentration of 0.8 - 2% (dry weight), which is significantly less than pasture, which can have up to 5% N (Dickinson et al., 2015). Given a dry biomass production under optimal conditions (i.e. under TMW-irrigation) of 5 t/ha/yr, native plants containing 1% N would remove 50 kg N/ha/yr. This is significantly less than the N being applied to the soil. Moreover, unless the vegetation is removed periodically, the N accumulated in the plants will eventually be returned to soil via leaf-fall and tree senescence (and subsequent decomposition of dead material). After the accumulation of N in soil via immobilisation, additional N will be lost via leaching or denitrification. Overseas studies have shown that 25 - 150 kg/ha of N applied N can be lost through denitrification (Paul and Zebarth, 1997; Mahmood et al., 1998). In New Zealand, studies with Dairy Shed Effluent reported that some 60 kg/ha/yr were lost through denitrification (Di and Cameron, 2000). Evidence of iron mottling in the soil profile in Robinsons Bay (Barton, 2017), indicates low-oxygen conditions that favour denitrification (Clough et al., 2001). Any N that is not removed by the biomass, fixed into soil organic matter or denitrified, will leach. Given the current data, we estimate that leaching under NZ-native vegetation under nominal conditions will be 15-60 kg N/ha/yr at Robinsons Bay, which is comparable to grazed pasture (Stats, 2019). A more accurate assessment of the likely N-leaching under NZ-native vegetation will be provided in an update report in Early 2020.

Establishing NZ native vegetation under Treated Municipal Wastewater irrigation

Irrigation with TMW significantly increases the growth of pasture and some exotic plants (Esperschuetz et al., 2016; Robinson et al., 2017). The response of NZ-native vegetation is species-dependent: while many species show significantly increased growth when irrigated with TMW, other species are unaffected or may even have lowered growth. The field trial in Pipers Valley has indicated that *Leptospermum scoparium* (mānuka), *Kunzea robusta* (kānuka), *Coprosma robusta* (karamu), *Cordyline australis* (cabbage tree), *Phormium tenax* (harakeke, flax) respond well to TMW irrigation with significantly increased growth over the four-year trial. In contrast *Griselinia littoralis* (kapuka, broadleaf)*, Phormium cookianum* (mountain flax)*, and Pittosporum eugenioides* (tarata, lemonwood) have no positive growth response. The contrasting responses of NZ-native species can result in increased weed competition during the establishment phase.

The critical success factor for establishing NZ-native vegetation are **species selection** and **weed control**. The trial at Pipers Valley Road has indicated the NZ-native species that respond well to TMW. These species should be selected for the majority of plantings in Robinsons Bay. Weed control should form part of the planting plan and include the contractors who will do the weeding. Planting into grass such as *Holcus lanthus* (Yorkshire Fog), has better outcomes than blanket spraying and planting into bare soil. Spot spraying may be appropriate. Close (1 m x 1 m, 10,000 stems/ha) plant spacing reduces the time that the site needs to be weeded but can reduce weeding options. Close planting is also more expensive. Compared to close planting, Lower density planting (e.g. 1 m x 3 m, 3333 stems per hectare) is less expensive to plant and to remove weeds, but the weeding will have to continue for several more years. A critical success factor is the appointment of a site manager who can monitor weeding and intervene as appropriate.

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Appendix 2: Phosphorus report

Phosphorus in Treated Municipal Wastewater irrigated onto NZ-native vegetation

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Executive summary

- Potentially, irrigating Treated Municipal Wastewater (TMW) onto NZ-native vegetation could result in the accumulation of phosphorus (P) in the soil to the point that the soil becomes infertile and excess P degrades local waterways. The Christchurch City Council commissioned the University of Canterbury to determine acceptable levels of P in TMW that is to be applied to NZ-native vegetation.

- An assessment was made using calculations of the likely effects of adding TMW on soil P concentrations and P losses that could lead to waterway degradation. These results of these calculations were compared with literature reports of the effects of soil P on soil fertility and P-losses. Note that the P concentration in TMW from the Akaroa wastewater treatment plant has a median P concentration of 6.6 mg/L and a maximum of 8.4 mg/L.

- Calculations revealed that irrigating 500 mm/yr of TMW containing either 5, 10 or 15 mg/L P would result in P accumulation in the soil. This is because P losses through vegetation removal, leaching, and runoff from TMW-irrigated native vegetation, are negligible compared to the P that is added to the soil.

- Over a 50-year period, the concentrations of soil P in the Pawson Silt Loam and Barry's Soil receiving 500 mm/yr of effluent containing 10 mg/L would increase by 84% and 100%, respectively. Nevertheless, even with these increases, the 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.

- In the aforementioned scenario, Olsen-P, a measure of plant-available P, would also 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). The increase in Olsen-P may be unfavourable for some NZ-native species, however, there are many other NZ-native species that will thrive under these high-P conditions. This indicates the importance of plant-selection for any treatment system.

- In the aforementioned scenario, there would be an increase in the amount of P-leaching below the top 0.3m of topsoil to around 2.2 kg/ha/yr after 50 years of application. 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 under TMW-irrigated NZ-native vegetation than an intensively-grazed pasture.

- Estimations using these calculations indicate that the application of 50 kg P/ha/yr with TMW is unlikely to cause serious soil fertility or environmental issues over a 50-year period. The life of the system could be extended using lower rates of P addition or by periodically harvesting the native vegetation.

Introduction

Treated Municipal Wastewater (TMW) contains environmentally significant concentrations of plant nutrients, including phosphorus (P). While the application of P to soil can improve plant growth (McLaren and Cameron 1996), excess P is can accumulate in soil where it may become toxic to plants (Hawkins et al. 2008). High concentrations of P in soil can increase the chance that this element can enter waterways via runoff, erosion or to a lesser extent, leaching (McDowell and Condron 2004). Elevated levels of P in waterways exacerbate eutrophication, including the uncontrolled growth of aquatic macrophytes and algae (Tilman et al. 2001).

Phosphorus is routinely added to agricultural soil in NZ. Most soils require more P to be added than is removed by plants, because much of the added P becomes immobilized and unavailable for plant uptake (McLaren and Cameron 1996). Measuring the total P in soil is a poor indicator of the P-availability to plants or P that is likely to leach into waterways, because only a fraction of the total P in soil is mobile and available to plants. Plant availability is often indicated by measurements using a mild chemical extractants. In New Zealand and elsewhere, 'Olsen-P' provides good information on the plant-availability of P in a soil (LandcareResearch 2017). Similarly, extractions using calcium chloride ($CaCl_2$), indicate the concentration of P in soil solution, which has the potential to leach through the soil profile (Sanchez-Alcala et al. 2014).

To convert a low-fertility soil, such as a forest soil, into productive pasture, a large application of P, 'capital P', is required. This can be as much as 500 kg P/ha (Dollery 2017). Thereafter, 'maintenance P' is applied, depending on the land use, usually between 5 and 40 kg P/ha/yr (McLaren and Cameron 1996). The application of P from TMW can be higher than that, which would be applied from P fertilisers. For example, the application of 500 mm/yr TMW from the Duvauchelle wastewater treatment plant, which contains an average of 11 mg/kg P(Gutierrez-Gines, McIntyre, et al. 2017) is the equivalent of 55 kg P/ha/yr. The P concentration in TMW from the Akaroa wastewater treatment plant has a median P concentration of 6.6 mg/L and a maximum of 8.4 mg/L. Irrigating 500 mm/yr of TMW from Akaroa would add 33 kg P/ha/yr.

While a significant amount of P that is added to agricultural soil is removed in the produce, the application of P to NZ native vegetation, where no plants are removed, will result in an accumulation of P in the system. This may result in toxicity to plants and or environmental degradation.

This report aims to determine the likely rate of P accumulation, P toxicity, and P mobility, resulting from the irrigation of TMW onto native vegetation on Bank's peninsula.

To assess these aims, the effects of irrigating 500 mm of TMW onto two Bank's Peninsula soils, the Pawson Silt Loam (PSL), 43°45'8.78"S 172°56'35.55"E and Barry's Soil (BSL), 43°44'53.06"S 172°55'41.44"E, also a silt loam, were estimated using mass balance calculations. These calculations used data from the PSL, BSL reported in (Gutierrez-Gines, McIntyre, et al. 2017) as well as other unpublished data from ongoing investigations. It was assumed that the amount of P removed in the NZ native vegetation was negligible. The calculations were run over a simulation period of 50 years. Other parameters used in the calculations are given in the Table.

The calculations assume that there is negligible runoff and erosion under the native vegetation because (a) the TMW would only be irrigated onto gently sloping land (<15^{o} for pasture and <19^{o} for NZ-native vegetation), (b) tree roots stabilize the soil, mitigating soil loss (Robinson et al. 2009), and (c) increase infiltration and preferential flow around the tree roots mitigate overland flow (Knechtenhofer et al. 2003; Sidle et al. 2006).

Table. Parameters used in the mass balance calculations for P application to NZ native vegetation on two soil types on Bank's Peninsula

	Pawson Silt Loam (PSL)	Barry's Soil (BSL)
Effluent P concentration (mg/L)	5, 10 or 15	5, 10 or 15
Effluent application rate (mm/yr)	500	500
P application rate (kg/ha/yr)	25, 50, or 75	25, 50, or 75
[1]Water flux (mm)	800	800
[2]Initial soil P concentration (mg/kg)	1046	599
[3]Olsen-P (mg/kg)	39	9
[4]Water soluble P ($CaCl_2$) (mg/L)	0.18	0.04
[2]Soil density (t/m^3)	1.4	1.4
Simulation depth (m)	0.3	0.3

[1]Estimated from rainfall (922 mm/yr) + TMW irrigation (500 mm/yr) – evapotranspiration (ca. 622 mm/yr)
[2]Measurements from (Gutierrez-Gines, McIntyre, et al. 2017)
[3]Unpublished data, Lincoln University
[4]Estimated from ratios with Olsen-P on similar soils from McDowell and Condron (2004) and Sanchez-Alcala et al. (2014).

Fig. 1 shows the results of these calculations. Under the nominal case of irrigating 500 mm/yr of TMW containing 10 mg/L P, over a 50-year period the total P concentration in the top 0.3 m will increase from 1046 to 1624 mg/kg in the PSL and from 599 to 893 mg/kg in the BSL. Even with this increase, the total concentration at the end of the 50-year period is still well within the range of P concentrations reported for NZ agricultural soils reported by McDowell and Condron (2004) and Reiser et al. (2014). It should be noted that the concentrations calculated here are averages and due to the highly heterogeneous nature of flow pathways in a forested soil (Knechtenhofer et al. 2003), it is likely that there will be localized areas with significantly higher concentrations. Gutierrez-Gines, McIntyre, et al. (2017) reported no significant increases in total soil P in a lysimeter experiment following the application of 2375 mm of TMW containing 11 mg/L P, probably because the total increase in P was within the measurement error and because of heterogeneity in the system.

In the nominal case, the plant-available or 'Olsen P' in these soils is likely to increase from 39 to 61 mg/kg in the PSL and increase from 9 to 14 mg/kg in the BSL. The initial Olsen-P concentration in the PSL is within the range (35-40 mg/kg) recommended by Dairy NZ to maintain high productivity on sedimentary soils (DairyNZ 2018). This is undoubtedly a result of good soil management under previous land use, grazed pasture. In contrast, the BSL, with an initial Olsen-P concentration of 9 mg/L is consistent with non-productive but managed land, in this case a golf course. Even with an increase to 14 mg/kg, the plant-available P would only be sufficient for low P-requiring crops such as for winter wheat (Tang et al. 2009). For pasture, Olsen-P values above 100 are excessive and values are considered 'high' from 50 – 100 (LandcareResearch 2017).

It is likely that the high plant-available P concentration on the PSL would inhibit the growth of some NZ-native species that are adapted to a low-P environment. LandcareResearch (2017) reports that for native vegetation, Olsen-P values of 8-12 mg/kg is considered high and 12 – 15 mg/kg is excessive. However, there are many reports that some NZ-native species can thrive with Olsen-P values manifold higher e.g. Gutierrez-Gines, Robinson, et al. (2017) and Reis et al. (2017). Indeed, 11 species of native plants are thriving on the very same PSL (with an initial Olsen-P of 39 mg/kg), which has received TMW for nearly 3-years (Figure 2).

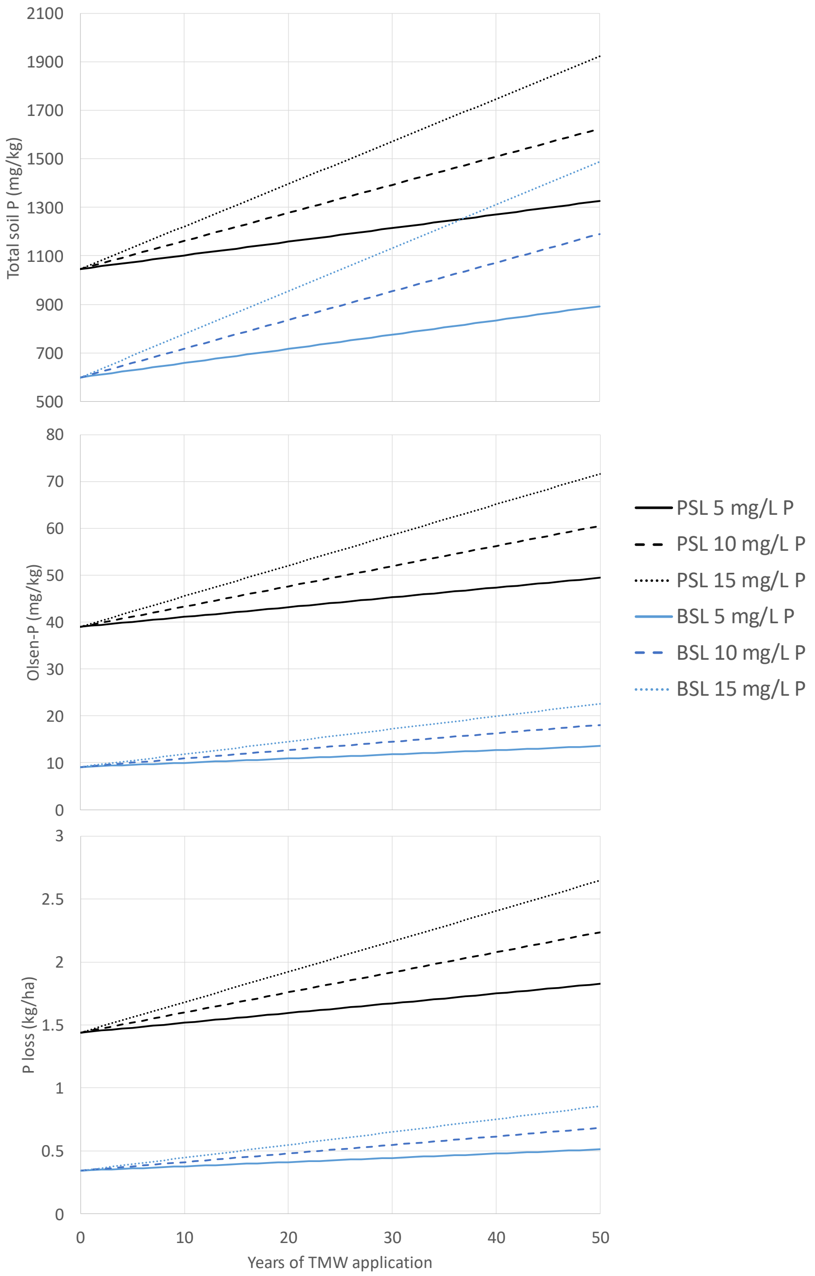

Figure 1.

Calculated phosphorus (P) in the top 0.3m of the Pawson Silt Loam (PSW) and Barry Soil (BSL) under irrigation with TMW at 500 mm/yr with a P concentration in the effluent of 5, 10 or 15 mg/L. The parameters used for the calculations are given in Table 1.

Fig. 1 also shows that irrigating TMW onto native vegetation will result in a significant increase in P leaching from the top 0.3 m of topsoil. This is because of the additional P added to the system in the TMW and the increased water flux through the soil. In the aforementioned scenario, P leaching below the top 0.3m would increase to 2.2 kg/ha/yr in the PSL and to 0.9 kg/ha/yr in the BSL after 50 years. It should be note that, depending on the depth of groundwater, most of this P lost from the top 0.3 m will be retained by the subsoil, which is rich in P-binding oxides of iron and aluminium (McLaren and Cameron 1996). In comparison, the estimated current total P-loss through soil loss from the same area under grazed pasture ranges from 2 – 15 kg/ha/yr, based on soil loss maps (https://statisticsnz.shinyapps.io/soil_erosion/). Under native vegetation irrigated with TMW, significantly less P would be lost through runoff or soil loss compared to a grazed pastureland because the trees increase infiltration and stabilize the soil (Robinson et al. 2009; Sidle et al. 2006). It is therefore likely that irrigating NZ-native vegetation with 500 mm/yr of TMW containing 10 mg/kg P will result in less P-loading on surface waters than a conventional grazed pasture.

Fig. 2. PhD candidate Alexandra Meister and Dr Jacqui Horswell among NZ native vegetation receiving Treated Municipal Wastewater, Pipers Valley Road, Duvauchelle. 12th February 2018.

The calculations indicate that TMW irrigated onto NZ-native vegetation with application P at a rate of 50 kg/ha/yr will result in soil and plant-available P concentrations that are still within the ranges of NZ agricultural soils and that excessive P-leaching is unlikely. This would be the case when irrigating 500 mm/yr of TMW from the Akaroa wastewater treatment plant, which would add the equivalent of 33 kg P/ha/yr. While it is likely that some NZ-native species will not tolerate these levels of plant-available P, there are published studies showing that many NZ-native species can tolerate such levels (Gutierrez-Gines, Robinson, et al. 2017; Reis et al. 2017). Lower P application rates will prolong the life of the system, as would periodic removal of some of the vegetation e.g. periodic harvesting of manuka or kanuka to produce high value essential oils.

The application of any element to a system at a rate than is greater than the rate that it is removed is ultimately unsustainable (Mills et al. 2005). If a soil P concentration were reached when a NZ-native ecosystem collapsed or if unacceptable concentrations of P were leaching, then the soil could usefully be converted to high-fertility agricultural soil for pasture or cropping.

Note that this report is based on calculations using soils from the Duvauchelle Golf Course and Pipers Valley Road. Soils from other locations on the peninsula (e.g. Robinson's Valley) may have different initial conditions due to differences in soil use history.

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Appendix 4: Development of the field trial from 2015 to 2019

August 2015

September 2015

November 2015

August 2016

November 2016

April 2017

Figure A-1: Development of the field trial from August 2015 to April 2017.

Figure A-2: Development of the field trial from June 2017 to September 2019.

Appendix S B Robinson – Soil Lysimeter Study

Final report (June 2017): A lysimeter experiment and field trial to determine options for the beneficial reuse of wastewater from Duvauchelle and Akaroa, Banks Peninsula

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This report provides end-of-contract outcomes from lysimeter and field trials. This project has been the subject of postgraduate research by Cameron McIntyre, Saloomeh Seyedalikhani, Minakshi Mishra and Obed Lense. Their dissertations and related publications will be made available when they are complete.

Note that the field trials will continue until at least the 30th of June 2018. The field trials will be the subject of postgraduate research at the University of Canterbury and the Centre for Integrated Biowaste Research (CIBR). Updates will be provided on:

http://www.kiwiscience.com/duvauchelle.html

Executive summary

- In 2014, the Christchurch City Council (CCC) commissioned Lincoln University to determine options for the beneficial reuse of Treated Municipal Wastewater (TMW) from Duvauchelle and Akaroa, Banks Peninsula through a lysimeter experiment and a field trial.

- Following an initial assessment of the soils where the TMW would be applied, a lysimeter trial was set up at Lincoln University in December 2014. This trial comprised 18 50 cm x 70 cm lysimeters containing intact soil cores from the golf course at Duvauchelle (12 lysimeters) and an area between Takamatua and Akaroa (6 lysimeters). The soils from Duvauchelle and Takamatua were Barry's soil and a Pawson silt loam, respectively.

- From December 2014 until April 2015, these lysimeters were irrigated with 10 mm per day, resulting in all lysimeters draining approximately equal volumes. On the 22nd of April, treatments started with municipal wastewater from Duvauchelle. Treatments comprised a control (Duvauchelle, Akaroa), 440 mm/yr (Duvauchelle), 825 mm/yr (Duvauchelle, Takamatua) and 1650 mm/yr (Duvauchelle). These treatments continued until the 3rd of October 2016. The lysimeters were then deconstructed and analysed.

- All lysimeters drained freely and there was no ponding. Nitrogen leaching was negligible in all treatments, although mineral nitrogen accumulated in the soil profile of the 1650 mm/yr treatment. It is unlikely that phosphorus, potassium, sulphur, calcium and magnesium will cause problems with either fertility or environmental quality in a system irrigated with TMW.

- Sodium-induced degradation of soil structure is a major concern when using TMW as irrigation water. Sodium accumulated in the soil columns in all the TMW treatments. The rate of accumulation was not proportional to the TMW application rate, indicating that sodium was moving down through the soil profile and leaching. The sodium accumulation ratio of the TMW was 15, indicating that in the long term (>10 years) at a moderate irrigation rate (<1000 mm) the soil may need to amended with gypsum, lime or dolomite to maintain soil structure.

- Pasture growth in the lysimeters was significantly enhanced by the TMW throughout the entire experiment. There were no signs of toxicity.

- A field trial comprising 11 native species, namely *Leptospermum scoparium, Kunzea robusta, Olearia paniculata, Pseudopanax arboreus, Coprosma robusta, Podocarpus cunninghamii, Griselinia littoralis, Pittosporum eugenioides, Cordyline australis, Phormium tenax, Phormium colensoi* was established on ca. 1000 m^2 of land near Pipers Valley Road. Trees irrigated with TMW grew better than or the same as unirrigated trees. There were no signs of toxicity. The plants with the greatest positive response to TMW were *Leptospermum scoparium, Olearia paniculata, Coprosma robusta, Podocarpus cunninghamii, Cordyline australis,* and *Phormium tenax.* The field trial will continue until at least June 2018.

- The use of TMW to produce valuable biomass such as cut-and-carry pasture, grazed pasture, or valuable native products such as manuka honey or essential oils constitutes the beneficial reuse of a valuable resource that is less environmentally damaging than disposal into the sea.

- It is recommended that the effluent be applied at a rate of 500 – 800 mm per year and that the soil is periodically monitored for aggregate stability. Gypsum, dolomite, or lime may need to be added periodically. A successfully designed system requires a hydrological and geotechnical assessment of the area to be irrigated.

Contents

Introduction

Land application of treated municipal wastewater

In New Zealand, the land application of Treated Municipal Wastewater (TMW) is the preferred option over discharge into waterways or the ocean (Sparling et al., 2006), where it can exacerbate eutrophication and / or toxic algal blooms (Sonune and Ghate, 2004). Compared to direct discharge into water, Irrigation of TMW onto land reduces the contaminants that enter waterways and therefore has positive effects on the water quality (Herath, 1997). The root-zones of plants remove nutrients contained in the TMW, mitigate pathogens (Mandal et al., 2007), and break down or immobilise contaminants (Chaudhry et al., 2005) that would otherwise degrade water bodies. TMW can reduce or eliminate the need for mineral fertilisers such as superphosphate, which contain elevated concentrations of toxic cadmium, fluorine and uranium that can accumulate in soil (Kim and Robinson, 2015). In many countries, including NZ, TMW is used to irrigate pasture, crops and forestry (Barton et al., 2005; Capra and Scicolone, 2004).

The application of TMW to land also carries risks that need to be mitigated for a successful operation. There are numerous examples of where land application of TMW has been discontinued because of environmental degradation. Excessive rates of TMW application to land can result in unacceptable nutrient leaching (Houlbrooke et al., 2003), runoff, soil instability and erosion, as well as accumulation of some components, such as sodium, in the topsoil (Cameron et al., 1997). High sodium concentrations can reduce plant growth through salinity and sodicity as well as degrade soil structure through the dispersion of clays (Mojid and Wyseure, 2013). The nature of the risks of the land application of TMW and therefore the design of a successful system is dependent on the quality of the TMW and the local environment. Therefore, every system needs to be specifically designed.

Potential for land application of TMW on Banks Peninsula

The successful application of TMW to land on Banks Peninsula requires particular attention to soil quality. Soils of the lowland areas of the peninsula where TMW could potentially be applied are mostly derived from loess with a relatively high clay content. They are often imperfectly drained and may contain a fragipan (an layer of impermeable soil). These soils present a higher risk of infiltration problems compared to free-draining soils and consequently an improperly designed TMW application system may be susceptible to surface runoff and erosion.

The Christchurch City Council seeks to reduce the direct disposal of TMW into Akaroa harbour. Several small communities now have their wastewater irrigated onto woodlots. There is now an on-going program of options analysis for alternatives to harbour disposal for the settlement of Duvauchelle. Potentially, some of the effluent produced in Akaroa could also be land-applied. Duvauchelle produces some 27600 m^3 of wastewater per year (based on 2016 data provided), which is currently discharged directly into the harbour through one long harbour outfall.

In 2014, the Christchurch City Council (CCC) approached Lincoln University regarding the possibility of irrigating TMW from Duvauchelle onto the local golf course. In subsequent discussions with stakeholders during public open days in 2015 and 2016, this brief was expanded to include cut-and-carry pasture as well as NZ native vegetation. While there are numerous examples of successful irrigation onto cut-and-carry pasture in NZ and elsewhere, there is a shortage of information on how native species will interact with TMW. Potentially, TMW could be irrigated onto NZ native vegetation, with a view to increasing the production of valuable native products or the creation of zones of ecological value (Meurk, 2008; Franklin et al., 2015). Manuka (*Leptospermum scoparium*) is an obvious candidate species because of its associated high-value honey and essential oils. Moreover, mānuka has been shown to kill soil-borne pathogens (Prosser et al., 2016) and reduce nitrate leaching (Esperschuetz et al., 2017b).

Other potential valuable native species are kanuka (*Kunzea robusta*) for essential oil production, horopito (*Pseudowintera colorata*), which produces antifungal compounds, harakeke (*Phormium tenax*) for fibre production, and a whole suite of species, including kapuka (*Griselinia littoralis*) that may be a nutritious supplement due to tannins and trace elements (Dickinson et al., 2015).

It is unclear whether TMW would confer the same growth benefits to native vegetation as to pasture. Many NZ-native species, such as mānuka, are adapted to low-fertility soils and it may not respond well to the addition of high concentrations of plant macronutrients. Franklin et al., (2015) reported that some responded positively to N (200 kg/ha equiv.), but *Leptospermum scoparium* did not. Dickinson et al. (2015) reported that biosolids improved the growth of *Grisilinea littoralis* and *Kunzea robusta*, but not *Dodonaea viscosa*.

A native ecosystem receiving TMW would likely remain unharvested or have only a small fraction of the biomass removed. Therefore, unlike a cut-and-carry pasture receiving TMW, there would be no significant removal of nutrients or contaminants from the system. It is likely that nitrate leaching and phosphorous accumulation in the soil would therefore be greater.

Aims

We aimed to determine the suitability of soils from the Duvauchelle golf course and Takamatua peninsula to receive treated municipal wastewater from the Duvauchelle Wastewater Treatment Plant. Specifically, we sought to determine whether irrigation rates of up to and in excess of 1000 mm per year would result in ponding, excess nitrate leaching, accumulation or depletion of elements in soil, changes in pasture growth and quality, change in the survival and growth of NZ native vegetation.

Materials and methods

Site description

On the 28th of August 2014, a site visit was made to Duvauchelle Golf Course (Barry's soil) and the Takamatua Peninsula (Pawson silt loam). Soil pits were opened with a view to ascertain whether the soils would be suitable for lysimetry, namely that they would have an adequate permeability to allow significant through-flow of water. Soil pits revealed both soils to be imperfectly drained (some mottling) but no evidence of a fragipan, perched water, or impermeably (reduced iron). The mean (standard deviation) of the size fractions for these soils are: course sand 1.2 (0.2)%, fine sand 44.5 (0.9)%, silt 28.1 (2.1)% and clay 24.0 (2.2%) (Anon, 1939). Fig. 1 shows the locations of the experimental sites.

Fig. 1. Locations where the lysimeters were excavated and of the ongoing field trial where TMW is being irrigated onto NZ native vegetation.

Lysimeter experiment

Two intact lysimeters were collected from the golf course at Duvauchelle on the 18th of September 2014. These lysimeters were taken to Lincoln University and irrigated with water (10 mm per day) until drainage stabilised in late October 2014. This demonstrated that the intact cores would drain and therefore be suitable for the full experiment. In November 2014, a further 10 lysimeters were taken from the golf course in Duvauchelle (43°44'53.06"S, 172°55'41.44"E) and six were taken from a paddock containing cattle (43°47'33.11"S, 172°57'16.96"E) between Takamatua and Akaroa (Fig. 1). Each lysimeter cylinder was placed on the soil surface, and gently tapped into the soil, while the soil surrounding the cylinder was excavated (Fig 2). Molten Vaseline was poured around the edge of the intact soil core before removal to the Lincoln University lysimeter facility.

The lysimeters, replete with intact soil cores, were installed at the Lincoln University lysimeter paddock (43°38'53.54"S, 172°28'7.69"E) in December 2014. The original vegetation was left upon the lysimeters. The Duvauchelle lysimeters were covered with a fescue / browntop mixture, while the Takamatua lysimeters were dominated by perennial ryegrass. A decision was taken not to remove and re-sow the pasture because this would have resulted in significant topsoil disturbance and consequent flush of nitrogen through the soil profile.

Between December 2014 and April 22nd 2015, the lysimeters were irrigated with 2 L (10 mm) of water per day. The lysimeters started to drain in February 2015 and by March 2015, similar volumes of leachate were obtained for all lysimeters. On the 22nd of April 2015, effluent application of the lysimeters began. Treated Municipal Wastewater (TMW) was collected by the Christchurch City Council (CCC) and delivered to Lincoln University in a 1000 L tank. Samples of the stored effluent were taken weekly. The tank was refilled as needed. There were three replicates of five treatments. Namely:

1) Barry's soil. Control (no effluent application)
2) Barry's soil. Wastewater added at ca. 500 mm / yr (0.4 L/day, 5x per week)
3) Barry's soil. Wastewater added at ca. 1000 mm / yr (0.75 L/day, 5x per week)
4) Barry's soil. Wastewater added at ca. 2000 mm / yr (1.5 L/day, 5x per week)
5) Pawson silt loam. Control.
6) Pawson silt loam. Wastewater added at ca. 1000 mm/yr (0.75 L/day, 5x per week)

Note that the actual annual rates were slightly less than anticipated. The actual annual rates for the 500 mm, 1000 mm, and 2000 mm treatments were 440 mm, 825 mm and 1650 mm per year. Drainage volumes were measured weekly or more often following high rainfall events. Pasture was harvested periodically, typically every three weeks, during the growing season. Fig. 3 shows the installed lysimeters, with PhD student, Minakshi Mishra measuring pasture growth and Dr Maria Jesus Gutierrez-Gines irrigating effluent and collecting drainage. On the 16th of November 2016, the lysimeters were deconstructed. Following a final harvest of the pasture, soil samples from 0-15 cm, 15-30 cm, 30-45 cm, and 45 – 60 cm were taken and stored for chemical analyses.

Fig. 2. Collecting lysimeters from the Takamatua peninsula, November 2014.

Fig. 3. Top: The installed lysimeters showing the six Pawson silt loam soil cores (front-left) and the 12 Barry's soil cores (rear-right). Centre left: Effluent application. Centre right: Drainage collection. Bottom: Destructive sampling of the lysimeters at the conclusion of the experiment. 16th of November, 2016.

Field trial

In July 2015, we planted 1350 native trees (Fig. 4), divided into 27 blocks of three different vegetation types (Table 1). Twelve of the 27 blocks are receiving treated municipal wastewater at a rate of 500 mm during the growing season (October – April), a similar rate to that used on an irrigated dairy farm in Canterbury. Effluent irrigation started in January 2016. Weeds were controlled using a lawnmower. An information board was installed near the roadside describing the aims of the experiment.

In May 2017 the survival of the plants was recorded along with the canopy volume of each individual plant. Soil and plant samples have been taken for chemical analysis. In June 2017, all areas within the plot that were not under native vegetation were planted with silver tussock (*Poa cita*). It is hoped that these tussocks will minimise the need for further weed control at the site.

Fig. 4. The field trial in Piper's valley road shortly after planting. The gate is at the top left of the picture.

Table 1. Composition of the thee vegetation types used in the experiment. The design of the field plot is shown below.

Vegetation type 1			**Vegetation type 2**			**Vegetation type 3**	
Mānuka	*Leptospermum scoparium*		Akiraho	*Olearia paniculata*		Kapuka	*Griselinia littoralis*
Kānuka	*Kunzea robusta*		Puahou	*Pseudopanax arboreus*		Tarata	*Pittosporum eugenioides*
			Karamu	*Coprosma robusta*		Tī kōuka	*Cordyline australis*
			Hall's tōtara	*Podocarpus cunninghamii*		Harakeke	*Phormium tenax*
						Wharariki	*Phormium colensoi*

1C	3E	3C	1E	2C	2E	1C	3E	C	gate
3C	2E	2C	2E	1C	3E	3C	2E	C	
2C	1E	1C	3E	3C	1E	2C	1E	C	

C=control E=effluent 1,2,3=vegetation type

Chemical analyses

Inorganic nitrogen species in soils were determined using an extraction on fresh soil (Blackmore et al., 1987). After adding 40 mL of a 2M KCl reagent to 4 g of soil, the solution was shaken on an end-over-end shaker for 1 h, centrifuged at 2000 rpm for 10 min and subsequently filtered through Whatman 41 filter paper. Extracted solutions, along with leachate and TMW samples were kept at -20°C until analysed. Nitrate-N (NO_3-N), nitrite-N ,(NO_2-N) and ammonium-N (NH_4-N) were determined using a flow injection analyser (FIA FS3000 twin channel analyser, Alpkem, USA).

Soils were dried at 105 °C and sieved to <2mm using a Nylon sieve. Plant samples kept in labelled paper envelopes and left in an oven at 70°C until a constant weight was obtained (approximately one week). Paper envelopes were immediately transferred in sealed polythene sacks to prevent absorption of moisture from the air. After weighing and grinding, samples were placed in sealed plastic vials.

Soil pH was determined using 10 g of soil and 25 mL of deionised water (18.2 MΩ resistivity; Heal Force® SMART Series, SPW Ultra-pure Water system, Model-PWUV) at a solid/water ratio of 1:2.5. The mixture was shaken, left to equilibrate for 24 hr before measurement and shaken again before determination with a pH meter (Mettler Toledo Seven Easy) (Blakemore, 1987). An Elementar Vario-Max CN Elementar analyser (Elementar ®, Germany) was used to analyse the total carbon and nitrogen content in the soil and plant samples.

Elemental analyses of plants, soils, and effluents were carried out using microwave digestion (MARSXPRESS, CEM Corporation, USA) of 0.5 g of sample in 8 mL of Aristar™ nitric acid (± 69%) and filtered by means of Whatman no. 52 filter paper (pore size 7 µm) after dilution with milliQ water to a volume of 10 mL. Certified Reference Materials (CRMs) for soil (International Soil analytical Exchange - ISE 921) and plant samples (International Plant analytical Exchange IPE 100) from Wageningen University, The Netherlands, were also digested.

Concentrations of Cd, B, Ca, Cr, Cu, Fe, K, Mg, Mn, Mo, Na, P, S and Zn were determined using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES Varian 720 ES - USA) in soils (Kovács et al., 2000) and in plants (Simmler et al., 2013; Valentinuzzi et al., 2015). Extraction and digestion solution and method blanks were analysed in triplicate as part of standard quality control procedure for the analysis and were as below the ICP-OES's detection limit for all metals. Recoverable concentrations of the CRMs were within 93% - 110% of the certified values.

Statistical analysis

Data were analysed using Minitab® 17 (Minitab Inc, State College, Pennsylvania, USA) and Microsoft Excel 2013. The ANOVA with Fisher's Least-Significance-Difference post-hoc test was used to assess the effects of different treatments. The significance level for all statistical analyses was $P<0.05$.

Results and discussion

Characteristics of the wastewater and soils

Table 2 shows the characteristics of the Treated Municipal Wastewater (TMW) from the Duvauchelle Wastewater Treatment Plant. The composition of the TMW is similar to data provided by the Christchurch City Council (CCC) from various times the past five years (data not shown). Of note are the elevated concentrations of nitrate (above drinking water standard of 11.3 mg/L nitrate-N), phosphate, and sulphur. When discharged into water bodies such as Akaroa harbour, these nutrients can exacerbate algal blooms, which can damage fisheries and tourism. The TMW contains sodium at a concentration that may pose a "slight to moderate" risk if irrigated onto the foliage of sensitive crops (Ayers and Westcot, 1985). Most pasture species are not overly sensitive. Although, the sodium tolerance of NZ native vegetation has not been well quantified, salt tolerance is expected in coastal and seaside species.

The Sodium Adsorption Ratio (SAR) is the sodium concentration divided by the square root of half the calcium and magnesium concentrations. The SAR is used in combination with EC (Electrical Conductivity) to indicate the likelihood that irrigation water will result in aggregate instability (dispersion of clay colloids) in soil, resulting in a breakdown in soil structure and consequent problems with infiltration, aeration, and drainage. The SAR of the TMW is at a level that may cause aggregate instability if used over the long term (Ayers and Westcot, 1985). Soil quality can be maintained by the occasional application of gypsum, dolomite, or lime (FAO, 2017). The total concentration of Ca and Mg in the soil is relatively large compared to the irrigation water (Table 2), so it is likely that irrigation could occur for many years before remedial measures would need to be taken. Nevertheless, the fertility of both soils could be improved with liming and the pH of the Pawson Silt Loam from the Takamatua peninsula is below the range recommended for agricultural soil (McLaren and Cameron, 1996).

Table 2. Characteristics of the Treated Municipal Wastewater used in the lysimeter experiment. Values in brackets represent the standard deviation of the mean (*geometric mean and standard deviation range). n=54 except trace elements n=9.

	Treated Municipal Wastewater	Barry's soil (Duvauchelle)	Pawson Silt Loam (Takamatua peninsula)
pH	7.5	5.2	4.8
EC (uS/cm)	423 (40)	-	
Total suspended solids (g/m3)	32	-	-
NH_4^+-N (mg/L)	0.49 (0.15 – 0.80)*	10.1 (7.5)	11 (6.8)
NO_3^--N (mg/L)	18 (7.5)	17.1 (13.2)	4.4 (1.1)
NO_2^--N (mg/L)	0.86 (0.09)	-	-
Total C (%)	-	4.4 (0.6)	5.4 (0.3)
Total N (%)	<25	0.38 (0.05)	0.48 (0.03)
Al (mg/L)	0.43 (0.11 – 1.7)*	32731 (1418)	34903 (3699)
B (mg/L)	0.10 (0.04)	-	
Ca (mg/L)	59 (12)	6770 (393)	5852(187)
Cd (mg/L)	<0.001	-	-
Cu (mg/L)	0.04 (0.03)	7.7 (0.2)	5.1 (1.4)
Fe (mg/L)	0.96 (0.25 – 3.6)*	20155 (2852)	16806 (4098)
K (mg/L)	22 (5.0)	4491 (346)	4008 (365)
Mg (mg/L)	19 (5.5)	4251 (76)	3575 (463)
Mn (mg/L)	0.06 (0.03)	624 (9)	496 (50)
Na (mg/L)	95 (21)	290 (10)	374 (30)
P (mg/L)	11 (5.0)	1046 (30)	599 (125)
S (mg/L)	25 (11)	490 (21)	430 (5)
Zn (mg/L)	0.17 (0.11)	68 (3)	62 (7)
Sodium Accumulation Ratio (SAR)	15 (2.6)	-	-

Table 3 shows the masses of the individual elements added if TMW were to be irrigated at 500 mm / yr. The annual mass of nitrogen added per hectare is approximately half of the maximum rate permitted in many jurisdictions (200 kg/ha/yr). Phosphorus and potassium are within the ranges that these nutrients would be added to maintain an intensively grazed pasture (DairyNZ, 2017a). However, the sulphur loading is more than double rates normally applied (20 – 50 kg/ha/yr). This excess is likely to leach because sulphur is poorly retained by most NZ soils, including the Banks Peninsula loess.

The values of the nutrients were calculated using the lowest cost fertiliser sold by Ballance Ltd. Note that the value of the nutrients is less than the sum of the individual elements because some fertilisers contain more than one element, for example, superphosphate contains both phosphorus and sulphur. The average cost of irrigation in NZ is $770 per ha/yr (Curtis, 2016). Combining the irrigation value with the savings from reduced fertiliser use give a total value of >$1178 /ha/yr.

Table 3. Mass and value of plant macronutrients added through irrigating treated municipal wastewater at a rate of 500 mm per year. The value was calculated from prices listed on http://www.ballance.co.nz/Our-Products/PriceListing. Accessed April 2017. Note that the total value of the nutrients is less than the sum of the individual elements because some fertilisers contain more than one element.

Element	Mass (kg/ha/yr)	Value of element in cheapest fertiliser (NZ$/ha/yr)
N	95	103
P	55	193
K	110	287
S	125	375
Mg	95	250
Ca	295	356

Lysimeter experiment

Irrigation with effluent visibly increased the vigour of the pasture in all the treatments (Fig. 5). Over the course of the experiment, there were significant increases in the biomass of nearly all the treatments (Table 4).

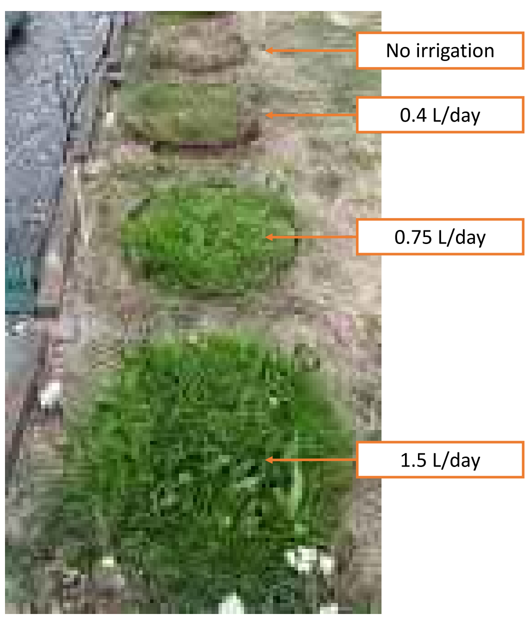

Fig. 5. Pasture growth on four lysimeters containing Barry's soil in February 2016. The numbers to the right of the picture indicate the volume of treated municipal wastewater that the lysimeter was receiving Monday – Friday.

Table 4. General parameters from the 21st of May 2015 until the 3rd of October 2016. Values in brackets represent the standard error of the mean (n=3).

Treatment	Total Irrigation (mm)	Total Rainfall (mm)	Total drainage (mm)	Total Evapotranspiration (mm)	Biomass production (t/ha equiv.)
Barry's soil					
Control	0	779	169 (22)[a]	610	5.4 (1.0)[a]
440 mm/yr	637		485 (23)[b]	931	6.3 (0.6)[a]
825 mm/yr	1190		736 (17)[c]	1233	8.9 (0.6)[b]
1650 mm/yr	2375		1375 (11)[d]	1779	12.3 (0.2)[c]
Pawson silt loam					
Control	0	779	148 (2)[a]	631	6.0 (0.3)[a]
825 mm/yr	1190		609 (32)[b]	1360	13.3 (0.7)[b]

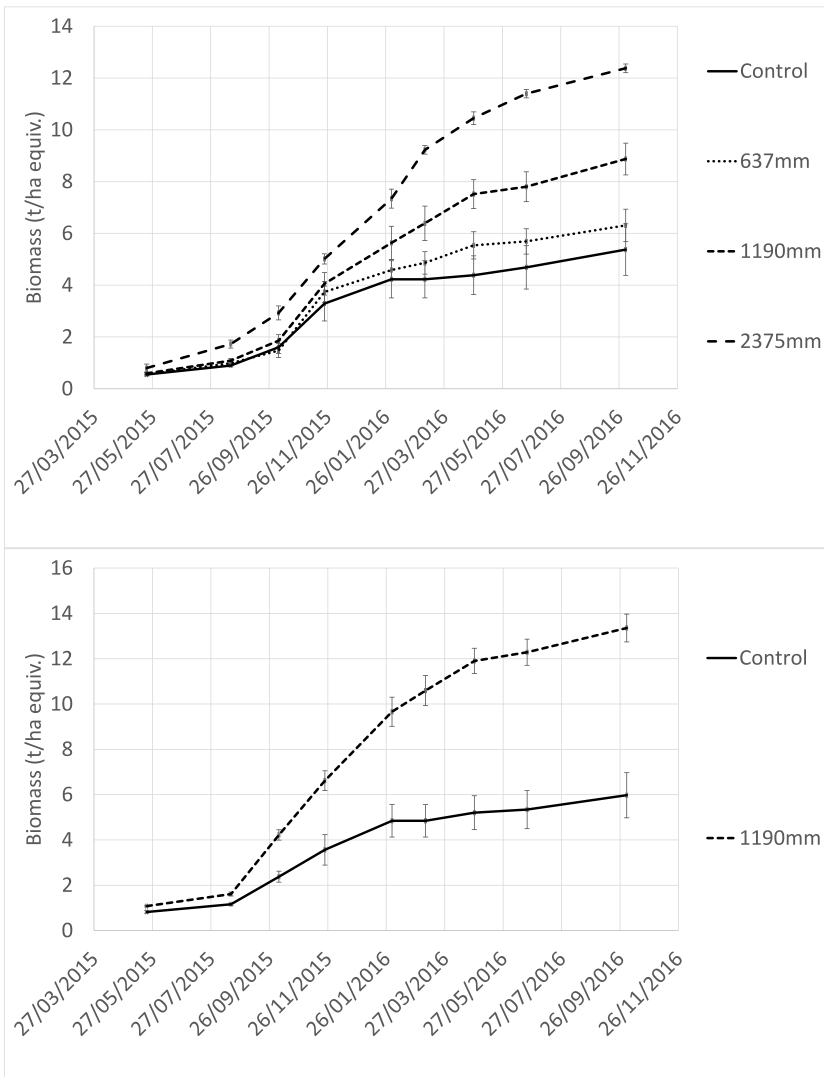

Fig. 6. Cumulative biomass production in the lysimeter experiment for the Barry's soil (top) and Pawson silt loam (bottom), expressed as tonnes per hectare equivalent. Bars represent the standard error of the mean (n=3).

Fig. 6 shows the cumulative biomass production for the pasture in the lysimeters. The biomass increase of the pasture in the treatments was greater than the controls for the whole duration of the experiment, even at the highest treatment rate. This indicates that increase in fertility resulting from the TMW application was maintained and that pasture growth was not significantly perturbed by any sodium or any other element in the TMW. The pasture growth in the Pawson silt loam lysimeters was significantly higher than in the lysimeters containing Barry's soil. This is most likely due to differences in the pasture composition as well as previous soil management. The Barry's soil lysimeters contained a fescue / browntop mixture, while the Pawson silt loam lysimeters were dominated by perennial ryegrass. Note that there were also other species present (Fig. 5), which were not removed so as not to disturb the soil. The Pawson silt loam was maintained as a graze pasture and possibly had historically received higher fertiliser additions than the Barry's soil, which was the fairway on the Duvauchelle Golf Course.

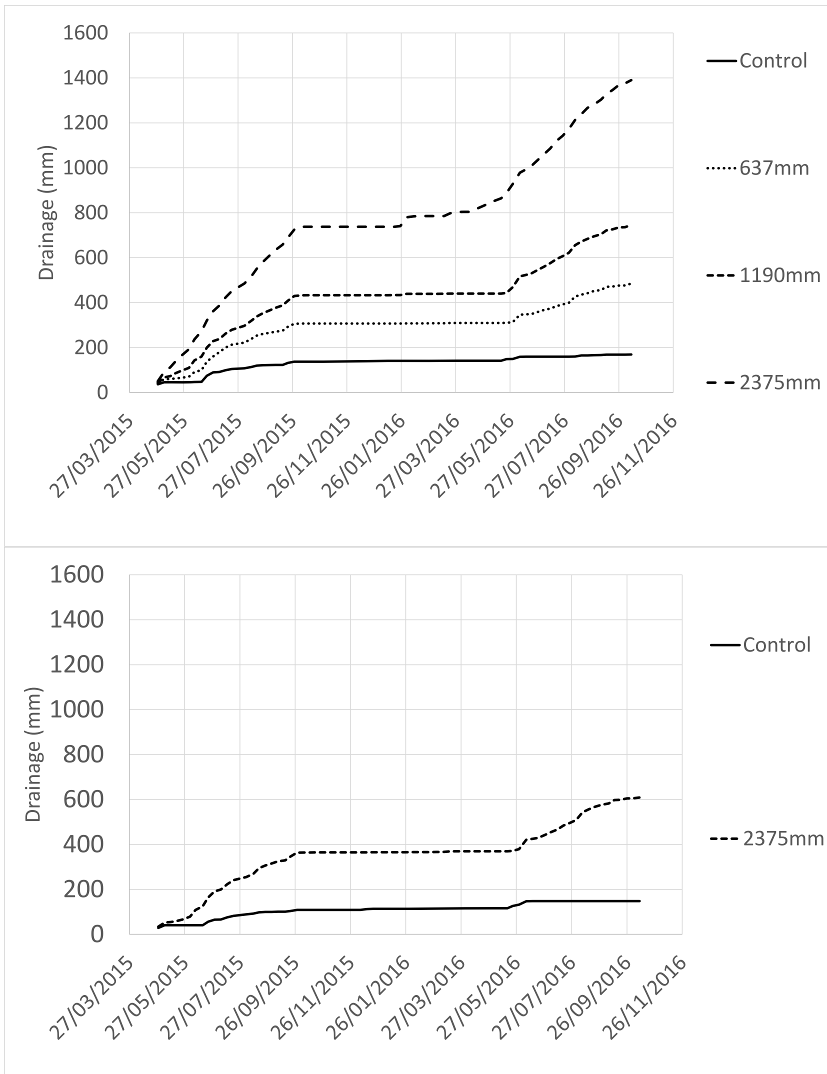

Fig. 7. Cumulative drainage from the lysimeters for the Barry's soil (top) and Pawson silt loam (bottom).

Drainage

All the lysimeters receiving TMW drained throughout the experiment, even at the highest application rate. There was no ponding or visible evidence that the soil structure had been degraded. Infiltration at various tensions forms part of an MSc degree by Cameron McIntyre. These data will be made available upon completion of his thesis, expected in late 2017.

Fig. 7 shows that all the treatments significantly increased drainage relative to the control. In a TMW application system on Banks Peninsula, drainage is unavoidable, irrespective of the vegetation type. Nevertheless, there would be marginally less drainage from a closed-canopy forest of high water-use trees because a significant portion of the incident rainfall is re-evaporated from the canopy before infiltration occurs (McNaughton and Jarvis, 1983). Unlike a dryland system, where deep rooted trees continue to transpire after pasture species have become dormant (Vogeler et al., 2001), rooting depth will have little impact on plant water use because the irrigation will ensure that the plants never become water stressed. Increased drainage does not necessarily imply that there will be unacceptable leaching of nitrogen or other potential contaminants. High levels of leaching requires both high drainage and a significant concentration of the contaminant in soil solution. If the contaminant is retained on the soil colloids, broken down, or taken up by the plant, then leaching will be minimal even under high drainage conditions.

Table 5. Mass of nitrogen (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation N (kg/ha equiv.)	Pasture N (%)	Pasture N (kg/ha equiv.)	Soil mineral N (kg/ha equiv.)	Leached N (kg/ha equiv.)
Barry's soil					
Control	<1	2.17 (0.13)^{ab}	115 (21)^{a}	71 (12)^{a}	0.32 (0.03)^{a}
637 mm	111	1.89 (0.12)^{b}	124 (14)^{a}	59 (7)^{a}	0.72 (0.08)^{b}
1190 mm	207	2.07 (0.09)^{ab}	193 (14)^{a}	87 (4)^{a}	1.09 (0.03)^{c}
2375 mm	415	2.47 (0.15)^{a}	288 (113)^{b}	149 (16)^{b}	1.97 (0.18)^{d}
Pawson silt loam					
Control	<1	2.66 (1.4)^{a}	151 (13)^{a}	72 (16)a	0.37 (0.06)^{a}
1190 mm	207	2.64 (1.4)^{a}	314 (11)^{b}	72 (17)a	1.05 (0.05)^{b}

Nitrogen

Irrigation with TMW had little effect on the pasture's nitrogen concentration (Table 5). This is environmentally important because grazing animals excrete excess nitrogen in their urine, which then subsequently leaches (Woods et al., 2016). Nevertheless, the TMW treatments significantly increased the amount of nitrogen that was extracted from the soil, primarily because of the increased pasture growth. This indicates that at least in part, nitrogen was limiting pasture growth in the lysimeters because under nitrogen sufficient conditions, additional nitrogen results in increase pasture concentration, a process called luxury uptake (McLaren and Cameron, 1996). For TMW irrigation rates up to 825 mm/yr, the mass of nitrogen extracted by the pasture was similar to or greater than the nitrogen that was applied. Given that our lysimeter experiment comprised two winters and just one summer, relatively less nitrogen was extracted than would be the case if we included a second growing season. It is therefore likely that pasture could remove the nitrogen added with TMW at rates above 1000 mm/yr. In the highest treatment (1650 mm/yr), the mass of N added was significantly greater than that which was removed in the pasture. This additional nitrogen was found as mineral nitrogen principally (NH_4^+, NO_3^-) in the soil profile. None of the other treatments showed accumulation of nitrogen in the soil. The mass of nitrogen leached from all treatments was <2 kg/ha equiv., which is negligible compared to the nitrogen leached from a grazed pasture, which can be >40 kg/ha/yr (Menneer et al., 2004).

Phosphorus

The phosphorus applied to the lysimeters with the TMW was 5 – 7 fold greater than the phosphorus removed by the pasture (Table 6). This discrepancy is normal because of phosphorus fixation in soil, a process that renders this nutrient unavailable for plant uptake (McLaren and Cameron, 1996). The strong adsorption of phosphorus in soil also results in negligible amounts of phosphorus being leached. Therefore, in a TMW irrigated soil, phosphorus will accumulate, just as it does in all NZ soils that receive phosphate fertilisers. Phosphorus can cause serious environmental issues when it enters waterways (Tilman et al., 2001). This could occur via runoff from a TME-irrigated area, particularly if it is accompanied by soil erosion. TMW irrigation onto a cut-and-carry pasture or NZ native vegetation will always be less than phosphorus losses from a grazed pasture (TMW irrigated or otherwise) because of the mechanical disturbance of soil by the animals' hooves (McDowell et al., 2003).

Table 6. Mass of phosphorus (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation P (kg/ha equiv.)	Pasture P (mg/kg)	Pasture P (kg/ha equiv.)	P leached (kg/ha equiv.)	Soil P (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	<1	2606 (36)^{a}	13 (2)^{a}	<1	3975 (495)^{a}
637 mm	77	2593 (165)^{a}	16 (2)^{a}	<1	3268 (598)^{a}
1190 mm	144	2648 (55)^{a}	25 (3)^{b}	<1	3154 (198)^{a}
2375 mm	289	3196 (82)^{b}	40 (1)^{c}	<1	3437 (339)^{a}
Pawson silt loam					
Control	<1	3651 (184)^{a}	20 (2)^{a}	<1	5808 (303)^{a}
1190 mm	144	3663 (8)^{a}	45 (2)^{b}	<1	4863 (425)^{a}

Potassium

As with phosphorus, more potassium was added with the TMW than was removed by the pasture (Table 7). Most of this potassium will accumulate in the soil, with only minor amounts leached. Leached potassium is relatively environmentally benign compared to nitrogen and phosphorus. The accumulation of potassium in soil is insignificant because the soil concentrations are at least one hundredfold greater than the amount being added. At the highest TMW application rate (1650 mm/yr), the pasture took up significantly more potassium than the controls. High potassium in animal feeds can induce magnesium deficiency in livestock, resulting in grass staggers. In extreme cases, this requires that the animals be supplemented with magnesium (DairyNZ, 2017b).

Table 7. Mass of potassium (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation K (kg/ha equiv.)	Pasture K (mg/kg)	Pasture K (kg/ha equiv.)	K leached (kg/ha equiv.)	Soil K (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	1	11624 (263)^{ab}	65 (12)^{a}	1 (0)^{a}	34597 (493)^{a}
637 mm	177	8990 (723)^{c}	68 (4)^{a}	2 (0)^{a}	34848 (785)^{a}
1190 mm	331	10349 (510)^{bc}	112 (8)^{a}	3 (0)^{a}	35627 (908)^{a}
2375 mm	662	13060 (1150)^{a}	179 (6)^{b}	4 (1)^{a}	35165 (1134)^{a}
Pawson silt loam					
Control	1	17252 (1847)^{a}	104 (15)^{a}	6 (2)^{a}	40824 (1322)^{a}
1190 mm	331	17933 (518)^{a}	229 (16)^{b}	21 (6)^{a}	37392 (3319)^{a}

Sulphur

Irrigation with TMW provided an excess of sulphur (Table 8), which will eventually leach through the soil profile to receiving waters. Sulphur leaching does not provoke eutrophication like nitrogen or phosphorus. There were no significant effects of the TMW irrigation on the sulphur concentration in the pasture or in the soil profile.

Table 8. Mass of sulphur (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation S (kg/ha equiv.)	Pasture S (mg/kg)	Pasture S (kg/ha equiv.)	S leached (kg/ha equiv.)	Soil S (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	<1	2376 (40)[a]	14 (3)[a]	7 (2)	2389 (169)[a]
637 mm	169	2653 (169)[a]	17 (2)[a]	21 (5)	2190 (168)[a]
1190 mm	317	2649 (113)[a]	24 (2)[b]	40 (13)	2065 (75)[a]
2375 mm	634	2676 (60)[a]	35 (2)[b]	67 (14)	2294 (124)[a]
Pawson silt loam					
Control	<1	2941 (164)[a]	17 (2)[a]	11 (1)	2275 (96)[a]
1190 mm	382	3111 (76)[a]	40 (0)[b]	45 (8)	1989 (196)[a]

Calcium and magnesium

The TMW provided net additions of magnesium and calcium to the soil (Tables 9 and 10). These elements are important in maintaining soil pH as well as offsetting the negative effects of sodium on soil structure (FAO, 2017). Despite being applied in excess of pasture requirements, neither element was taken up at higher concentrations in the TMW treatments. Potential increases in magnesium uptake may have been offset by the elevated potassium levels in the TMW (McLaren and Cameron, 1996).

Table 9. Mass of calcium (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation Ca (kg/ha equiv.)	Pasture Ca (mg/kg)	Pasture Ca (kg/ha equiv.)	Mg leached (kg/ha equiv.)	Soil Ca (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	3	3879 (527)[a]	24 (5)[a]	20 (5)[a]	48351 (1620)[a]
637 mm	371	3373 (216)[a]	26 (4)[a]	55 (13)[a]	46775 (748)[a]
1190 mm	696	3350 (69)[a]	39 (3)[ab]	61 (10)[a]	47506 (1059)[a]
2375 mm	1392	3327 (170)[a]	51 (0)[b]	92 (18)[a]	48786 (1433)[a]
Pawson silt loam					
Control	<1	5581 (396)[a]	31 (2)[a]	22 (6)[a]	53218 (3475)[a]
1190 mm	696	4890 (183)[a]	68 (2)[b]	92 (5)[a]	49948 (4004)[a]

Table 10. Mass of magnesium (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation Mg (kg/ha equiv.)	Pasture Mg (mg/kg)	Pasture Mg (kg/ha equiv.)	Mg leached (kg/ha equiv.)	Soil Mg (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	<1	2065 (279)^{a}	13 (3)^{a}	6 (1)^{a}	33017^{a}
637 mm	124	1823 (110)^{a}	15 (2)^{a}	21 (7)^{a}	32580^{a}
1190 mm	232	1964 (52)^{a}	23 (1)^{ab}	23 (1)^{a}	32074^{a}
2375 mm	463	1960 (210)^{a}	33 (3)^{b}	50 (17)^{a}	32469^{a}
Pawson silt loam					
Control	<1	2481 (106)^{a}	16 (1)^{a}	5 (1)^{a}	42274 (2734)^{a}
1190 mm	463	2572 (78)^{a}	38 (2)^{b}	30 (2)^{a}	40351 (2596)^{a}

Sodium

Elevated concentrations of sodium in irrigation waters are concerning because accumulation of sodium can lead to aggregate instability and reduced permeability of soil (Tanji, 1997). Table 11 shows that significantly more sodium was added to soil than was taken up by the pasture. Some of this excess sodium leached, while the remainder accumulated in the soil profile (Fig 7). There were significantly higher sodium concentrations in the TMW-irrigated effluent on the Pawson silt loam, but surprisingly, not on the Barry's soil. This elevated sodium concentration indicates that TMW from Duvauchelle is not suitable for irrigation onto plants that are sensitive to sodic or saline conditions. Elevated concentrations of sodium in pasture increase its palatability to stock (Chiy et al., 1998) and farmers occasionally "fertilise" their pastures with sodium for this reason.

Fig. 8 shows the distribution of sodium within the soil profile of the control and TME-treated lysimeters. The TMW treatments had significantly higher sodium concentrations than the controls at the 0-15 cm and 15 – 30 cm depths. The greatest difference in soil sodium concentrations was between the control (ca. 285 mg/kg) and the 440 mm/yr treatment (ca. 375 mg/kg). Doubling the irrigation rate to 825 mm/yr only increased the sodium in the surface soil to ca. 405 mg/kg, and quadrupling the TMW irrigation rate increased sodium to ca. 420 mg/kg. This indicates that above ca. 400 mg/kg, sodium is not strongly retained by the soil and migrates down through the soil profile and will eventually be lost via leaching. This effect has been replicated in laboratory columns containing a Pawson silt loam, where sodium-spiked TMW (up to 260 mg/L) was irrigated (C. McIntyre, unpublished data). It is therefore unlikely that in the short-to-medium term (<10 years), sodium will accumulate to unacceptable levels in soils. Over the long term, the soils may require periodic amendments with gypsum or dolomite to maintain structure (FAO, 2017).

Table 11. Mass of sodium (kg/ha equiv) in the treated municipal wastewater, pasture, soil and drainage water over the entire lysimeter experiment. Values in brackets represent the standard error of the mean (n=3). For each soil type, values with the same letter are not significantly different. The Barry's soil and Pawson silt loam were tested independently.

	Irrigation Na (kg/ha equiv.)	Average Pasture Na (mg/kg)	Pasture Na (kg/ha equiv.)	Na leached (kg/ha equiv.)	Soil Na (0 – 60 cm) (kg/ha equiv.)
Barry's soil					
Control	5	2243 (475)[a]	10 (3)[a]	45 (6)[a]	2492 (76)[a]
637 mm	605	2256 (241)[a]	13 (3)[a]	159 (18)[b]	2840 (137)[ab]
1190 mm	1131	2651 (159)[a]	23 (3)[ab]	264 (23)[b]	2980 (106)[b]
2375 mm	2256	3109 (308)[a]	45 (6)[b]	412 (61)[b]	3113 (122)[b]
Pawson silt loam					
Control	5	2525 (198)[a]	13 (1)[a]	30 (0)[a]	2428 (181)[a]
1190 mm	1131	4038 (273)[b]	50 (2)[b]	232 (32)[b]	2610 (239)[a]

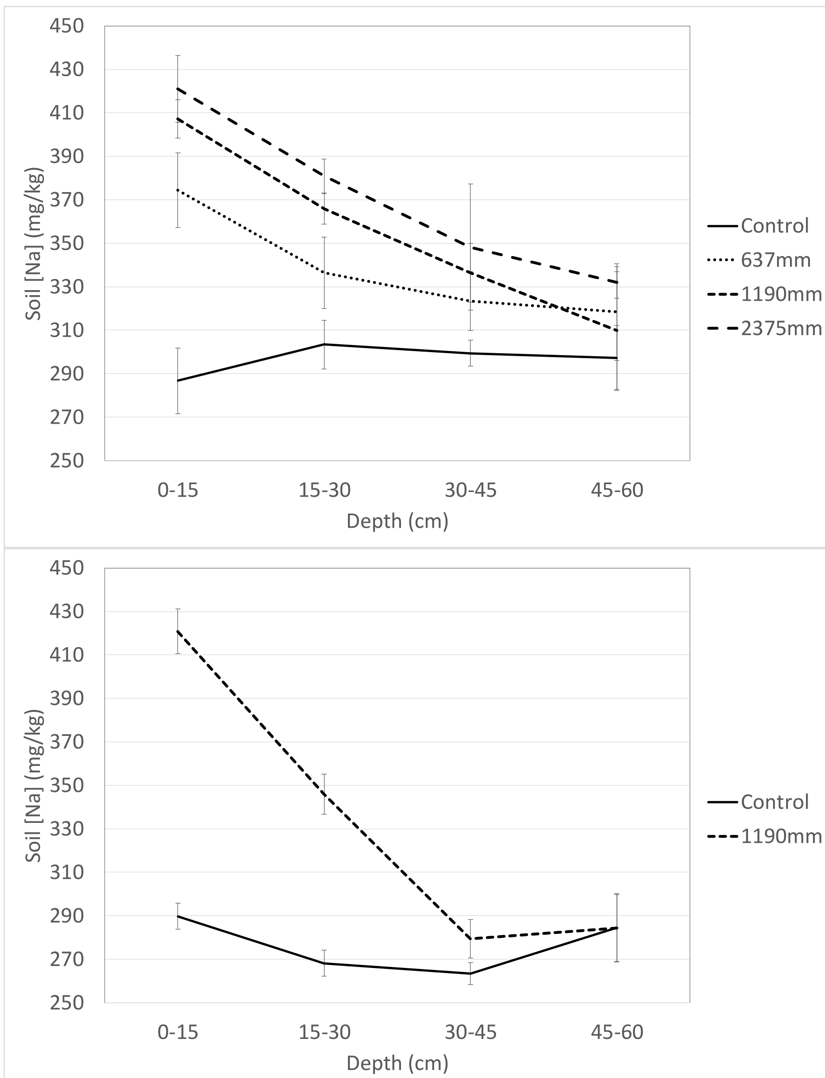

Fig. 8. Soil sodium concentration as a function of depth at the end of lysimeter experiment for the Barry's soil (top) and Pawson silt loam (bottom), expressed as tonnes per hectare equivalent. Bars represent the standard error of the mean (n=3).

Field trial

Plant survival

Fig. 9 shows the survival of individual species in the field plot as a percentage of the number planted. Most of the plant deaths occurred during the spring of 2015 - which was extraordinarily dry – before irrigation with TMW had started. Survival in March 2016 was similar to May 2017 (data not shown). As of May 2017, there were no significant differences between the irrigated and non-irrigated plots. Note that Fig. 9 does not include the additional control plots, at the Southern end of the field trial. These non-irrigated plots have a higher mortality, which we attribute to the soils, which are distinct (stonier) than the remainder of the field trial.

The only significant failure is *Pseudopanax arboreus*. This species has survived well in areas of the trial that are protected from the wind, but elsewhere survival is very poor. Potentially, this species could be used for wastewater treatment, but it should be planted in sheltered areas once the other species have become established.

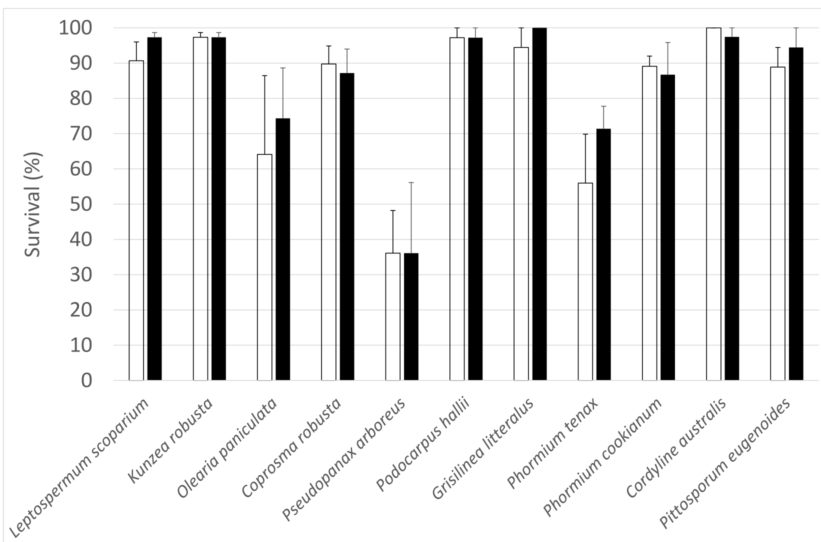

Fig. 9. Percentage survival of the plants in the field plot on Pipers Valley Road as of May 2017. There were no significant differences between the controls (striped bars) and treatments (black bars). Error bars represent the standard error of the mean of three plots, with each plot containing 5 – 25 plants.

Plant growth

Fig. 10 shows the field trial, along with the information board. Plants growing in the effluent-treated plots are visibly larger than the control plots. This observation is borne-out by measurement of the canopy volume (Fig. 11). Compared to the control, the canopy volume of all species in the TMW plots is either larger or not significantly different. There are no signs of toxicity or salt damage (burning of the leaves) on any of the plants. Nevertheless, there are stark differences between the species in how they respond to effluent. *Griselinia littoralis*, *Phormium cookianum*, and *Pittosporum eugenioides* are not significantly larger in the TMW-irrigated plots and are, in general, smaller than the other species in the trial.

Fig. 10. The field plot on Pipers Valley Road in June, 2017, showing the plant trial, information board, and boarders that were planted with *Poa picta* in May 2017.

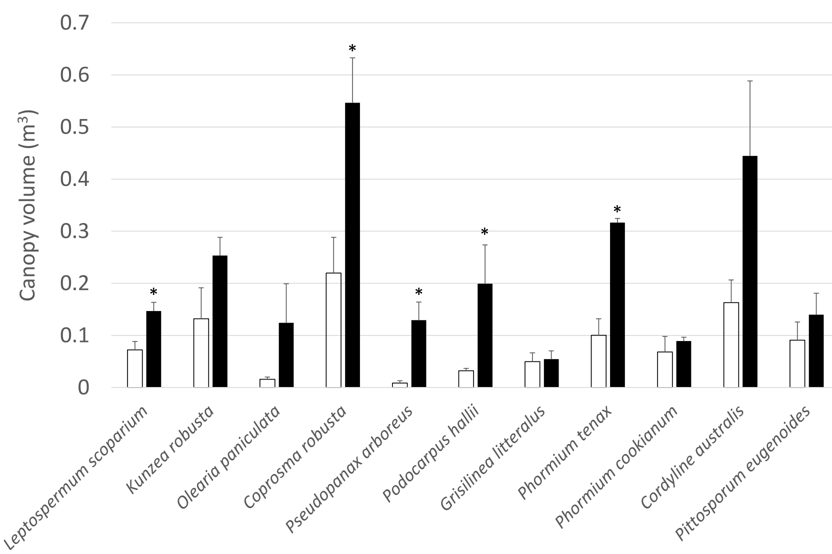

Fig. 11. Canopy volume of the plants in the field plot on Pipers Valley Road as of May 2017. Asterisks (*) signify significant differences between the controls (striped bars) and treatments (black bars). Error bars represent the standard error of the mean of three plots, with each plot containing 5 – 25 plants.

Plant stability in a wet area

One of the TMW-treated plots in the trial was established on a boggy area, as evidenced by waterlogging at the time of planting. Two trees have fallen over in this area (Fig 12). It is likely that TMW irrigation will reduce plant stability because the nutrients contained therein increase the shoot: root ratio of most plants (Agren and Franklin, 2003), thereby creating “top heavy” trees that are more likely to topple in soft substrates. *Cordyline australis* and *Phormium tenax* are more suited to grow in boggy patches.

Fig. 12. Fallen *Pittosporum eugenoides* and *Kunzea robusta* in the field plot at Pipers Valley Road in June, 2017.

In general, NZ native species will take up less water and nitrogen than pasture species from an irrigated shallow rooted environment. However, in the Banks Peninsula environment, the water flux through closed-canopy native vegetation and pasture may be similar because of the “umbrella effect”, whereby a significant proportion of rainfall is re-evaporated from the canopy before it reaches the ground (McNaughton and Jarvis, 1983). A mature stand of irrigated native vegetation is likely to leach more nitrogen than irrigated cut-and-carry pasture because little nitrogen is being removed from the system.

Next steps

In each plot of the field trial, five soil samples have been taken and sub-samples from five replicates of each plant species have been analysed. Results from this sampling will be made available upon completion of the PhD theses of Obed Lense and Saloomeh Seyedalikhani. This is expected to occur in early 2018. The field plots will be monitored for various postgraduate projects for at least another three years.

Irrigation of treated municipal wastewater onto NZ native plants: beneficial reuse or disposal?

Disposal of TMW implies discharge into an environment with the aim of minimising negative environmental effects but not gaining value from the TMW. Examples of disposal include discharge to waterways, the ocean, and the application of TMW to land at rates that are far in excess of plant requirements for water and nutrients. This contrasts with beneficial reuse where the irrigation value and nutrient value of the TMW is used to produce valuable biomass, offsetting costs for fertilisers and irrigation that would otherwise have to be met by the landowner. Using this definition, irrigation of TMW to produce of cut-and-carry pasture or pasture for grazing is an example of beneficial reuse.

Clearly, TMW irrigation is not required to establish and grow NZ native plants on Banks Peninsula – nor is it required to grow pasture. Therefore, TMW-irrigation onto NZ native plants can only be considered a beneficial reuse if it generates more value than would otherwise be realised on a non-irrigated system. Irrigating TMW onto mānuka (*Leptospermum scoparium*) ecosystems for the production of honey or essential oils would be an example of beneficial reuse of the water and nutrients contained within TMW because most of Banks Peninsula is too dry to support mānuka production (there are small pockets of mānuka in Nikau Palm Gully and on Quail Island). Moreover, mānuka has been demonstrated to be effective in reducing nitrogen losses from soil (Esperschuetz et al., 2017a). Using TMW to accelerate the production of any product derived from native plants is an example of beneficial reuse.

NZ native plants may have a role in the land application of TMW even if no valuable native product is realised. Native plants, including mānuka and kānuka, could be used on paddock margins of TMW-accelerated pasture (cut-and-carry or grazed) to reduce environmental impacts. There are innumerable examples of where NZ native plants have been used successfully to improve environmental outcomes on conventional farms. Replacing a conventional grazed pasture with a well-designed TMW-application system is likely to improve the water quality of the local streams.

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A lysimeter experiment and field trial to determine options for the beneficial reuse of wastewater from Duvauchelle and Akaroa, Banks Peninsula (October 2014 – June 2017)

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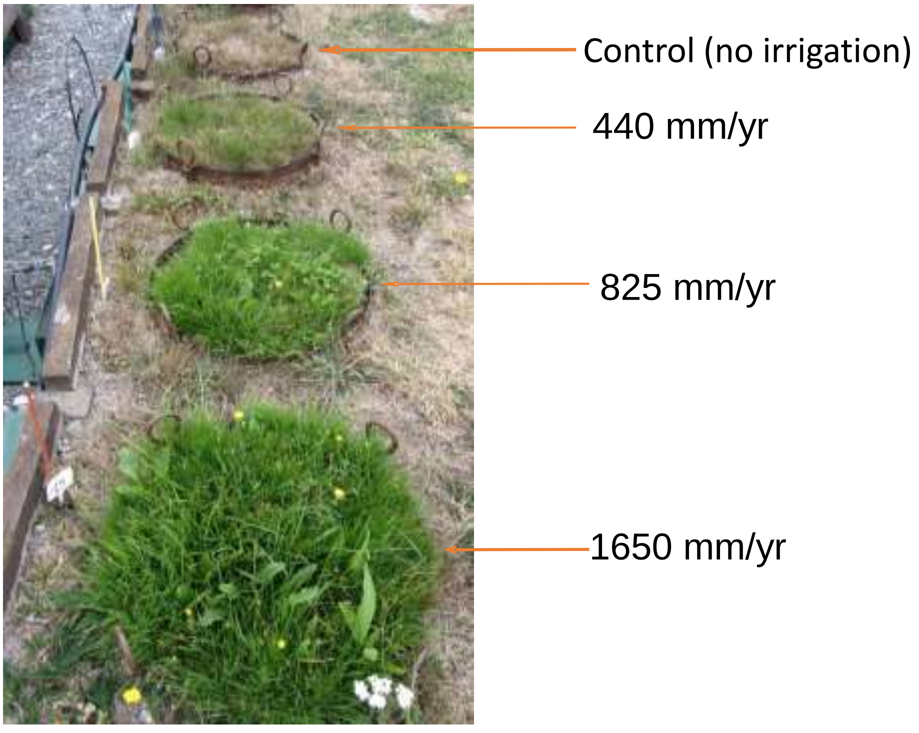
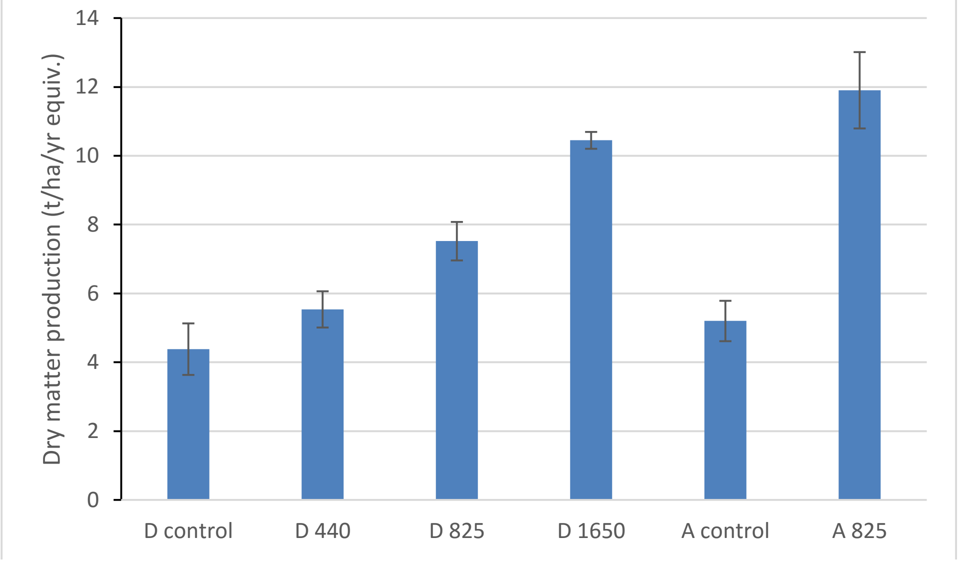
2
1
3
3
2

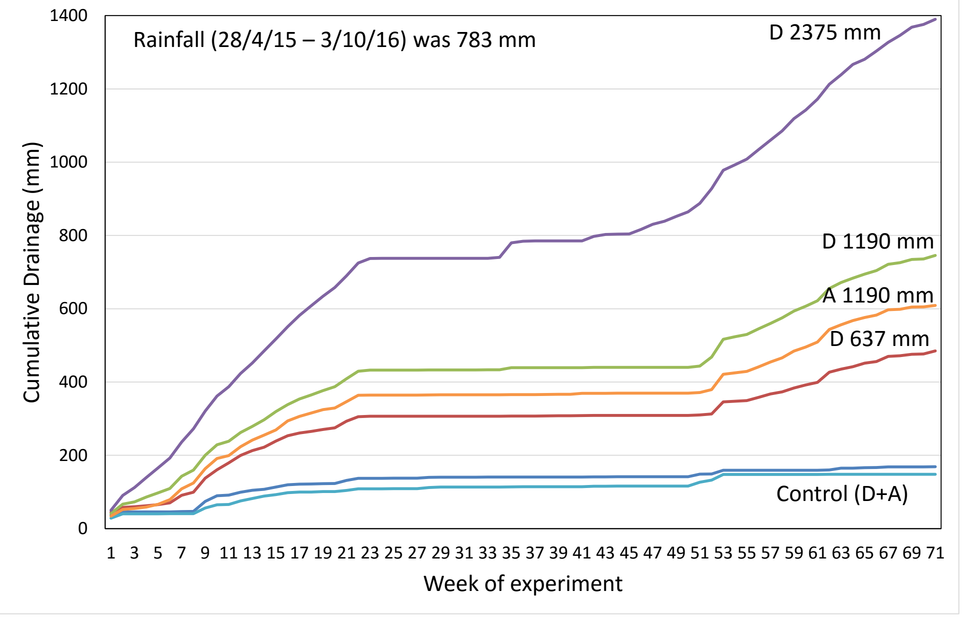

Irrigation with effluent
Pasture
Intact soil profile
Gravel layer
Drainage



Wastewater accelerates pasture growth



All soils drained freely with no ponding



No significant nitrate leaching

- Total N in treated wastewater ca. 30 mg/L
- Average nitrate-N concentration in drainage <0.3 mg/L
- Total nitrate-N leached <1 kg/ha/yr in all treatments

Field trial, Pipers valley road

NZ-native species with and without treated wastewater

Vegetation type 1		Vegetation type 2		Vegetation type 3	
Mānuka	*Leptospermum scoparium*	Akiraho	*Olearia paniculata*	Kapuka	*Griselinia littoralis*
Kānuka	*Kunzea robusta*	Puahou	*Pseudopanax arboreus*	Tarata	*Pittosporum eugenioides*
		Karamu	*Coprosma robusta*	Tī kōuka	*Cordyline australis*
		Hall's tōtara	*Podocarpus cunninghamii*	Harakeke	*Phormium tenax*
				Wharariki	*Phormium colensoi*

Next steps

- Column leaching experiments

- Greenhouse experiments
- Final report: June 2017
- Ongoing research on field plot

- Information available on:

www.kiwiscience.com/BanksPeninsula.html

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Appendix T B Robinson - Phosphorus Effects Paper

Phosphorus in Treated Municipal Wastewater irrigated onto NZ-native vegetation

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Executive summary

- Potentially, irrigating Treated Municipal Wastewater (TMW) onto NZ-native vegetation could result in the accumulation of phosphorus (P) in the soil to the point that the soil becomes infertile and excess P degrades local waterways. The Christchurch City Council commissioned the University of Canterbury to determine acceptable levels of P in TMW that is to be applied to NZ-native vegetation.

- An assessment was made using calculations of the likely effects of adding TMW on soil P concentrations and P losses to that could lead to waterway degradation. These results of these calculations were compared with literature reports of the effects of soil P on soil fertility and P-losses.

- Calculations revealed that irrigating 500 mm/yr of TMW containing either 5, 10 or 15 mg/L P would result in P accumulation in the soil. This is because P losses through vegetation removal, leaching, and runoff from TMW-irrigated native vegetation, are negligible compared to the P that is added to the soil.

- Over a 50-year period, the concentrations of soil P in the Pawson Silt Loam and Barry's Soil receiving 500 mm/yr of effluent containing 10 mg/L would increase by 84% and 100%, respectively. Nevertheless, even with these increases, the 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.

- In the aforementioned scenario, Olsen-P, a measure of plant-available P, would also 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). The increase in Olsen-P may be unfavourable for some NZ-native species, however, there are many other NZ-native species that will thrive under these high-P conditions. This indicates the importance of plant-selection for any treatment system.

- In the aforementioned scenario, there would be an increase in the amount of P-leaching below the top 0.3m of topsoil to around 2.2 kg/ha/yr after 50 years of application. 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 under TMW-irrigated NZ-native vegetation than an intensively-grazed pasture.

- Estimations using these calculations indicate that the application of 50 kg P/ha/yr with TMW is unlikely to cause serious soil fertility or environmental issues over a 50-year period. The life of the system could be extended using lower rates of P addition or by periodically harvesting the native vegetation.

Introduction

Treated Municipal Wastewater (TMW) contains environmentally significant concentrations of plant nutrients, including phosphorus (P). While the application of P to soil can improve plant growth (McLaren and Cameron 1996), excess P is can accumulate in soil where it may become toxic to plants (Hawkins et al. 2008). High concentrations of P in soil can increase the chance that this element can enter waterways via runoff, erosion or to a lesser extent, leaching (McDowell and Condron 2004). Elevated levels of P in waterways exacerbate eutrophication, including the uncontrolled growth of aquatic macrophytes and algae (Tilman et al. 2001).

Phosphorus is routinely added to agricultural soil in NZ. Most soils require more P to be added than is removed by plants, because much of the added P becomes immobilized and unavailable for plant uptake (McLaren and Cameron 1996). Measuring the total P in soil is a poor indicator of the P-availability to plants or P that is likely to leach into waterways, because only a fraction of the total P in soil is mobile and available to plants. Plant availability is often indicated by measurements using a mild chemical extractants. In New Zealand and elsewhere, 'Olsen-P' provides good information on the plant-availability of P in a soil (LandcareResearch 2017). Similarly, extractions using calcium chloride ($CaCl_2$), indicate the concentration of P in soil solution, which has the potential to leach through the soil profile (Sanchez-Alcala et al. 2014).

To convert a low-fertility soil, such as a forest soil, into productive pasture, a large application of P, 'capital P', is required. This can be as much as 500 kg P/ha (Dollery 2017). Thereafter, 'maintenance P' is applied, depending on the land use, usually between 5 and 40 kg P/ha/yr (McLaren and Cameron 1996). The application of P from TMW can be higher than that, which would be applied from P fertilisers. For example, the application of 500 mm/yr TMW from the Duvauchelle wastewater treatment plant, which contains an average of 11 mg/kg P(Gutierrez-Gines, McIntyre, et al. 2017) is the equivalent of 55 kg P/ha/yr.

While a significant amount of P that is added to agricultural soil is removed in the produce, the application of P to NZ native vegetation, where no plants are removed, will result in an accumulation of P in the system. This may result in toxicity to plants and or environmental degradation.

This report aims to determine the likely rate of P accumulation, P toxicity, and P mobility, resulting from the irrigation of TMW onto native vegetation on Bank's peninsula.

To assess these aims, the effects of irrigating 500 mm of TMW onto two Bank's Peninsula soils, the Pawson Silt Loam (PSL), 43°45'8.78"S 172°56'35.55"E and Barry's Soil (BSL), 43°44'53.06"S 172°55'41.44"E, also a silt loam, were estimated using mass balance calculations. These calculations used data from the PSL, BSL reported in (Gutierrez-Gines, McIntyre, et al. 2017) as well as other unpublished data from ongoing investigations. It was assumed that the amount of P removed in the NZ native vegetation was negligible. The calculations were run over a simulation period of 50 years. Other parameters used in the calculations are given in the Table.

The calculations assume that there is negligible runoff and erosion under the native vegetation because (a) the TMW would only be irrigated onto gently sloping land (<15°), (b) tree roots stabilize the soil, mitigating soil loss (Robinson et al. 2009), and (c) increase infiltration and preferential flow around the tree roots mitigate overland flow (Knechtenhofer et al. 2003; Sidle et al. 2006).

Table. Parameters used in the mass balance calculations for P application to NZ native vegetation on two soil types on Bank's Peninsula

	Pawson Silt Loam (PSL)	Barry's Soil (BSL)
Effluent P concentration (mg/L)	5, 10 or 15	5, 10 or 15
Effluent application rate (mm/yr)	500	500
P application rate (kg/ha/yr)	25, 50, or 75	25, 50, or 75
[1]Water flux (mm)	800	800
[2]Initial soil P concentration (mg/kg)	1046	599
[3]Olsen-P (mg/kg)	39	9
[4]Water soluble P ($CaCl_2$) (mg/L)	0.18	0.04
[2]Soil density (t/m^3)	1.4	1.4
Simulation depth (m)	0.3	0.3

[1]Estimated from rainfall (922 mm/yr) + TMW irrigation (500 mm/yr) – evapotranspiration (ca. 622 mm/yr)
[2]Measurements from (Gutierrez-Gines, McIntyre, et al. 2017)
[3]Unpublished data, Lincoln University
[4]Estimated from ratios with Olsen-P on similar soils from McDowell and Condron (2004) and Sanchez-Alcala et al. (2014).

Fig. 1 shows the results of these calculations. Under the nominal case of irrigating 500 mm/yr of TMW containing 10 mg/L P, over a 50-year period the total P concentration in the top 0.3 m will increase from 1046 to 1624 mg/kg in the PSL and from 599 to 893 mg/kg in the BSL. Even with this increase, the total concentration at the end of the 50-year period is still well within the range of P concentrations reported for NZ agricultural soils reported by McDowell and Condron (2004) and Reiser et al. (2014). It should be noted that the concentrations calculated here are averages and due to the highly heterogeneous nature of flow pathways in a forested soil (Knechtenhofer et al. 2003), it is likely that there will be localized areas with significantly higher concentrations. Gutierrez-Gines, McIntyre, et al. (2017) reported no significant increases in total soil P in a lysimeter experiment following the application of 2375 mm of TMW containing 11 mg/L P, probably because the total increase in P was within the measurement error and because of heterogeneity in the system.

In the nominal case, the plant-available or 'Olsen P' in these soils is likely to increase from 39 to 61 mg/kg in the PSL and increase from 9 to 14 mg/kg in the BSL. The initial Olsen-P concentration in the PSL is within the range (35-40 mg/kg) recommended by Dairy NZ to maintain high productivity on sedimentary soils (DairyNZ 2018). This is undoubtedly a result of good soil management under previous land use, grazed pasture. In contrast, the BSL, with an initial Olsen-P concentration of 9 mg/L is consistent with non-productive but managed land, in this case a golf course. Even with an increase to 14 mg/kg, the plant-available P would only be sufficient for low P-requiring crops such as for winter wheat (Tang et al. 2009). For pasture, Olsen-P values above 100 are excessive and values are considered 'high' from 50 – 100 (LandcareResearch 2017).

It is likely that the high plant-available P concentration on the PSL would inhibit the growth of some NZ-native species that are adapted to a low-P environment. LandcareResearch (2017) reports that for native vegetation, Olsen-P values of 8-12 mg/kg is considered high and 12 – 15 mg/kg is excessive. However, there are many reports that some NZ-native species can thrive with Olsen-P values manifold higher e.g. Gutierrez-Gines, Robinson, et al. (2017) and Reis et al. (2017). Indeed, 11 species of native plants are thriving on the very same PSL (with an initial Olsen-P of 39 mg/kg), which has received TMW for nearly 3-years (Figure 2).

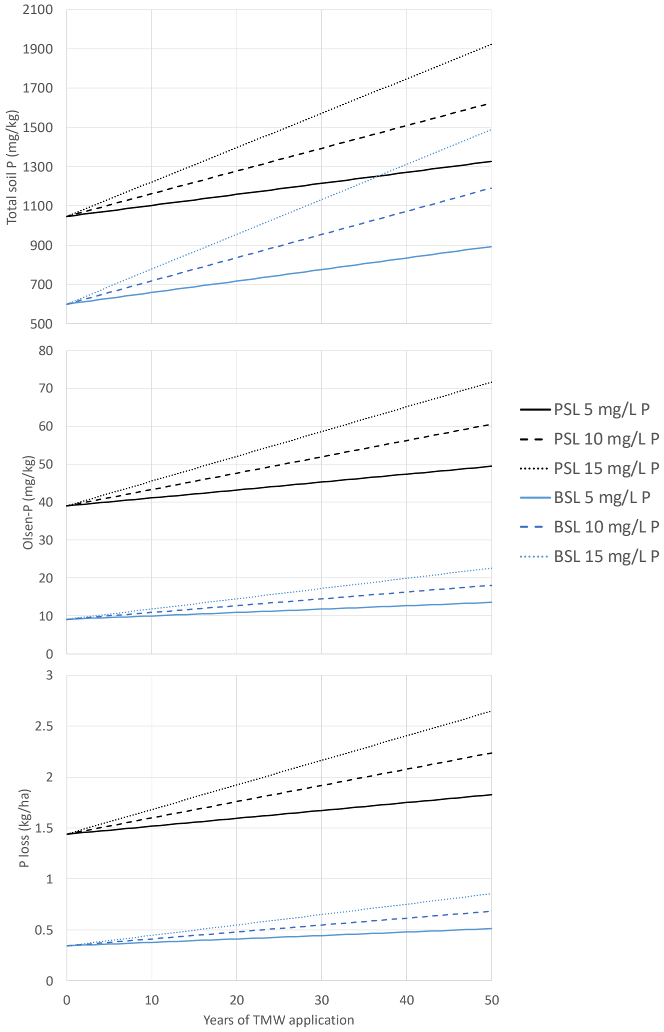

Figure 1.

Calculated phosphorus (P) in the top 0.3m of the Pawson Silt Loam (PSW) and Barry Soil (BSL) under irrigation with TMW at 500 mm/yr with a P concentration in the effluent of 5, 10 or 15 mg/L. The parameters used for the calculations are given in Table 1.

Fig. 1 also shows that irrigating TMW onto native vegetation will result in a significant increase in P leaching from the top 0.3 m of topsoil. This is because of the additional P added to the system in the TMW and the increased water flux through the soil. In the aforementioned scenario, P leaching below the top 0.3m would increase to 2.2 kg/ha/yr in the PSL and to 0.9 kg/ha/yr in the BSL after 50 years. It should be note that, depending on the depth of groundwater, most of this P lost from the top 0.3 m will be retained by the subsoil, which is rich in P-binding oxides of iron and aluminium (McLaren and Cameron 1996). In comparison, the estimated current total P-loss through soil loss from the same area under grazed pasture ranges from 2 – 15 kg/ha/yr, based on soil loss maps (https://statisticsnz.shinyapps.io/soil_erosion/). Under native vegetation irrigated with TMW, significantly less P would be lost through runoff or soil loss compared to a grazed pastureland because the trees increase infiltration and stabilize the soil (Robinson et al. 2009; Sidle et al. 2006). It is therefore likely that irrigating NZ-native vegetation with 500 mm/yr of TMW containing 10 mg/kg P will result in less P-loading on surface waters than a conventional grazed pasture.

Fig. 2. PhD candidate Alexandra Meister and Dr Jacqui Horswell among NZ native vegetation receiving Treated Municipal Wastewater, Pipers Valley Road, Duvauchelle. 12th February 2018.

The calculations indicate that TMW irrigated onto NZ-native vegetation with application P at a rate of 50 kg/ha/yr will result in soil and plant-available P concentrations that are still within the ranges of NZ agricultural soils and that excessive P-leaching is unlikely. While it is likely that some NZ-native species will not tolerate these levels of plant-available P, there are published studies showing that many NZ-native species can tolerate such levels (Gutierrez-Gines, Robinson, et al. 2017; Reis et al. 2017). Lower P application rates will prolong the life of the system, as would periodic removal of some of the vegetation e.g. periodic harvesting of manuka or kanuka to produce high value essential oils.

The application of any element to a system at a rate than is greater than the rate that it is removed is ultimately unsustainable (Mills et al. 2005). If a soil P concentration were reached when a NZ-native ecosystem collapsed or if unacceptable concentrations of P were leaching, then the soil could usefully be converted to high-fertility agricultural soil for pasture or cropping.

Note that this report is based on calculations using soils from the Duvauchelle Golf Course and Pipers Valley Road. Soils from other locations on the peninsula (e.g. Robinson's Valley) may have different initial conditions due to differences in soil use history.

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Impacts of nitrogen application to Pasture and Native Plantings on Banks Peninsula

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Executive summary

- Based on effluent flow-rate data, effluent chemistry, and the land available for irrigation, the nitrogen (N) application rate in Robinsons Bay would be 125 - 172 kg N/ha/yr, which is below the threshold of 200 kg/ha/yr set by many jurisdictions in New Zealand and overseas.
- Applied N will either accumulate in the soil (which is environmentally benign), be removed in the vegetation, be denitrified into nitrogen gas or nitrous oxide, or leach into groundwater.
- Irrigation of the Treated Municipal Effluent (TMW) onto cut-and-carry pasture is likely to result in negligible (<2 kg/ha/yr) nitrate leaching. Experiments have demonstrated that the pasture will remove nearly all of the N that is applied.
- Irrigation of TMW onto grazed pasture will have similar nitrate leaching to a regular grazed pasture where fertiliser has been applied.
- Preliminary data indicate that Irrigation of TMW onto NZ native vegetation will result in nitrate leaching of 15 - 60 kg/ha/yr, similar to grazed pastures. These figures will change as data from experiments in Pipers Valley come to hand. This is expected in early 2020.
- Species selection and weed control are the critical success factors for establishing NZ native vegetation under TMW irrigation.

Introduction

Nitrogen (N), in the form of ammonium (NH_4^+) or nitrate (NO_3^-), is the most important plant macronutrient in soil. Other forms of N, such as nitrogen gas (N_2) and organic N are not available to plants and must be converted to available forms by biological processes (McLaren and Cameron, 1996). New Zealand agriculture relies on N supplementation to soil, via fertilisers (mainly urea), soil conditioners (such as compost), or N-fixation from legumes such as clovers.

While N addition usually improves plant growth, excessive N application can lead to NO_3^- leaching through the soil profile where it may contaminante surface waters or groundwater (Martin et al., 2017). Elevated N application may also result in increased emissions of nitrous oxide (N_2O), a greenhouse gas with a global warming potential some 300 times greater than carbon dioxide (Taghizadeh-Toosi et al., 2011). High concentrations of NO_3^- in drinking water can be harmful to human health, particularly infants (Knobeloch et al., 2000), while elevated NO_3^- concentrations in aquatic or marine ecosystems can exacerbate eutrophication (de Jonge et al., 2002). The New Zealand Drinking Water Standard for NO_3^- is 11.3 mg/L NO_3^--N

(Di and Cameron, 2000). The Australian and New Zealand Guidelines (NIWA, 2013) for NO_3^- in freshwater range from 1 mg/L NO_3^--N for pristine environments with high biodiversity and conservation values (99% species protection) through to 6.9 mg/L NO_3^--N for environments which are measurable degraded (80% species protection).

Treated Municipal Wastewater (TMW) contains agronomically significant concentrations of N, making it a potential fertiliser replacement but also a potential source of groundwater or surface water contamination. When irrigated onto soil, this N undergoes biologically and chemically-mediated cycling (Fig. 1). Ultimately, the applied N leaves the soil via plant uptake (and removal of the harvested or grazed biomass), volatilisation as N_2 or N_2O, or leaching (as NO_3^-). The amount of NO_3^- leaching or N_2O emissions from an area irrigated with TMW depends on the irrigation rate, the N-concentration in the TMW, the climatic conditions, and the land use.

This report aims to determine the likely effect of TMW irrigation on growth of NZ-native vegetation, grazed pasture, and cut-and-carry pasture on 35 hectares of irrigable land from the Thacker farm, Banks Peninsula. The production rate and chemistry of the TMW was provided by the Christchurch City Council. The soil properties, pasture uptake rates were assessed in a previous report (Robinson et al., 2017) as well as data from an ongoing field trial in Pipers Valley, Duvauchelle. At the time of writing (August 2019), we are awaiting the final results of N-fluxes from the field trial, which is due to conclude in December 2019. As such, we will amend this report with the results of the field trial as they come to hand.

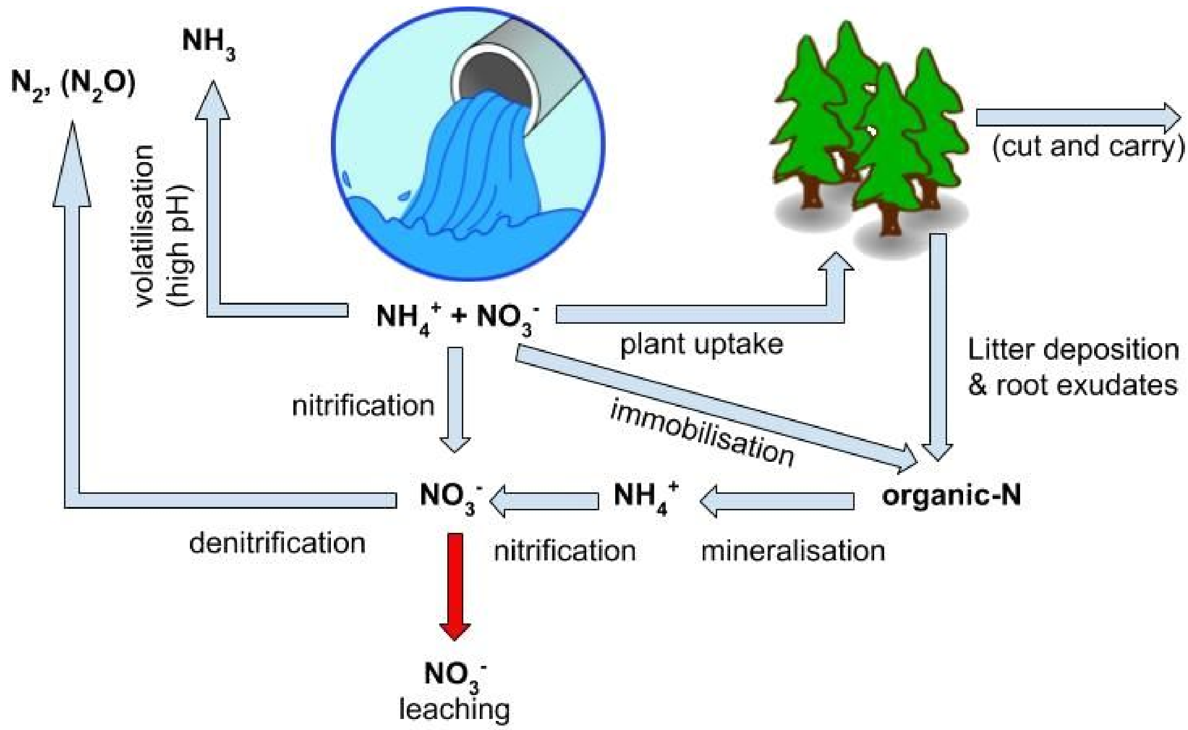

Fig. 1. Nitrogen fluxes following the application of Treated Municipal Wastewater to soil. This diagram assumes that the Wastewater has been treated to a high standard (such as is the case on Banks Peninsula) and the concentration of dissolved organic matter (and organic N) is low.

Nitrogen in the Treated Municipal Wastewater and nitrogen application rates

TMW from Duvauchelle and Akaroa (Feb 2017 - Feb 2019) had average total N concentrations of 18.5 and 25.4 mg N/L, with standard deviations of ca 7.5 mg/L in both cases. At the time of measurement, some 50% of the N was present as NH_4^+, with the remainder mostly comprising NO_3^-. However, the NH_4^+ is rapidly oxidised to NO_3^- in the environment or when the effluent is stored. (Clough et al., 2001). Once irrigated onto soil, any N added that is not taken up by plants will either oxidise to NO_3^- thence be denitrified back to N_2 (or N_2O) gas, become immobilised into soil organic matter, or leach into groundwater (Fig. 1). The rate of application affects the fate of N, with higher application rates resulting in increased N-leaching and potentially increased N_2O emissions. The likely N application rates on Banks Peninsula are 125 - 172 kg N/ha/yr shown in Table 1. These values are below the 200 kg/ha/yr threshold, which is set by many jurisdictions (Clark and Harris, 1996).

Table 1. Annual nitrogen Application (kg N/ha/yr) as a function of irrigation rate and effluent N concentration, given the area of potentially irrigable land in Robinsons Bay is some 35 ha (Barton, 2017). The likely irrigation rate is 678 mm/yr, resulting from an effluent flow rate of 650 m^3/day.

	TMW @ 18.5 mg N/L	TMW @ 25.4 mg N/L
Irrigation 500 mm	92.5	127
Irrigation 678 mm	**125**	**172**
Irrigation 1000 mm	185	254

Nitrate leaching under cut-and-carry pasture, grazed pasture and NZ - native vegetation

Previous research using lysimeter experiments on Banks Peninsula soil (Robinson et al., 2017) has shown that under cut-and-carry pasture, these irrigation rates resulted in negligible NO_3^- leaching (<1 kg N/ha/yr), even at application rates of 207 kg N/hr/yr equivalent. Compared to the previous lysimeter experiments, the groundwater at Robinsons Bay is deeper (at least 4 m (Barton, 2017), which will result in more denitrification of the applied N, thereby reducing N-leaching. However, this effect may be offset by the greater precipitation (ca. 1000 mm/yr) on the peninsula compared to the 660 mm/yr that fall at the Lincoln University lysimeter facility. Even with a small increase in drainage caused by high rainfall events on Banks Peninsula, it is likely that cut-and-carry pasture on the Thacker Farm receiving TMW will have negligible N-leaching.

In contrast to TMW-irrigated cut-and-carry systems, grazed pastures over much of the Canterbury Plains and small parts of Banks Peninsula typically leach >45 kg N/hr/yr (Stats, 2019). If the TMW-irrigated pasture were used for grazing, it is likely that the N-leaching rates would be similar to those of a non-TMW-irrigated pasture where N-fertiliser had been applied.

New Zealand native plant species have an N concentration of 0.8 - 2% (dry weight), which is significantly less than pasture, which can have up to 5% N (Dickinson et al., 2015). Given a dry biomass production under optimal conditions (i.e. under TMW-irrigation) of 5 t/ha/yr, native plants containing 1% N would remove 50 kg N/ha/yr. This is significantly less than the N being applied to the soil. Moreover, unless the vegetation is removed periodically, the N accumulated in the plants will eventually be returned to soil via leaf-fall and tree senescence (and subsequent decomposition of dead material). After the accumulation of N in soil via immobilisation, additional N will be lost via leaching or denitrification. Overseas studies have shown that 25 - 150 kg/ha of N applied N can be lost through denitrification (Paul and Zebarth, 1997; Mahmood et al., 1998). In New Zealand, studies with Dairy Shed Effluent reported that some 60 kg/ha/yr were lost through denitrification (Di and Cameron, 2000). Evidence of iron mottling in the soil profile in Robinsons Bay (Barton, 2017), indicates low-oxygen conditions that favour denitrification (Clough et al., 2001). Any N that is not removed by the biomass, fixed into soil organic matter or denitrified, will leach. Given the current data, we estimate that leaching under NZ-native vegetation under nominal conditions will be 15-60 kg N/ha/yr at Robinsons Bay, which is comparable to grazed pasture (Stats, 2019). A more accurate assessment of the likely N-leaching under NZ-native vegetation will be provided in an update report in Early 2020.

Establishing NZ native vegetation under Treated Municipal Wastewater irrigation

Irrigation with TMW significantly increases the growth of pasture and some exotic plants (Esperschuetz et al., 2016; Robinson et al., 2017). The response of NZ-native vegetation is species-dependent: while many species show significantly increase growth when irrigated with TMW, other species are unaffected or may even have lowered growth. The field trial in Pipers Valley has indicated that *Leptospermum scoparium* (mānuka), *Kunzea robusta* (kānuka), *Coprosma robusta* (karamu), *Cordyline australis* (cabbage tree), *Phormium tenax* (harakeke, flax) respond well to TMW irrigation with significantly increased growth over the four-year trial. In contrast *Griselinia littoralis* (kapuka, broadleaf)*, Phormium cookianum* (mountain flax)*, and Pittosporum eugenioides* (tarata, lemonwood) have no positive growth response. The contrasting responses of NZ-native species can result in increased weed competition during the establishment phase.

The critical success factor for establishing NZ-native vegetation are **species selection** and **weed control**. The trial at Pipers Valley Road has indicated the NZ-native species that respond well to TMW. These species should be selected for the majority of plantings in Robinsons Bay. Weed control should form part of the planting plan and include the contractors who will do the weeding. Planting into grass such as *Holcus lanthus* (Yorkshire Fog), has better outcomes than blanket spraying and planting into bare soil. Spot spraying may be appropriate. Close (1 m x 1 m, 10,000 stems/ha) plant spacing reduces the time that the site needs to be weeded but can reduce weeding options. Close planting is also more expensive. Compared to close planting, Lower density planting (e.g. 1 m x 3 m, 3333 stems per hectare) is less expensive to plant and to remove weeds, but the weeding will have to continue for several more years. A critical success factor is the appointment of a site manager who can monitor weeding and intervene as appropriate.

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Appendix U Irrigation Model Report

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27 January 2022

Christchurch City Council
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Attention: Kylie Hills

Dear Kylie

Akaroa Treated Effluent Disposal Flow Balance Modelling

1.1 Background

Christchurch City Council (CCC) is investigating locations, storage requirements and extent of land area required to dispose of treated wastewater from the Akaroa township. This letter summarises the findings of the Soil Moisture Balance (SMB) model built to determine the size of treated storage required to balance high rainfall events and seasonal changes in disposal rates for the 40ha treated wastewater disposal area.

The SMB model is described in further detail in the attached letter *Akaroa Recycled Water Scheme – Irrigation Model Results for Recycled Water Disposal at Robinsons Bay with Supplementary Wetland* (Pattle Delamore Partners, January 2022). The SMB model needs to be considered in conjunction with the results of the hydraulic network drainage model (NDM). These results are summarised in the *Akaroa Wastewater Network Modelling Long Time Series and Network Upgrade Scenarios* report (Beca, 26th February 2021).

1.2 Network Hydraulic Model

The NDM with upgraded network scenarios was used to determine the daily design flows from the Akaroa network to be input to the SBM. The model results determined that with the various upgrades required to reverse the network to pump to the new Wastewater Treatment Plant (WWTP) location, a daily flow volume of 3,562m^3/day is pumped to the WWTP. This is based on CCC's selected design storm of a 1 in 10-year Average Recurrence Interval (ARI) 24-hour duration event, for the 2052 projected population. At rainfall intensities beyond this event, raw wastewater will spill to the harbour from Engineered Overflow Points (EOPs) in the network.

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Note that the proposed capacity, based on NDM outputs, of the new terminal pump station to the WWTP is 95l/s. The updated modelling in the February 2021 report found this pump station capacity to be greater than earlier network modelling, due to:

- Updated design storms based on revised CCC *Waterways, Wetlands and Drainage Guide (WWDG)*, which requires adjusting storms to account for the worst case climate change scenario of RCP 8.5.
- Design storm hyetograph updated to latest WWDG version compared with previous modelling

The 95l/s pump station capacity is greater than the average daily flows used in the SMB modelling. The terminal pump station capacity is higher to match instantaneous peak flows from the network. This means that the network can supply a higher daily flow to the WWTP than WWTP treatment and disposal capacity. The differences will be balanced out by a raw wastewater pond on the inlet to the WWTP. This pond is yet to be sized. A control loop will be required in the terminal pump station controls to stop pumping when the raw wastewater buffer pond is full. This will result in overflows to the harbour.

1.3 Soil Moisture Balance Model

The full results of the SMB modelling are detailed in the attached letter. In summary the results found that to dispose of the treated wastewater to the 40 ha of tree plantation, treated wastewater ponds ranging in size from 26,000m³ to 11,250m³ are required to buffer flows such that no uncontrolled overflows after the WWTP are anticipated. The upper figure is based on no reduction in inflow and infiltration (I&I) to the wastewater network, and no reduction in retentate flows at the L'Aube Hill Water Treatment Plant (WTP). The lower figure is based on a 20% reduction in I&I and 75% reduction in retentate flows, and having covered storage. The I&I and retentate reduction is a key assumption used in this modelling and is discussed further below.

1.4 Residual Risks and Opportunities

A number of residual risks and opportunities remain which will need further attention as the project progresses:

1.4.1 Inflow & Infiltration Reduction:

The modelling described in the attached letter includes high level assumptions on the reduction in I&I to the network and retentate flow from the Water Treatment Plant (WTP). CCC is currently undertaking a programme of physical works to reduce I&I. CCC is also undertaking measures to reduce and find beneficial re-use for retentate flow.

Flows should be monitored closely to measure the success of these programmes and assessed against the assumption in I&I reduction used in the SMB modelling. Not achieving the assumed reductions risks increasing the size of storage and/or land disposal.

Conversely, if I&I and retentate reduction measures are better that assumed in this work, an opportunity for reducing storage and disposal field sizing is presented.

Reduction in flows due to the I&I reduction programme need to be viewed cautiously against changes in tourist numbers to Akaroa following the onset of the Covid 19 pandemic.

1.4.2 Network Drainage Model Calibration

The NDM is calibrated to data collected from a flow monitoring exercise in 2013, with validation undertaken against more recent data from flow meters installed on the network pump stations. These flow meters were not installed at the time of the network monitoring exercise. In hydraulic modelling it is generally recommended models are recalibrated following significant changes to the network, and around every 10 years. In this instance the I&I and retentate reduction measures and various sewer renewals, as well as the time since the original flow monitoring exercise, suggest the model is due for re-calibration.

The existing calibrated model found that the majority of annual wastewater volume from I&I comprised of groundwater derived infiltration (GWDI) rather than rainfall derived inflow and infiltration (RDII). Therefore, the SBM model is sensitive to groundwater infiltration parameters, which could have significant ramifications for sizing of storage and disposal. It is suggested several short periods of monitoring could be undertaken; during winter when groundwater is high and again during summer when groundwater is low, but population is high. This will allow for the re-calibration of the model to dry weather flows. Having monitors on the gravity side of the pump stations will allow greater quantification of minimum night flows to determine groundwater infiltration compared to assessing pump station SCADA data alone. Not needing to reassess the RDII response to recalibrate wet weather flows will avoid the long and costly monitoring required to capture sufficient rainfall events.

Additional monitoring will also provide more data to measure the success of the I&I reduction measures.

1.4.3 Difference in WWTP Capacity to Terminal Pump Station Capacity

There is currently a discrepancy between the proposed WWTP capacity (to be between 1,200 to 1,900m³/day) and the modelled peak daily disposal rate from the network (3,562m³/day). The SMB modelling found that the worst-case scenario was during rainfall over consecutive days for an extended period, rather than a single day of heavy rain.

The effect of the treatment capacity being lower than the terminal network pump station capacity used for the SMB modelling is that wastewater will back up in the raw wastewater buffer pond. Disposal of a large rainfall event will therefore occur over a longer period. This presents both a risk and an opportunity. Further modelling may find that the storage and disposal requirements increase or decrease, depending on extended rainfall patterns.

It is recommended that once the WWTP capacity is confirmed the SMB model is re-run based on the WWTP daily flow capacity.

1.5 Next Steps

It is recommended the following actions are undertaken:

- Confirm WWTP capacity
- Confirm raw wastewater buffer pond capacity once WWTP capacity is confirmed
- Undertake flow monitoring exercise with monitoring periods in winter to capture high groundwater, and summer to capture low groundwater and high population flows. Re-calibrate dry weather events in network model and rerun SMB with updated inputs from NDM and WWTP capacity.
- Monitor effect of I&I and retentate reduction programmes and assess against assumptions made in the modelling.

Yours sincerely

Logan Thomson

Associate - Civil Engineering

on behalf of

Beca Limited

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Email: Logan.Thomson@beca.com

Copy

Rae Stewart, Beca

Attached:

- *Akaroa Recycled Water Scheme – Irrigation Model Results for Recycled Water Disposal at Robinsons Bay with Supplementary Wetland* letter report.

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27 January 2022

Logan Thomson
Associate – Civil Engineer, Water
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PO Box 13960
CHRISTCHURCH 8141

Dear Logan

AKAROA RECYCLED WATER SCHEME - IRRIGATION MODEL RESULTS FOR RECYCLED WATER DISPOSAL AT ROBINSONS BAY WITH SUPPLEMENTARY WETLAND

1.0 Introduction

Christchurch City Council (CCC) is investigating options to irrigate recycled water from a proposed wastewater treatment plant (WWTP) servicing the Akaroa township. Pattle Delamore Partners Ltd (PDP) have been engaged by Beca Ltd to prepare a soil moisture balance (SMB) assessment to quantify the volume of recycled water storage required as part of the irrigation scheme.

Irrigation of recycled water to 40 ha of trees planted at the head of bays sites: Robinsons Bay, Hammond Point, and Takamatua has been modelled. PDP has previously modelled various irrigation to land scenarios at these sites. This letter has been prepared to present the recycled water storage requirements of the irrigation scheme using an updated long-term wastewater flow series derived from the Beca network drainage model (NDM).

2.0 Model Method and Inputs

2.1 Wastewater Flow Estimate

2.1.1 Dry Weather Flow

Beca has developed a NDM for the Akaroa township. The NDM estimates wastewater flows generated within the catchment servicing the WWTP from 19 Dec 2008 to 29 Feb 2020 accounting for future population growth. The NDM outputs the wastewater flow broken down into the following constituents: Baseflow, composed of the water treatment plant retentate flow and ground water derived inflow and infiltration (GWDII); rainfall derived inflow and infiltration (RDII); and population flow. The rainfall used for the NDM is from the Akaroa EWS rainfall gauge located near Stanley Park, Akaroa.

The SMB uses the longest period of data available to best capture the wide range of climate trends. This provides a better representation of wet and dry years the system will encounter and helps reduce bias from a smaller dataset. The long-term flow series for the Akaroa WWTP has been developed from 1 January 1972 to 30 April 2021 using Virtual Climate Station Network (VCSN) data.

The NDM is the foundation for developing the long-term flow series. The dry weather flow (all wastewater flow components except for RDII) have been taken directly from the NDM. Table 1 shows the components of the dry weather flow.

Table 1: Dry Weather Flow

Parameter	Flow (m^3/day)
Baseflow	285
Peak Population (Jan)	894
Summer Population (Dec, Feb)	506
Population (Mar – Nov)	236

It is noted that while the base flow has been assumed to be a constant daily rate, based on the long term NDM results, the retentate and GWII vary monthly. Table 2 shows the components of the baseflow broken down monthly. The retentate has been modelled as the monthly average flow recorded at the L'Aube Hill water treatment plant, as supplied by CCC from SCADA records. The GWII was estimated as the base flow constant minus the retentate flow for each month. This separation of the baseflow has been provided as I&I reduction scenarios differ in proportions for the two components.

Table 2: Base Flow

Parameter	Retentate Flow (m^3/day)	GWII (m^3/day)
January	116	169
February	121	164
March	127	158
April	109	177
May	97	188
June	83	202
July	92	193
August	88	197
September	99	186
October	104	181
November	118	167
December	118	168

2.1.2 Wet Weather Flow

The RDII in the NDM is estimated using the Akaroa EWS rainfall station. The Akaroa EWS has data available from mid-December 2008 to the present day. Given this relatively short period, rainfall from the NIWA Virtual Climate Station Network (VCSN) 20249 was selected to estimate RDII in the long-term flow series. The VCSN stations are generated on a 5 km grid and provide estimates of daily rainfall based on the spatial interpolation of actual data observations made at climate stations located around the country. VCSN 20249 is located approximately 4 km north of the Akaroa township and provides rainfall from 1 January 1972 to 30 April 2021. A comparison between VCSN 20249 and Akaroa EWS indicates that on average there is a difference in annual rainfall totals of approximately 4%. The timing of measured rainfall events is similar for the two-rainfall series, providing confidence in using the VCSN 20249 dataset to estimate RDII.

A relationship between the NDM RDII (generated from the Akaroa EWS) and VCSN 20249 rainfall over the period December 2008 to February 2020 has been developed. Figure 1 shows the RDII response in the wastewater network corresponding to rainfall events. A rainfall event is considered independent if there have been two or more consecutive no rainfall days prior to the start. The RDII is summed on a rainfall event basis.

A manual trendline has been selected to estimate the relationship between RDII and a rainfall event. The manual trendline is tailored to fit the larger rainfall events (> 100 mm rainfall events). It is noted that, although non-linear trendlines may provide a better overall fit to the data, the purpose of the long-term flow series is to provide an estimate of the peak recycled water storage volume required over the long-term modelling period. Therefore, the trendline is chosen to favour larger rainfall (resulting in larger RDII) events.

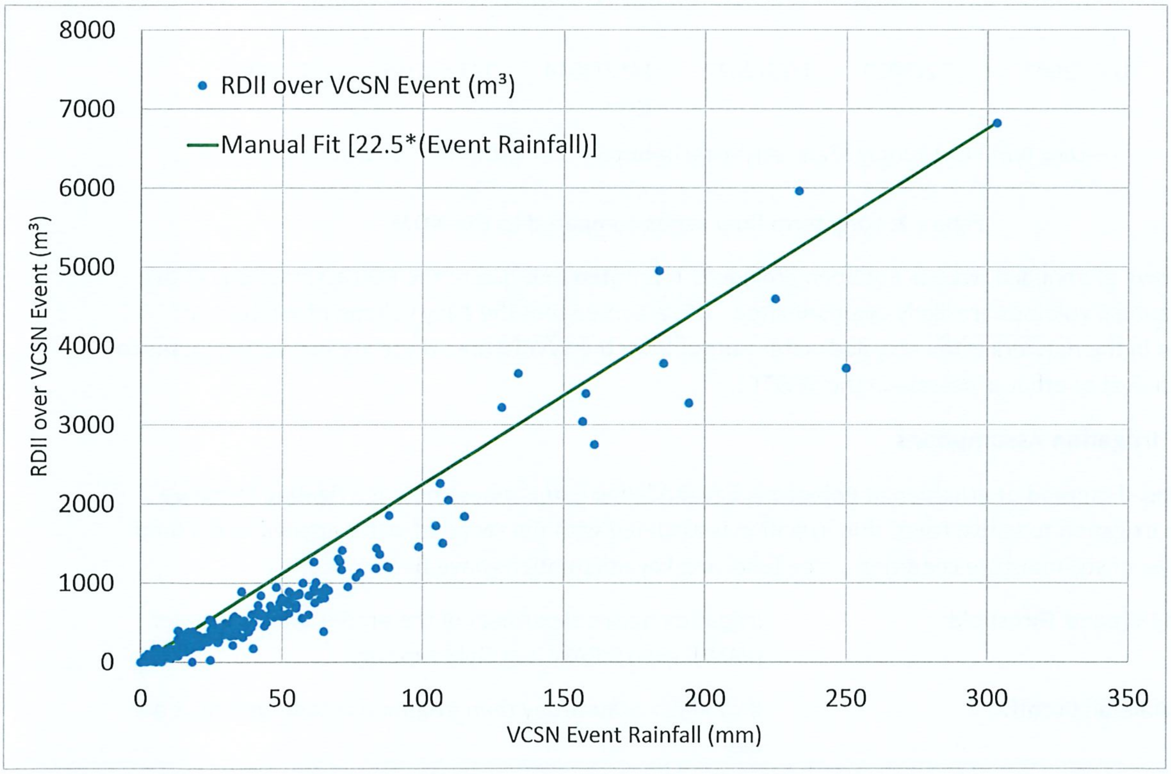


Figure 1: Relationship between VCSN Rainfall Events and the RDII response from the Beca NDM.

The relationship was then applied to rainfall events from the VCSN 20249 rainfall series from January 1972 to April 2021. This produced the RDII component of the long-term wastewater flow series. The long-term flow series is compared to the NDM in Figure 2. In general, the long-term flow series overestimates the wastewater flows. There are a few events in the NDM which are underestimated in the long-term flow series, these are indicated by the points above the trendline in Figure 1. Overall, the long-term flow series is considered appropriate for the purpose of the model. The under-estimated events are not influential in determining the peak recycled water storage requirements.

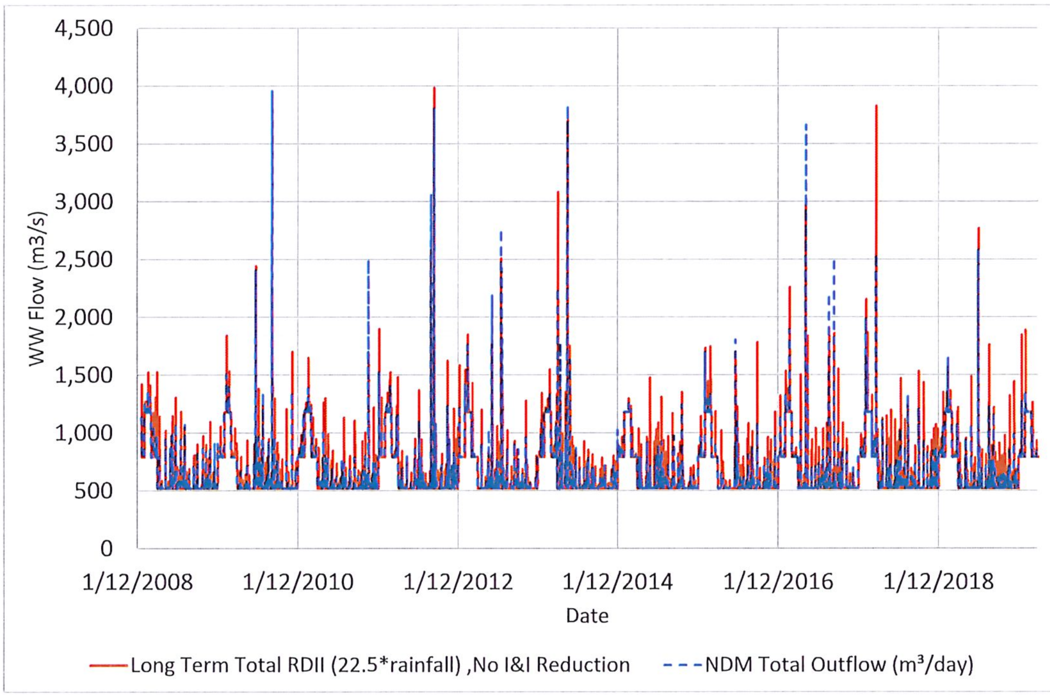


Figure 2: Long term flow series compared to the NDM

A breakdown of annual flows has not been provided. It is noted that due to the RDII assumptions above, RDII and annual volumes are likely overestimated. It is assumed that the daily volume of wastewater generated in the network is the recycled water output from the WWTP (i.e., there are no volume losses to sludge removal or other processes in the WWTP).

2.2 Irrigation Assumptions

The proposed method of irrigation at Robinsons Bay modelled in this assessment is irrigation to native trees. For irrigation to native trees, drip irrigation is assumed with the recycled water applied to the land irrespective of soil moisture conditions. The following key assumptions have been made:

Irrigation Demand Threshold:	Irrigation occurs regardless of the profile available water (PAW), even if PAW is at field capacity
Extreme Rainfall Cutoff:	If rainfall > 50mm/day then irrigation ceases until next dry day
Irrigation Season:	All year round
Irrigation Efficiency:	100% efficiency
Rainfall:	NIWA VCSN 20249 and Akaroa EWS
Maximum Irrigation Application (mm/day):	Dec–Feb: 2.75, Mar–May: 2.15, Sep–Nov: 2.15, Jun–Aug: 1.5

The maximum irrigation application per day is less than the Long-Term Acceptance Rate of the soils and is selected to avoid surface ponding when the PAW is at field capacity.

The rainfall described for the SMB is a composite of VCSN 20249 and Akaroa EWS. This is due to a more representative rainfall over the irrigation area being required. For the RDII estimation, the relationship between the VCSN and RDII (modelled using the Akaroa EWS) was used to estimate RDII over the long-term rainfall record. As the relationship was based on a representative RDII, it is appropriate for its purpose.

2.3 Wetland Operation Rules

The effect that a constructed wetland has on recycled water storage requirements was investigated by extending the soil moisture balance model previously created by PDP. This model is described in the PDP letter to Beca "Irrigation Model Results for Akaroa Treated Wastewater Land Disposal at Robinsons Bay" dated 9 May 2017.

A sub-surface wetland is proposed, which will be filled with granular media and planted with wetland species. A minimum water level will be required in the wetland to maintain plant growth and a freeboard will extend the potential depth of the wetland above the surface of the media. The model diverts any required recycled water from the WWTP to the wetland each day to replace evapotranspiration losses and maintain the minimum water level for plant health. It was agreed with CCC and Beca that the surface area for the wetland would be 3,800 m².

When the recycled water storage is 100% full, excess water will be diverted to the wetland. These flows comprise both recycled water and any rainfall over the storage. If the volume within the wetland exceeds the maximum level, there is a controlled outflow to the harbour.

The controlled wetland discharge to the harbour has been set at a constant rate of 2 L/s until the wetland freeboard is exceeded. If the wetland freeboard is exceeded, the volume of water above the freeboard will overflow to the harbour at an unrestricted rate.

<u>Wetland Model Summary</u>

Wetland Surface Area:	3,800 m²
Wetland Media Depth:	0.6 m
Wetland Total Depth (including freeboard):	1.0 m
Wetland Media Porosity:	30%
Wetland Minimum Level:	300 mm
Wetland (Controlled) Outlet Flow:	2 L/s

The above parameters result in a total volume of water in the wetland (including freeboard) of 2,204 m³.

2.4 Model Schematic

Figure 3 shows the schematic of the overall irrigation scheme. Figure 4 below shows a graphical representation of the extended irrigation model. The irrigation model currently assumes the flows generated at the Akaroa township are irrigated to land. All flows are buffered in a single pond. In practice, these flows would enter multiple ponds through the system as illustrated in Figure 3. The final volumes of the in-line storage are dependant on the final design of the WWTP treatment capacity (expected to be limited to 1,200 m³/day to 1,900 m³/day.

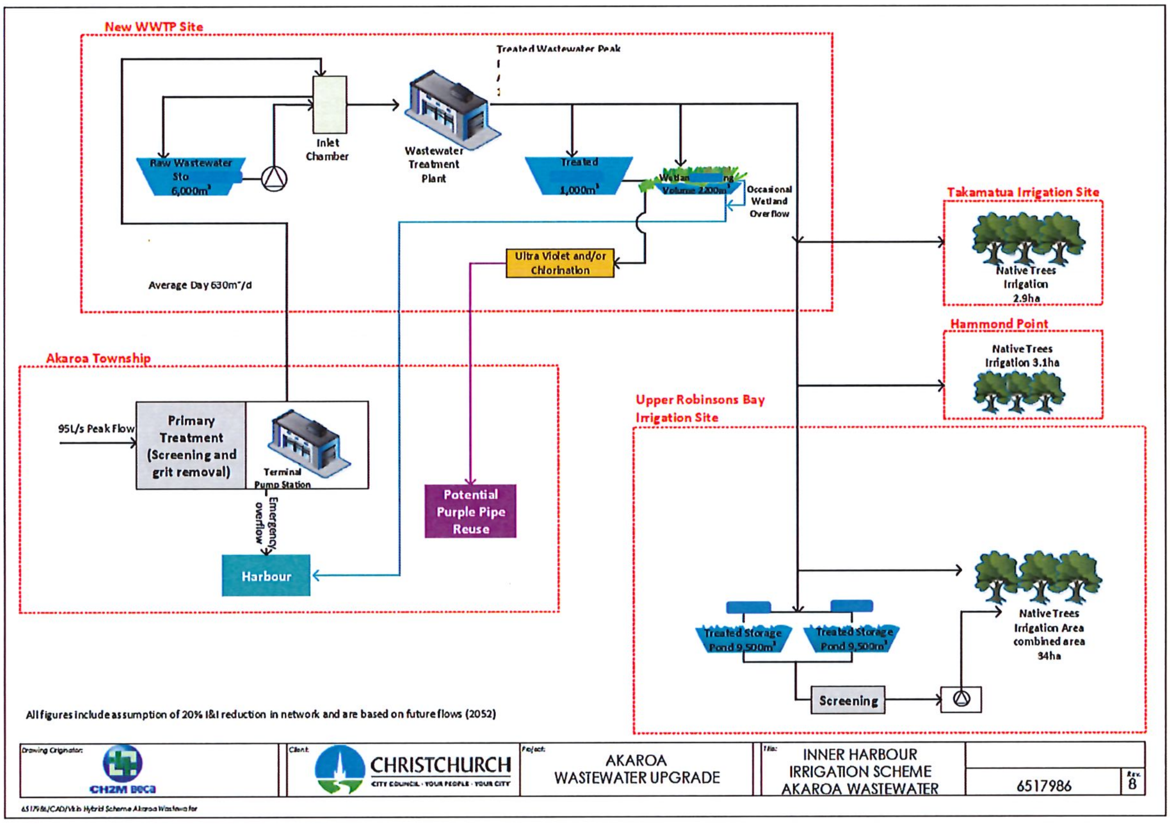
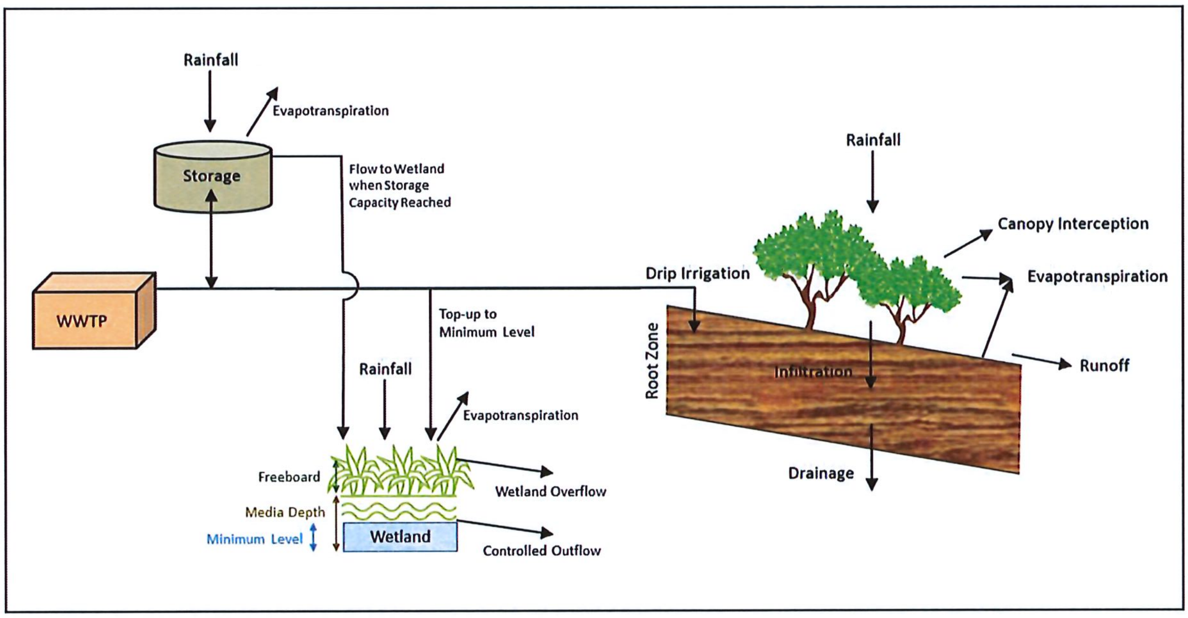


Figure 3: Schematic of Inner Bays Irrigation and Reuse Scheme (Provided by Beca)



Extended Soil Moisture Balance Concept Incorporating Wetland

Figure 4: Schematic showing the soil moisture balance

3.0 Updated Model Results

3.1 Model Inputs

Five scenarios are evaluated in this letter.

1. Updated wastewater flow series
2. Scenario 1 with a 3,562 m^3/day flow cap. This value corresponds to the volume from the network during a 24-hour, 1 in 10 year average recurrence interval storm. Flows exceeding this cap overflow into the harbour prior to the WWTP.
3. Scenario 2 with additional 20% reduction in GWII and RDII was assumed and a 75% reduction in retentate flows.
4. Scenario 3 with a maximum storage pond at 12,000 m^3 and storage pond surface area at 6,000 m^2
5. Scenario 4 with the storage pond covered (surface area 0 m^2). This removes added volume from rainfall on the storage pond itself.

For the first three scenarios, the storage surface area was kept constant at 10,000 m^2 for the purposes of calculating rainfall accumulation over the storage pond. The effect on storage volumes with the changing of parameters could, therefore, be assessed. The storage volume was 'limitless' so no overflows would occur.

Scenarios 2, 3, 4 and 5 assessed the effects of a flow cap through the wastewater network prior to the WWTP. Flows exceeding 3,562 m^3/day are assumed to overflow out of the network and bypass the WWTP and irrigation systems. After the WWTP, flow is either directed to 'top up' the wetland, irrigated to land, or diverted to the recycled water storage pond.

For scenarios 3, 4 and 5, a 20% reduction in GWII and RDII was assumed and a 75% reduction in retentate flows as instructed by CCC. The discharge location of the retentate flows can be controlled, reducing the volume required to be sent to the WWTP. Therefore, a greater reduction in flows from this source can be applied.

Scenario 5 assumes that the storage pond is covered. This removes the accumulation of rainfall within the storage pond footprint.

3.2 Model Results

Table 3 shows the peak storage required for native tree irrigation of the Inner Harbour Irrigation Scheme (previously referred to as Robinsons Bay) for each of the scenarios outlined above.

Table 3: Model Results for Irrigation to Native Trees – Inner Harbour Irrigation Scheme

Scenario	Peak Storage	Storage Overflow to Wetland
1	26,900	-
2	26,900	-
3	15,900	-
4	12,000	1,750
5	11,250	-

Table 3 shows that a modelled 12,000 m^3 with a surface area of 6,000 m^2 will provide storage with a limited recycled water overflow into the wetland. The model shows one overflow event where the storage volume is exceeded and recycled water overflows into the wetland. The recycled water is discharged from the wetland to the harbour via the controlled 2 L/s discharge discussed in section 2.3. There are no uncontrolled recycled water overflows from the wetland to the harbour in the model as the wetland freeboard is not exceeded.

Figure 5 shows the build-up of peak storage in scenario 4. While a single rainfall event ultimately causes the exceedance of storage volume, preceding events contribute to partially filling the pond. It is the total volume from these events over the period which contribute to the storage overflow. This is explaining why scenario 2 shows no change in the peak storage required even when the daily flow is capped. A daily flow cap does not substantially reduce the volume of flow over the event duration. Scenarios 3 and 4 include reductions in the I&I and retentate components of the flow. These target the volumes of wastewater flow through the WWTP, and hence, show a major reduction in the storage requirements. Overall, scenario 4 provides sufficient storage where over the 49-year period modelled, only one exceedance of the recycled water storage pond was predicted.

With a covered storage pond, the peak storage needed reduces to 11,250 m^3. Figure 6 shows the build-up of peak storage in scenario 5. The historic rainfall data used in the model has a 212 mm and 232 mm rainfall event in the month preceding the peak storage. During these events, there is no irrigation due to the rainfall cut off. This results in a reduced storage requirement when the storage pond is covered, as illustrated in the difference between scenario 3 and 5 (both have no overflows). With allowance for overflow events from the storage pond to the wetland, further reductions in storage requirements can be achieved.

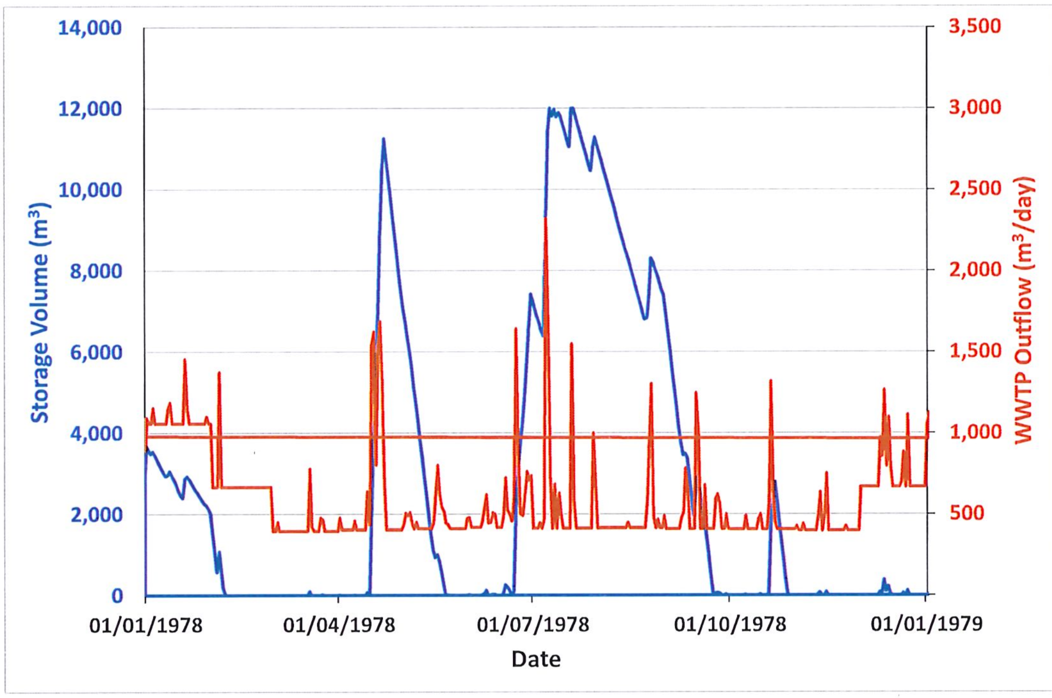


Figure 5: Build-up of storage during overflow period

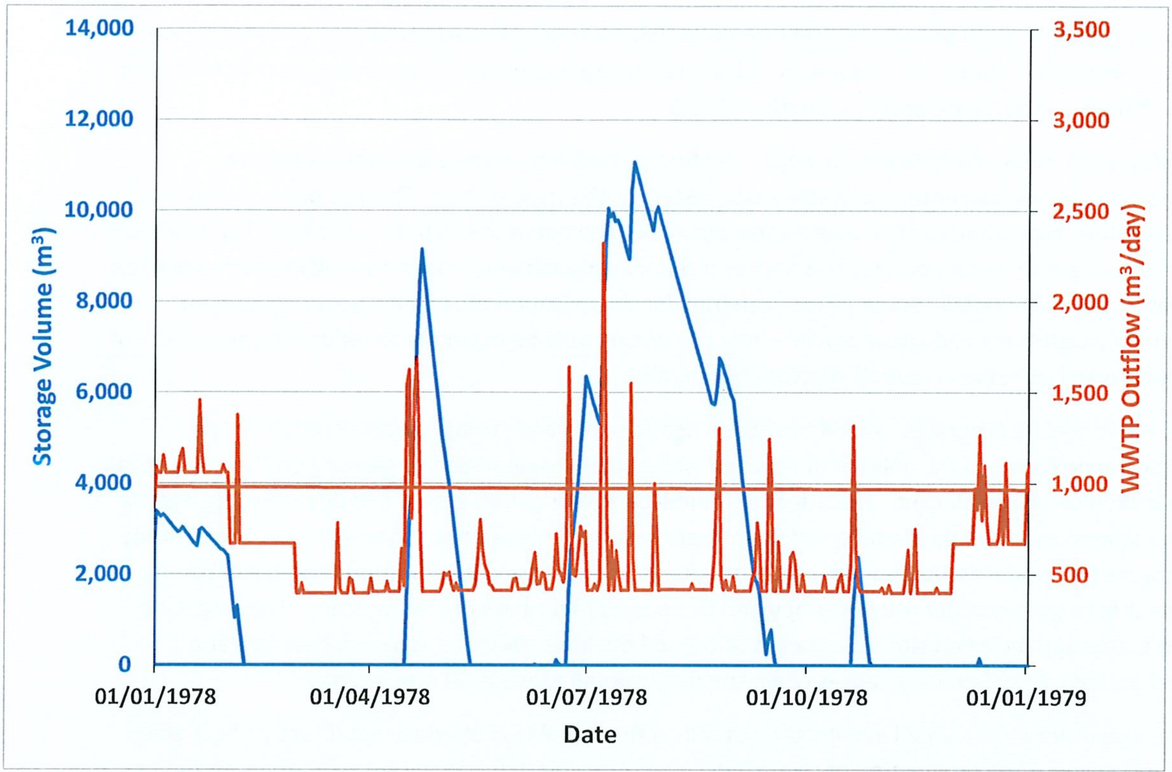


Figure 6: Build-up of storage during peak period with a covered storage pond

4.0 Potential Effects of Climate Change

This section discusses the potential effect of climate change to the model in a qualitative manner. The land disposal system needs to operate as designed from its startup (presumably with current weather patterns) and with the effect of any future changes to the climate of Banks Peninsula. Consequently, only effects of climate change that require an increase to the storage and irrigation areas in the future are relevant.

The effects of climate change on the Akaroa scheme are assessed based on the National Institute of Water & Atmospheric Research report "Climate Change Projections for the Canterbury Region" (NIWA, 2020). The NIWA report assesses the Representative Concentrations Pathways (RCPs) 4.5 and 8.5 scenarios. The NIWA report considers the effects of climate change at the years 2040 and 2090. RCP4.5 is considered to be a 'stabilisation' scenario where greenhouse gas concentrations and therefore, radiative forces, stabilise by 2100. The RCP8.5 is the 'business as usual' scenario and predicts very high greenhouse gas concentrations.

It should be noted that the NIWA report presents changes to the average rainfall and evapotranspiration (among other climate parameters) and the report itself is based on averaging the results of six different climate models. Consequently, some variation both between the climate model projections and variation from the averages can be expected.

The soil moisture balance model developed for the Akaroa scheme uses both rainfall and potential evaporation to calculate the irrigation requirements.

4.1 Rainfall

The impacts of rainfall on the Banks Peninsula vary depending on the RCP scenario and projected timeframe. For RCP 4.5, by the year 2040, the annual mean rainfall is expected to increase by up to 5%

compared to the 1986-2005 period. By 2090 for the RCP8.5 scenario, there is predicted to be either no change or a decrease of up to 5%. Seasonally, winter rainfalls are expected to increase under RCP4.5 with either no change or a decrease predicted under RCP8.5.

Rainfall affects the model outputs in two ways. The first is rainfall over the wastewater network catchment. This rainfall can enter the wastewater system in the form of RDII. This has been assessed by Beca in sizing the components of the wastewater network. The network has been sized based on a RCP8.5 scenario. The irrigation model derives and applies a relationship between rainfall and RDII which would be affected by changes to rainfall. Some of the scenarios for the irrigation of recycled water contain an assumption of a significant reduction of RDII – this reduction could be expected to reduce the sensitivity of the network to any increase in rainfall intensity or quantity.

Secondly, the model incorporates rainfall over the irrigation area and storage pond. Rainfall on the storage pond contributes to the volume of recycled water to be irrigated and depending on the pond area, the contribution can be significant. The effect of rainfall on the irrigation area is less direct for the Akaroa model: the system as currently modelled allows irrigation to occur regardless of the soil moisture content. This is because the model assumes a low irrigation rate (1mm/d in the critical winter period) can be applied via drip irrigation under a tree canopy and this occurs regardless of soil moisture. This irrigation rate value is selected based on site observation of the soil qualities ability to accommodate irrigation during wet periods. Irrigation only ceases when the daily rainfall exceeds 50 mm in a day.

Therefore, except for large rainfall events, the rainfall on the irrigable areas does not directly affect when irrigation will occur. The combination of rainfall and evapotranspiration, does, however, affect the soil's ability to accommodate the water. This is accommodated in the model by using a conservative maximum irrigation application depth which varies with the season.

4.2 Potential Evapotranspiration

The annual potential evapotranspiration deficit accumulation is projected to increase for both RCP 4.5 and RCP 8.5 scenarios. For the Akaroa wastewater scheme, this would likely increase the ability to irrigate a larger amount volume, on an annual basis. Using the current climate data for evapotranspiration builds a level of conservatism with respect to the long-term operation of the scheme.

The NIWA report provides projections of the change to soil moisture deficit which is based on a combination of factors including rainfall and evapotranspiration. The NIWA report predicts no change to the number of days of soil moisture deficit during the winter period for either RCP 4.5 or RCP8.5 scenarios. For the other seasons, a small increase in days with a soil moisture deficit is predicted. The sizing of the storage volume and land area for the Akaroa scheme is driven by the ability to dispose of the recycled water during the winter months and so in this regard, the use of existing climate data in the Akaroa model has a neutral effect with respect to climate change.

4.3 Summary

The Akaroa irrigation model has been designed to size the land irrigation area and storage volume to avoid discharges from the designed system. It is periods of wet weather (typically during winter) that dictate the sizing of the irrigation area and storage volume needed to avoid discharges of recycled water to the environment.

The NIWA projection for climate change in the Canterbury region, and specifically for Banks Peninsula, indicate that winter rainfall is variable depending on the RCP scenario considered, and the time frame. The effects range from either a small increase in annual mean rainfall (5% increase for RCP4.5 in 2040) to no change or a small decrease in average annual rainfall for the more pessimistic RCP8.5 scenario at the year 2090. The model uses a conservative (low) irrigation application rate in winter, which climate influences are not expected to reduce. The current model is based on irrigation regardless of PAW, which allows for certainty in the volume of recycled water being discharged. Rainfall on the recycled water storage pond may result in reduced capacity following short, intense storms. Options for covering the storage pond may provide increased utilisation of the storage capacity for recycled water.

For potential evapotranspiration and overall soil moisture deficit, the NIWA projections indicate that climate change will increase the ability to dispose of recycled water to land in the Akaroa area on an average annual basis.

It should be noted that the current modelling of sizing of storage and disposal area tends to be driven by periods of prolonged wet weather rather than individual extreme weather events. Information on the changes to extreme cases is limited and specifically noted as a limitation in the NIWA report and so remains an area of uncertainty.

It should also be noted that while the system needs to be sized to cater for future climate, it must also be suited to the existing climate to operate within the early years of its construction. On balance we believe the sensitivity of the model to climate change is neutral or balanced out

5.0 Conclusion

PDP has run four scenarios to estimate the peak storage of recycled water from the proposed Akaroa WWTP. The irrigation will occur to 40 ha of trees planted at the head of bays sites on the Banks Peninsula. This letter was prepared to update peak storage model results based on new wastewater flows, estimated from the Beca NDM. The results of the modelling indicate that with 20% I&I reduction and 75% retentate reduction (as instructed by CCC) a 12,000 m^3 storage pond with a surface area of 6,000 m^2 will result in one storage overflow event over the 49-year modelling period. If the reductions assumed are not realised there is a risk that more storage may be needed and/or more an overflows may occur.

Covering the storage pond results in a reduction in storage volume over the modelled period. It is estimated that 11,250 m^3 of storage will provide sufficient storage with no overflows shown over the 49 years of modelled data.

The sensitivity to climate change has been qualitatively assessed using projections published by NIWA. The projected effects of climate change indicate the annual rainfall over the network and irrigation catchments are expected to be similar or increase by up to 5% depending on the RCP4.5 climate change scenario. Overall, it is anticipated that the intensity of large rainfall events will increase while the duration of events will decrease. While this has an influence on the design of the wastewater network, the effects of climate change are not expected to greatly impact the disposal of recycled water for the Akaroa wastewater scheme. The historical long-term rainfall is expected to provide a reasonable estimate of storage requirements accounting for potential climate effects.

6.0 Limitations

- This model has been prepared for the purpose of estimating the peak treated recycled water storage requirements for the Akaroa wastewater disposal scheme. The assumptions surrounding the development of the long-term flow record reflect this purpose and may not be suitable for assessments of the typical operating conditions

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of wastewater flows provided by Beca and Christchurch City Council and the analysis of future flows carried out by Beca. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Beca for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

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Outline of PDP Akaroa Wastewater Irrigation Model

This memo outlines the input and output parameters for the recent modelling work for considering irrigation of Akaroa wastewater. The model calculates a soil moisture balance to evaluate if irrigation can be applied and if not, the volume of wastewater to be stored.

1.0 Inputs

Wastewater Volumes	This is a two-part estimation. The first is population derived flow (from 2052 population). The second is an estimation of inflow and infiltration (I&I) from rainfall and groundwater. The I&I was estimated by Beca for the 2009-2018 period and included: groundwater infiltration (GWI) into the system and rainfall derived I&I (RDII). The Beca I&I estimates were verified by PDP against measured flows from the Akaroa wastewater PS616 (Glen Pump Station) flow meter. The RDII for the long-term rainfall data was estimated by taking a linear relationship between the rainfall and modified Beca I&I estimates. The relationship has evolved since the letter issued in June 2018 as a result of an updated Beca network model and a longer wastewater flow meter dataset. This has resulted in approximately 28% lower RDII estimates. A constant GWI rate was estimated to best match the base flow recorded by the flow meter.
Areas	A range of irrigation areas were assessed at Goughs Bay, Robinsons Bay, and Pompeys Pillar.
Rainfall/PET	The rainfall and Potential Evapotranspiration (PET) data was a combination of data obtained from NIWA's virtual climate station network (VCSN) and real climate station data when available. Note PET represents Evapotranspiration (ET) for a well-watered pasture (i.e the pasture can extract whatever water from the soil it needs for optimal pasture growth) (See below for impact on ET due to soil moisture deficit).
Irrigation Method	Drip (Robinsons bay only): low flow rate (1.5 to 2.75 mm/day depending on season); irrigation to trees; 100% efficiency. K-line (Goughs Bay and Pompeys Pillar): Constant flow rate (7 mm/day); irrigation to pasture; 85% efficient.
Rainfall Interception	For drip irrigation to trees, rainfall interception (37% of rainfall) from the tree canopy is taken into account. The rainfall interception occurs before any water reaches the ground.
PAW	Plant Available Water (PAW) is the available water for plants in the soil profile over a fixed rooting depth (field capacity minus permanent wilting point). Additional water can be held by the soil between field capacity and saturation point. This is assumed to drain through the soil relatively quickly and is not available for plant uptake. Note this PAW differs from the total water holding capacity of the soil. For instance, the S-map data for Claremont soils (one of the soils in the Akaroa area) indicates the PAW over the first 30 cm (which is the pasture rooting depth we have assumed in the modelling) of soil is 48 mm however the total water holding capacity over the full depth of the soil is 95 mm. This additional capacity for the soil to hold water before the soil reaches saturation is not included in the modelling. Water held in the layer below the rooting zone will not be lost to evapotranspiration but will slowly drain out through gravity, Then the water holding capacity will become available for storage of water draining through the root zone in excess of the plant uptake. The drainage of this water is slower than the water that drains through during saturated conditions (such as during and after prolonged heavy rainfall)

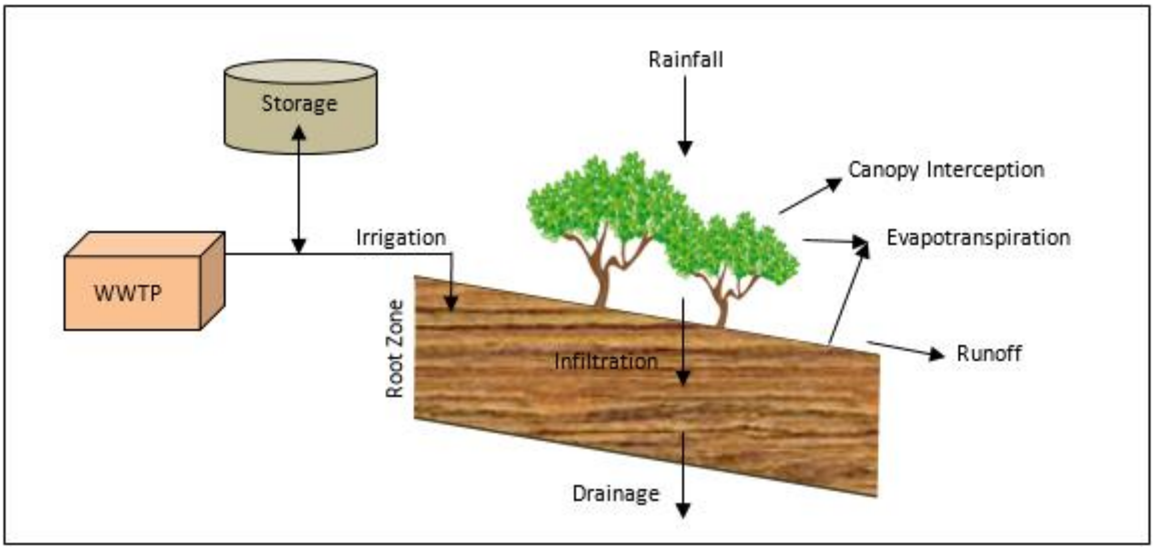
ET and PET	Evapotranspiration (ET) is the water loss from evaporation off the surface of plants/ground and the water released to the atmosphere when plants transpire. Plant transpiration decreases with decreasing soil moisture as water becomes more difficult for plant roots to extract. The relationship between ET and PET in the model uses an approximate equation (Heiler, 1981).
Irrigation Behaviour	Drip: irrigation is applied regardless of the soil moisture conditions (low application rate to prevent ponding and organic matter build up in the soil). Irrigation ceases when there is more than 50 mm of rainfall. This irrigation method is rendered possible due to the significant interception of rainfall provided by the canopy cover. K-Line: irrigation ceases when the soil moisture is calculated to have reached field capacity or if 50 mm or more of rainfall occurs in a single rainfall event.
Rainfall Runoff Coefficient	The runoff coefficients are based on previous investigations into runoff from hilly areas. Runoff in the model is dependent on the monthly total rainfall.

2.0 Outputs

Soil Moisture Balance	The soil moisture balance is calculated using the Rainfall, WW irrigated, and PET inputs. It is updated daily; the final soil moisture becomes an input for the following day.
WW Irrigation	The wastewater irrigated is limited by the wastewater available and the irrigation behaviour. If the irrigation demand is higher than the available WW supply, then WW from storage will be applied.
Runoff	The portion of the rainfall that does not infiltrate the soil profile and is lost to overland flow.
Drainage	Drainage is excess water above PAW excluding canopy interception and runoff. All excess water is assumed to discharge as drainage to groundwater.
Storage	Storage volume is the accumulation of all the water which is not irrigable due to increased flows or the irrigation triggers described in the 'irrigation behaviour' input above. The storage value reported is the peak storage required over the whole 47 year modelling period.

3.0 Conceptual Diagram

The model applies the rainfall and water loss (arrows pointing out of the soil in diagram below) inputs each day to determine the soil moisture level. Depending on this soil moisture level, wastewater irrigation is applied. Where the soil moisture level is high enough that irrigation is not required, the wastewater is stored. The soil moisture level is then used as an input for the next day. The interaction between the key components of the model is shown schematically in the diagram below.



Storage
Rainfall
Canopy Interception
Irrigation
Evapotranspiration
WWTP
Root Zone
Infiltration
Runoff
Drainage

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2 April 2019

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Dear Raelene

IRRIGATION MODEL RESULTS FOR LAND DISPOSAL OF TREATED WASTEWATER AT ROBINSONS BAY, GOUGHS BAY AND POMPEYS PILLAR

1.0 Introduction

Christchurch City Council (CCC) is investigating treated wastewater irrigation options for the proposed Akaroa Wastewater Treatment Plant (WWTP). As part of the peer review work by the Technical Experts Group, Pattle Delamore Partners Ltd (PDP) prepared a soil moisture balance assessment for irrigation of wastewater to land. This assessment was summarised in the letter to Beca "Irrigation Model Results for Land Disposal of Treated Wastewater at Goughs Bay, Robins Bay and Pompeys Pillar" dated 25 June 2018. Since this letter was prepared, Beca has carried out additional work and revised the predicted wastewater flow for the new scheme.

PDP has now updated the soil moisture balance assessment to incorporate the revised wastewater flow provided by Beca. The purpose of this letter is to present an estimate of the required irrigable area and wastewater storage volume using the revised flow.

Three potential irrigation areas have been modelled, including: Robinsons Bay, Goughs Bay and Pompeys Pillar.

2.0 Model Method and Inputs

2.1 Wastewater Flow Estimate

Beca has provided PDP with a revised wastewater flow estimate for Akaroa. The flow was developed in two parts described in the following sections.

Part 1: Population Based Flow Estimate

Beca has provided PDP with a current and future (2052) population derived flow estimate, developed based on measured Biological Oxygen Demand (BOD) data from the wastewater treatment plant over the 2018/2019 Christmas and New Year period, in conjunction with flow meter data provided by CCC. Three distinct periods of population trends were identified over the year, including: winter (1st Mar – 23rd Dec), summer (24th Dec – 28th Feb) and peak (31st Dec – 6th Jan). The population estimates were converted into a daily wastewater flow by assuming a daily flow generation of 220 L/day/person. The current and future population-based flow estimates for the winter period is shown in Table 1.

Table 1: Current and Future Population Based on BOD

Period	Current Population	Current Population Based Flow (m^3/day)	Future (2052) Population	Future (2052) Population Based Flow (m^3/day)
Winter	765	168	840	185
Summer	2,077	457	2,348	517
Peak	3,999	880	4,557	1,003

Figure 1 shows the resulting current and future (2052) population derived flow over the year.

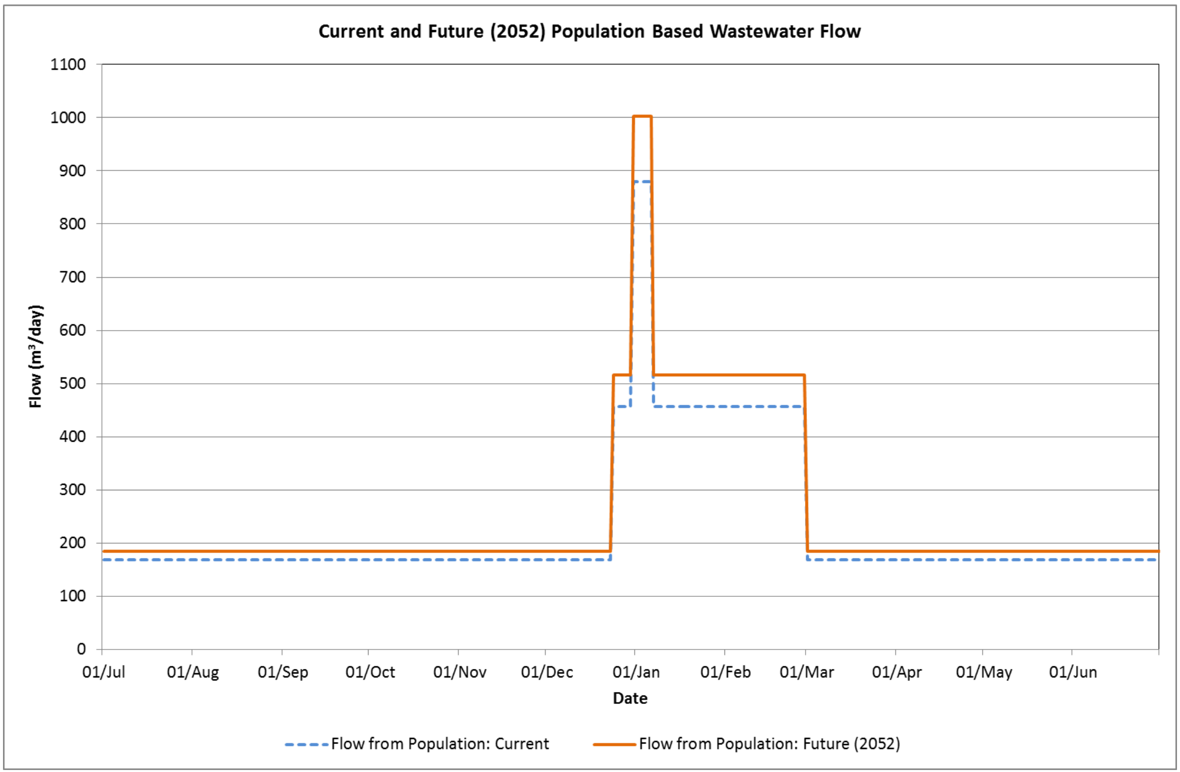

Figure 1: Current and Future (2052) Population Based Flow

Part 2: Inflow and infiltration (I&I)

Beca has provided PDP with a daily I&I estimate from 2009 to 2018 which has been generated from a rainfall based I&I software package utilising the Stanley Park Rainfall Gauge hourly rainfall from 2009 to 2018. The I&I estimate includes groundwater infiltration (GWI) to account for groundwater leakage into the system and rainfall derived inflow and infiltration (RDII).

Figure 2 shows measured flow at flowmeter PS616 (located immediately upstream of the treatment plant) versus the Beca I&I estimate. The current population derived flow as described in Part 1 has been added to the Beca I&I estimate to enable a direct comparison to the measured flow.

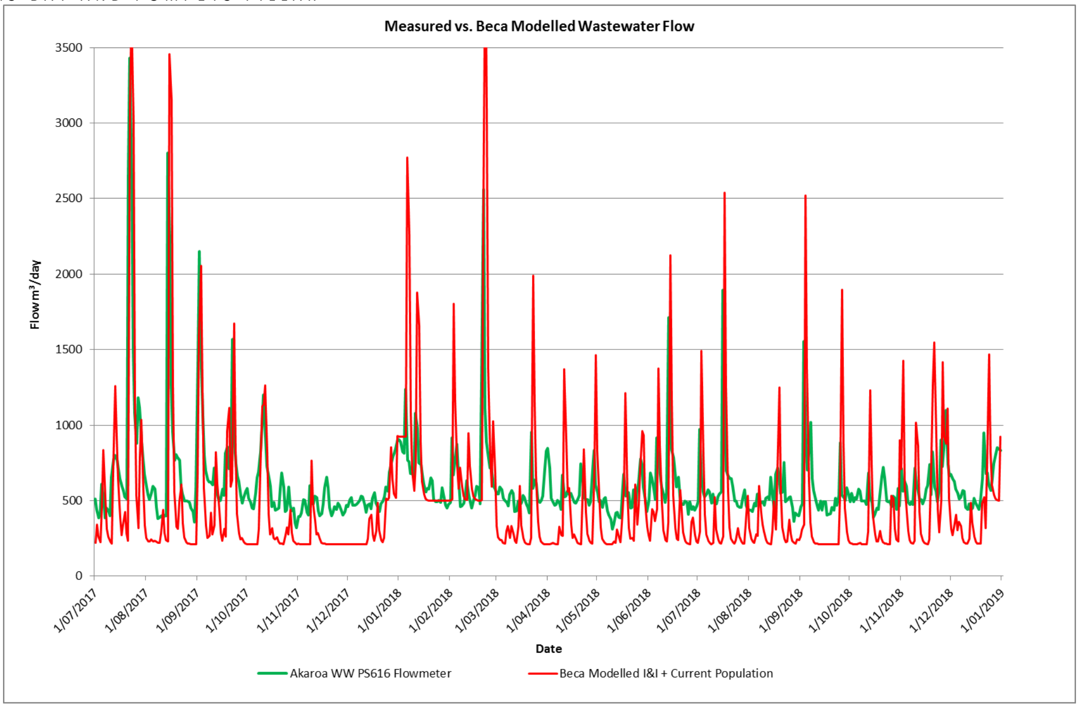

Figure 2: Measured Flow at PS616 vs. Beca I&I Estimate

Figure 2 shows that the Beca I&I estimate over predicts wastewater flow during large storm events and under predicts flow during dry weather.

PDP has adjusted the Beca I&I estimate to create a modelled flow that better fits the measured flow. The adjustments included reducing the peak I&I and adding a tailing off factor to gradually decrease I&I over several days once the storm event has passed. The groundwater infiltration was also modified to better match dry weather flow. A constant GWI of 328 m^3/day between March and February and a constant GWI of 44 m^3/day between January and February was assumed. Figure 3 shows the resulting modelled wastewater flow for the period July 2017 to Dec 2018.

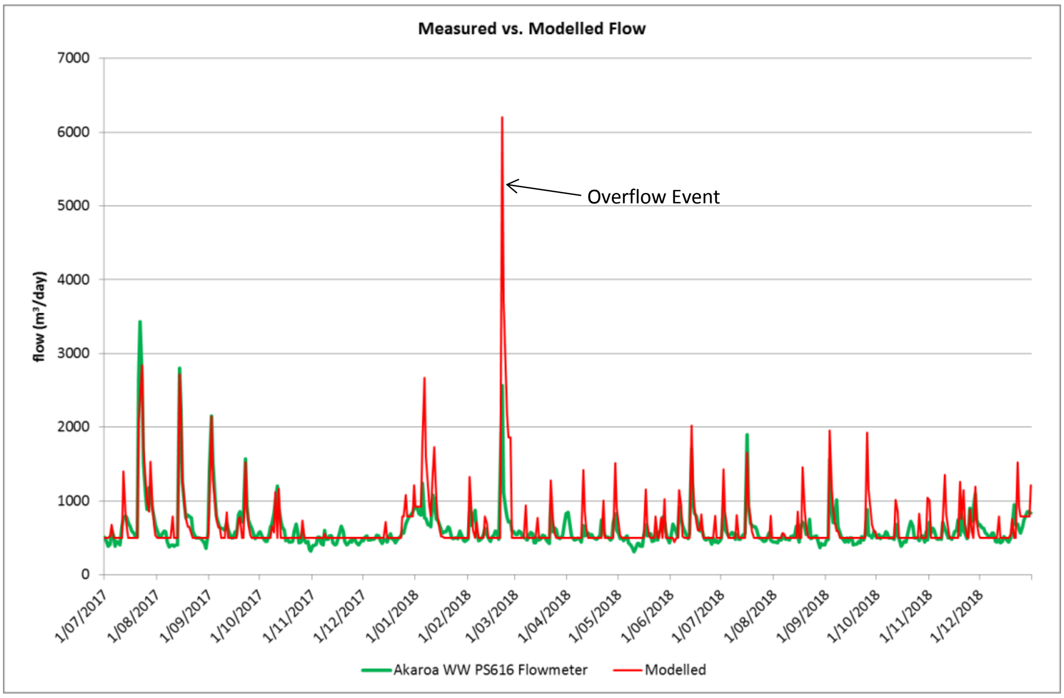

Figure 3: Measured vs. Modelled Flow

Figure 3 shows a good match between the measured and modelled flows. During a storm event in February 2018, the measured flow was significantly lower than the modelled flow. CCC records indicate that this storm event caused an overflow of the system which would result the flow meter underestimating the actual flow during the event.

Figure 4 shows an event total plot of measured rainfall at Stanley Park verses the modelled flow.

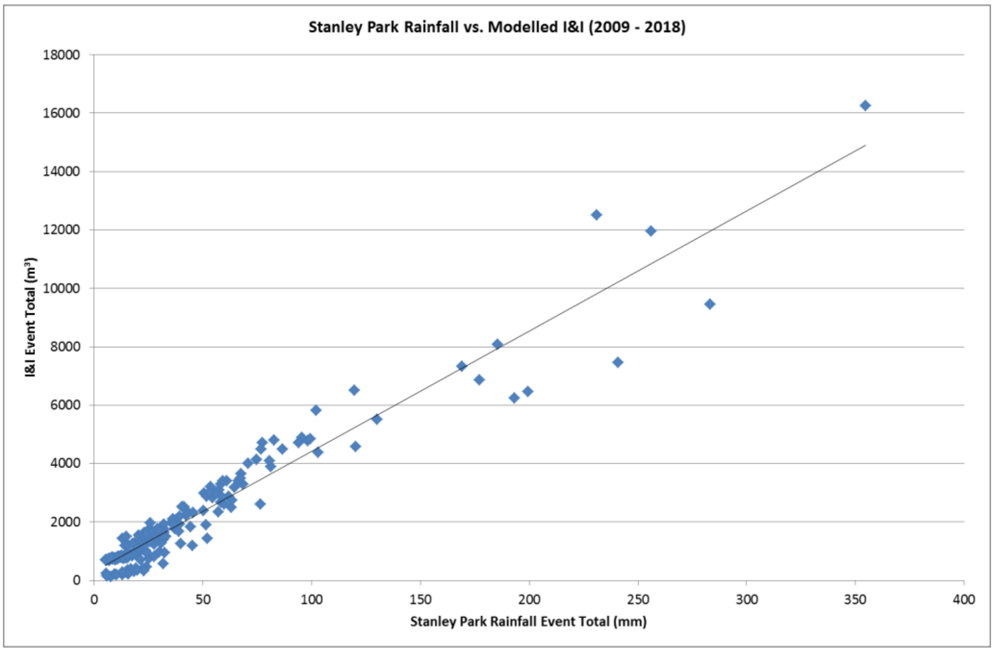

Figure 4: Stanley Park Rainfall vs. Modelled I&I Event Totals from 2009 to 2018

Figure 4 shows that there is a correlation between the measured rainfall and the modelled I&I. A linear trendline was fitted to the plot to obtain a relationship between rainfall and I&I. The resulting trendline relationship was then applied to a long term NIWA virtual climate station network (VCSN) station 20249 record to obtain I&I for each rainfall event from 1972 to 2018. The VCSN record has been developed by NIWA using interpolation of surrounding weather stations to develop a consistent long-term record. The VCSN data includes adjustments for altitude. PDP has reviewed some of the rainfall records available and the VCSN data is consistent with those rainfall records with adjustments for altitude.

Combined Flow

A combined flow was obtained by combining the population derived flow with the I&I from the modelled flow. Table 2 shows the key statistics for the modelled flow compared to the measured flow at PS616 over the period July 2017 to December 2018.

Table 2: Measured and Modelled Flow Estimate (Jul 2017 – Dec 2018)

	Measured Flow at PS616	Modelled Flow: Current Population
Average (m^3/day)	616	667
Median (m^3/day)	530	496
Max (m^3/day)	3,432	6,204
Min (m^3/day)	311	444
Volume (m^3)	338,051	365,998

Table 3 shows the statistics for the modelled flow over the full model period (1972 to 2018).

Table 3: Modelled Flow Estimate Statistics from 1972 - 2018

	Current Population	Future (2052) Population
Average (m^3/day)	627	652
Max (m^3/day)	7,609	7,626
Min (m^3/day)	212	229
Average Annual Volume (m^3)	229,000	238,000

The proportion of flow attributed to population derived flow and I&I (GWI and RDII) is shown in Table 4.

Table 4: Annual Future Population, GWI and RDII Based Volume,

	Population Based Flow Volume [1]	GWI Volume	RDII Volume
Average (m^3)	93,338	102,975	41,846
Max (m^3)			78,584
Min (m^3)			19,150

Notes:

1. *Future (2052) population flow.*

It is noted that I&I contributes to a large portion of the total flow. The effect of reducing the total flow through reducing population-based flow (through water conservation) and reducing I&I has been assessed. The model has been run with various percentage reductions and the results are presented in Section 4. The model assumes that the maximum capacity of the WWTP is 1200 m^3/day. Any flow in excess of this is diverted to an untreated wastewater storage pond, before passing through the WWTP once capacity becomes available. After the WWTP, flow is either irrigated or diverted to treated wastewater storage.

PDP has been provided with information from CCC (via Beca) that indicates that there have been 38 overflows since July 2012. Of these 38 overflow events, 23 have estimated volumes of discharge between 0.25 and 2,225 m^3. To accommodate this overflow volume, additional storage volume will be required. A decision on how CCC will manage these overflows is yet to be confirmed. Once that decision has been made, the impact on the storage required can be considered further.

3.0 Irrigation Methods

3.1 Irrigation of Native Trees via Drip

For irrigation to native trees, drip irrigation is assumed with the wastewater applied to the land irrespective of soil moisture conditions. The following key assumptions have been made:

Irrigation Demand Threshold:	Irrigation occurs regardless of the profile available water (PAW), even if PAW is at field capacity
Extreme Rainfall Cutoff:	If rainfall > 50mm/day then irrigation ceases
Irrigation Season:	All year round
Irrigation Efficiency:	100% efficiency
Maximum Irrigation Application (mm/day):	Dec–Feb: 2.75, Mar–May, Sep–Nov: 2.15, Jun–Aug: 1.5

The maximum irrigation application per day is less than the Long-Term Acceptance Rate of the soils and is selected to avoid surface ponding when the PAW is at field capacity.

3.2 Irrigation of Pasture via Impact Sprinkler

For irrigation to pasture it is assumed that impact sprinklers (such as K-line or fixed pole mounted sprinklers) are used and the wastewater is applied to the land based on a soil moisture balance (i.e. Irrigation is only applied when the soil moisture content is assessed to be less than the maximum Plant Available Water). The following assumptions have been made:

Irrigation Demand Threshold:	Irrigation based on daily soil moisture balance up to a maximum Profile Available Water
Irrigation Season:	All year round, Dec to Mar for south facing land (15.3 ha) at Goughs Bay
Maximum irrigation application rate:	7 mm/day
Irrigation Efficiency:	85% efficiency

3.3 Soils and Rainfall

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

Soil Profile Available Water (PAW)

Goughs Bay	Pasture: 36 mm
Robinsons Bay	Pasture: 48 mm, Trees: 85 mm
Pompeys Pillar	Pasture: 48 mm

Rainfall

Goughs Bay	NIWA VCSN 20379 and Long Bay Road AWS
Robinsons Bay	NIWA VCSN 20249 and Akaroa EWS
Pompeys Pillar	NIWA VCSN 20380

The appropriate rainfall gauge data was used over the VCSN data for dates where data was available.

4.0 Model Results

The long term (1972 to 2018) model results have been presented as they produce the most conservative storage volumes.

4.1 Tree Irrigation at Robinsons Bay: No Reductions in I&I

Table 5 shows the peak storage required for native tree irrigation at Robinsons Bay using the revised future wastewater flow estimates compared the results presented in June 2018.

Table 5: Model Results for Irrigation to Native Trees at Robinsons Bay

Native Trees	**Irrigation Land Area (ha)**	**50**	**60**	**70**
	June 2018 Model Peak Storage (m^3)	43,000	34,000	28,000
	Revised Model Peak Storage (m^3)	28,000	21,000	20,000

Table 5 shows that the revised wastewater flows result in a reduction of peak storage compared to the modelling done in 2018. Table 6 shows the peak storage required for tree irrigation at Robinsons Bay using the updated future wastewater flow estimate and various reductions in I&I and population flow.

Table 6: Maximum Storage Volumes Required for Drip Irrigation to Trees at Robinsons Bay

Reduction Scenarios		Maximum Storage Volume Required (m^3) for Corresponding Irrigation Area			
I&I	**Population flow**	**30 ha**	**40 ha**	**60 ha**	**80 ha**
0%	**0%**	463,000[1]	36,000	21,000	19,000
	10%	172,000[1]	35,000	21,000	19,000
	20%	106,000[1]	34,000	20,000	19,000
	30%	69,000	33,000	20,000	18,000
20%	**0%**	40,000	24,000	16,000	15,000
	10%	34,000	23,000	15,000	15,000
	20%	32,000	22,000	15,000	15,000
	30%	30,000	21,000	15,000	15,000
40%	**0%**	21,000	14,000	12,000	12,000
	10%	20,000	13,000	12,000	12,000
	20%	19,000	13,000	12,000	12,000
	30%	18,000	12,000	12,000	12,000
60%	**0%**	10,000	9,000	9,000	9,000
	10%	9,000	8,000	8,000	8,000
	20%	9,000	8,000	8,000	8,000
	30%	8,000	8,000	8,000	8,000

Notes:
All scenarios are based off a future (2052) population flow.
1. *Inadequate area for irrigation, the storage pond cannot empty and therefore peak volume will rise indefinitely.*

Table 6 shows that the maximum storage volume is most sensitive to reductions in I&I. Maximum storage generally occurs during the winter period and after a series of significant rainfall events which cause a large I&I flow into the storage. Therefore, reducing the I&I flow significantly reduces the maximum storage volume required.

4.1 Pasture Irrigation at Goughs Bay

Table 7 shows the peak storage required for pasture irrigation at Goughs Bay. Two simulations are assessed, one assuming a 20% reduction in I&I is achieved, the other assumes no reduction. The areas presented are totals, 15.3 ha of the south facing land is only irrigated December to March.

Table 7: Model Results for Irrigation to Pasture at Goughs Bay

Pasture	Irrigation Land Area (ha)		80	90	100	115
	Peak Storage (m^3)	20% I&I Reduction	58,000	51,000	44,000	38,000
		No I&I Reduction	78,000	70,000	62,000	52,000

4.2 Pasture Irrigation at Pompeys Pillar

Table 8 shows the peak storage required for pasture irrigation at Pompeys Pillar assuming a 20% reduction in I&I.

Table 8: Model Results for Irrigation to Pasture at Pompeys Pillar

Pasture	Irrigation Land Area (ha)		80	90	100
	Peak Storage (m^3)	20% I&I Reduction	46,000	41,000	37,000
		No I&I Reduction	65,000	58,000	52,000

5.0 Conclusions

The wastewater flow for Akaroa has been estimated by combining population derived flow with a modelled I&I estimate. The average annual volume of modelled wastewater is approximately 229,000 m^3 under the current population scenario and approximately 238,000 m^3 under the future (2052) population scenario.

Based on the revised wastewater flow estimate for the future population and a 20% reduction in I&I; approximately 40,000 m^3 of storage is required to irrigate 30 ha of land at Robinsons Bay, 58,000 m^3 is required to irrigate 80 ha of land at Goughs bay, and 48,000 m^3 of storage is required to irrigate 80 ha of land at Pompeys Pillar.

6.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of wastewater flows provided by Beca from Christchurch City Council and the analysis of future flows carried out by Beca. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Beca for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED

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20 January 2020

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Dear Raelene

IRRIGATION MODEL RESULTS FOR LAND DISPOSAL OF TREATED WASTEWATER - INGLEWOOD SCENARIO

1.0 Introduction

Christchurch City Council (CCC) is investigating treated wastewater irrigation options for the proposed Akaroa Wastewater Treatment Plant (WWTP). As part of the peer review work by the Technical Experts Group, Pattle Delamore Partners Ltd (PDP) prepared a soil moisture balance model for irrigation of wastewater.

PDP has now updated the soil moisture balance model to incorporate a revised irrigation area and wastewater flow series provided by Beca. The purpose of this letter is to present an estimate of the required wastewater storage volume using the revised area and flow. This scenario is known as the Inglewood scenario.

A single potential irrigation area has been modelled in this assessment comprising 34.5 hectares (ha) of land in the Inner Harbour Irrigation Scheme (Robinsons Bay).

2.0 Model Method and Inputs

The base case model used for the Inglewood Scenario is the Inner Harbour Irrigation Scheme as presented in *'Akaroa Wastewater Updated Investigation into Alternative Land Disposal and Reuse Options'*, Beca, 2019. The Inglewood scenario includes the following additional assumptions:

- 34.5 ha of irrigation area at the Thacker property (Robinsons Bay); and
- Revised wastewater flow series (provided by Beca).

2.1 Revised Wastewater Flow Series

Beca has provided PDP with a revised wastewater flow series for the Inglewood scenario. The revised flow series includes a level of flow reduction that Citycare has achieved using distributed temperature sensing (DTS) and a targeted inflow and infiltration (I&I) reduction programme. The flow reductions are:

- 40% reduction in average flow;
- 70% reduction in average dry weather flow (ADWF); and

- 30% reduction in peak wet weather flow (PWWF).

All other assumptions are the same as those used in previous modelling for the as presented in the Beca, 2019 report.

3.0 Model Results

Table 1 presents the required storage volume using the revised irrigation area and flow series.

Table 1: Model Results for Inglewood Scenario	
Irrigation Land Area (ha)	**34.5**
Peak Storage (m^3)	16,000

Table 1 shows that 16,000 m^3 of storage is required to irrigate 34.5 ha of land.

4.0 Conclusions

The wastewater flow series for Akaroa has been revised by combining previously derived flow rates with a modelled flow reduction based upon reduction of I&I and use of DTS. This flow reduction model is referred to as the Inglewood scenario.

Based on the soil moisture balance model results, a storage volume of 16,000 m^3 is required to irrigate 34.5 ha of land within the Inner Harbour Irrigation Scheme (Robinsons Bay).

5.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of wastewater flows provided by Beca from Christchurch City Council and the analysis of future flows carried out by Beca. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Beca for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

PATTLE DELAMORE PARTNERS LIMITED

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Approved by

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Appendix V Meister & Robinson – Nitrate Assessment

An assessment of the likely fate of nitrate irrigated onto NZ-native vegetation with Treated Municipal Wastewater in Robinsons Bay, Banks Peninsula

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Disclaimer: A robust quantification of N fluxes from TMW-irrigated native vegetation in Robinsons Bay would require experiment(s) to determine the rate of denitrification. As such, the numbers provided in this report should be considered as estimates only.

Executive summary

- The Christchurch City Council (CCC) has commissioned University of Canterbury (UC) and the Institute of Environmental Science and Research (ESR) to provide an estimate of the nitrogen (N) losses from native trees irrigated with Treated Municipal Wastewater at Robinsons Bay on Bank's Peninsula. This assessment was made based on a literature review and results from a field trial at nearby Duvauchelle.

- The proposed N application rates in Robinsons Bay (up to 95 kg N/ha/yr) are low compared to other land treatment schemes in NZ and elsewhere, where >1500 kg N/ha/yr may be applied.

- Plant N uptake in a field trial at nearby Duvauchelle, indicates that native plants may take up ca. 35 kg N/ha/yr. Eventually, this N will be returned to the soil via dead plant material, however, ca. 10% of this N will be lost through denitrification during decomposition. Insect herbivory may increase these losses.

- Conditions for denitrification at Robinsons Bay are likely to be high due to irrigation onto an imperfectly drained soil. There is likely to be adequate organic matter to support denitrification. Rates may be limited by pH. We have considered that ca. 10 kg/ha will be lost due to denitrification. This is conservatively estimated based on the literature.

- Based on the literature review, we conservatively estimate that for a mature stand of NZ-native vegetation, ca. **13.5 kg N/ha/yr** will be lost from the system through non-returned plant uptake and denitrification from soil. The remainder of the nitrate will leach.

- Nitrate data from the nearby field trial at Duvauchelle (receiving 200 kg N/ha) on two sampling occasions indicate that TMW application had nitrate concentrations 25% higher than the control. Given the increased waterflux through the site, this equates to TMW causing a 75% increase in leaching.

- More N is likely to be taken up by the plants during the establishment phase, so nitrate leaching may be lower between the time of canopy closure and stand maturation. Potentially, selectively harvesting the trees may increase N removal rates. Increasing soil pH may increase denitrification.

Nitrogen added to soil with Treated Municipal Wastewater at Robinsons Bay

Potentially, Treated Municipal Wastewater (TMW) will be irrigated to native trees in Robinsons Bay at a rate of 703 mm/ha/yr. Possible application rates of nitrate are 21, 35, 55, 75, or 95 kg N/ha/yr depending on the level of treatment of the TMW, with the most likely rate of application being <55 kg N/ha. This is an order of magnitude lower than many other land treatment systems which apply up to 4500 mm/yr with N loadings commonly in the vicinity of 1500 kg N/ha/yr [1], [2].

Nitrogen that is added to soil with TMW may be present as organic N, ammonium, nitrite, or nitrate. Analysis of TMW from nearby Duvauchelle, indicated the partitioning was 23: 2: 3: 72 for organic N, ammonium, nitrite, and nitrate respectively. While nitrate is generally considered to have the greatest mobility in soil, high rates of application (>2000 mm/yr) and/or high soil pH can result in considerable leaching of organic N: Barton [3] reported that dissolved organic N represented 69-87% of N leached from TMW-irrigated soil in a site receiving 50 mm/week applied at 10 mm/hr for 5h. This is manifold higher than the proposed application rates at Robinsons Bay, and therefore leaching of organic N at Robinsons Bay will be low. It is assumed that N fixation will be minimal at Robinsons Bay because non-leguminous species will be planted and the elevated N present in the soil through TMW irrigation will not favour root colonisation by N-fixing rhizobia [4].

Fate of nitrate in soil

Nitrate is the most mobile and most bioavailable N species in soil. In most soils, including the Pawson Silt Loam, nitrate is repelled from soil colloids meaning it can freely leach out of the soil profile and be transported to receiving waters. Ultimately, N that is applied to soil will leach as nitrate unless it is taken up by soil microorganisms (immobilisation), taken up by plants, or lost via a the formation of a volatile N compound, such as ammonia, N_2 gas, nitrous oxide, or nitric oxide [4], [5]. Immobilisation occurs if the C: N ratio in the soil is high (>25). Except for organic-rich effluents, applying N with TMW will result in the soil C:N ratio decreasing until immobilisation is not an important factor removing nitrate from soil solution.

Nitrogen that is taken up by plants will be returned to the soil as leaf litter and dead plant material, unless biomass is removed from the site, for example by harvesting or browsing animals. Most N returned to the soil is organic N, that is ultimately mineralised and then nitrified through microbial transformation. Ultimately, in non-managed forest ecosystems, N can only be removed from the system by leaching or volatilisation, either in the soil profile, or in the process of decomposition of senesced plant material. The purpose of this review is to review the literature to determine the likely rate of denitrification from NZ-native vegetation irrigated with TMW.

Factors affecting nitrogen volatilisation

In high pH soils, N may be lost as ammonia (NH_3) [6], however, ammonia volatilisation is unlikely to be a major contributor to N loss on Banks Peninsula as most soils are moderately acidic.

Most denitrification occurs when the available oxygen in the soil drops to the point where some organisms replace oxygen with nitrate as the primary oxidising agent [7]. While denitrification occurs at the highest rate in anaerobic conditions such as waterlogged soils, microsites within the soil can be anaerobic and result in significant denitrification, even from an otherwise aerobic soil [8]. Denitrification is more prevalent in heavy soils, such as the Pawson Silt Loam in Robinsons Bay, than in lighter sandy soils [9], [10].

Biological denitrification requires the presence of organic carbon as a substrate for the denitrifying bacteria and archaea. Denitrification rates may be limited by organic carbon at soil levels <3% [11]. Acidic soil pH can significantly reduce denitrification, resulting in lower gaseous emissions of nitrous oxide, nitric oxide(s) and N_2 gas from acidic than neutral or alkaline soils [12]. Chemical denitrification can be significant in acidic soils, however, there is little information on the magnitude of such “chemo-denitrification” on the total N losses from soil [4].

Assuming the Pawson Silt Loam in Robinsons Bay is similar to our field plot in Duvauchelle, the only edaphic factor that is expected to limit denitrification is pH. The Pawson silt loam in Duvauchelle is acidic with a pH of 5.5-5.7 in the topsoil [13]. The other conditions are favourable for denitrification. The soil has a high water holding capacity and is poorly drained [14]. Furthermore, it contains relatively high organic matter, with an average C content in the topsoil of >3% [13]. There will be no limitation due to nitrate availability, as it is being applied with the TMW.

An estimation of nitrate removal from TMW-irrigated soils at Robinsons Bay

Initially, plant uptake will account for a significant fraction of the N-applied via TMW. Assuming average plant biomass production on the TMW-irrigated plot is 5t/ha/yr and the average plant N concentration is 0.7% [15], then the plants will remove 35 kg/ha/yr. This uptake rate is similar to *Pinus radiata* N-removal in TMW-irrigated soils [16] During the first 5-10 years, there will be minimal return to the soil. Thereafter, the N returned to the soil will be equivalent to what is taken up minus losses through herbivory and decomposition. In overseas ecosystems, some 90% of N in fallen leaf litter remains in the soil-plant system [17], [18]. Assuming net N losses from herbivory are negligible, and 90% of the biomass N is returned to the soil, the NZ-native trees taking up 35 kg N/ha/yr would result in the net removal of 3.5 kg N/ha/yr. Potentially, more N will be lost from the system through herbivory, where denitrification may occur in the alimentary canals of e.g browsing insects. However, there are no quantitative data to enable an estimation of what these losses may be.

New Zealand and overseas studies have shown denitrification rates from TMW-irrigated forests between 4 - >100 kg N/ha/yr (Table 1). Measurements of denitrification at Whakarewa showed that <2.4 kg N/ha/yr were being lost [19]. This relatively low rate was attributed to the intermittent nature of the irrigation and the coarse textured soil at the site (a pumice soil with a density of 0.5 g/cm^3). The authors suggested that denitrification would be significantly higher on needs to contain less free-draining and finer-textured soils. Such soils occur at Robinsons Bay. It is therefore likely that denitrification at Robinsons Bay will be at least 10 kg/ha N. Consequently, at least **13.5 kg of N/ha/yr** will be lost from mature native forest irrigated with TMW at Robinsons Bay.

Table 1. Denitrification rates in TMW-irrigated forest systems

Site	Soil	TMW rate (kg N/ha/yr)	Denitrification rate (kg N/ha/yr)	Reference
Whakarewarewa (NZ)	Pumice	298	1.7-2.4	[19]
Falmouth, Massachusetts (USA)	Inceptisols(mesic Typic Dystrochrepts and mesic Typic Udipsa-ments)	370-480	2-21 (as N_2O), total N will be higher	[20]
Central Appalachians (USA)	fine-loamy, silicious, mesic, Typic Hapludult	62.9	22.1	[21]
Geogria (USA)	Typic Kanhapludults with A horizon textures ranging from fine-sandy loam to sandy-clay loam	407	5-10	[22]
Shepparton (Australia)	Brown Sodosol (clay loam)	123-160	17.0-77.7	[23]

Results from a field study

Sampling at Duvauchelle in 2018 and 2021 showed that nitrate concentrations in the topsoils (0 - 10 cm) were 50% (2018) 25% (2021) higher in the trees receiving TMW compared to the unirrigated trees [13]. The 2018 sampling at four depth profiles showed that at a depth of 60 cm, the TMW irrigated soils had nitrate concentrations 25% higher than the control, and that nitrate concentrations at 60 cm were just 25% of the surface nitrate concentrations. It is not possible to calculate an annualised leaching rate from the plots because the water flux through the soil profile will differ depending on the rainfall and evapotranspiration throughout the year, as will soil microbial activity and plant uptake. Nevertheless, given the annual rainfall of ca. 1000 mm, and a conservative estimate of annual evapotranspiration of 500 mm, it would be expected that the drainage from the TMW-irrigated plots receiving 1000 mm or TMW in addition to the 1000 mm of rainfall, would be threefold higher than the controls. Therefore the leaching from the TMW-irrigated plots is likely to be 75% greater than the control. NZ-native forests (without TMW irrigation) typically leach ca. 2.5 kg N/ha/yr, with localised leaching rates up to 12 kg N/ha/yr [24]. If irrigation with TMW at 1000 mm/yr, equivalent to a loading rate of 200 kg N/ha/y, increases this leaching by 75% then the nitrate leaching from the site would be in the order of 4.4-21 kg N/ha/yr. This implies that N-losses from the system are significantly higher than the 13.5 kg N/ha/yr obtained from the literature review. However, without a full mass-balance experiment the rate of nitrate leaching (or denitrification) cannot be quantified.

At the time of writing (July 2022), the field trial at Duvauchelle is currently 7-years old. The ecosystem is still developing and canopy closure has only occurred in 2020. It is, therefore, likely that these trees will be taking up N at a significantly higher rate than than 35 kg N/ha/yr. It is anticipated that the rate of N-uptake will decrease as the trees mature. Selective harvesting of the NZ-native trees may increase N-removal rates.

Conclusions

Given the biological and physicochemical parameters at Robinsons Bay, we anticipate that at least **13.5 kg N/ha/yr** of the applied N will be lost via denitrification, either directly from the soil or indirectly from decomposing leaf litter. Our field trial at nearby Duvauchelle indicates that significantly more N is being lost from the system through the action of plants or, perhaps, soil denitrification. Given that we have no data on nitrogen losses from the system there is a large uncertainty around our estimation. Potentially, denitrification could be increased though increasing the soil pH (which may be limiting) or selection of species that promote conditions for denitrifying organisms.

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Appendix W Statutory Policy Assessment

Appendix W: Statutory Policy Assessment

New Zealand Coastal Policy Statement

Provision	Assessment
OBJECTIVES	
Objective 1 *To safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land, by:* *• maintaining or enhancing natural biological and physical processes in the coastal environment and recognising their dynamic, complex and interdependent nature;* *• protecting representative or significant natural ecosystems and sites of biological importance and maintaining the diversity of New Zealand's indigenous coastal flora and fauna; and* *• maintaining coastal water quality, and enhancing it where it has deteriorated from what would otherwise be its natural condition, with significant adverse effects on ecology and habitat, because of discharges associated with human activity.*	While some parts of the ATWIS are within the coastal environment, they are well landward of the CMA and given the scheme concept design and operational philosophy, will not adversely affect its integrity, form, function, or resilience. Contaminant migration to coastal waters is expected to be negligible such that natural biological processes and indigenous biodiversity are not expected to be affected. Similarly, the effect of removing the existing discharge from the harbour and replacing it with the proposed land-based scheme will improve overall water quality, particularly in respect of cultural values. The ATWIS will not result in significant adverse effects on ecology or habitat. The scheme will therefore support this objective.
Objective 2 *To preserve the natural character of the coastal environment and protect natural features and landscape values through:* *• recognising the characteristics and qualities that contribute to natural character, natural features and landscape values and their location and distribution;* *• identifying those areas where various forms of subdivision, use, and development would be inappropriate and protecting them from such activities; and* *• encouraging restoration of the coastal environment.*	The scheme has been assessed as resulting in a positive effect on the existing natural features and landscape character in the coastal environment, including a positive effect on natural character and visual amenity values. The development of the scheme does not therefore constitute inappropriate development in this setting. Objective 2 will be achieved by the development of the ATWIS.
Objective 3 *To take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment by:* *• recognising the ongoing and enduring relationship of tangata whenua over their lands, rohe and resources;* *• promoting meaningful relationships and interactions between tangata whenua and persons exercising functions and powers under the Act;* *• incorporating mātauranga Māori into sustainable management practices; and* *• recognising and protecting characteristics of the coastal environment that are of special value to tangata whenua.*	The ongoing relationship of Ngāi Tahu with fresh and coastal waters in the Whakaroa / Akaroa Basin, and the coastal environment as affected by the scheme, has been recognised by the long term involvement of Ngāi Tahu in the development of the scheme, working closely with the applicant over several years. These relationships and interactions have informed the development of the scheme in a manner that responds to, and respects those values as expressed by Ngāi Tahu and Ōnuku Rūnanga. Objective 3 will be achieved by the development of the scheme.
Objective 4 *To maintain and enhance the public open space qualities and recreation opportunities of the coastal environment by:*	The ATWIS will enhance the public recreational opportunities in the coastal environment in respect of public access to tracks to be developed within the Hammond Point and Old Coach Road Storage sites.

• *recognising that the coastal marine area is an extensive area of public space for the public to use and enjoy;* • *maintaining and enhancing public walking access to and along the coastal marine area without charge, and where there are exceptional reasons that mean this is not practicable providing alternative linking access close to the coastal marine area; and* • *recognising the potential for coastal processes, including those likely to be affected by climate change, to restrict access to the coastal environment and the need to ensure that public access is maintained even when the coastal marine area advances inland.*	The Hammond Point network is intended to provide public access from Robinsons Bay to Takamātua via walking tracks within the coastal environment. While not within the CMA, the tracks will facilitate public access within the coastal environment, and to public areas of the CMA either side of Hammond Point, contributing to achieving this objective.
Objective 5 *To ensure that coastal hazard risks taking account of climate change, are managed by:* • *locating new development away from areas prone to such risks;* • *considering responses, including managed retreat, for existing development in this situation; and* • *protecting or restoring natural defences to coastal hazards.*	The potential for coastal hazards to adversely affect the infrastructure or operations of the scheme has been considered, with the scheme located in areas that are not unduly exposed to, or prone to coastal hazard risk. The area most likely to be exposed to potential coastal hazard is Hammond Point, however the scheme and related infrastructure is elevated well above, and inland of the CMA and is not considered vulnerable to coastal processes. The scheme achieves this objective.
Objective 6 *To enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development, recognising that:* • *the protection of the values of the coastal environment does not preclude use and development in appropriate places and forms, and within appropriate limits;* • *some uses and developments which depend upon the use of natural and physical resources in the coastal environment are important to the social, economic and cultural wellbeing of people and communities;* • *functionally some uses and developments can only be located on the coast or in the coastal marine area;* • *the coastal environment contains renewable energy resources of significant value;* • *the protection of habitats of living marine resources contributes to the social, economic and cultural wellbeing of people and communities;* • *the potential to protect, use, and develop natural and physical resources in the coastal marine area should not be compromised by activities on land;* • *the proportion of the coastal marine area under any formal protection is small and therefore management under the Act is an important means by which the natural resources of the coastal marine area can be protected; and* • *historic heritage in the coastal environment is extensive but not fully known, and vulnerable to loss or damage from inappropriate subdivision, use, and development.*	The development of the ATWIS in general will enable community wellbeing, health and safety by providing an effective means of managing wastewater in a safe and environmentally and culturally appropriate way. The effects assessments show that the use of natural and physical resources for the scheme will have a minimal adverse effect on the values of the environment, including the ability to use coastal resources (including for recreation, social, economic and cultural uses). Overall, the effects on coastal values have been found to be negligible to positive. Overall, the ATWIS will help to achieve this objective.
POLICIES	
Policy 3 Precautionary approach *(1) Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse.*	Given the level of treatment and quality of the treated wastewater, the large land application area involved, subsequent treatment by natural processes in the soils and by vegetation in the irrigation sites, and the resulting diluted, dispersed and diffuse nature of the

	residual contaminants entering the harbour, any effects on coastal water quality will not be significantly adverse, and are likely to be less than minor. Similarly, other effects on the quality of the coastal environment will not be significant. The proposal is therefore consistent with this policy.
Policy 6 Activities in the coastal environment *(1) In relation to the coastal environment:* *(a) recognise that the provision of infrastructure, the supply and transport of energy including the generation and transmission of electricity, and the extraction of minerals are activities important to the social, economic and cultural well-being of people and communities:* *…* *(h) consider how adverse visual impacts of development can be avoided in areas sensitive to such effects, such as headlands and prominent ridgelines, and as far as practicable and reasonable apply controls or conditions to avoid those effects;*	Wastewater management infrastructure is recognised as essential to the wellbeing of the community and the environment. The visual effects of the scheme have been assessed as positive overall, including in the coastal environment. The ATWIS is therefore consistent with this policy.
Policy 11 – Indigenous biological diversity (biodiversity) *To protect indigenous biological diversity in the coastal environment:* *a. avoid adverse effects of activities on:* *i. indigenous taxa that are listed as threatened or at risk in the New Zealand Threat Classification System lists;* *ii. taxa that are listed by the International Union for Conservation of Nature and Natural Resources as threatened;* *iii. indigenous ecosystems and vegetation types that are threatened in the coastal environment, or are naturally rare[6];* *iv. habitats of indigenous species where the species are at the limit of their natural range, or are naturally rare;* *v. areas containing nationally significant examples of indigenous community types; and* *vi. areas set aside for full or partial protection of indigenous biological diversity under other legislation; and* *b. avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on:* *i. areas of predominantly indigenous vegetation in the coastal environment;* *ii. habitats in the coastal environment that are important during the vulnerable life stages of indigenous species;* *iii. indigenous ecosystems and habitats that are only found in the coastal environment and are particularly vulnerable to modification, including estuaries, lagoons, coastal wetlands, dunelands, intertidal zones, rocky reef systems, eelgrass and saltmarsh;*	The baseline assessment did not identify any indigenous taxa classified as 'threatened', however did record taxa that are 'at risk', and therefore Policy 11(a) applies, noting that Z.muelleri is recorded as being of 'least concern' on the IUCN Red List. The assessment of effects determined that irrigating the Robinsons Bay Valley site will result in adverse effects that are less than minor, on the estuarine environment. The activity will not completely avoid all adverse effects on the estuarine environment, and therefore, given the absolute nature of Policy 11(a), will not be consistent with that part of this policy however the anticipated effect on e.g. Z.muelleri is noted in the EOS report as effectively negligible. The scheme however will avoid any *significant* adverse effects on the matters listed in Policy 11(b) and will therefore be consistent with that part of the policy.

iv. habitats of indigenous species in the coastal environment that are important for recreational, commercial, traditional or cultural purposes; *v. habitats, including areas and routes, important to migratory species; and* *vi. ecological corridors, and areas important for linking or maintaining biological values identified under this policy.*	
Policy 13 Preservation of natural character *(1) To preserve the natural character of the coastal environment and to protect it from inappropriate subdivision, use, and development:* *(a) avoid adverse effects of activities on natural character in areas of the coastal environment with outstanding natural character; and* *(b) avoid significant adverse effects and avoid, remedy or mitigate other adverse effects of activities on natural character in all other areas of the coastal environment;*	The effect of the scheme on natural character values, natural features and landscapes, and visual amenity values has been assessed as positive overall. The development of the ATWIS is therefore not assessed as inappropriate in the coastal environment and is therefore consistent with these policies.
Policy 14 Restoration of natural character *Promote restoration or rehabilitation of the natural character of the coastal environment, including by:* *a. identifying areas and opportunities for restoration or rehabilitation;* *b. …;* *c. where practicable, imposing or reviewing restoration or rehabilitation conditions on resource consents and designations, including for the continuation of activities; and recognising that where degraded areas of the coastal environment require restoration or rehabilitation, possible approaches include:* *i. restoring indigenous habitats and ecosystems, using local genetic stock where practicable; or* *ii. …* *iii. creating or enhancing habitat for indigenous species; or* *iv. …*	
Policy 15 Natural features and natural landscapes *To protect the natural features and natural landscapes (including seascapes) of the coastal environment from inappropriate subdivision, use, and development:* *(a) avoid adverse effects of activities on outstanding natural features and outstanding natural landscapes in the coastal environment; and* *(b) avoid significant adverse effects and avoid, remedy, or mitigate other adverse effects of activities on other natural features and natural landscapes in the coastal environment;*	
Policy 18 Public open space *Recognise the need for public open space within and adjacent to the coastal marine area, for public use and appreciation including active and passive recreation, and provide for such public open space, including by:*	The scheme design includes provision for access within the coastal environment of the Hammond Point irrigation site for passive recreation (walking). Connecting public walking tracks from Robinsons Bay and Takamātua Bay, the development will facilitate

(a) ensuring that the location and treatment of public open space is compatible with the natural character, natural features and landscapes, and amenity values of the coastal environment; *(b) taking account of future need for public open space within and adjacent to the coastal marine area, including in and close to cities, towns and other settlements;* *(c) maintaining and enhancing walking access linkages between public open space areas in the coastal environment;* ***Policy 19 Walking access*** *(1) Recognise the public expectation of and need for walking access to and along the coast that is practical, free of charge and safe for pedestrian use.* *(2) Maintain and enhance public walking access to, along and adjacent to the coastal marine area, including by:* *…* *(c) identifying opportunities to enhance or restore public walking access, for example where:* *(i) connections between existing public areas can be provided; or* *(ii) improving access would promote outdoor recreation; or …*	public access to the CMA either side of the point in a manner that will be compatible with, and sensitive to the setting. The scheme will be consistent with these policies.
Policy 21 Enhancement of water quality *Where the quality of water in the coastal environment has deteriorated so that it is having a significant adverse effect on ecosystems, natural habitats, or water based recreational activities, or is restricting existing uses, such as aquaculture, shellfish gathering, and cultural activities, give priority to improving that quality by:* *…* *(e) engaging with tangata whenua to identify areas of coastal waters where they have particular interest, for example in cultural sites, wāhi tapu, other taonga, and values such as mauri, and remedying, or, where remediation is not practicable, mitigating adverse effects on these areas and values.*	The discharge of human wastewater to water is culturally inappropriate and regardless of the quality of the discharge, can prevent the exercise of cultural practices such as harvesting of kai moana. While the quality of harbour water is not resulting in significant adverse ecosystem effects, one of the key drivers for the ATWIS concept was to replace the existing WWTP discharging to the harbour with a 100% land-based scheme and thereby cease direct discharges of wastewater to coastal waters. As the scheme will replace direct treated wastewater discharges with the land-based scheme, water quality will be enhanced both physically and in a cultural sense, and the activity is therefore consistent with this policy.
Policy 23 Discharge of contaminants *(1) In managing discharges to water in the coastal environment, have particular regard to:* *(a) the sensitivity of the receiving environment;* *(b) the nature of the contaminants to be discharged, the particular concentration of contaminants needed to achieve the required water quality in the receiving environment, and the risks if that concentration of contaminants is exceeded; and* *(c) the capacity of the receiving environment to assimilate the contaminants; and:* *(d) avoid significant adverse effects on ecosystems and habitats after reasonable mixing;* *(e) use the smallest mixing zone necessary to achieve the required water quality in the receiving environment; and*	Any discharges to water will be diffuse discharges via seepage, most likely within groundwater. The assessment provided in the application describes the nature of any such seepages and the capability of the receiving environment to assimilate it. Significant adverse effects on the quality and life-supporting capacity of receiving waters are unlikely and will be minimised to the extent practicable. The applicant has extensively investigated alternatives to the scheme and took account of the effect of the ATWIS on tangata whenua values when choosing to advance the scheme. The proposal is consistent with this policy.

(f) minimise adverse effects on the life-supporting capacity of water within a mixing zone. *(2) In managing discharge of human sewage, do not allow:* *(a) discharge of human sewage directly to water in the coastal environment without treatment; and* *(b) the discharge of treated human sewage to water in the coastal environment, unless:* *(i) there has been adequate consideration of alternative methods, sites and routes for undertaking the discharge; and* *(ii) informed by an understanding of tangata whenua values and the effects on them*	

Canterbury Regional Policy Statement

Provision	Assessment
Chapter 5 – Land Use and Infrastructure	
Objective 5.2.2 Integration of land-use and regionally significant infrastructure (Wider Region) *In relation to the integration of land use and regionally significant infrastructure:* *1. To recognise the benefits of enabling people and communities to provide for their social, economic and cultural well-being and health and safety and to provide for infrastructure that is regionally significant to the extent that it promotes sustainable management in accordance with the RMA.*	The ATWIS promotes sustainable management in a manner consistent with Part 2 of the RMA as set out in section 12.1 of the application document. The scheme meets the definition of regionally significant infrastructure and provides the community with an effective means of managing the effects of urban (Akaroa) wastewater generation to the benefit of the community's health and safety, and their economic, social. environmental and cultural wellbeing. The scheme will bring significant benefits to the community that are consistent with achieving this objective.
Policy 5.3.2 Development conditions (Wider Region) *To enable development including regionally significant infrastructure which:* *1. ensure that adverse effects are avoided, remedied or mitigated, including where these would compromise or foreclose:* *a. existing or consented regionally significant infrastructure;* *b. options for accommodating the consolidated growth and development of existing urban areas;* *c. the productivity of the region's soil resources, without regard to the need to make appropriate use of soil which is valued for existing or foreseeable future primary production, or through further fragmentation of rural land;* *d. the protection of sources of water for community supplies;* *e. significant natural and physical resources;* *2. avoid or mitigate:* *a. natural and other hazards, or land uses that would likely result in increases in the frequency and/or severity of hazards;* *b.* reverse sensitivity effects and conflicts between incompatible activities, including identified mineral extraction areas; and	Wastewater infrastructure is considered to be regionally significant infrastructure – as such, the ATWIS will avoid, remedy or mitigate the identified adverse effects. It will not compromise other regionally significant infrastructure, is integral to future growth of the Akaroa Urban area, or unduly compromise productive soils. It will not affect any community water supply or result in significant adverse effects on natural and physical resources. The scheme is not unduly exposed to natural hazards and does not exacerbate existing natural hazard risks. It also avoids reverse sensitivity effects and does not result in incompatible land uses. The scheme is fundamental to the efficient and effective provision of infrastructure. Overall, the proposal is consistent with this policy.

3. integrate with: a. the efficient and effective provision, maintenance or upgrade of infrastructure; and b. …	
Policy 5.3.5 Servicing development for potable water, and sewage and stormwater disposal (Wider Region) *Within the wider region, ensure development is appropriately and efficiently served for the collection, treatment, disposal or re-use of sewage and stormwater, and the provision of potable water, by:* *1. avoiding development which will not be served in a timely manner to avoid or mitigate adverse effects on the environment and human health; and* *2. requiring these services to be designed, built, managed or upgraded to maximise their on-going effectiveness.*	Future growth in Akaroa will be provided for by the ATWIS as it will enable appropriate and efficient treatment, disposal and re-use of wastewater, and has been scaled to accommodate future anticipated population increases. The scheme has been designed to be effective on an ongoing basis and is consistent with this policy.
Policy 5.3.6 Sewerage, stormwater and potable water infrastructure (Wider Region) *Within the wider region:* *4. Avoid development which constrains the on-going ability of the existing sewerage, stormwater and potable water supply infrastructure to be developed and used.* *5. Enable sewerage, stormwater and potable water infrastructure to be developed and used, provided that, as a result of its location and design:* *a. the adverse effects on significant natural and physical resources are avoided, or where this is not practicable, mitigated; and* *b. other adverse effects on the environment are appropriately controlled.*	The ATWIS does not constrain existing infrastructure networks and has been designed to accommodate forecast future growth in Akaroa, therefore enabling and supporting future urban development. The scheme avoids or mitigates adverse effects on significant natural and physical resources (e.g. soil and air quality, water quality and the harbour, biodiversity values), with all actual and potential effects able to be appropriately controlled. The scheme is consistent with this policy.
Policy 5.3.9 Regionally significant infrastructure (Wider Region) *In relation to regionally significant infrastructure (including transport hubs):* *…* *3. provide for the expansion of existing infrastructure and development of new infrastructure, while:* *a. recognising the logistical, technical or operational constraints of this infrastructure and any need to locate activities where a natural or physical resource base exists;* *b. avoiding any adverse effects on significant natural and physical resources and cultural values and where this is not practicable, remedying or mitigating them, and appropriately controlling other adverse effects on the environment; and* *c. when determining any proposal within a sensitive environment (including any environment the subject of section 6 of the RMA), requiring that alternative sites, routes, methods and design of all components and associated structures are considered so that the proposal satisfies sections 5(2)(a) – (c) as fully as is practicable.*	The scheme has been designed to accommodate future forecast growth in Akaroa and the associated expansion of the existing network and wastewater volumes. It has been designed to integrate with the natural and physical resources of the harbour area to the extent practicable, while avoiding or mitigating adverse effects on significant natural and physical resources and cultural values. Alternatives to the scheme have been extensively considered prior to the scheme being selected, and it has been determined to satisfy s5(2)(a) – (c) of the RMA (refer section 12 of the application). The ATWIS is consistent with this policy.

Chapter 7 – Fresh Water	
Objective 7.2.3 Protection of intrinsic value of waterbodies and their riparian zones *The overall quality of freshwater in the region is maintained or improved, and the life supporting capacity, ecosystem processes and indigenous species and their associated fresh water ecosystems are safeguarded.*	The effects assessments show that the ATWIS will not substantially alter the quality of freshwater affected by the scheme or reduce the life supporting capacity or ecosystem processes supported by it . The minimal effect of the scheme on freshwater quality and related habitat safeguards the overall quality of the freshwater such that it may be considered maintained, remaining within the various attribute bands determined in the baseline state. The activity will not prevent this objective being achieved.
Objective 7.2.4 Integrated management of fresh water resources *Fresh water is sustainably managed in an integrated way within and across catchments, between activities, and between agencies and people with interests in water management in the community, considering:* *1. the Ngāi Tahu ethic of Ki Uta Ki Tai (from the mountains to the sea);* *2. the interconnectivity of surface water and groundwater;* *3. the effects of land uses and intensification of land uses on demand for water and on water quality; and* *4. kaitiakitanga and the ethic of stewardship; and* *5. any net benefits of using water, and water infrastructure, and the significance of those benefits to the Canterbury region.*	The scheme is cognisant of the interconnectedness of water across the catchment and receiving environments of the land, groundwater and connected surface water, and the harbour environment (as reflected in the concept of Ki Uta Ki Tai). The effects assessments consider all receiving environments. The effects on freshwater quality are minimal, as are the effects on the quality and integrity of the land and harbour environments. As the scheme will better enable the removal of direct treated wastewater discharges from the harbour as sought by Ngāi Tahu for some time, it may be considered to be aligned with kaitiakitanga and the ethic of stewardship. The scheme, specifically the use of water to irrigate indigenous vegetation, will have an overall positive net benefit in respect of indigenous vegetation restoration and related biodiversity outcomes. The scheme will sustainably manage the freshwater resources involved and supports the achievement of this objective.
Policy 7.3.7 Water quality and land uses *To avoid, remedy or mitigate adverse effects of changes in land uses on the quality of fresh water (surface or ground) by:* *1. identifying catchments where water quality may be adversely affected, either singularly or cumulatively, by increases in the application of nutrients to land or other changes in land use; and* *2. controlling changes in land uses to ensure water quality standards are maintained or where water quality is already below the minimum standard for the water body, it is improved to the minimum standard within an appropriate timeframe.*	The effects assessments show that Robinsons Bay Stream will remain within current attribute bands, demonstrating that the ATWIS appropriately mitigates the effects of the use of land for irrigating treated wastewater. The scheme is therefore consistent with this policy.
Chapter 8 - The Coastal Environment	
Objective 8.2.4 Preservation, protection and enhancement of the coastal environment *In relation to the coastal environment:* *1. Its natural character is preserved and protected from inappropriate subdivision, use and development; and* *2. Its natural, ecological, cultural, amenity, recreational and historic heritage values are restored or enhanced.*	Aspects of the natural character of the coastal environment as affected by the scheme will be protected and restored (i.e. the ecological, cultural, amenity and recreational values present). The cultural values of the harbour will also be enhanced. The scheme will support this objective being achieved.
Objective 8.2.5 Provision of access	The scheme will support this objective being achieved by enhancing public access along the CMA by

Maintenance and enhancement of appropriate public and Ngāi Tahu access to and along the coastal marine area to enhance recreational opportunities and to enhance the ability of Ngāi Tahu as tāngata whenua to access kaimoana and exercise tikanga Māori.	connecting future coastal pathways over Hammond Point between Robinsons and Takamātua Bay's.
Objective 8.2.6 Protection and improvement of coastal water *Protection of coastal water quality and associated values of the coastal environment, from significant adverse effects of the point and non-point discharge of contaminants; and enhancement of coastal water quality where it has been degraded.*	The ATWIS will not result in any significant adverse effect on coastal water quality and will likely result in an overall positive effect by enabling the current Akaroa WWTP discharge to the harbour to cease in favour of the ATWIS which has been determined to result in a 'very low' degree of adverse effect on water quality. This objective will be achieved.
Policy 8.3.4 Preservation of the natural character of the coastal environment *To preserve and restore the natural character of the coastal environment by:* *1. protecting outstanding natural features and landscapes including seascapes from inappropriate occupation, subdivision, use and development;* *2. protecting and enhancing indigenous ecosystems and associated ecological processes;* *3. promoting integrated management of activities that affect natural character in the coastal environment and the coastal marine area, in particular coastal landforms and landscapes that are significant, representative or unique to the region;* …	There are no outstanding natural features or landscapes affected by the scheme. The effect of the ATWIS on natural features and landscapes has been assessed as positive. The scheme will not have an effect on the seascape and does not constitute inappropriate use or development of resources. The effect of the scheme on indigenous ecosystems and ecological processes is expected to be minimal to negligible, and fundamentally the scheme will preserve the natural character of the coastal environment as expressed through objective 8.2.4. The proposal is consistent with this policy.
Policy 8.3.5 Maintenance and enhancement of public and Ngāi Tahu access *To maintain and enhance public and Ngāi Tahu access to and along the coastal marine area, subject to:* *1. protecting public health and safety.* *2. avoiding significant adverse effects on natural, physical, amenity, recreational, cultural and historic heritage values of the coastal environment.* *3. avoiding damage to natural buffers to coastal erosion.* *4. protecting Ngāi Tahu sites of special value.* *5. protecting the stability, performance, maintenance and operation of regionally significant infrastructure in the coastal environment or other commercial maritime facilities.* *6. avoiding conflicts with the legal rights and lawful activities of owners/occupiers of land in the coastal environment.* *7. ensuring compliance with legislative maritime security requirements for ships and port facilities.*	The scheme is consistent with this policy insofar as it provides for improved access along the CMA by pathways connecting Robinsons Bay and Takamātua Bay over Hammond Point.
Policy 8.3.6 Regionally significant infrastructure *In relation to regionally significant infrastructure in the coastal environment:* *1. provide for its efficient and effective development, operation, maintenance and upgrade;*	Providing for the development of the ATWIS as regionally significant infrastructure in the coastal environment is consistent with this policy.

Policy 8.3.7 Improve water quality in degraded areas *To improve the quality of Canterbury's coastal waters in areas where degraded water quality has significant adverse effects on natural, cultural, amenity and recreational values.*	Although the harbour's water quality does not typically adversely affect the values identified in the policy, the ATWIS is likely to enable an overall improvement in harbour water quality by replacing the current harbour discharge with the land-based scheme. The proposal is consistent with this policy.
Policy 8.3.9 Direct discharge of sewage into the coastal marine area *To ensure that human sewage is not discharged directly into the coastal marine area without treatment and where:* *1. Alternative methods, sites and routes for undertaking the discharges have been considered; and* *2. There has been consultation with Ngāi Tahu as tāngata whenua and particular regard had for their values and the effects of discharges on those values; charges on those values;*[sic] *the human sewage is treated in a manner appropriate to the receiving environment.*	The ATWIS will not result in the direct discharge of untreated wastewater to any receiving environment. Despite the scheme avoiding all direct discharges to water, particular regard has been had to the effect of the scheme on the values of Ngāi Tahu as tāngata whenua, and alternatives to the proposed discharge have been assessed. The scheme is consistent with this policy to the extent that it is relevant to the scheme.
Chapter 9 – Ecosystems and Indigenous Biodiversity	
Objective 9.2.1 Halting the decline of Canterbury's ecosystems and indigenous biodiversity *The decline in the quality and quantity of Canterbury's ecosystems and indigenous biodiversity is halted and their life-supporting capacity and mauri safeguarded.*	The effects assessments show that the scheme will adversely affect indigenous biodiversity and ecosystem health in the receiving environment to a very minor degree, effectively safeguarding the overall life-supporting capacity of the harbour by facilitating the removal of the current harbour discharge. It will also result in a positive effect on terrestrial biodiversity from the planting of the irrigation areas and peripheral zones. The scheme overall will support this objective.
Policy 9.3.4 Promote ecological enhancement and restoration *To promote the enhancement and restoration of Canterbury's ecosystems and indigenous biodiversity, in appropriate locations, where this will improve the functioning and long term sustainability of these ecosystems.*	The scheme will result in the ecological enhancement of the planted areas and improved indigenous biodiversity. It is consistent with this policy.
Policy 9.3.5 Wetland protection and enhancement In relation to wetlands: *…* *3. To generally promote the protection, enhancement and restoration of all of Canterbury's remaining wetlands.* *…*	Although there are no wetlands within the irrigated areas, there may be some beneficial outcomes for wetlands nearby with the potential for more reliable moisture levels to better support wetland environments. The assessment of effects shows that the scheme, to the extent that it may affect wetlands, will be positive overall.
Chapter 11 – Natural Hazards	
Objective 11.2.1 Avoid new subdivision, use and development of land that increases risks associated with natural hazards *New subdivision, use and development of land which increases the risk of natural hazards to people, property and infrastructure is avoided or, where avoidance is not possible, mitigation measures minimise such risks.*	The use of the land needed for the ATWIS will not result in an increased risk to people, property or infrastructure from natural hazards, having been designed around the geotechnical hazards identified, and being cognisant of coastal hazard risks. The scheme will assist with meeting this objective.
Objective 11.2.3 Climate change and natural hazards *The effects of climate change, and its influence on sea levels and the frequency and severity of natural hazards, are recognised and provided for.*	The anticipated effects of climate change have been taken into account in the design of the scheme and associated modelling and are addressed in the application. Changes in the frequency and severity of

	natural hazards are taken into account. The scheme will help to achieve this objective.
Policy 11.3.1 Avoidance of inappropriate development in high hazard areas *To avoid new subdivision, use and development (except as provided for in Policy 11.3.4) of land in high hazard areas, unless the subdivision, use or development:* *1. is not likely to result in loss of life or serious injuries in the event of a natural hazard occurrence; and* *2. is not likely to suffer significant damage or loss in the event of a natural hazard occurrence; and* *3. is not likely to require new or upgraded hazard mitigation works to mitigate or avoid the natural hazard; and* *4. is not likely to exacerbate the effects of the natural hazard; or* *5. …*	The proposed use of land for the ATWIS is not subject to high natural hazard risk, and the scheme has been designed to avoid areas that are. In particular, the scheme design and proposed operation will be cognisant of the risks that are present and will be designed and operated in a manner that avoids or minimises exacerbating those risks. Overall, as the ATWIS is not inappropriately located in respect of natural hazard risks, the proposal is consistent with this policy.
Policy 11.3.4 Critical infrastructure *New critical infrastructure will be located outside high hazard areas unless there is no reasonable alternative. In relation to all areas, critical infrastructure must be designed to maintain, as far as practicable, its integrity and function during natural hazard events.*	As new critical infrastructure, the ATWIS avoids high hazard areas, and will be designed to maintain integrity and function to the extent practicable, in natural hazard events. The scheme is therefore consistent with this policy.
Policy 11.3.8 Climate change *When considering natural hazards, and in determining if new subdivision, use or development is appropriate and sustainable in relation to the potential risks from natural hazard events, local authorities shall have particular regard to the effects of climate change.*	The anticipated effects of climate change as they relate to the scheme and to its effect on natural hazards has been taken into account in developing the scheme concept to ensure that any effect of climate change on the scheme's operation will be minimal. The proposal is consistent with this policy.
Chapter 12 - Landscape	
While the effects of the scheme on landscape are a key consideration, the RPS Landscape provisions relate to identification and assessment methodology and are therefore not relevant to this application. The relevant matters are also addressed in the LVIA report.	
Chapter 13 – Historic Heritage	
Objective 13.2.1 Identification and protection of significant historic heritage *Identification and protection of significant historic heritage items, places and areas, and their particular values that contribute to Canterbury's distinctive character and sense of identity from inappropriate subdivision, use and development.*	The significant heritage items present on the Robinsons Bay Valley site will be safeguarded, through fencing and by irrigation setbacks that effectively separate the lower part of the site from the remainder of the scheme. These measures will achieve this objective.
Policy 13.3.2 Recognise places of cultural heritage significance to Ngāi Tahu *To recognise places of historic and cultural heritage significance to Ngāi Tahu and protect their relationship*	Recognition of the value of Takapūneke and of Whakaroa/Akaroa Harbour to Ngāi Tahu is a key component of the scheme's concept and design. The proposal is consistent with this policy.

and culture and traditions with these places from the adverse effects of inappropriate subdivision, use and development.	
Policy 13.3.3 Historic cultural and historic heritage landscapes *Significant historic cultural and historic heritage landscapes are to be protected from inappropriate subdivision, use and development. When determining the significance of values of historic cultural or historic heritage landscapes, the following matters will be considered:*	The assessment of the heritage values present on the Robinsons Bay Valley site included the heritage landscape of the site and provision has been made to retain the viewshaft across the site from Robinsons Bay Valley Road as detailed in the Heritage Assessment report. The development of the Robinsons Bay Valley site is consistent with this policy.
Chapter 14 – Air Quality	
Objective 14.2.2 Localised adverse effects of discharges on air quality *Enable the discharges of contaminants into air provided there are no significant localised adverse effects on social, cultural and amenity values, flora and fauna, and other natural and physical resources.*	The proposal will achieve this objective given the absence of anticipated odour discharges from any part of the scheme. The proposal is consistent with Policies 14.3.1 and 14.3.3 for the same reasons.
Policy 14.3.1 Maintain and improve ambient air quality *In relation to ambient air quality:* *1. …* *2. Where existing ambient air quality is higher than required by the standards set, to only allow the discharge of contaminants into air where the adverse effects of the discharge on ambient air quality are minor.*	
Policy 14.3.3 Avoid, remedy or mitigate localised adverse effects on air quality *To set standards, conditions and terms for discharges of contaminants into the air to avoid, remedy or mitigate localised adverse effects on air quality.*	
Policy 14.3.5 Relationship between discharges to air and sensitive land-uses *In relation to the proximity of discharges to air and sensitive land-uses:* *…* *3. New activities which require resource consents to discharge contaminants into air are to locate away from sensitive land uses and receiving environments unless adverse effects of the discharge can be avoided or mitigated.*	While the anticipated discharges to air are permitted activities, the design of the pipeline air valves will take account of the proximity to sensitive land uses or receivers and avoid or suitably mitigate effects as needed. The proposal will be consistent with this policy.
Chapter 15 - Soils	
Objective 15.2.1 Maintenance of soil quality *Maintenance and improvement of the quality of Canterbury's soil to safeguard their mauri, their life supporting capacity, their health and their productive capacity.*	The soil quality and health of the land across the scheme is not expected to be adversely affected by it, however it will be closely monitored, and remediation measures applied if required. The scheme will support the achievement of this objective.
Policy 15.3.1 Avoid remedy or mitigate soil degradation *In relation to soil:* *1. to ensure that land-uses and land management practices avoid significant long-term adverse effects on soil quality, and to*	No significant long term adverse effects on soil quality or structure are anticipated as a result of the proposed irrigation given the characteristics of the treated wastewater, the rate and method of application, the development of the indigenous forest to irrigate to, and

remedy or mitigate significant soil degradation where it has occurred, or is occurring; and 2. *to promote land-use practices that maintain and improve soil quality.*	ongoing monitoring. The proposal is consistent with this policy.
Policy 15.3.2 Avoid and remedy significant induced soil erosion *To avoid significant new induced soil erosion resulting from the use of land and as far as practicable remedy or mitigate significant induced soil erosion where it has occurred. Particular focus is to be given to the desirability of maintaining vegetative cover on nonarable land.*	Soil erosion induced by construction will be actively managed and minimised and will not be significant. Operational soil erosion will be minimal, controlled by managing application rates and by ensuring substantial vegetation cover is maintained on all irrigation areas. The proposal will therefore be consistent with this policy.

National Policy Statement for Freshwater Management

Provision	Assessment
OBJECTIVE	
(1) The objective of this National Policy Statement is to ensure that natural and physical resources are managed in a way that prioritises: *(a) first, the health and well-being of water bodies and freshwater ecosystems* *(b) second, the health needs of people (such as drinking water)* *(c) third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.*	The effect of the ATWIS on freshwater quality (as indicated by Robinsons Bay Stream) and the associated health and wellbeing of the stream and related ecosystems has been a key driver for the scheme design. The scheme concept minimises the potential for direct discharge to the stream, with all wastewater treated to a very high standard and then irrigated to land within the receiving soil capacity. This approach has been driven by a desire to minimise the actual and potential effects on the health of the stream and the ecosystems it supports. The scheme also enables the community to provide for their social, economic and cultural wellbeing through effective wastewater management. In that sense the scheme will help to achieve this objective.
Policies	
Policy 1: *Freshwater is managed in a way that gives effect to Te Mana o te Wai.*	Tangata whenua were actively involved in the development of the concept for the scheme, reflecting and enabling the principles of mana whakahaere, kaitiakitanga and manaakitanga. The decision making process required for the activity to lawfully proceed enables the governance aspects of Te Mana o te Wai, and scheme design reflects both principles of stewardship, and care and respect for freshwater. The scheme concept is consistent with this policy.
Policy 2: *Tangata whenua are actively involved in freshwater management (including decision making processes), and Māori freshwater values are identified and provided for.*	Ngāi Tahu values in respect of fresh and harbour water quality (cultural, spiritual and physical) have been consistent themes in developing the scheme concept, as has consultation and engagement between Ōnuku Rūnanga and the applicant. The proposal is consistent with this policy.
Policy 3: *Freshwater is managed in an integrated way that considers the effects of the use and development of land on a whole-of-catchment basis, including the effects on receiving environments.*	The effect of using the proposed land for treated wastewater irrigation on Robinsons Bay Stream wasn taken into account, including by modelling the impact of irrigation, retiring land from grazing (beyond that needed for irrigation) and the cumulative effect of the activity on nitrate-N in Robinsons Bay Stream. The proposal is consistent with this policy.

Policy 5: *Freshwater is managed (including through a National Objectives Framework) to ensure that the health and well-being of degraded water bodies and freshwater ecosystems is improved, and the health and well-being of all other water bodies and freshwater ecosystems is maintained and (if communities choose) improved.*	The assessment in the application shows that the effect of the scheme on the quality of Robinsons Bay Stream is minimal, remaining within the interquartile range of the existing water quality for key contaminants, and within the existing Attribute Bands, and therefore effectively 'maintained' in respect of the ecological effects. The proposal is therefore consistent with this policy.
Policy 7: *The loss of river extent and values is avoided to the extent practicable.*	As assessed for the objective above, minimising the adverse effects of the scheme (i.e. loss of values) on the Robinsons Bay Stream quality to the extent practicable is a key driver for the scheme concept. The scheme is consistent with this policy.
Policy 9: *The habitats of indigenous freshwater species are protected.*	The scheme will not alter the quality of the receiving environment to an extent that will adversely impact the habitat of the freshwater species identified such as causing a change from the current baseline conditions or attributes. The proposal will be generally consistent with this policy.
Policy 13: *The condition of water bodies and freshwater ecosystems is systematically monitored over time, and action is taken where freshwater is degraded, and to reverse deteriorating trends.*	Ongoing long term monitoring is proposed as part of the scheme's operation to monitor the condition of Robinsons Bay Stream, Robinsons Bay and Childrens Bay as relates to the operation of the scheme. If any deterioration attributable to the scheme is identified, the applicant will have a number of options to address the effect appropriately. The proposal is consistent with this policy.
Policy 15: *Communities are enabled to provide for their social, economic, and cultural wellbeing in a way that is consistent with this National Policy Statement.*	Given the minimal effect the ATWIS is expected to have on receiving freshwater environments, the scheme will enable the community to manage their wastewater in a way that safeguards their social, environmental and cultural wellbeing, and that is affordable for the community, achieving the objective of the NPS-FM and consistent with this policy.

Canterbury Regional Coastal Environment Plan

Provision	Assessment
OBJECTIVES	
Objective 6.1 *To protect, and where appropriate enhance, the following areas, sites and habitats of high natural, physical, heritage or cultural value:* *a. Areas of Significant Natural Value (identified in Schedule 1, and shown on the Planning Maps in Volume 2);* *…* *c. Areas within the intertidal or subtidal zone that contain unique, threatened, rare, distinctive or representative marine life or habitats (including coastal wetlands) or are significant habitats of marine species generally;* *…* *g. Coastal landforms and landscapes, submerged platforms and seascapes that are regionally, nationally or internationally representative or unique, including the*	The Robinsons Bay tidal flats are identified in Schedule 1 and shown on RCEP Map 7.22 as an Area of Significant Nature Conservation Value. Clause (c) applies given the values identified in the estuary baseline and effects assessment. Clause (g) applies as the ATWIS will take place within the coastal environment of Banks Peninsula. Hammond Point is noted in the Christchurch District Plan (CDP) as an area of at least high natural character and is in the coastal environment. Given the negligible adverse effects anticipated on the values of significance under clauses (a) and (c), and the positive effect of the development of Hammond Point on landscape character and amenity values, the

Kaikoura coast, Banks Peninsula, Kaitorete Spit, and the Timaru reefs; *…*	ATWIS is considered to support the achievement of Objective 6.1.
Objective 6.2 *To protect, and where appropriate, enhance natural character and amenity values of the Banks Peninsula coastal environment including:* *a. Volcanic and coastal landforms and features;* *b. Estuarine and coastal vegetation and habitat;* *c. Coastal processes and ecosystems;* *d. Areas of high water quality;* *e. Areas of high visual amenity value, and/or otherwise unmodified by structures or other activities, in particular outer bays and open coast.*	The LVIA report assessed the ATWIS as having a positive effect on natural character and amenity values. The scheme will therefore help to achieve Objective 6.1.
Objective 7.1 *Enable present and future generations to gain cultural, social, recreational, economic, health and other benefits from the quality of the water in the Coastal Marine Area, while:* *a. maintaining the overall existing high natural water quality of coastal waters;.* *b. safeguarding the life-supporting capacity of the water, including its associated: aquatic ecosystems, significant habitats of indigenous fauna and areas of significant indigenous vegetation;* *c. safeguarding, and where appropriate, enhancing its value for providing mahinga kai for Tāngata whenua;* *d. protecting wahi tapu and Wāhi taonga of value to Tāngata whenua;* *e. preserving natural character and protecting outstanding natural features and landscapes, where water quality is an aspect of their value, from reductions in water quality;* *f. maintaining, and where appropriate enhancing, amenity values; and* *g. recognising the intrinsic values of ecosystems and any finite characteristics of the coastal environment.*	The adverse effects of the ATWIS on coastal water quality and associated amenity values in the harbour will be negligible, and in some cases will be positive. The scheme is fundamental to enabling the direct discharge of treated wastewater at Red House Bay to permanently end, along with the more significant adverse effects on water quality associated with the existing scheme. The ATWIS will support the achievement of Objective 7.1 as a means of better enabling the community to enjoy the benefits associated with good harbour water quality.
POLICIES	
Policy 6.2 *Environment Canterbury and Territorial Local Authorities will seek to ensure that the adverse effects of subdivision, use and development of land in the coastal environment landward of the Coastal Marine Area, on the identified values of Areas of Significant Natural Value and on the identified values of areas of high natural, physical, heritage, or cultural value, are avoided, remedied or mitigated.*	The ATWIS will generally avoid adverse effects associated with using the identified land areas for irrigating treated wastewater. Those effects that are not able to be avoided will be substantially mitigated. Many of the effects of the scheme, including in respect of areas of high natural, physical, heritage and cultural value have been assessed as positive. Overall the ATWIS is consistent with Policy 6.2.
Policy 6.3 *Environment Canterbury will encourage the restoration or rehabilitation of areas or sites within the coastal environment where this would: assist in maintaining or enhancing the integrity or functioning of sites of high natural, physical or cultural value and Areas of Significant Natural Value; contribute to the preservation of natural character; maintain the ecological functioning*	Given the positive effect of planting indigenous vegetation, on the integrity and function of the irrigation areas and the Old Coach Road storage site, as well as the contribution to ecological function, natural character and amenity values, cultural, heritage and intrinsic values, the ATWIS is consistent with this policy.

of the coast; or enhance intrinsic, cultural, heritage or amenity values.	
Policy 7.5 *Only grant a resource consent to discharge human sewage into water, or onto or into land in the Coastal Marine Area, without it passing through land or a specially constructed wetland outside the Coastal Marine Area, where:* *a. the discharge better meets the purpose of the Act than disposal through land or a wetland outside the Coastal Marine Area; and* *b. there has been consultation by the applicant with Tāngata whenua in accordance with Tikanga Māori and due weight has been given to sections 6, 7 and 8 of the Act; and* *c. there has been consultation by the applicant with the community generally; and* *d. the discharge is not within an Area of Significant Natural Value, unless the applicant satisfies Environment Canterbury that exceptional circumstances justify the discharge in such an area.*	All treated wastewater will be discharged to land with no treated or untreated wastewater discharged directly to water (fresh or coastal). This policy does not therefore apply.
Policy 7.7 *Ensure that the discharges of water or contaminants into water, or onto or into land in the Coastal Marine Area avoid significant adverse effects on cultural or spiritual values associated with sites, (e.g. areas covered by controls such as Taiāpure or mahinga Mātaitai), of special significance to the Tāngata whenua.*	The ATWIS is supported in principle by tāngata whenua. It will enable the culturally offensive discharge at Red House Bay to end, and as the scheme discharges to land, is consistent with protecting cultural and spiritual values associated with coastal water, and the values of special significance associated with the harbour as a Taiāpure. The policy is not relevant to the ATWIS as there is no discharge to the CMA.
Policy 7.8 *After reasonable mixing, the discharge of a contaminant or water into water, or onto or into land in the Coastal Marine Area, (either by itself or in combination with the same, similar, or other contaminants or water) should not:* *a. give rise to any significant adverse effects on the existing habitats or feeding grounds of indigenous fauna or any significant adverse effects on aquatic ecosystems; and* *b. have acute or chronic toxic effects on fish, either directly or indirectly as a result of an adverse effect on aquatic organisms. …*	Any residual contaminants that enter Robinsons Bay either directly or via Robinsons Bay Stream are expected to be minimal and are not anticipated to result in any significant adverse effect on habitats, feeding grounds or ecosystems. No acute or chronic toxic effects on fish or any other aquatic organism are expected either. The policy is not relevant to the ATWIS as there is no discharge to the CMA.
Policy 7.10 *Promote measures that avoid, remedy or mitigate the adverse effects of point and non-point source discharges of contaminants outside the Coastal Marine Area where the discharge can adversely affect the quality of water in the Coastal Marine Area.*	The scheme will result in discharges to land that will affect Robinsons Bay Stream and therefore potentially water quality in Robinsons Bay. The high treatment of wastewater, its slow rate irrigation to land, uptake by plants, destocking of the irrigated land, and close monitoring of any effects on stream and harbour water quality are all measures that are intended to help to avoid, remedy or mitigate effects on the CMA. Consequently the ATWIS is consistent with this policy.

Canterbury Land and Water Regional Plan

Provision	Assessment
OBJECTIVES	

3.1 - Land and water are managed as integrated natural resources to recognise and enable Ngāi Tahu culture, traditions, customary uses and relationships with land and water.	The proposal recognises the connection between the irrigation of highly treated wastewater to land and the effects on ground and surface water. Discharging treated wastewater to land and enabling the current harbour discharge to cease is strongly aligned with Ngāi Tahu cultural values, traditions, customary uses and relationships with land and water. The proposal will support this objective being achieved.
3.2 - Water management applies the ethic of ki uta ki tai – from the mountains to the sea – and land and water are managed as integrated natural resources recognising the connectivity between surface water and groundwater, and between fresh water, land and the coast.	Significant consideration has been given to the rate, method and locations for irrigating treated wastewater to land in cognisance of the potential effects on land and soil, ground water, surface water and the harbour. In particular, the applicant has undertaken extensive investigations into the actual and potential effect of irrigating in Robinsons Bay Valley on the quality of Robinsons Bay Stream with a view to minimising the adverse effects of contaminants entering the stream. The proposal reflects the ethic of ki uta ki tai, and therefore helps to achieve this objective.
3.3 - Nationally and regionally significant infrastructure is enabled and is resilient and positively contributes to economic, cultural and social wellbeing through its efficient and effective operation, on-going maintenance, repair, development and upgrading.	The proposed scheme is regionally significant infrastructure. The scheme is not unduly vulnerable to natural hazard risk including anticipated climate change effects and is considered to be resilient. Treating wastewater to a high standard and then irrigating it to land will positively contribute to the community's social and cultural wellbeing, including as relates to improved environmental outcomes. The proposed scheme will help to achieve this objective.
3.6 - Water is recognised as essential to all life and is respected for its intrinsic values.	The scheme recognises the value of fresh and coastal (harbour) water and the potential effects of irrigating treated wastewater to land by ensuring all wastewater is highly treated before irrigation, and by the design of the scheme to minimise adverse effects on receiving water quality. The proposal helps to achieve this objective.
3.7 - Fresh water is managed prudently as a shared resource with many in-stream and out-of-stream values.	The in-stream values of the receiving water are recognised and will be safeguarded to the extent practicable by the design and proposed operation of the scheme. By doing so, the scheme represents the prudent management of freshwater and its values.
3.8 - The quality and quantity of water in fresh water bodies and their catchments is managed to safeguard the life-supporting capacity of ecosystems and ecosystem processes, including ensuring sufficient flow and quality of water to support the habitat and feeding, breeding, migratory and other behavioural requirements of indigenous species, nesting birds and, where appropriate, trout and salmon.	Minimising the effects of the scheme on freshwater quality is core to the scheme's design and proposed operation. The outcome is a scheme that will result in minimal adverse effects on receiving water quality and its capacity to support life, including indigenous species. The proposal will support the achievement of this objective.
3.16 - Freshwater bodies and their catchments are maintained in a healthy state, including through hydrological and geomorphic processes such as flushing and opening hāpua and river mouths, flushing algal and weed growth, and transporting sediment.	The proposal will result in minimal adverse effects on receiving water quality and its ability to support a healthy habitat. The irrigation to land will not cause a substantial change in the hydrology of Robinsons Bay Stream, helping to achieve this objective.
3.17 - The significant indigenous biodiversity values of rivers, wetlands and hāpua are protected.	The scheme will not degrade the biodiversity or natural character values present in Robinsons Bay Stream or

	any other fresh water body given the construction approach and the land-based design of the scheme. This is helped by the substantial planted setbacks and riparian margins across the scheme. Consequently the adverse effects of the scheme on the biodiversity values of the stream will be very low, substantially helping to achieve this objective.
3.19 - Natural character values of freshwater bodies, including braided rivers and their margins, wetlands, hāpua and coastal lagoons, are protected.	
3.23 - Soils are healthy and productive, and human-induced erosion and contamination are minimised.	The soils within the irrigation areas will be affected by construction activities and irrigation however with appropriate effects mitigation and the addition of a substantial number of indigenous plants and trees on the sites, it is expected that soil health and productivity will be maintained. The irrigation areas will be used in perpetuity for wastewater management and retained as forested areas which will help to retain site soils, preventing erosion and minimising sediment loss from those sites. The proposal will help to achieve this objective.
3.24 - All activities operate at good environmental practice or better to optimise efficient resource use and protect the region's fresh water resources from quality and quantity degradation.	The scheme has been designed to reflect good environmental practice, from the highly effective treatment process to 100% land application. The use of the irrigation areas will enable reforesting of approximately 37 ha of Banks Peninsula with indigenous species and will provide public access to and within the sites for recreation. The scheme represents efficient resource use of the land for the scheme by enabling it to be used for wastewater management as well as being a community recreational asset. This will be achieved while minimising adverse effects on freshwater resources. The proposal is consistent with achieving this objective.
POLICIES	
2A.1 *(1) When considering any application for a discharge the consent authority must have regard to the following matters:* *(a) the extent to which the discharge would avoid contamination that will have an adverse effect on the life-supporting capacity of fresh water including on any ecosystem associated with fresh water; and* *(b) the extent to which it is feasible and dependable that any more than minor adverse effect on fresh water, and on any ecosystem associated with fresh water, resulting from the discharge would be avoided.* *(2) When considering any application for a discharge the consent authority must have regard to the following matters:* *(a) the extent to which the discharge would avoid contamination that will have an adverse effect on the health of people and communities as affected by their contact with freshwater; and* *(b) the extent to which it is feasible and dependable that any more than minor adverse effect on the health of people and communities as affected by their contact with fresh water resulting from the discharge would be avoided.*	The discharge has been determined to have a minimal (less than minor) adverse effect on the life-supporting capacity of Robinsons Bay Stream and its associated aquatic ecosystems, and the effects assessment shows that it is feasible and dependable that appropriate operation of the scheme will result in a minor adverse effect on the stream and its associated values. The ATWIS will also avoid adverse effects on the stream that would affect people's health and wellbeing from contact with the stream. The proposal is consistent with this policy.

(3) This policy applies to the following discharges (including a diffuse discharge by any person or animal): *(a) a new discharge or* *(b) …*	
2A.3 The loss of extent of natural inland wetlands is avoided, their values are protected, and their restoration is promoted, except where: *(a) the loss of extent or values arises from any of the following:* *(i) the customary harvest of food or resources undertaken in accordance with tikanga Māori* *(ii) restoration activities* *(iii) scientific research* *(iv) the sustainable harvest of sphagnum moss* *(v) the construction or maintenance of wetland utility structures (as defined in the Resource Management (National Environmental Standards for Freshwater) Regulations 2020)* *(vi) the maintenance or operation of specified infrastructure, or other infrastructure (as defined in the Resource Management (National Environmental Standards for Freshwater) Regulations 2020* *(vii) natural hazard works (as defined in the Resource Management (National Environmental Standards for Freshwater) Regulations 2020); or* *(b) the regional council is satisfied that:* *(i) the activity is necessary for the construction or upgrade of specified infrastructure; and* *(ii) the specified infrastructure will provide significant national or regional benefits; and* *(iii) there is a functional need for the specified infrastructure in that location; and* *(iv) the effects of the activity are managed through applying the effects management hierarchy.*	Some natural wetland areas may be affected by the scheme as set out in the Terrestrial Ecology effects assessment report, however the report concludes that the effects would generally be positive, particularly with the additional planting of indigenous wetland species. The ATWIS is considered to result in a positive effect on the few wetlands (or wet areas) potentially affected by the scheme as destocking the land will end grazing, allow regrowth and prevent further pugging of wetland soils. Also, irrigation will most likely improve the consistency of moisture levels in wet areas, further enhancing the viability of the wetland vegetation to establish and thrive. Overall, the scheme is likely to avoid the loss of the extent of any existing wetlands within the scheme area and is expected to result in an overall positive outcome for the limited wetlands affected by the scheme. The proposal is consistent with this policy.
2A.4 The loss of river extent and values is avoided, unless the council is satisfied: *(a) that there is a functional need for the activity in that location; and* *(b) the effects of the activity are managed by applying the effects management hierarchy.*	Any loss of values in Robinsons Bay Stream will be minimal, and adverse effects will be minimised to the extent practicable consistent with the effects management hierarchy. Accordingly, the scheme will be consistent with Policy 2A.4(b).
4.1 - *Lakes, rivers, wetlands and aquifers will meet the fresh water outcomes set in Sections 6 to 15 within the specified timeframes. If outcomes have not been established for a catchment, then each type of lake, river or aquifer should meet the outcomes set out in Table 1 by 2030.*	There are no relevant freshwater outcomes for the streams and wetlands in the scheme area in Sections 6 to 15. The scheme will not prevent the indicators for Banks Peninsula set out in Table 1a for QMCI, periphytons or siltation from being achieved and is therefore consistent with this policy.
4.2 - *The management of lakes, rivers, wetlands and aquifers will take account of the fresh water outcomes, water quantity limits and the individual and cumulative effects of land uses, discharges and abstractions will meet the water quality limits set in Sections 6 to 15 or Schedule 8 and the individual and cumulative effects of abstractions will meet the water*	There are no relevant freshwater outcomes for the streams and wetlands in the scheme area in Sections 6 to 15. Schedule 8 in the operative LWRP does not refer to the rivers in Banks Peninsula and is also therefore not relevant.

quantity limits in Sections 6 to 15.	Plan Change 7 to the LWRP introduced a revised Schedule 8 that includes dissolved oxygen and ammonia nitrogen limits for Banks Peninsula. As that aspect of PC7 is not subject to appeals, it can be considered operative. The assessment of effects in the application shows that the limits set through PC7 Schedule 8 will be complied with in the Robinsons Bay Stream and therefore the proposal is consistent with this policy.
4.3 - *Surface water bodies are managed so that:* *(a) toxin producing cyanobacteria do not render rivers or lakes unsuitable for recreation or human and animal drinking-water;* *(b) fish are not rendered unsuitable for human consumption by contaminants;* *(c) the natural colour of the water in a river is not altered;* *(d) the natural frequency of hāpua, coastal lakes, lagoons and river openings is not altered;* *(e) the passage for migratory fish species is maintained unless restrictions are required to protect populations of native fish;* *(f) reaches of rivers are not induced to run dry, thereby maintaining the natural continuity of river flow from source to sea,* *(g) variability of flow, including floods and freshes, is maintained to avoid prolonged "flatlining" of rivers; to facilitate fish passage; and to mobilise bed material; and* *(h) the exercise of customary uses and values is supported.*	The effects of the ATWIS on the qualities of Robinsons Bay Stream will not result in the adverse effects identified in this policy and the proposal is therefore consistent with this policy.
4.4 *Groundwater is managed so that:* … *(e) overall water quality in aquifers does not decline; and* …	Given the anticipated effect of the scheme on groundwater being limited to that beneath the Robinsons Bay Valley irrigation area, and the assumption that 99% of irrigation will enter the Robinsons Bay Stream, the effect of the scheme on groundwater quality is expected to be highly localised and will not cause an overall decline across the aquifer.
4.7 - *Resource consents for new or existing activities will not be granted if the granting would cause a water quality or quantity limit set in Sections 6 to 15 to be breached or further over allocation (water quality and/or water quantity) to occur or in the absence of any water quality standards in Sections 6 to 15, the limits set in Schedule 8 to be breached. Replacement consents, or new consents for existing activities may be granted to:* *(a) allow the continuation of existing activities at the same or lesser rate or scale, provided the consent contains conditions that contribute to the phasing out of the over allocation (water quality and/or water quantity) within a specified timeframe; or* *(b) exceed the allocation limit (water quality and/or water quantity) to a minor extent and in the short-term if that exceedance is part of a proposal to phase out the overallocation within a specified timeframe included in Sections 6 to 15 of this Plan.*	There are no relevant freshwater outcomes for the streams and wetlands in the scheme area in Sections 6 to 15. Schedule 8 in the operative LWRP does not refer to the rivers in Banks Peninsula and is therefore not relevant either. Plan Change 7 to the LWRP introduces a revised Schedule 8 that includes limits for Banks Peninsula. As that aspect of PC7 is not subject to appeals, it can be considered operative. The assessment in the attached application shows that the limits set through PC7 Schedule 8 will be complied with in Robinsons Bay Stream and therefore the proposal is consistent with this policy.

4.12 - *There are no direct discharges to surface water bodies or groundwater of:* *(a) untreated sewage, wastewater (except as a result of extreme weather related overflows or system failures) or bio-solids;* *(b) solid or hazardous waste or solid animal waste;* *(c) animal effluent from an effluent storage facility or a stock holding area;* *(d) organic waste or leachate from storage of organic material; and* *(e) untreated industrial or trade waste.*	The scheme will not discharge any untreated wastewater and will not directly discharge treated wastewater to groundwater or to surface water (fresh or coastal). It also does not involve discharges of sludge from the treatment process, with all solids collected and removed for treatment and / or disposal elsewhere. The proposal is consistent with this policy.
4.13 - For other discharges of contaminants into or onto land where it may enter water or to surface water bodies or groundwater (excluding those passive discharges to which Policy 4.26 applies), the effects of any discharge are minimised by the use of measures that: *(a) first, avoid the production of the contaminant;* *(b) secondly, reuse, recovers or recycles the contaminant;* *(c) thirdly, minimise the volume or amount of the discharge; or* *(d) finally, wherever practical utilise land-based treatment, a wetland constructed to treat contaminants or a designed treatment system prior to discharge; and* *(e) in the case of surface water, results in a discharge that after reasonable mixing meets the receiving water standards in Schedule 5 or does not result in any further degradation in water quality in any receiving surface waterbody that does not meet the water quality standards in Schedule 5 or any applicable water conservation order.*	It is not practicable to avoid the generation of domestic wastewater from Akaroa. A portion of the treated wastewater will be reused for irrigating Jubilee Park, and more may be used by future development of the purple pipe scheme. The volume of the discharge will be minimised by reducing I&I. The ATWIS discharges will only be to land, where natural processes will result in further 'treatment' of contaminants, although the extent of natural treatment is incidental rather than a core part of the scheme design. The discharge will not prevent Robinsons Bay Stream complying with the standards in Schedule 5. The proposal is consistent with this policy.
4.14 - *Any discharge of a contaminant into or onto land where it may enter groundwater (excluding those passive discharges to which Policy 4.26 applies):* *(a) will not exceed the natural capacity of the soil to treat or remove the contaminant; and* *(b) will not exceed available water storage capacity of the soil; and* *(c) where meeting (a) and (b) is not practicable, the discharge will:* *i. meet any nutrient limits in Schedule 8 or Sections 6 to 15 of this Plan; and* *ii. utilise the best practicable option to ensure the size of any contaminant plume is as small as is reasonably practicable; and* *iia. ensure there is sufficient distance between the point of discharge, any other discharge and drinking-water supplies to allow for the natural decay or attenuation of pathogenic micro-organisms in the contaminant plume; and* *iii. not result in the accumulation of pathogens, or a persistent or toxic contaminant that would render the land unsuitable for agriculture, commercial,*	Although the operative Schedule 8 limits do not apply, the irrigated wastewater will generally meet the relevant limits set out in Schedule 8 as set through PC7. The application rate and the large irrigation area will minimise the potential for a contaminant plume to form. Any private water takes are unlikely to be affected by the discharge however they will have an alternative water supply provided. No contaminants are expected to accumulate to the extent that the irrigation areas would become unsuitable for the establishment and maintenance of indigenous forest, or prevent public access for cultural, commercial or recreational purposes. Given the characteristics and topography of the irrigation areas groundwater drainage will not be impeded. The proposal is generally consistent with this policy.

domestic, cultural or recreational use or water unsuitable as a source of potable water or for agriculture; and iv. *not raise groundwater levels so that land drainage is impeded.*	
4.14B - *Have regard to Ngāi Tahu values, and in particular those expressed within an iwi management plan, when considering applications for discharges which may adversely affect statutory acknowledgement areas, nohoanga sites, surface waterbodies, silent file areas, culturally significant sites, Heritage New Zealand sites, any listed archaeological sites, and cultural landscapes, identified in this Plan, any relevant district plan, or in any iwi management plan.*	Irrigating treated wastewater to land in preference to surface water is consistent with Ngāi Tahu values to avoid such discharges to water. In particular, a key driver for the proposed scheme is to enable the existing treated wastewater discharge to Akaroa Harbour to cease, reflective of Ngāi Tahu values afforded to Akaroa Harbour as a Statutory Acknowledgement area. The design of the scheme at the Robinsons Bay irrigation area reflects the identified heritage and cultural landscape values of the site. The Cultural Assessment Report provided by the Ngāi Tahu parties sets out the effect of the scheme on Ngāi Tahu values and confirms that the scheme has appropriate regard to those values. An assessment of the scheme in the context of the Mahaanui Iwi Management Plan provisions is set out in this appendix below. The proposal is consistent with this policy.
Earthworks, land excavation and deposition of material into land over aquifers	
4.18 - *The loss or discharge of sediment or sediment-laden water and other contaminants to surface water from earthworks, including roading, works in the bed of a river or lake, land development or construction, is avoided, and if this is not achievable, the best practicable option is used to minimise the loss or discharge to water.*	Given the scale of some of the earthworks required for constructing this scheme and the nature of the soils on Banks Peninsula it is not likely to be feasible to avoid all construction-related discharges to water. The applicant will require erosion, dust, sediment and stormwater management plans to be prepared as part of a comprehensive overarching Construction Environmental Management Plan (CEMP). These plans will implement best practice, including as described in ECan's *'Erosion and Sediment Control Toolbox for Canterbury'* to minimise sediment mobilisation, and losses to water. Construction activities that disturb site soils will be implemented in a way that is consistent with this policy.
4.19 - *The discharge of contaminants to groundwater from earthworks, excavation, waste collection or disposal sites and contaminated land is avoided or minimised by ensuring that:* *(a) activities are sited, designed and managed to avoid the contamination of groundwater;* *(b) existing or closed landfills and contaminated land are managed and monitored where appropriate to minimise any contamination of groundwater; and* *(c) there is sufficient thickness of undisturbed sediment in the confining layer over the Coastal Confined Aquifer System to prevent the entry of contaminants into the aquifer or an upward hydraulic gradient is present which would prevent aquifer contamination.*	The potential for discharges of construction-phase contaminants to groundwater will be actively managed through the CEMP and minimised to the extent practicable. Contaminated land within the Robinsons Bay Irrigation area has been identified and will not be disturbed or irrigated. Mobilisation of the contaminants identified, by the irrigation will therefore be avoided. Contaminants associated with the irrigation of treated wastewater will be discharged to land, with groundwater likely to be the secondary receiving environment. It is unlikely that contaminants would enter the aquifer given the expectation that 99% of the applied irrigation will enter Robinsons Bay Stream. As any discharge of contaminants that enter groundwater will be minimised, the proposal is generally consistent with this policy.
Soil Stability	
4.20 - *On erosion-prone land, any medium and large-scale earthworks, harvesting of forestry or other clearance of vegetation is undertaken in a manner which minimises the exposure of soil to erosion,*	Medium and large scale earthworks are limited to the Robinsons Bay irrigation area for construction of the tank platforms, and construction of the Old Coach Road storage site facilities.

controls sediment run-off and re-establishes vegetation cover as quickly as possible. 4.22 - *Sedimentation of water bodies as a result of land clearance, earthworks and cultivation is avoided or minimised by the adoption of control methods and technologies, such as maintaining continuous vegetation cover adjacent to water bodies, or capturing surface run-off to remove sediment and other contaminants or by methods such as direct drilling crops and cultivation that follows the contours of a paddock.*	Appropriate sediment and stormwater management measures will precede any disturbance and will be actively managed until disturbed areas are stabilised. On the Robinsons Bay Irrigation area in particular, large areas of land adjacent to permanent and ephemeral streams will be undisturbed and will further help to minimise sediment migration to streams. Given the location of earthworks, the retention of vegetated setbacks from watercourses, and the use of appropriate management and mitigation measures, sedimentation of waterways will be minimised, and the activity will be consistent with these policies.
4.23 - Any water source used for drinking-water supply is protected from any discharge of contaminants that may have any actual or potential adverse effect on the quality of the drinking-water supply including its taste, clarity and smell and community drinking water supplies are protected so that they align with the CWMS drinking-water targets and meet the drinking-water standards for New Zealand.	For the reasons set out in the application, the potential for water supplies to be adversely affected is minimal, given the expectation that applied irrigation will enter Robinsons Bay Stream, and noting that the treated wastewater meets the NZDWS for Nitrate-N prior to irrigation. However the potential for adverse effects on the nearby domestic water sources is noted, hence the applicant's provision of an alternative potable water supply to those parties. Accordingly, the proposal is not consistent with this policy, given the potential for adverse effects, and the policy's 'protected' edict.
Nutrient Management	
4.39 - Irrespective of the nutrient allocation status of a catchment as shown on the Series A Planning Maps, to allow the following discharges, provided the design and management of the discharge treatment system minimises the discharge of nutrients that may enter water: *(a) wastewater discharge from a marae;* *(b) community wastewater treatment schemes;* *(c) wastewater discharge from a hospital, a school or other education institution; or* *(d) on-site domestic wastewater discharges.*	The scheme has been designed and configured to minimise the scale and extent of adverse effects on the receiving environment, including in respect of nutrients that may enter the streams and harbour. The quality ofthe treated wastewater, the method and rate of applying it to land and the careful management of the irrigation regime will ensure that the discharge of nutrients to water is minimised to the extent practicable. The proposal is consistent with this policy.
Site Dewatering	
4.76 - *Localised land subsidence or other significant effects on the flows or levels of surface water or groundwater from the dewatering of construction sites or other sites, is avoided by limiting the rate or duration of pumping or other appropriate mitigation measures.* *4.76A - Adverse effects on surface water quality are minimised through limiting the concentration of sediment and other contaminants present in the dewatering water prior to its discharge to surface water.*	Dewatering may be required in respect of pipeline installation. Dewatering will not be large scale and will be limited spatially and temporally and will be minimised to the extent needed (short term). Dewatered water will be settled prior to discharge to minimise suspended sediment. Dewatering will be undertaken in a manner consistent with these policies.
Wetlands and riparian margins	
4.84 - Wetlands and riparian planting are developed as integral parts of land drainage systems, discharges to land and water and stormwater systems in both rural and urban areas, to reduce the effects of those activities on water quality and to enhance indigenous biodiversity and amenity values.	The subsurface wetland and extensive riparian planting are proposed as integral parts of the scheme. The riparian planting in particular is proposed to help manage the effects of the irrigation activity (interception, uptake etc.), enhance indigenous biodiversity and amenity values (a broader range of species) and to enhance in-stream habitat. The scheme is consistent with this policy.

4.85 - *Water quality, indigenous biodiversity and ecosystem health in lakes, rivers, wetlands, hāpua, coastal lakes and lagoons are enhanced through establishing or restoring riparian planting.*	The health of the wetlands identified in the vicinity of the Robinsons Bay Valley irrigation area is currently marginal due to stock access and the effects of historic agricultural land uses. Removing stock from the site will allow wetland plants to naturally regenerate, however additional planting is proposed to support the recovery of wetland species. Further, the irrigation activity is expected to support moisture levels in these areas and improve the consistency and quality of wetlands. The proposal is therefore consistent with this policy as relates to proposed riparian planting.
Activities in Beds of Lakes and Rivers	
4.86 - *Activities that occur in the beds or margins of lakes, rivers, wetlands, hāpua, coastal lakes and, lagoons are managed or undertaken so that:* *(a) the character and channel characteristics of rivers including the variable channel characteristics of braided rivers are preserved;* *(b) sites and areas of significant indigenous biodiversity values or of cultural significance to Ngāi Tahu are protected; and* *(c) existing lawful access to the bed of the lake, river, wetland, hāpua, coastal lake, or lagoon for recreational, customary use, water intakes or supplies or flood control purposes, is not precluded, except where necessary to protect public health and safety.*	The pipelines required for the scheme will be placed beneath permanently flowing streams and will not affect the characteristics of the streambeds or margins. No existing lawful public access will be affected. The proposal is consistent with this policy.
4.88 - *Earthworks, structures, or the planting or removal of vegetation (other than by spraying) in the beds of lakes, rivers, hāpua, coastal lakes and lagoons, or within a wetland boundary do not occur in flowing or standing water unless any effects on water quality, ecosystems, or the amenity, recreational or cultural values will be minor or the effects of diverting water are more significant than the effects of the activity occurring in flowing or standing water.*	No earthworks or planting will occur in flowing or standing water, and no structures are proposed in proximity to the beds or margins of watercourses. The activities near streams will not exacerbate erosion or restrict flood flows. The proposal will be consistent with these policies.
4.89 - *Earthworks, structures (including defences against water), vegetation planting or removal, or other activities in the beds of lakes or rivers, do not materially restrict flood flows in any river, or create or exacerbate erosion of the bed or banks of any river or the bed or margins of any lake.*	
Section 10 – Banks Peninsula	
Not applicable as the provisions only apply to the Wairewa catchment. No part of the ATWIS lies within the catchment.	

Christchurch District Plan

Provision	Assessment
Chapter 3 – Strategic Directions	
Objective 3.3.9 - Natural and cultural environment *a. A natural and cultural environment where:*	The ATWIS will result in a network of high quality public walking tracks across the three main sites. The effect of the scheme development and operation on the natural features and landscapes of Banks Peninsula, and natural character values of

i. People have access to a high quality network of public open space and recreation opportunities, including areas of natural character and natural landscape; and *ii. Important natural resources are identified and their specifically recognised values are appropriately managed, including:* *A. outstanding natural features and landscapes, including the Waimakariri River, Lake Ellesmere/Te Waihora, and parts of the Port Hills/Nga Kohatu Whakarakaraka o Tamatea Pokai Whenua and Banks Peninsula/Te Pātaka o Rakaihautu; and* *B. the natural character of the coastal environment, wetlands, lakes and rivers, springs/puna, lagoons/hapua and their margins; and* *C. indigenous ecosystems, particularly those supporting significant indigenous vegetation and significant habitats supporting indigenous fauna, and/or supporting Ngāi Tahu mana whenua cultural and spiritual values; and* *D. the mauri and life-supporting capacity of ecosystems and resources; and* *iii. Objects, structures, places, water/wai, landscapes and areas that are historically important, or of cultural or spiritual importance to Ngāi Tahu mana whenua, are identified and appropriately managed.*	the harbour and streams will be localised and predominantly positive. The effects of the scheme on indigenous ecosystems will also be minimal, with primarily positive effects on Ngāi Tahu mana whenua cultural and spiritual values and the life-supporting capacity of ecosystems and resources. Adverse effects on features with historical and cultural importance are also avoided or minimised to the extent practicable. Overall, the ATWIS will help to achieve this objective.
Objective 3.3.12 – Infrastructure *a. The social, economic, environmental and cultural benefits of infrastructure, including strategic infrastructure, are recognised and provided for, and its safe, efficient and effective development, upgrade, maintenance and operation is enabled;* *b. …*	The ATWIS will result in substantial social, cultural and environmental benefits, and significant economic benefits in respect of providing the community with an effective wastewater treatment scheme. The scheme has been designed to operate in a manner that minimises the adverse effects associated with wastewater management, and therefore supports the enablement of the scheme in line with this Objective.
Objective 3.3.12 – Infrastructure *c. - The adverse effects of infrastructure on the surrounding environment are managed, having regard to the economic benefits and technical and operational needs of infrastructure.*	The ATWIS will result in adverse (albeit minimal) effects on the surrounding environment, and in many respects the effects of the scheme will be positive. The economic benefits to the community of having an effective wastewater treatment scheme with a minimal adverse effect on receiving environment quality are significant. The ATWIS is consistent with achieving this objective.
Objective 3.3.17 - Wai (Water) features and values, and Te Tai o Mahaanui *a. The critical importance of wai (water) to life in the District, including surface freshwater, groundwater, and Te Tai o Mahaanuui (water in the coastal environment) is recognised and provided for by:* *i. taking an integrated approach to managing land use activities that could adversely affect wāi (water), based on the principle of 'Ki Uta Ki Tai' (from the mountains to the sea);*	The ATWIS considers the effect on the catchments including modelling the cumulative effect on fresh and harbour water quality, in line with Ki Uta ki Tai. The anticipated effects of the scheme on the life-supporting capacity of water will be minimal, and effectively maintained in respect of Robinsons Bay Stream and improved in respect of the harbour. The scheme concept was strongly underpinned by, and aligned with Ngāi Tahu values and cultural interests in wai. Overall the proposal is consistent with this policy.

ii. *ensuring that the life supporting and intrinsic natural and cultural values and characteristics associated with water bodies and coastal waters, their catchments and the connections between them are maintained, or improved where they have been degraded;* iii. *ensuring subdivision, land use and development of land is managed to safeguard the District's potable wai (water) supplies, waipuna (springs), and water bodies and coastal waters and their margins; particularly Ōtākaro (Avon River), Ihutai (Avon-Heathcote Estuary), Whakaraupō (Lyttelton Harbour), Whakaroa (Akaroa Harbour) and Te Tai o Mahaanui;* iv. *ensuring that Ngāi Tahu values and cultural interests in wai (water) as a taonga are recognised and protected*	
Chapter 6.6 – Water Quality Setbacks	
Objective 6.6.2.1 - Protection of water bodies and their margins from inappropriate use and development 1. *Activities and development in water body margins are managed in a way that protects and/or enhances the following values and functions of the water body and its margins: flood management; water quality; riparian or aquatic ecosystems; the natural character and amenity values of the water body; historic heritage or cultural values; and access where appropriate for recreation activities, customary practices including mahinga kai, or maintenance*	Riparian planting is proposed where streams are present in the Robinsons Bay Irrigation area to provide greater biodiversity, improve instream habitat and amenity values and help safeguard streams quality. Some mahinga kai species will also be planted. Overall, the activity will achieve this objective.
Policy 6.6.2.1.2 - Setbacks from water bodies 1. *Manage adverse effects of activities on water bodies and their margins within water body setbacks in a manner that is consistent with the classification of the water body.* The Banks Peninsula waterway setback functions is: 1. *Providing interim protection of values for waterways on Banks Peninsula that have not yet been classified.* 2. *Maintaining or enhancing habitat for terrestrial, and aquatic animals and plants.* 3. *Encouraging the establishment, retention and maintenance of appropriate riparian vegetation.* 4. *Contributing to the open space character and amenity values of the immediate area.*	Activities will include planting, provision of public walking tracks and crossings at the Robinsons Bay Valley irrigation site, and installation of subsurface pipelines. The proposal will achieve the anticipated setback functions for Banks Peninsula while managing potential adverse effects on the affected waterbodies. The proposal will be consistent with this policy.
Policy 6.6.2.1.3 – Management of activities in water body setbacks *(refer to the extensive policy)*	The proposed works will be carried out in a manner that safeguards existing values, including by thrusting / drilling beneath riverbeds to place pipelines without disturbing riparian margins, maintaining the existing values. Riparian planting will be undertaken in some areas that will enhance existing values, as well as biodiversity, water quality and instream habitat, mahinga kai values etc. Activities in riparian margins will be consistent with this policy.
Chapter 8 – Subdivision, Development and Earthworks	
Objective 8.2.4 - Earthworks	The earthworks associated with the scheme are limited to the extent needed to facilitate

Earthworks facilitate subdivision, use and development, the provision of utilities, hazard mitigation and the recovery of the district.	the development of functional and effective utility infrastructure. The earthworks are therefore in line with achieving this objective.
Policy 8.2.4.1 - Water quality *Ensure earthworks do not result in erosion, inundation or siltation, and do not have an adverse effect on surface water or groundwater quality*	All earthworks undertaken will be subject to a CEMP that will carefully manage and minimise the potential for erosion or siltation. This will include provision for erosion and sediment control measures aligned with ECan's ESC Toolbox, and adequate to manage the risk of adverse effects on ground or surface water.
Policy 8.2.4.3 - Benefits of earthworks *Recognise that earthworks are necessary for subdivision and development, the provision of utilities, hazard mitigation and the recovery of the district.*	As the earthworks are limited in extent and location to those necessary to develop the scheme as essential utility infrastructure, the proposal is wholly consistent with this policy.
Policy 8.2.4.4 - Amenity *Ensure, once completed, earthworks do not result in any significant shading, visual impact, loss of privacy or other significant detraction from the amenity values enjoyed by those living or working in the locality.*	The adverse effects of the earthworks on visual and amenity values will be limited to the construction phase and immediately following, until mitigation planting matures. The effect of the proposal on amenity values overall has been assessed as minimal to positive (see the LVIA). The proposal is consistent with this policy.
Policy 8.2.5.2 - Nuisance *Subject to Policy 8.2.4.3, ensure that earthworks avoid more than minor adverse effects on the health and safety of people and their property, and do not generate continuous or persistent noise, vibration, dust or odour nuisance.*	All earthworks will be undertaken in compliance with a certified CEMP which will include adequate provisions to minimise nuisance dust, vibration and noise, noting that there are no residential or sensitive activities immediately adjacent to the larger earthworks proposed. The activity will be carried out in a manner consistent with this policy.
Chapter 9 – Natural and Cultural Heritage	
Objective 9.1.2.1.2 - Maintenance and enhancement of indigenous biodiversity *The Christchurch District's indigenous biodiversity is maintained and enhanced.*	The extensive planting proposed will provide a substantial increase in the number and range of indigenous plants across the ATWIS footprint and provide habitat to support indigenous fauna that is not currently present at these sites. The removal and management of pest plants and animals is part of the recommendations in the terrestrial ecology report that will be adopted by the applicant. Taonga species will be incorporated into the plantings and will be made available to some extent in the future for cultural harvest. The proposal will achieve this objective and is consistent with the respective policies.
Policy 9.1.2.2.10 - Maintenance and enhancement of indigenous biodiversity *a. Enable activities that maintain and enhance indigenous biodiversity including:* *i. planting with appropriate indigenous species; and* *ii. the removal or management of pest plant and animal species and for biosecurity works*	
Policy 9.1.2.2.12 - Cultural heritage and customary rights *a. Ngāi Tahu mana whenua cultural heritage values associated with indigenous biodiversity will be maintained and enhanced through:* *i. providing for the customary harvesting of taonga species by Ngāi Tahu, while ensuring such harvest will maintain the indigenous biodiversity of the site;* *ii. non-regulatory incentives and assistance; and*	

iii. providing for the planting of indigenous vegetation for the purpose of customary harvesting.	
Objective 9.2.2.1.3 - Significant features and rural amenity landscapes *a. ...* *b. The rural amenity landscapes of the Christchurch District that are listed in Appendix 9.2.9.1.4 are maintained.* ***Objective 9.2.2.1.4 - Natural character*** *a. The natural character of the Christchurch District's coastal environment, wetlands, and lakes and rivers and their margins is preserved.*	Appendix 9.2.9.1.4(a)(i) identifies the qualities of the rural amenity landscapes of Banks Peninsula. Appendix 9.2.9.1.5 sets out the qualities that apply to outstanding and high (and very high) natural character in the coastal environment, with Part (vi)(C) referring to Akaroa Harbour, and specifically Takamātua Bay and Hammond Point / Te Umu Te Rehua. The qualities identified will not be adversely affected by the proposal, as assessed and determined in the LVIA report. The natural character qualities of Robinsons Bay Stream, Grehan Stream and their margins will be similarly unaffected. Accordingly, the ATWIS will achieve these objectives.
Policy 9.2.2.2.5 - Recognising and maintaining the qualities of rural amenity landscapes *a. Recognise the qualities of the identified rural amenity landscapes described in Appendix 9.2.9.1.4 and maintain them by:* *i. avoiding use and development that breaks the skyline, including the crater rim, ridgelines on Banks Peninsula and radial spurs of the Port Hills;* *ii. avoiding visually prominent development;* *iii. ensuring subdivision, use and development does not result in over domestication of the landscape;* *iv. requiring development to be separated from identified important ridgelines on Banks Peninsula, taking into account visual separation and horizontal and vertical separation; and* *v. enabling farming, conservation activities and recreation activities which contribute to rural landscape character of Banks Peninsula.*	The proposal is consistent with the direction of this policy in recognising and maintaining the rural amenity qualities identified in Appendix 9.2.9.1.4 as affected by the proposal. This is evident from the assessment and conclusions set out in the LVIA report attached as part of this application. Further, the proposed indigenous vegetation is considered to be a positive contribution to the landscape character of the sites affected.
Policy 9.2.2.2.7 - Recognising and preserving the natural character qualities of the coastal environment *a. Recognise and preserve the natural character qualities of areas within the coastal environment that have:* *i. outstanding natural character as described in Appendix 9.2.9.1.5;* *ii. high (and very high) natural character as described in Appendix 9.2.9.1.5; and* *iii. other areas with natural character;* *b. Protect those qualities from inappropriate subdivision, use and development by:* *i. managing the adverse effects of subdivision, use and development;*	The ATWIS is generally consistent with this policy as it will recognise and enhance the natural character qualities of the parts of the scheme within the coastal environment. The proposal overall is not considered to be 'inappropriate' use and development of land as the adverse effects of the scheme development and operation will be appropriately managed, significant adverse effects will be avoided, Ngāi Tahu values have been recognised and provided for, adverse effects on natural character values are generally avoided or mitigated, riparian setbacks are included in the design, most built elements of the scheme will be screened from public view and will not be prominent, and coastal water quality will be maintained and overall may be improved.

ii. avoiding significant adverse effects of subdivision, use and development; *iii. …;* *iv. recognising and providing protection for Ngāi Tahu values in locations of special significance to tāngata whenua;* *v. …;* *vi. …;* *vii. avoiding development in areas of high natural character, except that where development cannot be practicably located outside of an area of high natural character, remedying or mitigating any adverse effects as far as practicable;* *viii. …;* *ix. requiring appropriate setbacks for use and development from riparian and coastal margins;* *x. ensuring development is not readily visible from public places and frequently visited viewpoints;* *xi. …; and* *xii. ensuring activities are carried out in a way that maintains or enhances water quality in the coastal environment.*	
Policy 9.2.2.2.8 - Natural character of wetlands, and lakes and rivers and their margins *a. Recognise and preserve the natural character qualities of wetlands, and lakes and rivers and their margins and their protection from inappropriate subdivision, use and development by:* *i. ensuring that location, intensity, scale and form of subdivision, use and development is appropriate;* *ii. minimising, to the extent practicable, indigenous vegetation clearance and modification (including earthworks, disturbance and structures);* *iii. …;* *iv. requiring appropriate setbacks of activities from those margins; and* *v. ensuring development is not readily visible from public places and frequently visited viewpoints.*	The LVIA report concludes that the scheme structures are an appropriate scale and location given the proposed mitigations (plantings, earthworks, colours, reflectivity etc.) and the overall land use will result in positive effects on landscape and natural character. Indigenous vegetation will be substantially enhanced, and riparian margins (setbacks) have been included in the scheme design from inception. Most built elements will be screened from public view and will not be prominent, especially following mitigation. The cumulative effect of the proposal on natural character values is assessed as negligible. Overall, the proposal is consistent with these policies.
Policy 9.2.2.2.9 - Cumulative effects on natural character *a. Assessments of effects on the natural character of the coastal environment, wetlands, and lakes and rivers and their margins shall include an assessment of the cumulative effects of:* *i. allowing more of the same activity;* *ii. allowing more of a particular effect, whether from the same activities or from other activities causing the same or similar effect; and* *iii. all activities in the coastal or freshwater environment at the site.*	
Policy 9.2.2.2.10 - Restoration of natural character *a. Promote opportunities to restore and rehabilitate natural character, such as through the removal of plant and animal pests, and supporting initiatives for regeneration of indigenous vegetation.*	The ATWIS represents a significant opportunity for the rehabilitation of natural character, pest control and regeneration of indigenous vegetation given the scale of

	proposed planting. The scheme is consistent with this policy.
Policy 9.2.2.2.13 - Ngāi Tahu customary use *a. Recognise and provide for Ngāi Tahu customary uses of natural resources, including land, water and other natural resources as an integral part of areas identified in the Plan as outstanding natural features and landscapes, significant features and rural amenity landscapes, and areas of natural character in the coastal environment.*	Ngāi Tahu customary uses of natural resources has been taken into account in the proposal, including the use of mahinga kai species across the scheme, the potential for future cultural harvest, and the focus on irrigating all treated wastewater to land, avoidance of any direct discharges to water, and minimising adverse effects on natural character, and water quality that may affect harvesting of kai moana. The proposal is consistent with this policy.
Objective 9.3.2.1.1 - Historic heritage *a. The overall contribution of historic heritage to the Christchurch District's character and identity is maintained through the protection and conservation of significant historic heritage across the Christchurch District in a way which:* *i. enables and supports:* *A. the ongoing retention, use and adaptive re-use; and* *B. the maintenance, repair, upgrade, restoration and reconstruction; of historic heritage; and* *ii. ...*	The heritage values associated with the land for the ATWIS have been identified. The proposed separation of the lower section of the Robinsons Bay Valley site will enable and support the ongoing retention and maintenance of the heritage values present and the potential for future use and repair. The proposal supports the achievement of these objectives.
Objective 9.5.2.1.1 - Areas and sites of Ngāi Tahu cultural significance *a. The historic and contemporary relationship of Ngāi Tahu mana whenua with their ancestral lands, water, sites, wāhi tapu and other taonga is recognised and provided for in the rebuild and future development of Ōtautahi, Te Pātaka o Rākaihautū and the greater Christchurch Area.*	The development of the ATWIS will enable the decommissioning of the current Akaroa WWTP and the rehabilitation of the site at Takapūneke in recognition of the relationship of Ngāi Tahu with the wāhi tapu site. The ATWIS has been designed with the relationship of Ngāi Tahu to land, water, and other taonga in mind. The proposed activity supports the achievement of this objective.
Objective 9.5.2.1.2 - Integrated management of land and water *a. Ngāi Tahu cultural values, including as to natural character, associated with water bodies, repo / wetlands, waipuna / springs and the coastal environment of Ōtautahi, Te Pātaka o Rākaihautū and the greater Christchurch Area are maintained or enhanced as part of the rebuild and future development of the District - Ki Uta Ki Tai (from the mountains to the sea)*	Ngāi Tahu cultural values have played a key part in developing the ATWIS and its design. Consequently, those values will be enhanced because of the scheme by removing the current WWTP from Takapūneke, and the discharge from the harbour. The effect of the scheme on the values of water (fresh and harbour) is acknowledged, noting that no direct discharges of wastewater to fresh or coastal water will occur. The scheme will help to enable customary use of fresh and coastal water resources and will support the achievement of both objectives.
Objective 9.5.2.1.3 - Cultural significance of Te Tai o Mahaanui and the coastal environment to Ngāi Tahu *a. The cultural significance of Te Tai o Mahaanui, including Te Ihutai, Whakaraupō, Koukourārata, Akaroa, Te Waihora, Te Roto o Wairewa and the coastal environment as a whole to Ngāi Tahu is recognised and Ngāi Tahu are able to exercise kaitiakitanga and undertake customary uses in accordance with tikanga within the coastal environment.*	
Policy 9.5.2.2.1 - Wāhi Tapu and Wāhi Taonga *…*	The scheme will involve earthworks and construction within areas identified in the

b. Protect Wāhi Tapu / Wāhi Taonga sites from inappropriate development, disturbance, damage or destruction, and ensure activities adjoining these sites do not adversely affect them	CDP maps as near to Wāhi Tapu / Wāhi Taonga sites. Consultation with mana whenua has ensured that the values present in these areas will not be affected. The scheme will be consistent with this policy.
Policy 9.5.2.2.3 - Ngā Wai *a. Recognise the cultural significance of the water bodies, waipuna / springs, repo / wetlands and those parts of the coastal environment identified as Ngā Wai, and manage the effects of land uses and activities on the surface of water to:* *i. protect the natural character of these water bodies and coastal waters by maintaining their natural character where it is high and enhancing it where it is degraded, including through the reinstatement of original water courses where practicable;* *ii. recognise historic and contemporary Ngāi Tahu customary uses and values associated with these water bodies and coastal waters and enhance opportunities for customary use and access;* *iii. ensure any land uses or activities on the surface of water in or adjoining these sites do not adversely affect taonga species or Ngāi Tahu customary uses in these areas;* *iv. ensure new land uses do not create an additional demand to be able to discharge sewage or stormwater directly into Ngā Wai, other water bodies or the coastal marine area, and address the need for existing land uses to discharge untreated sewage or stormwater into these areas; and* *v. ensure that cultural values are recognised and provided for in the design, location and installation of utilities, while enabling their safe, secure and efficient installation.*	The use of land (construction and operation) for the ATWIS has been designed to minimise any adverse effects on Ngā Wai values. Doing so better enables customary uses and provides for terrestrial and aquatic taonga species. By avoiding discharges to water (fresh or harbour) the scheme will better provide for cultural values associated with water. The proposal is consistent with this policy.
Policy 9.5.2.2.4 - Archaeological sites *a. Avoid damage to or destruction of Ngāi Tahu mana whenua archaeological sites within identified sites of Ngāi Tahu cultural significance or any unmarked or unrecorded archaeological site when undertaking earthworks, building or utility activities.* ***Policy 9.5.2.2.6 - Identified Sites of Ngāi Tahu Cultural Significance*** *a. Kaitiakitanga, and the relationship of Ngāi Tahu and their culture and traditions with their ancestral lands, water, sites, wāhi tapu and other taonga, shall be recognised and provided for by managing cultural values of identified sites of Ngāi Tahu cultural significance in the manner set out in Policies 9.5.2.2.1 to 9.5.2.2.5*	The construction of the scheme will involve earthworks in areas identified in the CDP schedules as of significance to Ngāi Tahu. The applicant has worked closely with mana whenua to ensure no known archaeological values will be affected and proposes an ADP condition to minimise the potential for unknown values to be damaged or destroyed. The proposal is consistent with these policies.
Objective 9.6.2.1.1 - The coastal environment *a. People and communities are able to provide for their social, economic and cultural wellbeing and their health and safety, while maintaining and protecting the values of the coastal environment, including:* *i. indigenous biodiversity and the maintenance of the ecological function and habitats;* *ii. natural features and landscapes;* *iii. natural character;* *iv. historic heritage;*	The proposed development of the Hammond Point site includes provision for public walking tracks within the site, and which will connect coastal tracks from Robinsons Bay to Takamātua Bay. The site development will facilitate and enhance access to and along the coast (noting that there is limited opportunity to do so within the Hammond Point site due to topography) that will not diminish the values of the

v. Ngāi Tahu cultural values; *vi. visual quality and amenity; and* *vii. recreation values*	Hammond point coastal environment. The scheme will help achieve these objectives.
Objective 9.6.2.1.2 - Access to and along the coast *a. Public access to and along the Coastal Marine Area is maintained or enhanced by providing access in places and in forms which are compatible with public health and safety, sensitivity of the receiving environment and protecting the natural, historic and Ngāi Tahu cultural values of the coastal environment.*	
Policy 9.6.2.2.1 - Effects of activities on the coastal environment *a. Ensure that subdivision, use and development is of a scale, and located, to maintain and protect the values of the coastal environment, including:* *i. indigenous biodiversity and the dynamic, complex and interdependent processes of ecosystems;* *ii. natural features and landscapes;* *iii. natural character, including the natural integrity and functioning of contributing and associated coastal processes;* *iv. historic heritage, recognising that historic heritage may span the line of mean high water springs;* *v. Ngāi Tahu cultural values;* *vi. visual quality and amenity values; and* *vii. recreation values.* *b. Recognise and provide for the operation, maintenance, upgrade and development of strategic infrastructure and utilities that have a technical, locational or functional need to be located in the coastal environment.*	The development and use of land at the Hammond Point and Old Coach Road sites within the coastal environment overlay on CDP planning maps will maintain, protect, and enhance the coastal environment values present. Specifically, indigenous biodiversity values associated with vegetation will be enhanced, as will the landscape and visual amenity values, and the natural character values at both sites. Ngāi Tahu cultural values are provided for at both sites, and recreational values are enhanced by providing public walking access to land currently under private ownership. The proposal is consistent with this policy.
Policy 9.6.2.2.2 - Access to and along the coast *1. Maintain existing public access to the Coastal Marine Area and provide additional public access where:* *1. there is demand for public access;* *2. there is an acceptably low risk of danger to public health or safety;* *3. public access does not compromise the safe and efficient operation of jetty facilities at Lyttelton, Akaroa and Diamond Harbour; and* *4. public access is in a form and at a level compatible with the sensitivity of the receiving environment, including farming operations and any sites of particular ecological or cultural sensitivity.* *2. Facilitate access by Ngāi Tahu mana whenua to and along the Coastal Marine Area for mahinga kai and other customary uses*	None of the sites involved in the proposed ATWIS lie within the CMA or currently provide public access to it, however the development of public walking access to the Hammond Point site will enhance public access to the CMA either side of the site by connecting future public tracks along the CMA from Robinsons Bay to Takamātua Bay. The proposal is consistent with this policy.
Chapter 11 – Utilities and Energy	
Objective 11.2.1 - Provision of utilities *a. Effective and efficient provision of utilities in a manner that is integrated with land use and development in the District.* *b. The continued operation, maintenance, upgrade and development of utilities throughout the District.*	The proposal is to replace the existing WWTP with a more appropriately located, modern and resilient wastewater treatment scheme.

	The ATWIS will provide a wastewater treatment system that can adequately serve existing and forecast growth in Akaroa. The applicant proposes to develop the scheme to provide effective and efficient wastewater treatment for the community. The WWTP and all essential elements of the ATWIS will be designed and constructed to be resilient to natural hazards (IL3) including earthquakes. The scheme will provide local and regional public health, cultural, recreational, economic, and environmental benefits and as critical infrastructure, will be appropriately resilient and operated efficiently. The ATWIS will support Objective 11.2.1, and is consistent with Policy 11.2.1.2.
Policy 11.2.1.2 - Benefits of utilities *a. Require that new utilities are designed and constructed to maintain function should a significant seismic event or other natural hazard event occur.* *b. Recognise the national, regional and local benefits of the secure and efficient operation of utilities by providing for the operation, maintenance, upgrade and development of utilities.*	
Objective 11.2.2 - Adverse effects *a. The adverse effects of new or upgraded utilities on other activities and the environment are managed, whilst having regard to the technical and operational requirements of utilities.* *b. The protection of utilities from the adverse effects of other activities.*	The adverse effects of developing and operating the ATWIS will be carefully managed. The utility will be developed on land owned by the applicant and will be protected both legally and physically from incompatible activities. The proposal will achieve this objective.
Policy 11.2.2.1 - Adverse effects of utilities *a. To ensure that, where reasonably practicable, and having regard to the benefits of utilities and their locational, technical and operational requirements, new or upgraded utilities:* *i. are located and designed in a way that minimises adverse effects;*	The location of the ATWIS has been dictated to some degree by land availability and characteristics (topography, soil type, current use, etc). The design of the scheme has taken into consideration the location and characteristics of each site and the surrounding area, and hence will minimise any adverse effects resulting from either its construction or operation. The proposal is consistent with this policy.
Chapter 17 - Rural	
Objective 17.2.1.1 - The rural environment *a. Subdivision, use and development of rural land that:* *i. supports, maintains and, where appropriate, enhances the function, character and amenity values of the rural environment and, in particular, the potential contribution of rural productive activities to the economy and wellbeing of the Christchurch District;* *ii. avoids significant, and remedies or mitigates other reverse sensitivity effects on rural productive activities and natural hazard mitigation works;* *iii. maintains a contrast to the urban environment; and* *iv. maintains and enhances the distinctive character and amenity values of Banks Peninsula and the Port Hills, including indigenous biodiversity, Ngāi Tahu cultural values, open space, natural features and landscapes, and coastal environment values.*	The ATWIS will be located almost exclusively within the Banks Peninsula rural zone. The technical assessments included with the application conclude that the scheme will generally be consistent with the key attributes of the rural zone, will generally enhance rural character and amenity values, and will not adversely affect surrounding productive activities. The scheme will use land that has previously been used for rural productive activities, replacing grazing with indigenous forest, so will not achieve that part of the objective. The LVIA assessments found that the scheme will enhance the distinctive character and amenity values of Banks Peninsula. The scheme will generally support this objective.
Policy 17.2.2.2 - Effects of activities utilising the rural resource *a. Ensure that activities utilising the rural resource avoid significant adverse effects on areas of important natural*	The ATWIS will utilise rural land. It will not result in significant adverse effects on any important natural resources (which are not defined in the CDP) and will have a positive

resources and avoid, remedy or mitigate other adverse effects on rural character and amenity values.	effect on rural character and amenity values. The scheme is therefore consistent with this policy.
Policy 17.2.2.4 - Function of rural areas *a. Ensure the nature, scale and intensity of subdivision, use and development recognise the different natural and physical resources, character and amenity values, conservation values and Ngāi Tahu values of rural land in the Christchurch District, including:* *i. the rural productive activities, recreation activities, rural tourism activities and conservation activities on Banks Peninsula and their integrated management with maintaining and enhancing landscape, coastal and indigenous biodiversity values;*	The use of land by the scheme is dominated by substantial indigenous vegetation which has been assessed as likely to enhance character and amenity values, Ngāi Tahu values, public recreation (walking tracks) and conservation activities (pest control, increased indigenous habitat and biodiversity). Overall, landscape, coastal and biodiversity values will be enhanced as a result of the scheme, which is consistent with this policy.
Policy 17.2.2.8 - Rural Banks Peninsula *a. Ensure that subdivision, use and development in the Rural Banks Peninsula Zone recognises, maintains and, where practicable, enhances the quality of the rural working environment by:* *i. restricting the scale, location and reflectivity of buildings to maintain a low density of built form that is not visually dominant and does not detract from views of cultural landscapes identified in the District Plan, sites of Ngāi Tahu cultural significance, or natural landforms and features;* *ii. encouraging the protection, maintenance and enhancement of indigenous biodiversity, natural features and landscapes, historic heritage, coastal environment values, and open space; and* *iii. encouraging public walking and cycling access connections where appropriate.*	The ATWIS will not adversely affect the quality of the rural working environment. The built form (tanks and subsurface wetland) is limited, located and designed to be visually recessive (colour, reflectivity, construction and positions) and consistent with structures in rural areas (e.g. tanks). Indigenous biodiversity and landscape values will be enhanced, and the adverse effects on values associated with the coastal environment, open space and natural features will be minimal. Public walking connections are an inherent part of the scheme design at each of the ATWIS sites. Overall, the rural values of Banks Peninsula will be maintained or enhanced such that the ATWIS is consistent with this policy.
Policy 17.2.2.11 - Catchment management approach for rural land *a. Encourage integrated subdivision and development on rural land at a catchment level that implements the principles of 'ki uta ki tai', maintains or enhances water quality, maximises the degree of openness and protects productive potential and enables biodiversity enhancement or recreation opportunities while avoiding, remedying or mitigating adverse effects on the rural environment.*	The scheme is cognisant of the principles of ki uta ki tai, and the cumulative effect of the scheme within the Robinsons Bay Valley catchment, and Akaroa Harbour overall. Water quality in Robinsons Bay Stream and Akaroa Harbour is expected to be generally maintained, however the planted areas will not maintain openness or protect the productive potential of the land retired from grazing, although the LVIA notes that the effect on the overall landscape openness will be negligible. The scheme will enable enhanced biodiversity and will also enhance public walking recreation opportunities. Overall, adverse effects on the rural environment are minimised and mitigated, and the proposal is generally consistent with this policy.

Mahaanui Iwi Management Plan

Provision	Assessment
Section 5.2 *Ranginui*	
Objective (1) *To protect the mauri of air from adverse effects related to the discharge of contaminants to air.*	Discharges of contaminants to air from the construction or operation of the ATWIS will be minimal and are expected to have a minor to negligible effect on the quality of the receiving environment, achieving this objective in a manner consistent with this policy.
Policy R1.1 *To protect the mauri of air from adverse effects associated with discharge to air activities.*	
Policy R1.4 *To support the use of indigenous plantings and restoration projects as a means to offset and mitigate industrial, agricultural and residential discharges to air.*	Although the planting proposed as part of the ATWIS is not intended for restoration purposes, it will help to mitigate the effects associated with the scheme in respect of maintaining air quality, avoiding aerosol migration offsite, and sequestering carbon emissions. The scheme is consistent with this policy.
Section 5.3 *Wai Māori*	
Objective (2) *Water quality and quantity in groundwater and surface water resources in the takiwā enables customary use mō tātou, ā, mō kā uri ā muri ake nei.*	The effects of the discharges on groundwater quality have been approximated by determining the effect on receiving surface water (minimised in respect of nitrogen). The effect on groundwater quality will not impact the availability of part of the plantings on the Robinsons Bay Valley site for future cultural harvest, and several species selected for the irrigation areas and wetland have mahinga kai values. The scheme will help to achieve this objective in part.
Objective (3) *Water and land are managed as interrelated resources embracing the practice of Ki Uta Ki Tai, which recognises the connection between land, groundwater, surface water and coastal waters.*	The ATWIS embraces Ki Uta ki Tai, recognising that it is essential to ensure what is applied to the land can be assimilated by it, and understanding that it will affect groundwater, surface water and coastal water, so the quality and application needs to be appropriately managed. The scheme achieves these objectives.
Objective (5) *Land and water use in the takiwā respects catchment boundaries, and the limits of our land and freshwater resources.*	
Objective (6) *Wetlands and waipuna are recognised and protected as wāhi taonga, and there is an overall net gain of wetlands in the takiwā as wetlands are restored.*	Wetland restoration will be an incidental outcome of the scheme as a result of increased soil moisture in some areas, and anticipated contributions to wetland and seepages. The planting programme includes recommendations to enhance wetland values by planting appropriate species. The ATWIS will help to achieve this objective.
Objective (8) *The practice of using water as a receiving environment for the discharge of contaminants is discontinued, and all existing direct discharges of contaminants to water are eliminated.*	As all discharges are to land, the scheme does not involve any direct discharges to water. The scheme will also enable the current WWTP discharge to the harbour to be eliminated. This objective will therefore be achieved.
Policy WM6.11 *Consented discharge to land activities must be subject to appropriate consent conditions to protect ground and surface water, including but not limited to:* *(a) Application rates that avoid over saturation and nutrient loading;* *(b) Set backs or buffers from waterways, wetlands and springs;* *(c) Use of native plant species to absorb and filter contaminants; including riparian and wetland establishment and the use of planted swales; and* *(d) Monitoring requirements to enable assessment of the effects of the activity.*	The application for consent includes proposed consent conditions to safeguard the quality of the receiving environment. The scheme includes recommendations to avoid over saturation and excessive nutrient loads, includes setbacks from waterways, uses native plants extensively to absorb and filter contaminants, and includes recommendations for monitoring the effects of the activity. The proposal is consistent with this policy.

Policy WM6.19 *To promote the restoration of wetlands and riparian areas as part of maintaining and improving water quality, due to the natural pollution abatement (treatment) functions of these taonga.*	The scheme includes extensive riparian planting within the Robinsons Bay Valley irrigation area including wet areas (seeps) with wetland species. This planting will, along with other benefits help to intercept applied irrigation, including blocking by stems and roots. Destocking of the planted areas will also help to reduce / avoid contamination of water by animal faeces. The proposal is consistent with these policies.
Policy WM13.3 *To support the establishment, enhancement and restoration of wetlands, riparian areas and waipuna as a measure to avoid, remedy or mitigate any actual or potential adverse effects of land use and development activities on cultural and environmental values.*	
Section 5.3 – *Wai Maori*	
Objective (1) *Water management effectively provides for the taonga status of water, the Treaty partner status of Ngāi Tahu, the importance of water to cultural well-being, and the specific rights and interests of tangata whenua in water.*	The ATWIS design has been founded on avoiding direct discharges of treated wastewater to water and irrigating treated wastewater to land. This recognises the significant adverse effect of such discharges on Ngāi Tahu's relationship with water as a taonga. Appropriate operational management of the scheme will help to achieve this objective.
Objective (2) *Water quality and quantity in groundwater and surface water resources in the takiwā enables customary use mō tātou, ā, mō kā uri ā muri ake nei.*	The effect of the ATWIS on water quality and quantity will be minimised by careful management of the treatment and irrigation processes. When considering the removal of the existing discharge to the harbour, the overall cultural quality of the harbour will improve, reducing barriers to customary use of the harbour environment. The scheme will help to achieve this objective.
Objective (3) *Water and land are managed as interrelated resources embracing the practice of Ki Uta Ki Tai, which recognises the connection between land, groundwater, surface water and coastal waters.*	The scheme utilises the concept of Ki Uta ki Tai, understanding that water and contaminants irrigated to land will ultimately affect fresh and coastal waters. Managing the treatment and irrigation processes will also manage the effects of the scheme on the land, water and coastal resources involved, and will help to achieve this objective.
Objective (4) *Mauri and mahinga kai are recognised as key cultural and environmental indicators of the cultural health of waterways and the relationship of Ngāi Tahu to water.*	Removing the existing wastewater discharges from the harbour in favour of the ATWIS is a step towards restoring the harbour's mauri and better providing for mahinga kai. The scheme will help to achieve this objective.
Objective (5) *Land and water use in the takiwā respects catchment boundaries, and the limits of our land and freshwater resources.*	Understanding the assimilative capacity of the receiving environments, and managing the scheme accordingly is a key part of the success of the ATWIS, and it will be operated in cognisance of the limits of the land and water receiving environments. The scheme will help to achieve this objective.
Objective (7) *All waterways have healthy, functioning riparian zones and are protected from inappropriate activities, including stock access.*	The scheme includes extensive riparian planting of indigenous species endemic to the location and grown from seeds sourced locally. These planted areas will help to safeguard the streams from contaminants including irrigated water and residual contaminants as well as sediment. They will also help to improve instream habitat quality. The scheme will help to achieve this objective in respect of the streams within the scheme footprint.
Objective (8) *The practice of using water as a receiving environment for the discharge of contaminants is discontinued, and all existing direct discharges of contaminants to water are eliminated.*	Eliminating direct contaminant discharges to water is a fundamental principle of the scheme, and one which will be achieved upon decommissioning the existing WWTP.

<table>
<tr><td>Policy WM6.2 To require that water quality in the takiwā is of a standard that protects and provides for the relationship of Ngāi Tahu to freshwater. This means that:
(a) The protection of the eco-cultural system (see Box - Eco-cultural systems) is the priority, and land or resource use, or land use change, cannot impact on that system; and
(b) Marae and communities have access to safe, reliable, and untreated drinking water; and
(c) Ngāi Tahu and the wider community can engage with waterways for cultural and social well-being; and
(d) Ngāi Tahu and the wider community can participate in mahinga kai/food gathering activities without risks to human health.</td><td>The design of the ATWIS intends to appropriately recognise and provide for the relationship of Ngāi Tahu to fresh and coastal water, including food gathering (e.g. cockles in Robinsons Bay). The scheme will not enable marae and communities to access untreated drinking water, however. The scheme will be partially consistent with this policy.</td></tr>
<tr><td>Policy WM6.11 Consented discharge to land activities must be subject to appropriate consent conditions to protect ground and surface water, including but not limited to:
(a) Application rates that avoid over saturation and nutrient loading;
(b) Set backs or buffers from waterways, wetlands and springs;
(c) Use of native plant species to absorb and filter contaminants; including riparian and wetland establishment and the use of planted swales; and
(d) Monitoring requirements to enable assessment of the effects of the activity.</td><td>Appropriate application rates for the scheme have been modelled according to the prevalent soil characteristics, and the proposed indigenous vegetation cover. Setbacks from waterways and wetlands are an important part of the scheme design, and extensive indigenous vegetation will be planted to assist with uptake of applied water and nutrients. The treatment process, application rates and resulting effects will be closely monitored to ensure that the outcomes are appropriate and carefully managed. The proposal is consistent with this policy.</td></tr>
<tr><td>Policy WM6.19 To promote the restoration of wetlands and riparian areas as part of maintaining and improving water quality, due to the natural pollution abatement (treatment) functions of these taonga.</td><td rowspan="2">While no wetlands of note are affected by the scheme, the riparian planting within the Robinsons Bay Valley site is consistent with these policies.</td></tr>
<tr><td>Policy WM13.7 To recognise the protection, establishment and enhancement of riparian areas along waterways and lakes as a matter of regional importance, and a priority for Ngai Tahu.</td></tr>
<tr><td colspan="2">Section 5.4 - Papatūānuku</td></tr>
<tr><td>Objective (1) The mauri of land and soil resources is protected mō tātou, ā, mō kā uri ā muri ake nei.</td><td>The scheme will be operated within the assimilative capacity of the land and the productive capacity of land and soil safeguarded for the long term sustainability of the scheme. The proposal will support the achievement of this objective.</td></tr>
<tr><td>Objective (3) Land use planning and management in the takiwā reflects the principle of Ki Uta Ki Tai.</td><td rowspan="2">The ATWIS reflects the principle of Ki Uta ki Tai, recognising that what is applied to the land must be assimilated by it, and understanding that as it will affect groundwater, surface water and coastal water, the quality and application of treated</td></tr>
<tr><td>Objective (4) Rural and urban land use occurs in a manner that is consistent with land capability, the assimilative</td></tr>
</table>

capacity of catchments and the limits and availability of water resources. ***Policy P1.1*** *To approach land management in the takiwā based on the following basic principles:* *(a) Ki Uta Ki Tai;* *(b) Mō tātou, ā, mō kā uri ā muri ake nei; and* *(c) The need for land use to recognise and provide for natural resource capacity, capability, availability, and limits, the assimilative capacity of catchments.* *…*	wastewater needs to be appropriately managed. The scheme will provide for current and future generations by enabling treated wastewater discharges to be removed from the harbour, and has been designed to accommodate long term population growth. The scheme will achieve these objectives and Policy P1.1.
Policy P7.1 *To require that local authorities recognise that there are particular cultural (tikanga) issues associate with the disposal and management of waste, in particular:* *(a) The use of water as a receiving environment for waste (i.e. dilution to pollution); and* *(b) Maintaining a separation between waste and food.* ***Policy P7.4*** *To continue to oppose the use of waterways and the ocean as a receiving environment for waste.* ***Policy P7.5*** *To require alternatives to using water as a medium for waste treatment and discharge, including but not limited to:* *(a) Using waste to generate electricity;* *(b) Treated effluent to forestry; and* *(c) Treated effluent to non food crop.*	The ATWIS will apply treated wastewater exclusively to land, with no direct discharges to water. With no direct discharge of treated wastewater to water, appropriate separation between waste and food (i.e. kai moana) will be achieved. The scheme involves irrigating treated wastewater to indigenous forest. The proposal is consistent with these policies.
Policy P7.6 *To require higher treatment levels for wastewater*	The scheme will treat wastewater to a very high standard, which will be of a higher quality than the existing treatment process. The scheme is consistent with this policy.
Policy P8.1 *To require that discharge to land activities in the takiwā:* *(a) Are appropriate to the soil type and slope, and the assimilative capacity of the land on which the discharge activity occurs;* *(b) Avoid over-saturation and therefore the contamination of soil, and/or run off and leaching; and* *(c) Are accompanied by regular testing and monitoring of one or all of the following: soil, foliage, groundwater and surface water in the area.*	The soil characteristics have been assessed and the concept scheme design takes them into account, working within the modelled assimilative capacity. Application rates and methods have been determined to avoid runoff and minimise the potential for contaminants to enter groundwater. Regular testing and monitoring will be undertaken as set out in proposed conditions. The proposal is consistent with this policy.
Policy P8.2 *In the event that accumulation of contaminants in the soil is such that the mauri of the soil resource is compromised, then the discharge activity must change or cease as a matter of priority.*	The monitoring proposed in the application is required in part to provide early indications of problematic cumulative effects in soils. In the event that any aspect of the scheme is not meeting adequate standards, the applicant has indicated a number of options to change the scheme to address the effects. The activity is therefore consistent with this policy insofar as there is the ability to make adjustments to the scheme to improve it.
Policy P11.1 *To assess proposals for earthworks with particular regard to:* *(a) Potential effects on wāhi tapu and wāhi taonga, known and unknown;* *(b) Potential effects on waterways, wetlands and waipuna;* *(c) Potential effects on indigenous biodiversity;* *(d) Potential effects on natural landforms and features, including ridge lines;*	The proposed earthworks for constructing the scheme have been indicated in material provided to the Ngāi Tahu parties in consultation. An Accidental Discovery Protocol condition has also been proposed and will be adhered to. Consequently the potential for effects on wāhi tapu and wāhi taonga are known and no concerns were raised. All earthworks will be preceded by a scheme-specific CEMP that will address the management of effects

(e) Proposed erosion and sediment control measures; and *(f) Rehabilitation and remediation plans following earthworks.*	on waterways and other values, including erosion, dust and sediment control methods. The effects of the scheme on landforms will be minimal and all earthworks will be fully rehabilitated – including extensive use of native vegetation. Consequently earthworks for the scheme will be consistent with these policies.
Policy P11.6 *To avoid damage or modification to wāhi tapu or other sites of significance as opposed to remedy or mitigate.*	
Policy P11.8 *To require the planting of indigenous vegetation as an appropriate mitigation measure for adverse impacts that may be associated earthworks activity.*	
Policy P11.9 *To require stringent and enforceable controls on land use and earthworks activities as part of the resource consent process, to protect waterways and waterbodies from sedimentation, including but not limited to:* *(a) The use of buffer zones;* *(b) Minimising the extent of land cleared and left bare at any given time; and* *(c) Capture of run-off, and sediment control.*	
Section 5.5 *Tane Mahuta*	
Objective (3) *The presence of indigenous biodiversity on the Canterbury landscape is enhanced, both in rural and urban environments.*	The scheme has been identified as resulting in a significant positive biodiversity net gain and enhancement to the visual amenity and landscape values of the harbour basin. The scheme will help to achieve this objective.
Objective (7) *Existing areas of indigenous vegetation are protected, and degraded areas are restored.*	Insofar as the existing land uses (historic and contemporary) have degraded indigenous vegetation, the scheme will result in substantial restoration of native vegetation across the three sites, contributing to achieving this objective.
Objective (8) *The establishment and spread of invasive pest and weed species is progressively and effectively controlled.*	Weed control will be an integral part of the land management involved in successfully establishing the vegetated areas. The scheme will therefore contribute to achieving this objective.
Policy TM3.1 *To approach the restoration of indigenous biodiversity in the takiwā based on the following principles:* *(a) Restoration of indigenous biodiversity is about restoring original and natural landscapes, and therefore the mauri of the land; and* *(b) Restoration of indigenous biodiversity is about restoring the relationship of Ngāi Tahu to important places and resources; including planning for customary use.*	The proposed plantings will go some way towards restoring the original (pre-European) landscapes and will have a substantial positive effect on biodiversity values in the locality of each irrigation area and the Old Coach Road site. Customary use has been provided for in the concept design by indicating an area for potential future customary harvest on the Robinsons Bay Valley site and include mahinga kai species. The ATWIS is consistent with this policy.
Policy TM3.5 *To require that seeds and plants for restoration projects are appropriate to the area, and as much as possible locally sourced.*	The plant stock for the ATWIS have been sourced from seeds collected from Banks Peninsula. The proposal is consistent with this policy.
Section 5.6 – *Tangaroa*	
Objective (3) *Discharges to the coastal marine area and the sea are eliminated, and the land practices that contribute to diffuse (non-point source) pollution of the coast and sea are discontinued or altered.*	The ATWIS will replace the current WWTP discharge with a fully land-based scheme, eliminating direct contaminant discharges to coastal waters. The diffuse discharge from the irrigation areas to the sea (Robinsons Bay Valley via the stream) will be carefully managed and will result

	from slow rate irrigation through soil. This objective will be partially achieved by the scheme.
Objective (8) *Coastal cultural landscapes and seascapes are protected from inappropriate use and development.*	The scheme has been assessed as having a positive effect on landscape (and seascape) values. This objective will be achieved.
Policy TAN2.1 *To require that coastal water quality is consistent with protecting and enhancing customary fisheries, and with enabling tāngata whenua to exercise customary rights to safely harvest kaimoana.*	The irrigation will avoid contaminants in coastal water that would prevent kai moana from being safe to eat and is therefore consistent with this policy.
Policy TAN2.2 *To require the elimination of all direct wastewater, industrial, stormwater and agricultural discharges into the coastal waters as a matter of priority in the takiwā.*	The ATWIS will replace the existing WWTP with coastal discharge with a fully land-based scheme, thereby being consistent with these policies.
Policy TAN2.3 *To oppose the granting of any new consents enabling the direct discharge of contaminants to coastal water, or where contaminants may enter coastal waters.*	
Policy TAN2.8 *To require that coastal water quality is addressed according to the principle of Ki Uta Ki Tai. This means:* *(a) A catchment based approach to coastal water quality issues, recognising and providing for impacts of catchment land and water use on coastal water quality.*	The ATWIS takes account of the effect of the irrigation on the assimilative capacity of the irrigation area soils, and the effect of the irrigation on groundwater, surface water and coastal water, and will have a minimal (negligible) effect on coastal water quality. Accordingly, the scheme is consistent with this policy.
Section 6.8 *Akaroa Harbour*	
Objective (1) *Elimination of discharges of contaminants to Akaroa Harbour.*	The ATWIS will replace the existing WWTP with coastal discharge with a fully land-based scheme, thereby helping to achieve this objective in respect of community wastewater discharges.
Objective (2) *Integrated approach to the management and development of Akaroa Harbour, based on the principle of Ki Uta Ki Tai and recognising the relationship between land use and coastal waters.*	The ATWIS takes account of the effect of the irrigation on the assimilative capacity of the irrigation area soils, and the effect of the irrigation on groundwater, surface water and coastal water, and will have a minimal (negligible) effect on coastal water quality. Accordingly, the scheme will help to achieve this objective.
Objective (3) *Ngāi Tahu, as tāngata whenua, are strongly involved in planning and decision making for the land, waters and historic and cultural heritage of Akaroa Harbour.*	The applicant has engaged with Ngāi Tahu as tāngata whenua consistently and over an extended period, and Ngāi Tahu cultural values are strongly reflected in the ATWIS. This objective is achieved by this proposal.
Policy A1.1 *To support incentives and initiatives to reduce the volume of wastewater entering the system, as per general policy on Waste management (Section 5.4, Issue P7), including but not limited to:* *(a) Requiring on site stormwater treatment and disposal to avoid stormwater entering the wastewater system.*	In parallel to the development of the ATWIS application and scheme, the applicant has undertaken steps to reduce I&I, a key part of achieving the scheme's outcomes. The scheme is consistent with this policy.
Policy A1.2 *To require the elimination of the discharge of wastewater to Akaroa Harbour, as this is inconsistent with Ngāi Tahu tikanga and the use of the harbour as mahinga kai. This includes:* *(a) Direct discharge from treatment plants;* *(b) Indirect discharge via land (run-off), surface waterways or groundwater; and* *(c) Wastewater coming back into harbour with tides and currents (if pumping out of harbour via pipeline).*	The ATWIS will replace the existing WWTP with coastal discharge with a fully land-based scheme, eliminating direct wastewater discharges from community wastewater schemes consistent with clause (a). Indirect discharges of irrigation passing through soil to groundwater then surface water are anticipated and will not meet clause (b). The scheme will be partially consistent with this policy.

Policy A1.3 *Wastewater should be treated and irrigated to land; subject to the following conditions:* *(a) Effluent is treated to the highest possible standard;* *(b) The land used as a receiving environment is suited to the nature and volume of discharge, to avoid run off or groundwater contamination;* *(c) The land used as a receiving environment is used productively, in a way that is conducive to assimilating waste, such as native or exotic timber plantation; and* *(d) Monitoring programs include both water and soil, and include clear strategies for responding to negative monitoring results.*	The ATWIS will be fully land-based, with irrigated wastewater being treated to a very high standard. Investigations show that the irrigation areas are appropriate to receive the irrigated treated wastewater with appropriate application management corresponding with the site characteristics, including to avoid runoff. Contaminant loads will be minimal, resulting in very low loads entering groundwater. The land will be retained in forest cover as a native timber plantation. The effects of the scheme will be closely monitored. The scheme will be consistent with this policy.
Policy A1.6 *To adopt a holistic and creative approach to finding a solution for wastewater management in the Akaroa Harbour area, including but not limited to:* *(c) Recognising and providing for the cumulative effects of discharges on the harbour, as opposed to assessing effects of individual discharges;* *(d) Minimising the volume of wastewater produced (Policy A1.1);* *(e) Recognising and providing for future urban growth and rural land use change;* *(f) Providing increased weight to cultural, social and environment costs and benefits, including costs to future generations; and* *(g) Affording equal weighting to those cultural effects that may be intangible (e.g. effects on tikanga) with effects identified and measured by western science.*	The ATWIS takes account of the cumulative effects of discharges on the harbour, noting that it will not increase the volume of wastewater discharged, and given the land-based nature of the scheme, will likely result in a decrease of contaminants entering harbour waters. The applicant has taken and will continue to take steps to reduce I&I into the network, with a corresponding reduction in wastewater volumes. Forecast growth rates for Akaroa have been factored into the scheme's modelling, and significant weight has been given to recognising and minimising cultural, social and environmental effects, and the effect on Ngāi Tahu cultural and spiritual values. The ATWIS is consistent with this policy.

Te Rūnanga o Ngāi Tahu Freshwater Policy Statement 1999

Objective 6.2 – Mauri *Restore, maintain and protect the mauri of freshwater resources.*	The mauri of the groundwater and streams affected by the scheme will be safeguarded to the extent that the scheme is land-based, and the highly treated wastewater will pass through soil as the primary receiving environment before entering groundwater. This objective will be partially achieved by the scheme.
Strategy: Point source discharges *31. Councils should prohibit the direct discharge of contaminants, particularly human effluent, to waterways. Discharges to land should be encouraged.*	The ATWIS is a fully land-based scheme that will replace the existing direct discharge of treated wastewater to the harbour. The scheme is wholly consistent with the achievement of this strategy.
Objective 6.3 – Mahinga Kai *To maintain vital, healthy mahinga kai populations and habitats capable of sustaining harvesting activity.*	The scheme will not prevent the harvest of existing mahinga kai species and introduces additional mahinga kai resources through the species selected for planting at the sub surface wetland and the irrigation areas. The scheme will help to achieve this objective and is consistent with this policy.
Policies: *2. Restore and enhance the mahinga kai values of lakes, rivers, streams, wetlands, estuaries and riparian margins.*	

Appendix X Proposed Consent Conditions

Appendix X – Proposed Conditions: To use land for a Community Wastewater Treatment System (ECan)

Applicant Name: Christchurch City Council

Consent Application: CRCXXXXXX

Land Use Consent (s9) to use land for a community wastewater system

Site Location: Akaroa Area

Consent Duration: [XXXX] years[1]

Attachments:

Plan CRCXXXXX A – Robinsons Bay Valley Irrigation Area

Plan CRCXXXXX B – Hammond Point Irrigation Area

Plan CRCXXXXX C – Jubilee Park

Plan CRCXXXXX D – Old Coach Road Site

1. This consent authorises the use of land to build, maintain and operate a community wastewater system and associated infrastructure at:
   a. Old Coach Road, Akaroa, legally described as Lot 7 – 10 DP 7273 (CT CB3C/568); and
   b. 11 Sawmill Road, Robinsons Bay Valley, Akaroa, legally described as Lot 2 DP 82749 (CT CB47D/512); and
   c. 6538 Christchurch Akaroa Road (State Highway 75), Hammond Point, Akaroa, legally described as Lot 1 DP 563448 (CT 1001524); and
   d. Jubilee Park, Akaroa, legally described as Lot 2 DP 2868, Lot 1 DP 79110 and Sec 2 SO Plan 18642;

   in general accordance with the application dated [DATE] and as shown on Plans CRCXXXXX A, B, C and D attached to and forming part of this consent.

2. The use of land shall be to operate a community wastewater treatment and irrigation system, including to:

   a. develop, maintain and operate structures and infrastructure to store, convey and irrigate treated wastewater from the Akaroa Wastewater Treatment Plant onto and into land; and

   b. plant and maintain indigenous vegetation over the term of this consent in general accordance with the Landscape Concept Plans submitted with the application and shown in Plans CRCXXXXXXA - D.

3. The operational storage capacity of the scheme shall consist of:

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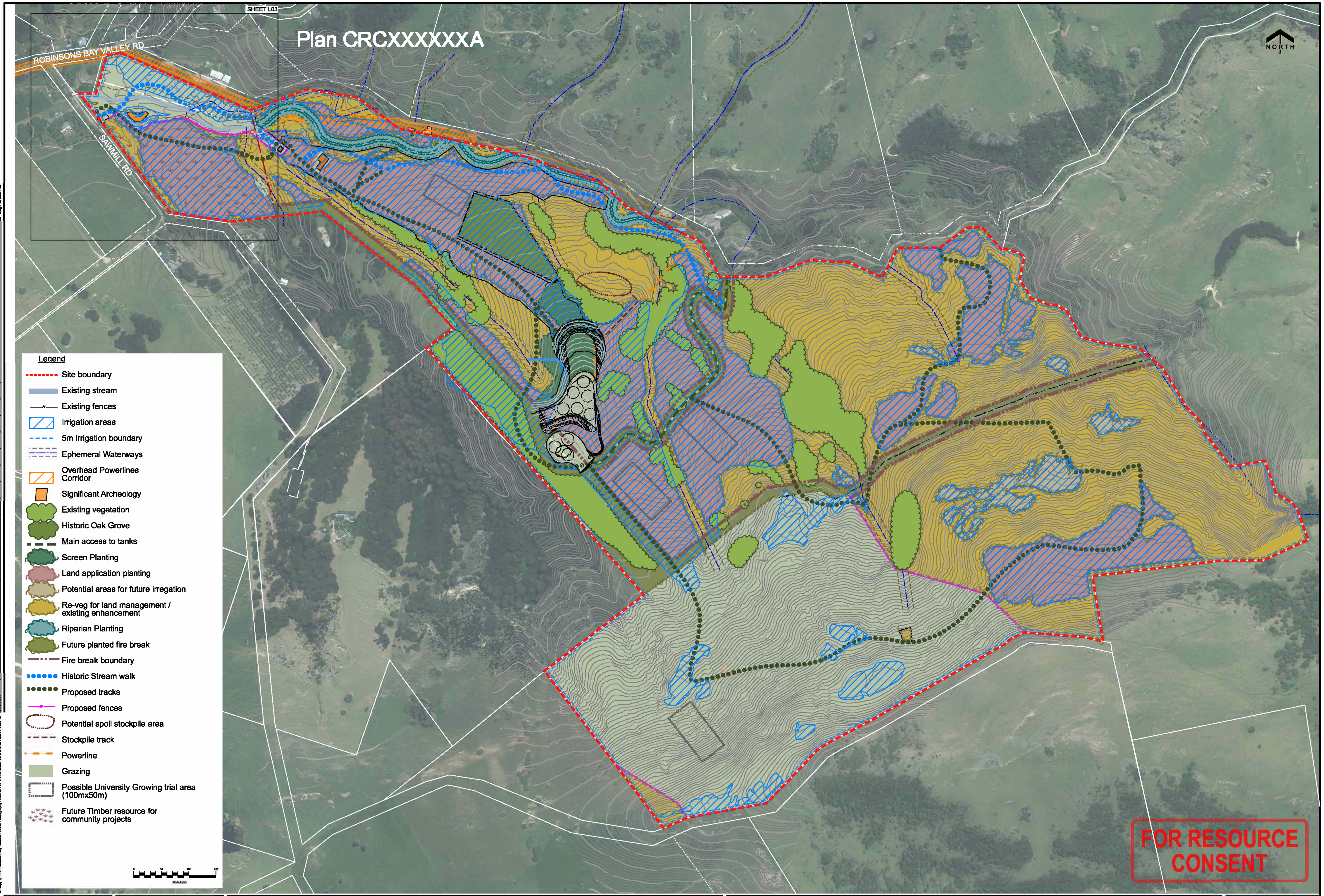
[1] To align with the expiry date on CRC150050 of 9 July 2054.

a. No less than 2,000 cubic metres of untreated wastewater storage in a covered storage tank located at Old Coach Road in general accordance with plan CRCXXXXXXD;
b. No less than 2,100 cubic metres of treated wastewater storage in a subsurface wetland located at Old Coach Road in general accordance with plan CRCXXXXXXD; and
c. Between 8,000 and 20,000 cubic metres of treated wastewater storage in covered tanks located within the Robinsons Bay Valley Irrigation site in general accordance with plan CRCXXXXXXA.

Lapsing

4. The lapsing provisions of Section 125 of the Resource Management Act 1991 shall not apply until [eight years from the date of issue].



Christchurch City Council

AKAROA WASTEWATER SCHEME

PLAN

SHEET L02

Original Plan Size: A1
ISSUE.1 12/2021
LP392501 CJ

Christchurch City Council

AKAROA WASTE SCHEME

HAMMOND POINT

SHEET L04

Original Plan Size: A1
ISSUE.1 21/12/2021
LP392501 CJ


Plan CRCXXXXXXC
Legend
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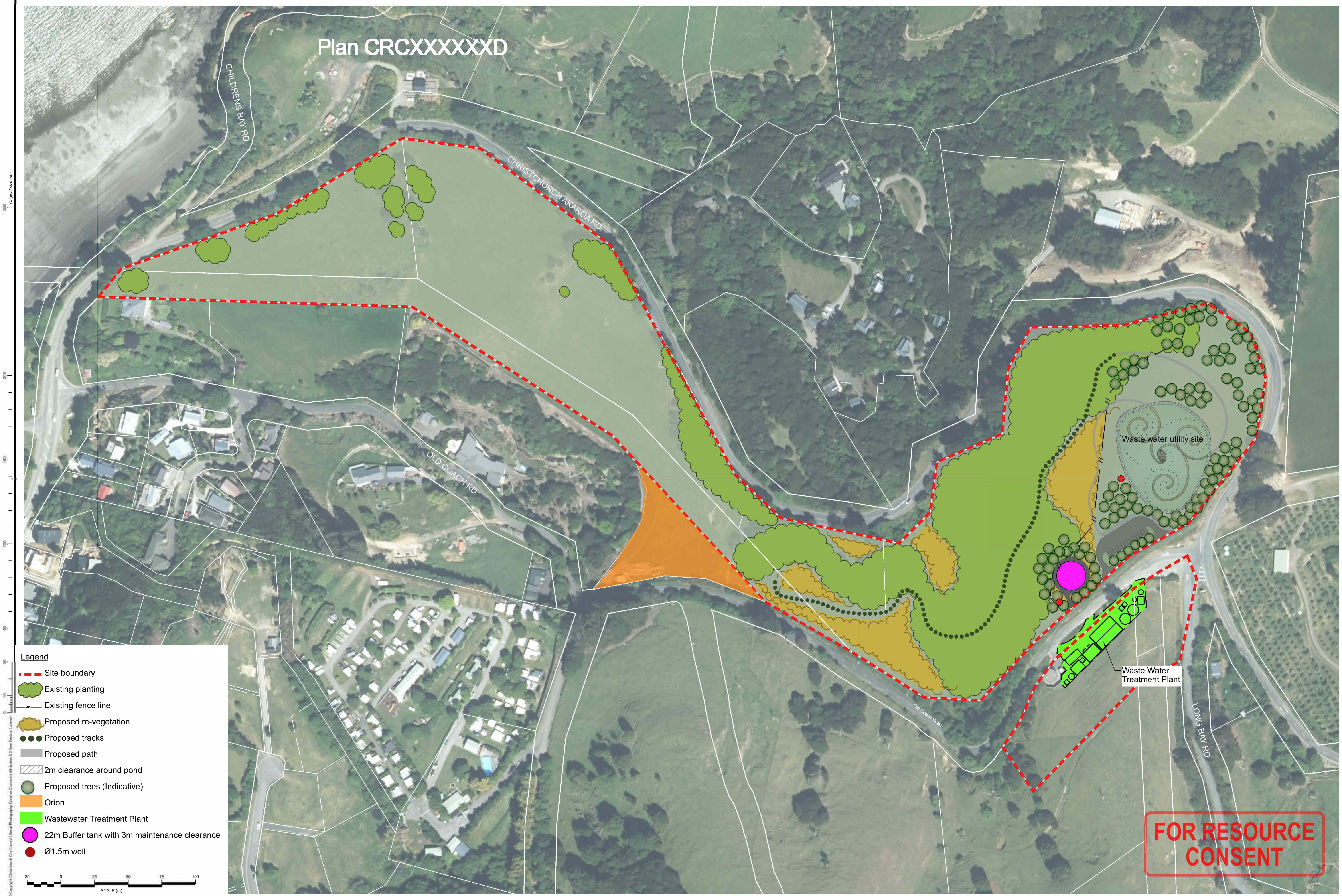

Christchurch City Council

AKAROA WASTEWATER
SCHEME

OLD COACH ROAD
PLAN

SHEET L04

Original Plan Size: A1
ISSUE. 1 12/2021
L P39250 CJ

Appendix X – Proposed Conditions

To discharge treated wastewater onto and into land, and onto and into land where it may enter water (ECan)

Applicant Name: Christchurch City Council

Consent Application: CRCXXXXXX

Proposed Activity: To discharge treated wastewater onto and into land, and onto and into land where it may enter water (s15 RMA)

Site Location: Akaroa Area

Proposed Consent Duration: [XXXX] years[1]

Attachments:

Plan CRCXXXXXX A – Robinsons Bay Valley Irrigation Area

Plan CRCXXXXXX B – Hammond Point Irrigation Area

Plan CRCXXXXXX C – Jubilee Park

Plan CRCXXXXXX D – Environmental Monitoring: Robinsons Bay Valley Irrigation Area

Plan CRCXXXXXX E – Environmental Monitoring: Hammond Point Irrigation Area and Coastal Water

Plan CRCXXXXXX F – Environmental Monitoring: Jubilee Park

Monitoring Site Schedule A

Location

1. This consent authorises the discharge of treated wastewater:
    a. onto land by surface drip irrigation at the Robinsons Bay Valley irrigation site: 11 Sawmill Road, Robinsons Bay Valley, Akaroa legally described as Lot 2 DP 82749 (CT CB47D/512); and
    b. onto land by surface drip irrigation at the Hammond Point irrigation site: 6538 Christchurch Akaroa Road (State Highway 75), Hammond Point, Akaroa, legally described as Lot 1 DP 563448 (CT 1001524); and
    c. into land by sub-surface drip irrigation at Jubilee Park, Akaroa, legally described as Lot 2 DP 2868, Lot 1 DP 79110 and Sec 2 SO Plan 18642;

    As shown on the attached Plans CRCXXXXXX A, B and C attached to and forming part of this consent.

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[1] To align with the expiry date on CRC150050 of 9 July 2054.

Irrigation Limits

2. The treated wastewater irrigated to land shall not exceed the following limits:
    a. To the Robinsons Bay Valley and Hammond Point Irrigation sites combined:
        i. A maximum of 1,210 m^3/day; and
        ii. A maximum annual application rate of 278,000m^3 per calendar year.
    b. To Jubilee Park:
        i. A maximum of 34 m^3/day;
        ii. A maximum annual application rate of 5,450 m^3 per calendar year.

    Advice Note: *The irrigation rates to the Robinsons Bay Valley and Hammond Point irrigation sites are based on 35.7 hectares of irrigated land. The irrigation rate to Jubilee Park is based on 0.7 hectares of irrigated land.*

3. Prior to commissioning the Akaroa Treated Wastewater Irrigation Scheme, the consent holder shall provide to the Canterbury Regional Council Attention: RMA Compliance and Enforcement Manager, confirmation from a suitably qualified and experienced Chartered Professional Engineer (CPEng) that the wastewater treatment system has been suitably designed to achieve the values specified in Condition (2).

4. Treated wastewater shall not be irrigated to:
    a. Land where surface ponding and / or surface runoff is present;
    b. Land within:
        i. 15 m of an ephemeral or permanent watercourse on the Robinsons Bay Valley or Hammond Point Irrigation sites;
        ii. 10 m of a natural inland wetland;
        iii. 10 m of a property boundary of land not owned by the consent holder.

    Advice Note: *surface ponding is defined as a continuous area of surface water greater than one square metre.*

5. Indigenous vegetation in the Robinsons Bay Valley and Hammond Point irrigation sites shall be planted and maintained over the term of this consent in general accordance with the Landscape Concept Plans submitted with the application and Plans CRCXXXXXXA and B attached to and forming part of this consent.

6. The irrigable land on the Robinsons Bay Valley and Hammond Point irrigation sites shall be destocked prior to commencing irrigation and remain ungrazed thereafter for the term of this consent other than for intermittent land management purposes.

Treated Wastewater Quality and Monitoring

7. The consent holder shall install and operate calibrated flow meters to record the daily volume of treated wastewater:
    a. Irrigated to the Robinsons Bay Valley irrigation site;
    b. Irrigated to the Hammond Point irrigation site; and
    c. Irrigated to Jubilee Park.

8. The data from the flow metres shall be recorded in cubic metres per day, and metering devices shall be accurate to +/- 5% of the allowable daily flows in Condition (2). Total daily flows shall be recorded and the results submitted in accordance with Condition (29).

9. Daily records shall be kept of the volume of treated wastewater irrigated to each irrigation zone(s) each day.

Advice Note: *The design of the irrigation system and the irrigation zones created shall be described in the Irrigation Management Plan required by Condition (31).*

10. Treated wastewater shall be sampled at the wastewater treatment plant prior to conveyance to the irrigation sites. The samples shall be grab samples collected at the frequencies specified and analysed for the contaminants listed in Table 1.

Table 1: Treated Wastewater Monitoring Frequencies and Parameters.

Weekly	Monthly	Annually
E. coli	Total Nitrogen (TN)	Lead (Pb)
	Nitrate Nitrogen (NO-3)	Copper (Cu)
	Carbonaceous five-day biochemical oxygen demand ($cBOD_5$)	Chromium (Cr)
	Dissolved Reactive Phosphorus (DRP)	Cadmium (Cd)
	Ammonia Nitrogen (NH_3-N)	Zinc (Zn)
		Sodium (Na)

11. The consent holder shall maintain a record of the Total Nitrogen concentration in the treated wastewater prior to irrigation. The mean concentration of Total Nitrogen shall not exceed 10 mg/L as determined using the results of all samples collected over a calendar year at the frequency described in Table 1, Condition (10).

12. The consent holder shall maintain a record of the *E. coli* concentrations in the treated wastewater prior to irrigation. The rolling mean *E. coli* concentration in treated wastewater shall not exceed 10 MPN/100m in four out of five consecutive samples as determined using the results of all samples undertaken two times per week as described in Table 1, Condition (10).

13. Treated wastewater sample results shall be collected, assessed and reported in accordance with Condition (26).

Surface Water Quality Monitoring – Robinsons Bay Stream

14. Surface water flows and quality shall be sampled in Robinsons Bay Stream at no less than two of the Surface Water and Quality monitoring locations shown on Monitoring Plan CRCXXXXXXD and described in Schedule A attached to and forming part of this consent, at or about:
    a. Monitoring Point SW04 for all sampling events; and
    b. one of Monitoring Points SW01, SW02 or SW03 where surface water is present.

15. Surface water samples shall be collected from Robinsons Bay Stream at the frequencies specified and shall be analysed for the contaminants listed in Table 2.

Table 2: Surface Water Monitoring Frequencies and Parameters for Robinsons Bay Stream.

Monthly	Annually
E. coli	Copper (Cu)
Five-day biochemical oxygen demand (BOD_5)	Zinc (Zn)
Dissolved Reactive Phosphorus (DRP)	
Ammonia Nitrogen (NH_3-N)	
Total Nitrogen (TN)	
Nitrate Nitrogen (NO-3)	
Dissolved Inorganic Nitrogen (DIN)	

pH	
Temperature	

16. Surface water sampling shall commence no less than 12 months prior to irrigation commencing.

17. Ecological monitoring of Robinsons Bay Stream shall be undertaken at appropriate in-stream sites no less than 12 months prior to irrigation, and every 24 months thereafter. The ecological monitoring and associated analysis and reporting shall be undertaken by a person suitably qualified and experienced in macroinvertebrate and periphyton biomass assessments.

Groundwater Quality Monitoring

18. Groundwater depth and quality shall be sampled at or about each Groundwater Level and Quality monitoring site shown on Plans CRCXXXXXXD, E and F and described in Schedule A attached to and forming part of this consent.

19. Groundwater samples shall be collected at the frequencies specified and analysed for the contaminants listed in Table 3.

Table 3: Groundwater Monitoring Frequencies and Parameters

Three Monthly	Six Monthly	Annually
E. coli	Five-day biochemical oxygen demand (BOD5)	Lead (Pb)
Ammonia Nitrogen (NH_3-N)	Dissolved reactive phosphorus (DRP)	Copper (Cu)
Total Nitrogen (TN)	Temperature (˚C)	Chromium (Cr)
Nitrate Nitrogen (NO-3)	Electrical Conductivity (EC, μS/cm)	Cadmium (Cd)
	pH	Zinc (Zn)
	Calcium (Ca, mg/L)	
	Magnesium (Mg, mg/L)	
	Sodium (Na, mg/L)	

20. Ground water sampling shall commence twelve months prior to irrigation commencing.

Coastal Water Quality Monitoring

21. Coastal water shall be sampled at or about each Coastal Water Quality monitoring site shown on Plan CRCXXXXXXE and described in Schedule A attached to and forming part of this consent.

22. Coastal water samples shall be collected at the at the frequencies specified and analysed for the contaminants listed in Table 4:

Table 4: Coastal Water Monitoring Frequency and Parameters

Monthly
E. coli
Total Nitrogen (TN)
Nitrate Nitrogen (NO-3)
Ammonia Nitrogen (NH_3-N)
Dissolved Reactive Phosphorus (DRP)
Dissolved Inorganic Nitrogen (DIN)
Temperature (° C)
Total phosphorus (TP)
Chlorophyll-a
pH

23. Coastal water sampling shall commence twelve months prior to irrigation commencing.

Soil Quality Monitoring

24. Soil shall be sampled at a depth of 100 – 250 mm at each Soil Moisture and Quality monitoring site shown on Plans CRCXXXXXXD, E and F, and described in Schedule A attached to and forming part of this consent.

25. Soil samples shall be collected at the frequencies specified, stored and analysed for the contaminants listed in Table 5.

Table 5: Soil Monitoring Frequencies and Parameters

Baseline	Two Yearly	Four Yearly
pH	pH	pH
Dissolved reactive phosphorus (DRP)	Dissolved reactive phosphorus (DRP)	Dissolved reactive phosphorus (DRP)
Ammonia Nitrogen (NH_3-N)	Ammonia Nitrogen (NH_3-N)	Ammonia Nitrogen (NH_3-N)
Total Nitrogen (TN)	Total Nitrogen (TN)	Total Nitrogen (TN)
potassium	potassium	potassium
calcium	calcium	calcium
magnesium	magnesium	magnesium
chloride	chloride	chloride
sodium	sodium	sodium
zinc		zinc
copper		copper
cadmium		cadmium
chromium		chromium
lead		lead
arsenic		arsenic

26. Prior to commencing irrigation, a single set of soil samples shall be taken and tested for the contaminants listed in Condition (24), Table 5, “Four Yearly”. The results of this testing shall be included in the first annual report required by condition (27).

Analysis and Reporting

27. All treated wastewater monitoring required by Condition 10, and receiving environment monitoring sampling required by conditions 15, 18, 21 and 24 shall be:
    a. Undertaken by suitably qualified and experienced person/s using recognised methods; and
    b. where laboratory analysis is required, shall be analysed at an International Accreditation New Zealand (IANZ) certified laboratory or by an organisation with a mutual agreement with IANZ.

28. The consent holder shall provide an Annual Report prepared by a suitably qualified person/s to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager and to Ōnuku Rūnanga, Attention: Environment Portfolio on the first working day of September each year. The report shall include but not be limited to:
    a. A description of all monitoring undertaken in the preceding 12 month period, including:
        i. the location and methods used to monitor, sample and analyse the quality of wastewater prior to irrigation; and
        ii. the location and methods to monitor, sample and analyse the quality of Robinsons Bay Stream, groundwater and soil at each irrigation area and Jubilee Park, and coastal water in Robinsons Bay;
    b. The results of all analysis undertaken in the preceding 12 month period;
    c. Describing any operational changes made or planned in response to monitoring results.
    d. The mean annual total nitrogen loading rate across the scheme;
    e. Details of any changes or upgrades to the treatment or irrigation process that may affect the quality or volume of the treated wastewater irrigated, the performance of the irrigation system and / or the receiving environment effects;
    f. A record of any non-compliance with the limits specified in this consent, and the actions taken or planned in response; and
    g. A record of any complaints received from the public and actions taken or planned in response.

Irrigation Management Plan

29. The consent holder shall prepare and implement an Irrigation Management Plan prepared by a person suitably qualified and experienced in irrigation system design and operation. The purpose of the Irrigation Management Plan is to set out how the consent holder will:

    a. Operate and maintain the irrigation system appropriate to the characteristics of, and effects on the receiving environment of each irrigation site, and the requirements of the scheme;
    b. Monitor and analyse the operation of the scheme and the effect of the scheme on the quality of the receiving environment; and
    c. Comply with the conditions of this consent.

30. The Irrigation Management Plan shall include, but not be limited to describing:

    a. how the irrigation system will be operated and maintained, including the layout, zones and management systems;
    b. the methods to be used to monitor the performance of the irrigation system including the volume and frequency of irrigation to each irrigation zone;
    c. the methods to be used to avoid irrigating to land where surface ponding and / or runoff is occurring;
    d. the methods to be used to monitor the effects of the scheme on the soil, surface freshwater and groundwater receiving environments;

e. the potential risks or events including emergency events that could adversely affect or interrupt the effective operation of the scheme, and appropriate measures to manage the effects of such events.

31. The Irrigation Management Plan shall be submitted to the Canterbury Regional Council Attention: RMA Compliance and Enforcement Manager, at least two months prior to the exercise of this consent.

32. The consent holder shall operate the Akaroa Treated Wastewater Irrigation Scheme in accordance with the Irrigation Management Plan at all times.

33. The Irrigation Management Plan may be amended as necessary to:
    a. Improve the efficiency and / or functionality of the irrigation scheme;
    b. reduce any adverse environment effects where necessary;
    c. adopt alternative locations or methods for receiving environment monitoring where necessary to improve its effectiveness; and
    d. improve compliance with the conditions of this consent.

    Any amendments to the Irrigation Management Plan shall be submitted to the Canterbury Regional Council Attention: RMA Compliance and Enforcement Manager within (20) working days of those changes taking effect, and the scheme shall be operated in accordance with the amended Irrigation Management Plan thereafter.

Potable Water Supply

34. Prior to commencing irrigation at the Robinsons Bay Irrigation site, the consent holder shall establish a reticulated potable water supply in compliance with the Water Services (Drinking Water Standards for New Zealand) Regulations 2022 or its successor and invite properties in the lower Robinsons Bay Valley that currently draw domestic water from springs or bores to connect to it.

Review

35. The Canterbury Regional Council may, once per year, on any of the last five working days of May or November, serve notice of its intention to review the conditions of this consent for the purposes of:

    a. Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment;

    b. Dealing with any adverse effect on the environment which may arise from the exercise of the consent;

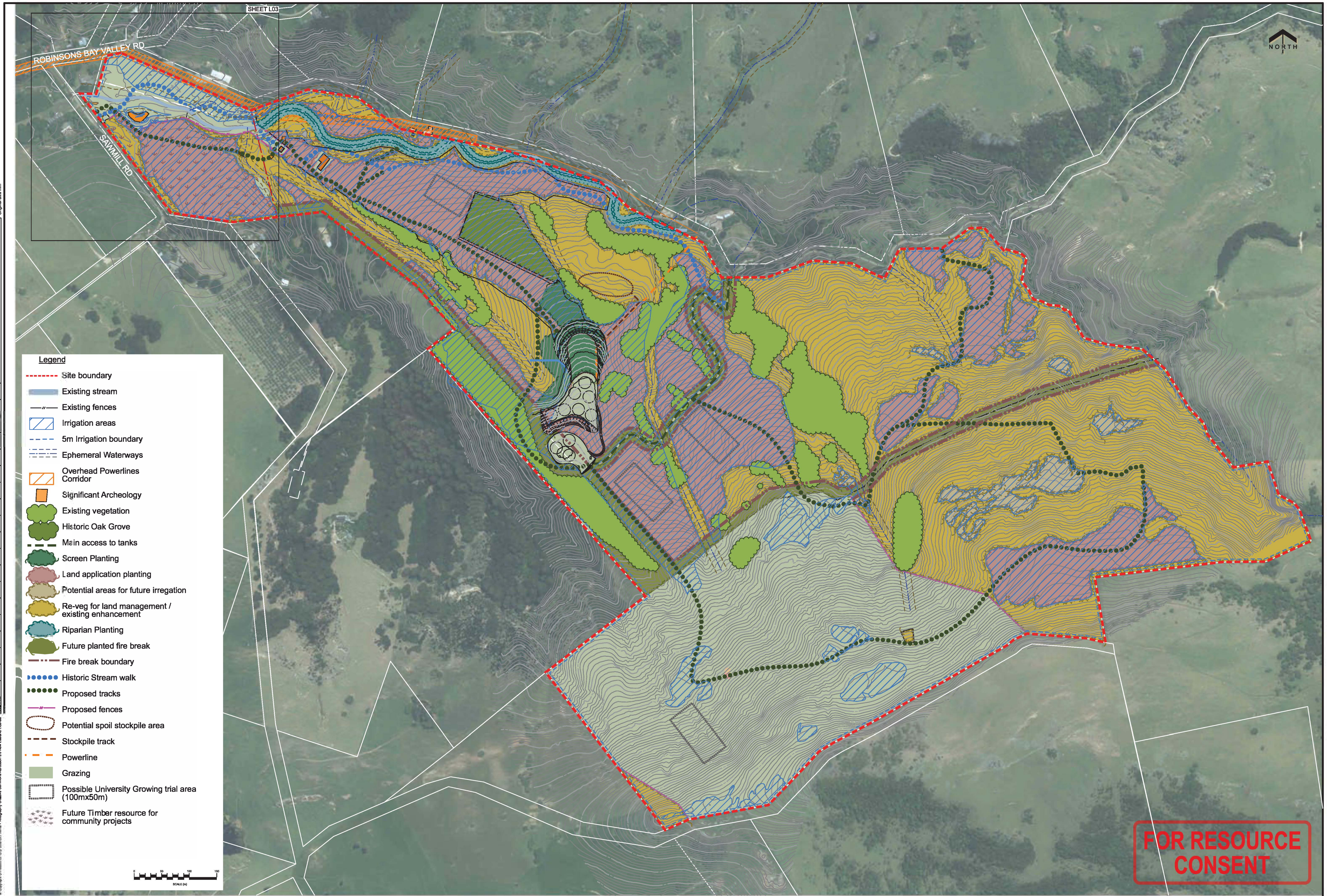
    c. Complying with the requirements of a relevant rule in an operative regional plan; or

    d. Requiring the Consent Holder to conduct monitoring instead of, or in addition to, that required by the consent.

Lapsing

36. The lapsing provisions of Section 125 of the Resource Management Act 1991 shall not apply until [eight years from the date of issue].

Plan CRCXXXXXXA



Christchurch City Council

AKAROA WASTEWATER SCHEME

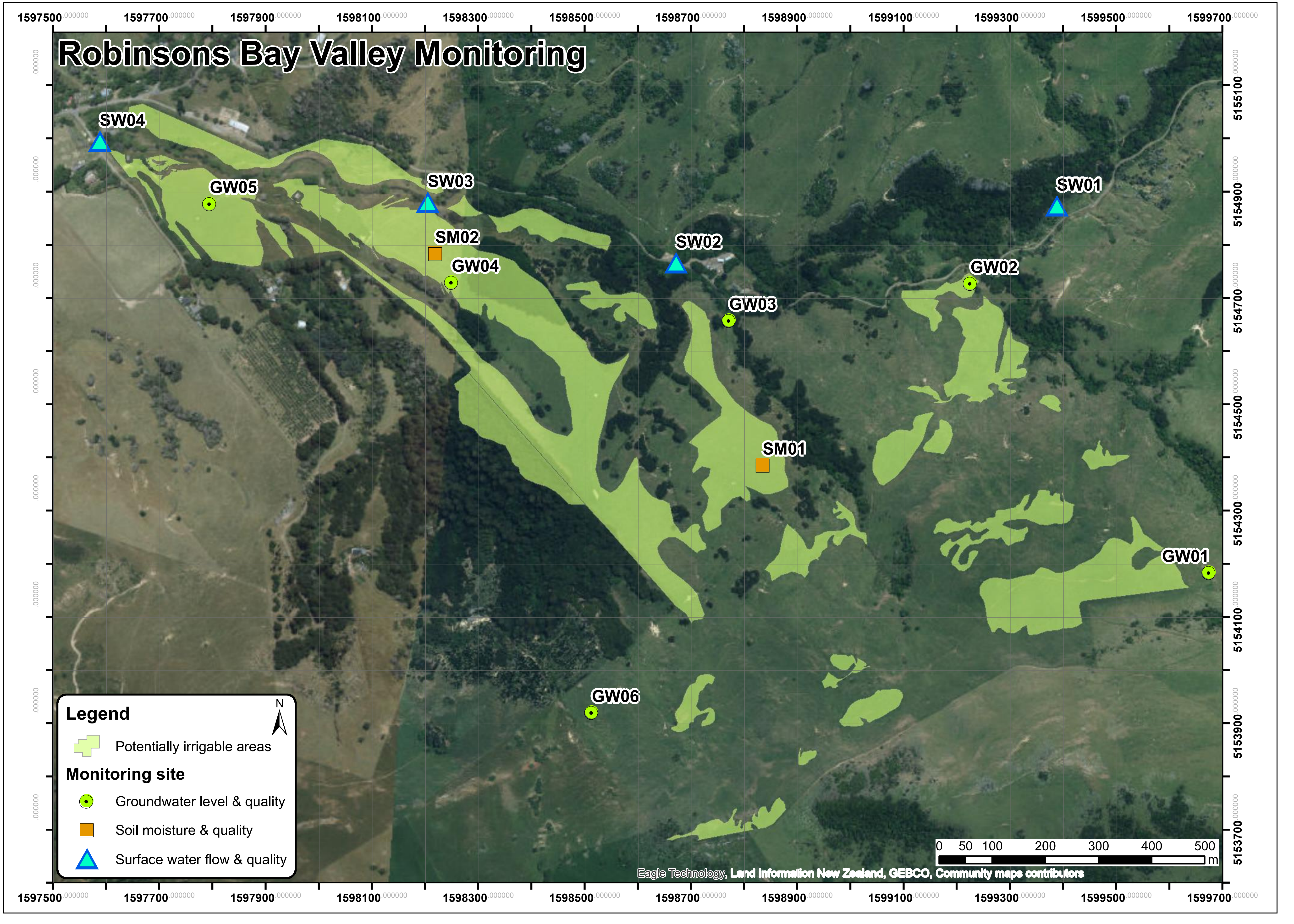
PLAN

SHEET L03

Original Plan Size: A1
ISSUE.1 12/2021
LP392501 CJ

Plan CRCXXXXXXB

Plan CRCXXXXXXC


Robinsons Bay Valley Monitoring
SW04
GW05
SW03
SM02
GW04
SW02
GW03
SW01
GW02
SM01
GW01
GW06
Legend
N
Potentially irrigable areas
Monitoring site
Groundwater level & quality
Soil moisture & quality
Surface water flow & quality
0 50 100 200 300 400 500
m
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
1597500
1597700
1597900
1598100
1598300
1598500
1598700
1598900
1599100
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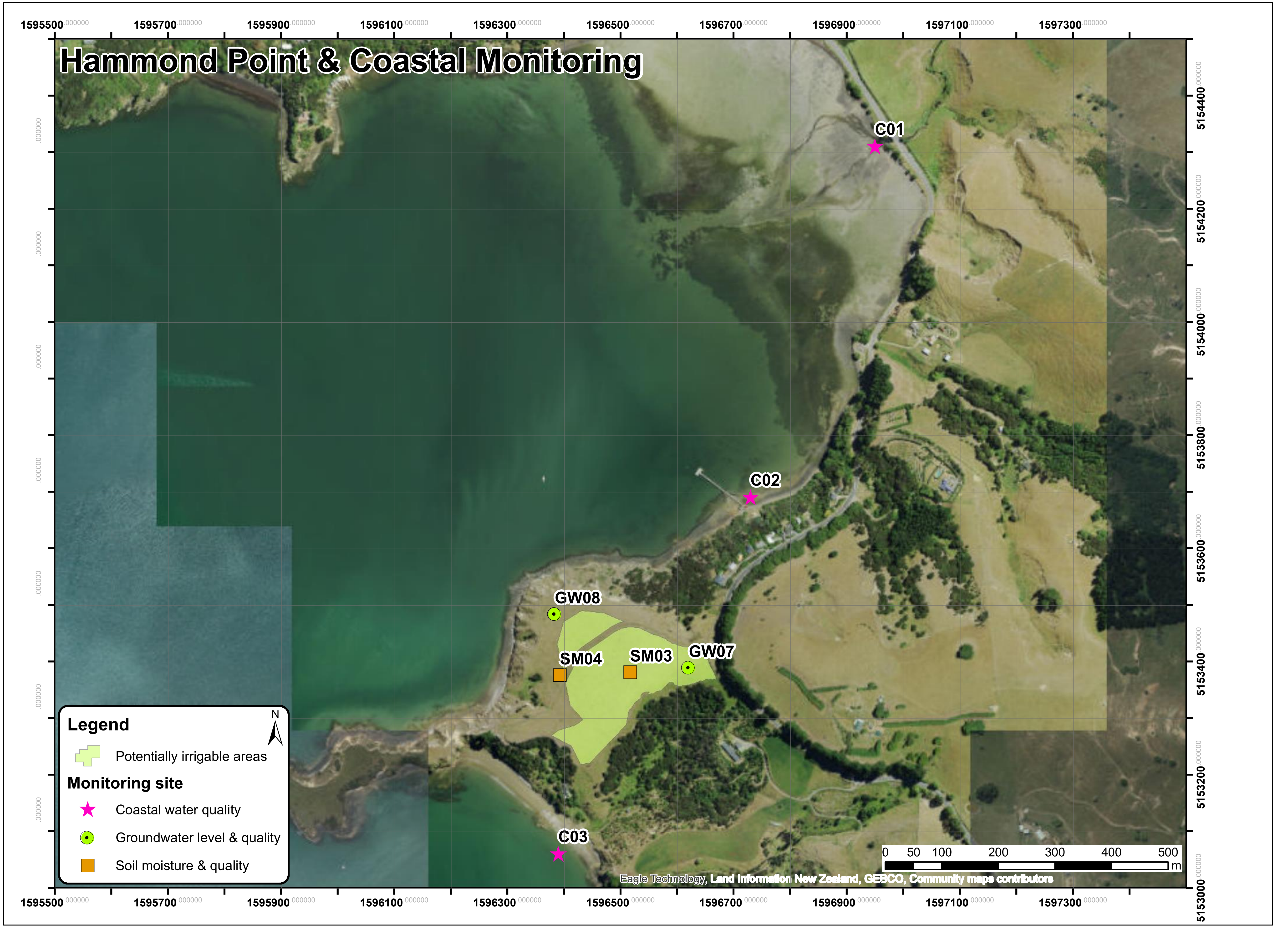
Hammond Point & Coastal Monitoring
C01
C02
C03
GW08
GW07
SM04
SM03
Legend
N
Potentially irrigable areas
Monitoring site
Coastal water quality
Groundwater level & quality
Soil moisture & quality
0 50 100 200 300 400 500 m
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
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1595700
1595900
1596100
1596300
1596500
1596700
1596900
1597100
1597300
5154400
5154200
5154000
5153800
5153600
5153400
5153200
5153000


Jubilee Park Monitoring
1597400
1597500
1597600
1597700
1597800
1597900
1598000
5150300
5150200
5150100
5150000
5149900
SM05
Legend
Potentially irrigable areas
Monitoring site
Soil moisture & quality
0 25 50 100 150 200 250
m
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
N

Schedule: A

Monitoring Sites - approximate locations (NZTM 2000)

Network	Label	Description	Easting	Northing
Robinsons Bay Valley	GW01	Groundwater level & quality	1599675	5154185
Robinsons Bay Valley	GW02	Groundwater level & quality	1599225	5154725
Robinsons Bay Valley	GW03	Groundwater level & quality	1598770	5154660
Robinsons Bay Valley	GW04	Groundwater level & quality	1598250	5154730
Robinsons Bay Valley	GW05	Groundwater level & quality	1597795	5154880
Robinsons Bay Valley	GW06	Groundwater level & quality	1598515	5153920
Robinsons Bay Valley	SM01	Soil moisture & quality	1598835	5154385
Robinsons Bay Valley	SM02	Soil moisture & quality	1598220	5154785
Robinsons Bay Valley	SW01	Surface water flow & quality	1599390	5154875
Robinsons Bay Valley	SW02	Surface water flow & quality	1598670	5154765
Robinsons Bay Valley	SW03	Surface water flow & quality	1598205	5154880
Robinsons Bay Valley	SW04	Surface water flow & quality	1597590	5154995
Hammond Point & Coastal	C01	Coastal water quality	1596950	5154310
Hammond Point & Coastal	C02	Coastal water quality	1596730	5153690
Hammond Point & Coastal	C03	Coastal water quality	1596390	5153060
Hammond Point & Coastal	GW07	Groundwater level & quality	1596620	5153390
Hammond Point & Coastal	GW08	Groundwater level & quality	1596385	5153485
Hammond Point & Coastal	SM03	Soil moisture & quality	1596520	5153385
Hammond Point & Coastal	SM04	Soil moisture & quality	1596390	5153375
Jubilee Park	SM05	Soil moisture & quality	1597440	5150035

Appendix X – Proposed Conditions: Earthworks in High Soil Erosion Risk Areas (ECan)

Applicant:	**Christchurch City Council**
Consent Application:	**CRCXXXXXX**
	Land Use Consent (s9) to undertake earthworks in a High Soil Erosion Risk Area, associated with the construction of the Akaroa Treated Wastewater Irrigation Scheme.
Location:	**Akaroa Area**
Consent Duration:	[Eight years from the date of issue]
Attachments:	*Plan CRCXXXXXXA – Robinsons Bay Valley Irrigation Area*
	Plan CRCXXXXXXB – Old Coach Road Site
	Plan CRCXXXXXXC – Pipelines

1. The works authorised by this consent shall be limited to the excavation, filling, shaping and contouring of land at:
   a. 80 Old Coach Road, Akaroa, legally described as Lot 3 DP 459704, and Sec 1 SP Plan 47316 (CT 659829);
   b. 11 Sawmill Road, Robinsons Bay Valley, Akaroa, legally described as Lot 2 DP 82749 (CT CB47D/512);
   c. Within legal road reserve between 80 Old Coach Road and the Akaroa Terminal Pump Station at Jubilee Park, Akaroa, and 80 Old Coach Road and 11 Sawmill Road, Robinsons Bay Valley;

   associated with the development of the Akaroa Treated Wastewater Irrigation Scheme as described in the application document titled *'Akaroa Treated Wastewater Irrigation Scheme – Application for Resource Consents and Assessment of Environmental Effects'* dated [DATE] and in general accordance with Plans CRCXXXXX A, B and C attached to and forming part of this consent.

2. This resource consent shall be exercised in conjunction with CRCXXXXXX [*the construction-phase stormwater discharge permit*].

Prior to Commencing Works

3. No less than ten (10) working days prior to commencing earthworks the Consent Holder or their agent shall hold a pre-construction site meeting inviting representatives of the Canterbury Regional Council, the consent holder, the primary contractor, and any other relevant party to discuss and document:

   a. A programme of works, including anticipated start and end dates, scheduling and staging of works;

b. Names and responsibilities of all parties, including names and 24 hour contact details for representatives of each party;
c. Expectations regarding communication between all relevant parties;
d. Site inspection requirements; and
e. Confirmation that all parties have copies of this resource consent document and all associated erosion, stormwater and sediment control plans prepared for the works.

4. Prior to commencing earthworks all persons exercising this consent shall be made aware of, and have access to:
   a. The contents of this resource consent document and all associated documents; and
   b. The Erosion, Dust and Sediment Control Plan required under Condition (5) of this resource consent.

Erosion, Dust and Sediment Control

5. The works authorised by this consent shall be undertaken in accordance with a site-specific Erosion, Dust and Sediment Control Plan (EDSCP).
   a. The EDSCP shall detail the erosion, dust and sediment control measures that will be applied at each of the sites identified in Condition (1) of this consent necessary to minimise the effects of earthworks beyond the boundaries of each site.
   b. The EDSCP shall be prepared in accordance with Environment Canterbury's Erosion and Sediment Control Toolbox for the Canterbury Region http://esccanterbury.co.nz/.

6. The EDSCP shall include, but not be limited to:
   a. A map showing the location of all works, site boundaries, contours and relevant features;
   b. Plans showing the type and location of erosion and sediment control measures, on-site catchment boundaries and sources of run-on and runoff;
   c. Drawings and specifications of designated erosion and sediment control measures;
   d. Inspection and maintenance programmes for the erosion and sediment control measures;
   e. Methods for stabilising exposed areas and stockpiles to minimise the discharge of dust from beyond the boundary of each site;
   f. Methods for stabilising exposed areas and stockpiles if works are to halt for more than five (5) consecutive working days; and
   g. Methods for stabilising exposed areas and decommissioning the erosion and sediment control measures after works have been completed.

7. The EDSCP shall be submitted to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, no less than ten (10) working days prior to works commencing, for confirmation that the measures described in the EDSCP are consistent with Environment Canterbury's Erosion and Sediment Control Toolbox and the conditions of this resource consent.

8. The works shall not commence until the consent holder has received written confirmation from the Canterbury Regional Council that the measures described in the EDSCP referred to in Condition (5) are consistent with the Erosion and Sediment Control Toolbox and the conditions of this consent.

   Advice Note:

   Notwithstanding Condition (8), if the consent holder has not received written confirmation within ten (10) working days of the RMA Compliance and Enforcement Manager receiving the EDSCP, the works may commence.

9. The confirmed EDSCP referred to in condition (5) shall be implemented prior to commencing construction and maintained as effective for the duration of the construction phase. No vegetation clearance, enabling works or earthworks shall commence on site until the erosion and sediment control measures required by the EDSCP for each phase are operational.

10. The EDSCP may be amended at any time. Amendments shall be:
    a. To improve the efficiency and effectiveness of the erosion, dust and sediment control measures used on site and described in the plan;
    b. Consistent with the conditions of this resource consent; and
    c. Submitted in writing to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, prior to being implemented.

    Advice Note:

    The amended EDSCP must be submitted to the RMA Compliance and Enforcement Manager for written confirmation that it remains consistent with the Erosion and Sediment Control Toolbox and the conditions of this consent, and confirmed as accepted prior to being implemented other than where immediate implementation is required in response to an emergency.

    Notwithstanding the above, if the consent holder has not received written confirmation within ten (10) working days of the RMA Compliance and Enforcement Manager receiving the EDSCP, the works may commence in accordance with the amended EDSCP.

11. Earthworks shall temporarily cease for the duration of a rain event that is forecast to exceed an intensity of 5 millimetres per hour or greater than 10 millimetres in a 24 hour period.

12. Erosion and sediment control measures shall be inspected at least once every seven (7) days, as well as following any rainfall event that results in rainfall of more than 5 millimetres per hour or greater than 10 millimetres in a 24 – hour period. Any accumulated sediment or debris shall be removed and necessary repairs made or maintenance undertaken to ensure effective functioning of all measures and devices. Records of any inspections and resulting actions shall be kept and provided to the Canterbury Regional Council on request.

13. The erosion, dust and sediment control measures shall not be decommissioned until disturbed areas are stabilised and any operational phase stormwater systems are functioning. Decommissioning shall be undertaken as follows:
    a. All exposed areas shall be stabilised to minimise the loss or mobilisation of sediment or sediment-laden water as soon as practicable following the completion of earthworks;
    b. Any visible debris, litter, sediment and / or hydrocarbons shall be removed from all sediment control measures; and
    c. Erosion and sediment control measures shall be removed.

Spill Management

14. All practicable measures shall be undertaken to prevent oil and fuel leaks from vehicles and machinery including but not limited to the following:
    a. Fuel and mechanical fluid storage and refuelling, repair or maintenance of vehicles, mechanical plant or machinery shall not take place within 20 metres of any surface waterbody or open excavations, or in an area where spilled fuel or fluids could enter water; and
    b. Fuel and mechanical fluids shall be stored securely or removed from site overnight.

15. All practicable measures shall be taken to avoid spills of fuel or any other hazardous substances within the site. In the event of a spill of fuel or any other hazardous substance:
    a. Spills shall be cleaned up as soon as practicable, any contaminated soils shall be removed, and measures shall be taken to prevent a recurrence;
    b. Where the spill exceeds five litres, the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, shall be informed within 24 hours of a spill event and the following information provided:

i. the date, time, location and estimated volume of the spill;
ii. the cause of the spill;
iii. the type of hazardous substance(s) spilled;
iv. clean up procedures undertaken;
v. details of the steps taken to control and remediate the effects of the spill on the receiving environment;
vi. an assessment of any potential effects of the spill; and
vii. measures to be undertaken to prevent a recurrence.

16. A spill kit(s) shall be kept on site at all times, and staff trained how to use it. The spill kit(s) shall be capable of absorbing the quantity of oil and petroleum products that may be spilt on site at any one time.

Following Completion of Works

17. All exposed surfaces shall be stabilised as soon as practicable but no later than 14 days following completion, or if they are not to be disturbed for a period of five (5) consecutive days or more during works.

18. The Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager shall be notified within ten (10) working days following the completion of works authorised by this consent.

Archaeological Values

19. In the event of any discovery of archaeological material:

a. The Consent Holder shall immediately:
   i. cease earthmoving operations in the affected area and place a cordon around it as necessary to prevent further disturbance; and
   ii. advise the Canterbury Regional Council; and
   iii. advise representatives of Ōnuku Rūnanga; and
   iv. advise the New Zealand Heritage New Zealand Pouhere Taonga.

b. If the archaeological material is determined to be Koiwi Tangata (human bones) or taonga (treasured artefacts), the consent holder shall immediately advise the office of Ōnuku Rūnanga of the discovery.

c. If the archaeological material is determined to be Koiwi Tangata (human bones), the consent holder shall immediately advise the New Zealand Police of the disturbance.

d. Work may recommence if Heritage New Zealand Pouhere Taonga (following consultation with Ōnuku Rūnanga if the site is of Māori origin) provides a statement in writing to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager that appropriate action has been undertaken in relation to the archaeological material discovered. The Canterbury Regional Council shall advise the consent holder on written receipt from Heritage New Zealand Pouhere Taonga and Ōnuku Rūnanga that work can recommence.

Advice Note: *This may be in addition to any agreements that are in place between the consent holder and Ōnuku Rūnanga.*

Advice Note: *Under the Heritage New Zealand Pouhere Taonga Act 2014 an archaeological site is defined as any place associated with pre-1900 human activity, where there is material evidence relating to the history of New Zealand. For sites solely of Māori origin, this evidence may be in the form of accumulations of shell, bone, charcoal, burnt stones, etc. In later sites, artefacts such as bottles or broken glass, ceramics, metals, etc., may be found or evidence of old foundations,* *wells, drains, tailings, races or other structures. Human remains/koiwi may date to any historic period. It is unlawful for any person to destroy, damage, or modify the whole or any part of an archaeological site without the prior authority of Heritage New Zealand Pouhere Taonga. This is the case regardless of the legal status of the land on which the site is located, whether the activity is permitted under the District or Regional Plan or whether a resource or building consent has been granted. The Heritage New Zealand Pouhere Taonga Act 2014 provides for substantial penalties for unauthorised damage or destruction.*

Review

19. The Canterbury Regional Council may, once per year, on any of the last five working days of May or November, serve notice of its intention to review the conditions of this consent for the purposes of:

    a. Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment;

    b. Dealing with any adverse effect on the environment which may arise from the exercise of the consent;

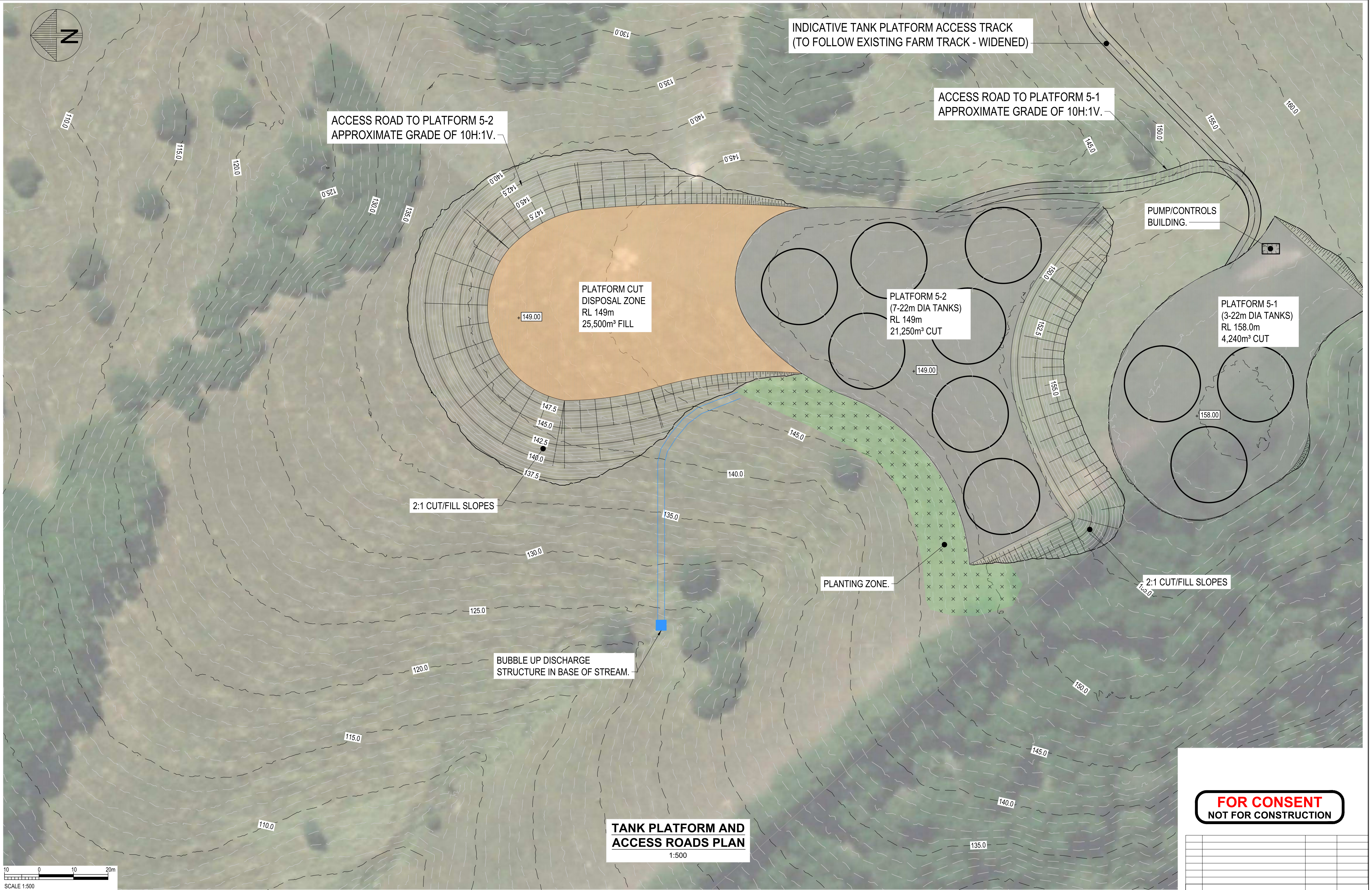
    c. Complying with the requirements of a relevant rule in an operative regional plan; or

    d. Requiring the Consent Holder to conduct monitoring instead of, or in addition to, that required by the consent.

Lapsing

20. The lapsing provisions of Section 125 of the Resource Management Act 1991 shall not apply until [eight years from the date of issue].

Plan CRCXXXXXXA



TANK PLATFORM AND ACCESS ROADS PLAN
1:500

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.	Mt PLNT GD2000	DESIGNED	Steve Woods		10.21
RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C151.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C151

PROJECT TITLE
AKAROA TREATED WASTEWATER
IRRIGATION SCHEME

DRAWING TITLE
OPTION 5 - PLATFORMS, CUT DISPOSAL & ACCESS ROADS

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
ORIGINAL SHEET SIZE A1
SCALES
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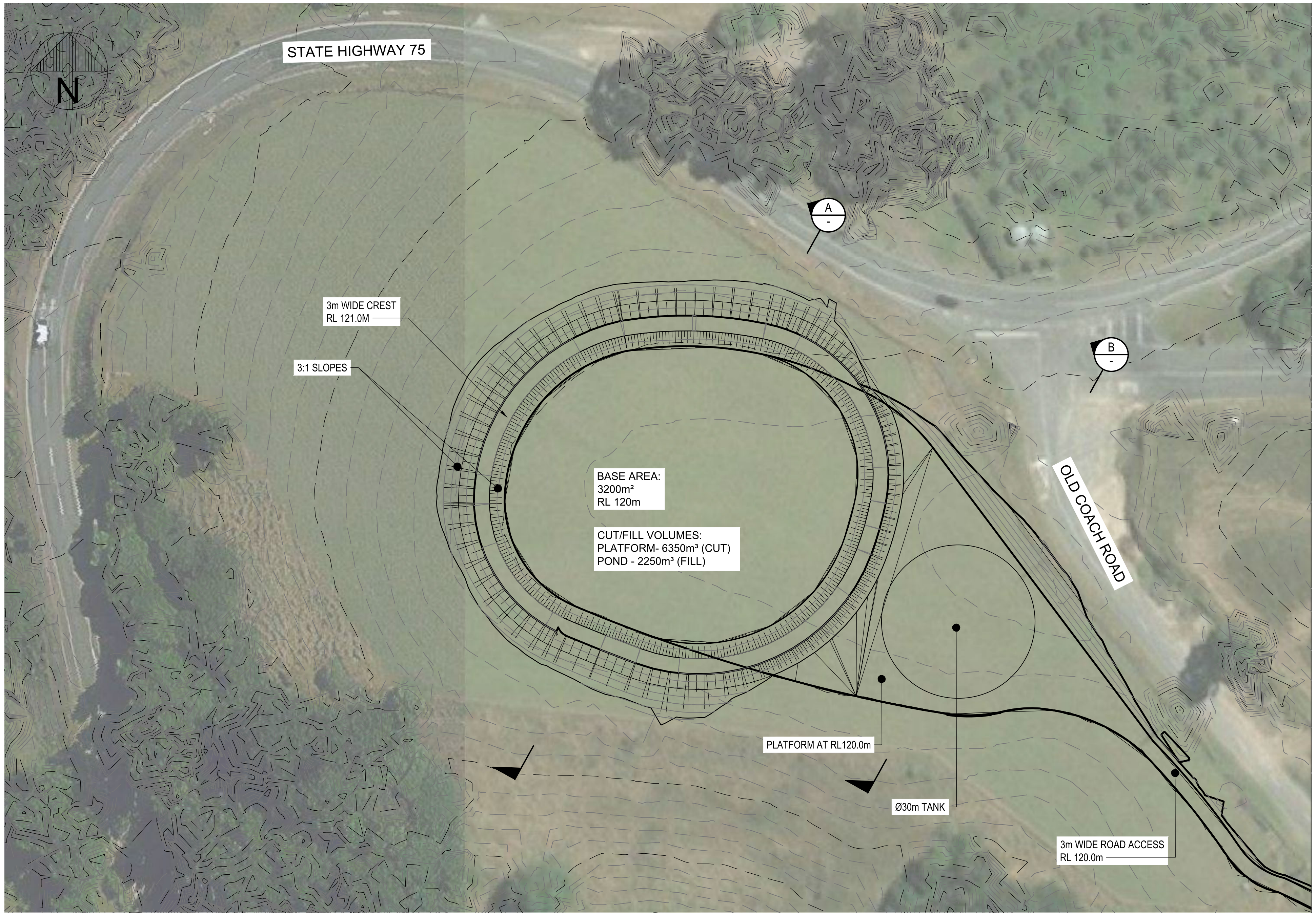
SHEET C151 OF



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1:500

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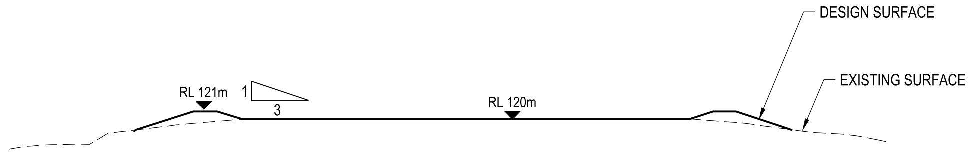
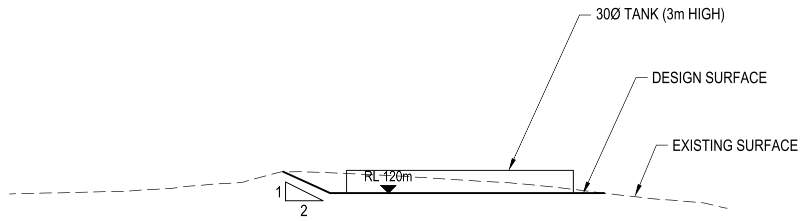


SECTION A
SCALE 1 : 500



SECTION B
SCALE 1 : 500

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

			NAME	SIGNED	DATE
DATUM	C.D.D.				
BENCH MK.		DESIGNED	Steven Woods		08/21
RL		DES. REVIEW			
SURVEY		DRAWN	Tom Frowein		08/21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-SK10.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER
DATE SIGNED
FOR CONSTRUCTION
DATE SIGNED

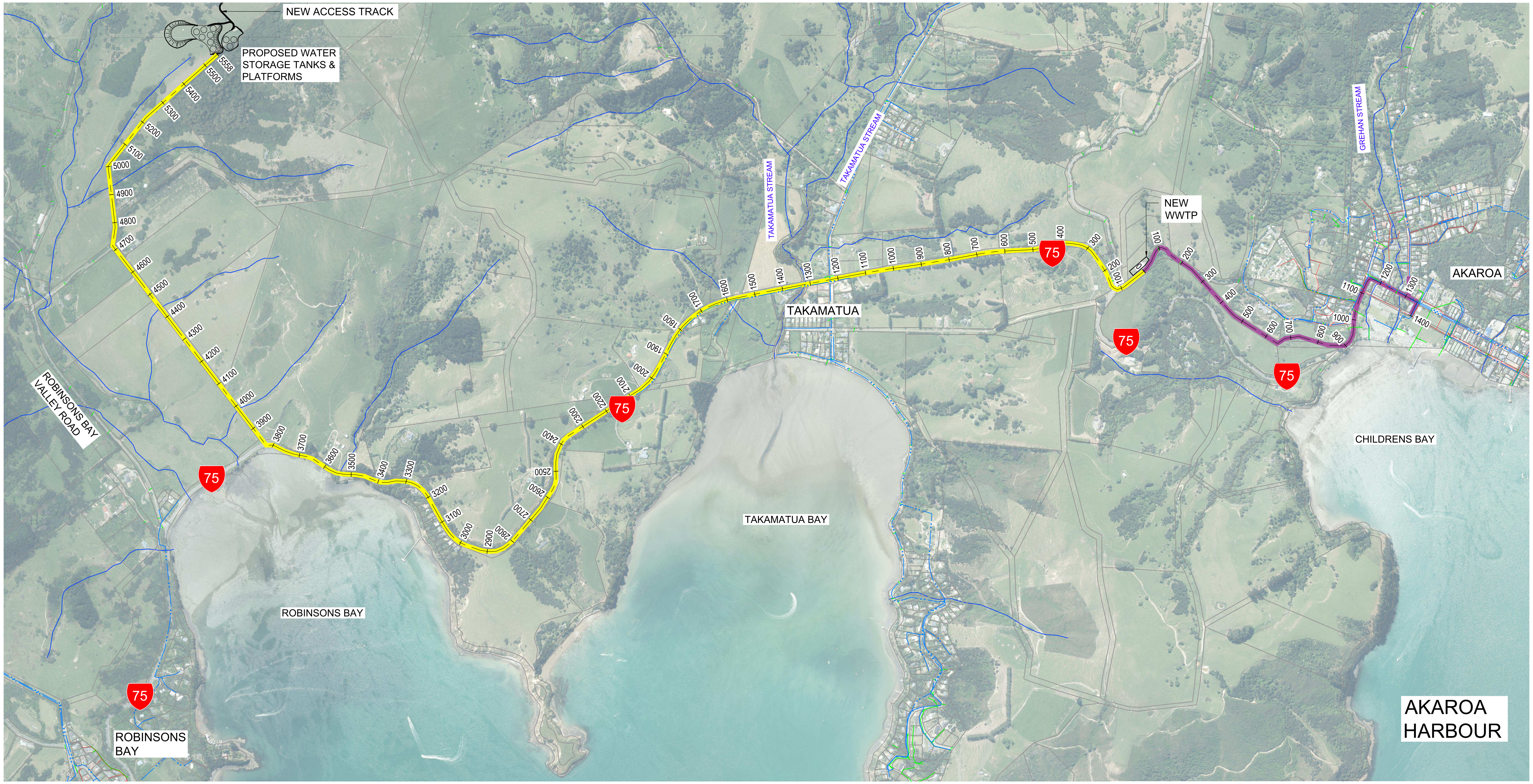
CONSULTANT
Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-SK10

PROJECT TITLE
AKAROA RECLAIMED WATER & REUSE SCHEME

DRAWING TITLE
WETLAND CONCEPT SITE PLAN

CONTRACT NUMBER
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
SHEET SK10 OF

Plan CRCXXXXXXC



WATER STORAGE TANKS & PIPELINE ROUTE - OVERVIEW PLAN

SCALE 1 : 7500

LEGEND :

- RIVER / STREAM
- WWTP DISCHARGE PIPELINE
- PURPLE PIPE SCHEME
- EXISTING COUNCIL WASTEWATER
- EXISTING COUNCIL STORMWATER
- EXISTING COUNCIL POTABLE WATER

NOTES:

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FOR CONSENT
NOT FOR CONSTRUCTION

100 0 100 200 300m
SCALE 1:7500

ISSUE	AMENDMENTS	SIGNED	DATE
B	UPDATED ACCESS TRACK	MR	07.06.22
A	INITIAL DRAFT		

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.	NZTM	DESIGNED	Mark Ridge		12.21
RL		DES. REVIEW			
SURVEY		DRAWN	Blair Timblick		12.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C200.DWG			
SAP WBS		PRINTED ON 6-Jul-22	BY Frowein, Tom		

APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C200

PROJECT TITLE
AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE
WATER STORAGE TANKS & PIPELINE ROUTE OVERVIEW PLAN

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
TSD PROJECT FILE NUMBER
SHEET C200 OF

Appendix X – Proposed Conditions: Construction-phase Stormwater Discharges (ECan)

Applicant Name: Christchurch City Council

Consent Application: CRCXXXXXX

Discharge Permit (s15) to discharge construction-phase stormwater to land and to water

Site Location: Akaroa Area

Consent Duration: [Eight years from the date of issue]

Attachments: *Plan CRCXXXXXXA – Robinsons Bay Valley Irrigation Area*

Plan CRCXXXXXXB – Old Coach Road Site

Plan CRCXXXXXXC – Pipelines

1. The exercise of this consent authorises the discharge of construction-phase stormwater and associated sediment from the construction of the Akaroa Treated Wastewater Irrigation Scheme and shall be exercised in accordance with CRCXXXXXX [*the earthworks consent*].

2. The activity shall be limited to the discharge of stormwater and sediment from:
   a. 80 Old Coach Road, Akaroa, legally described as Lot 3 DP 459704, and Sec 1 SP Plan 47316 (CT 659829) to the Council-owned network on Old Coach Road;
   b. 11 Sawmill Road, Robinsons Bay Valley, Akaroa, legally described as Lot 2 DP 82749 (CT CB47D/512) to land and to an ephemeral stream bed on the Robinsons Bay Valley Irrigation site at or about NZTM 1598416 5154505; and
   c. Within legal road reserve between 80 Old Coach Road and 11 Sawmill Road, Robinsons Bay Valley to land;

   associated with the development of land and structures, and the installation of new pipelines and irrigation infrastructure for the Akaroa Treated Wastewater Irrigation Scheme as described in the application document titled *'Akaroa Treated Wastewater Irrigation Scheme – Application for Resource Consents and Assessment of Environmental Effects'* dated [DATE] and in general accordance with Plans CRCXXXXXX A, B and C attached to and forming part of this consent.

Prior to Commencing Works

3. No less than ten (10) working days prior to commencing construction works the Consent Holder or their agent shall hold a pre-construction site meeting inviting representatives of the Canterbury Regional Council, the consent holder, the primary contractor and any other relevant party to discuss and document:
   a. A programme of works, including anticipated start and end dates, scheduling and staging of works;
   b. Names and responsibilities of all parties, including names and 24 hour contact details for representatives of each party;
   c. Expectations regarding communication between all relevant parties;
   d. Site inspection requirements; and
   e. Confirmation that all parties have copies of this resource consent document and all associated erosion, stormwater and sediment control plans prepared for the works.

4. Prior to commencing construction works all persons exercising this consent shall be made aware of, and have access to:
   a. The contents of this consent document and all associated documents;
   b. The Stormwater Management Plan required under Condition (5) of this resource.

Stormwater Management Plan

5. The works shall occur in accordance with the Stormwater Management Plan (SMP) which shall include, but not be limited to:
   a. A map showing the location of all works, site boundaries, contours and relevant features;
   b. A description of the methods to be used to manage construction-phase stormwater and sediment-laden water, and detailed plans showing the location of sediment control measures, on-site catchment boundaries, discharge points and sources of runoff;
   c. A programme of works, which includes but is not limited to, a proposed timeframe for the works, and inspection, monitoring and maintenance schedules for all stormwater control measures;
   d. identification of the points where stormwater and sediment-laden water will leave the control of the consent holder.

6. The SMP shall be submitted to the Canterbury Regional Council, Attention: Regional Leader – Monitoring and Compliance, at least ten (10) working days prior to works commencing, for confirmation that the measures described in the SMP are consistent with the conditions of this resource consent.

7. Works shall not commence until the consent holder has received written confirmation from the Canterbury Regional Council that the measures described in the SMP referred to in Condition (5) are consistent with the conditions of this consent.

   Advice Note:

   Notwithstanding Condition (7), if the consent holder has not received the certification within ten (10) working days of the Regional Leader – Monitoring and Compliance receiving the SMP, the works may commence.

8. The confirmed SMP may be amended at any time. Amendments shall be:
   a. To improve the efficiency and effectiveness of construction-phase stormwater management measures in a manner consistent with the conditions of this resource consent; and
   b. Submitted in writing to the Canterbury Regional Council, Attention: Regional Leader– Monitoring and Compliance, prior to any amendment being implemented.

   Advice Note:

   The amended SMP must be submitted to the Regional Leader – Monitoring and Compliance for written confirmation that it remains consistent with the conditions of this consent, and confirmed as accepted prior to being implemented other than where immediate implementation is required in response to an emergency.

   Notwithstanding the above, if the consent holder has not received written confirmation within ten (10) working days of the Regional Leader – Monitoring and Compliance receiving the SMP, the works may commence in accordance with the amended SMP.

Monitoring

9. The discharges to the ephemeral stream on the Robinsons Bay Valley Irrigation site authorised under this consent shall not at any time:
   a. result in oil, grease, floatable or suspended materials in any waterbody;
   b. result in significant adverse effects on aquatic life; or
   c. contain a total suspended solids concentration of more than 50 milligrams per litre except where the background concentration of suspended solids in Robinsons Bay Stream is greater than 50 milligrams per litre as measured at a point 10 metres upstream of the confluence with the ephemeral stream.

10. Where the background concentration of suspended solids in Robinsons Bay Stream is greater than 50 milligrams per litre, and construction-phase stormwater from the ephemeral stream is discharging to Robinsons Bay Stream, the clarity of water in Robinsons Bay Stream shall be visually assessed no less than once per day using a recognised method to measure visual clarity.

11. The visual clarity of Robinsons Bay Stream shall not be reduced by more than 35 percent after reasonable mixing as measured at a point 50 m downstream of the confluence of Robinsons Bay Stream and the ephemeral stream.

12. Following the commencement of earthworks on the Robinsons Bay Valley Irrigation site, and until all disturbed surfaces are stabilised, Robinsons Bay Stream shall be visually assessed, photographed and recorded at least daily for any sheen, oil or grease resulting from the discharge to the ephemeral stream.

13. If the visual assessment undertaken under Condition (12) identifies a sheen, oil or grease in the discharge from the ephemeral stream and / or within Robinsons Bay Stream, the consent holder shall:
    a. identify the origin of the sheen, oil or grease as soon as practicable and remediate the source of the contamination without undue delay; and
    b. monitor the effectiveness of the remedial action taken to ensure the measures referred to in condition 13(a) avoid future such discharges to Robinsons Bay Stream.

14. Any observed non-compliance with condition (11) or (13) shall be reported to the Canterbury Regional Council, Attention: Regional Leader – Monitoring and Compliance within two (2) working days, along with a description of all measures taken to rectify, and to prevent a recurrence.

Review

19. The Canterbury Regional Council may, once per year, on any of the last five working days of May or November, serve notice of its intention to review the conditions of this consent for the purposes of:

    a. Requiring the adoption of the best practicable option to remove or reduce any adverse effect on the environment;

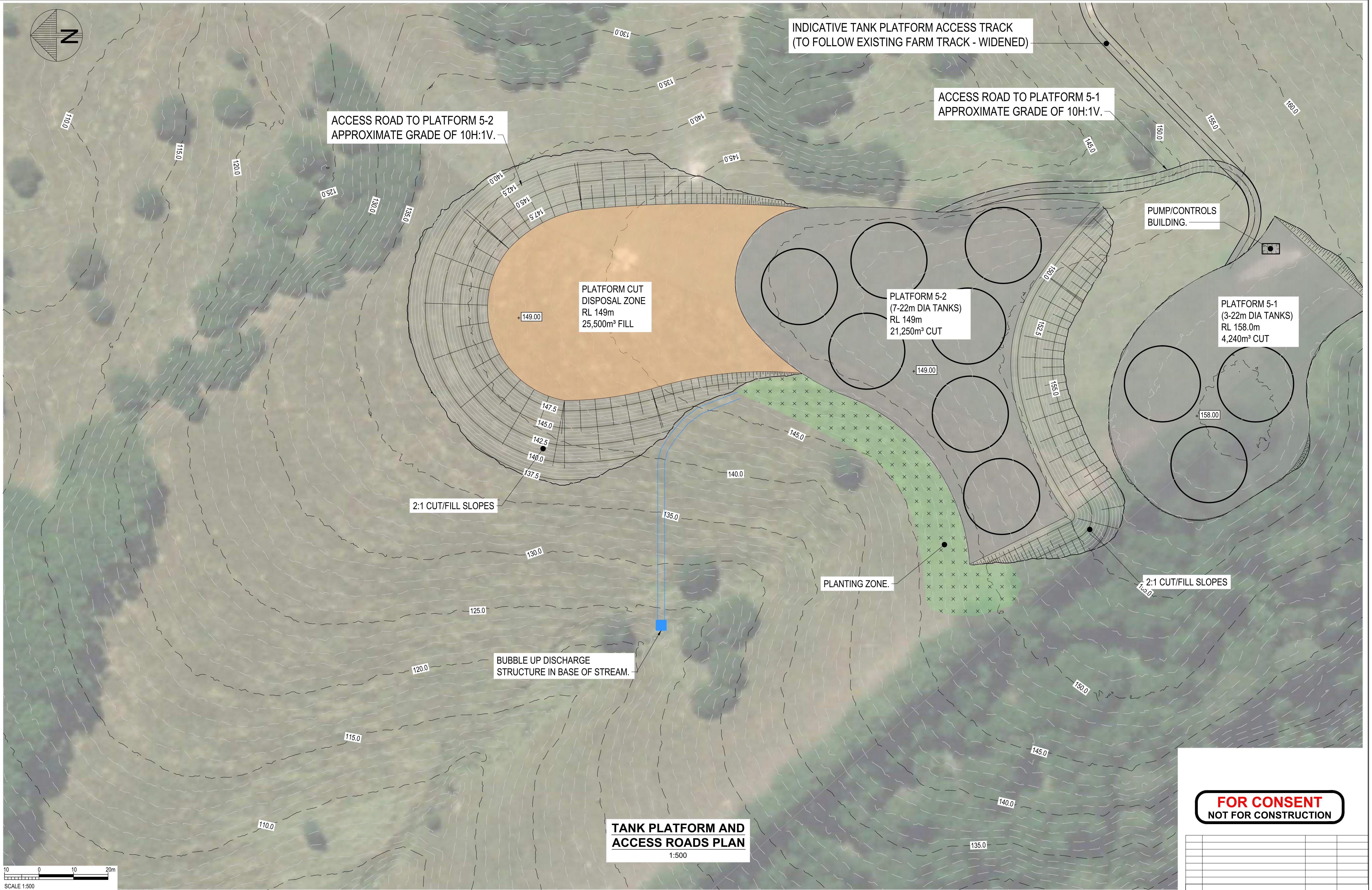
    b. Dealing with any adverse effect on the environment which may arise from the exercise of the consent;

    c. Complying with the requirements of a relevant rule in an operative regional plan; or

    d. Requiring the Consent Holder to conduct monitoring instead of, or in addition to, that required by the consent.

Lapsing

Plan CRCXXXXXXA



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BENCH MK.	Mt PLNT GD2000	DESIGNED	Steve Woods		10.21
RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C151.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

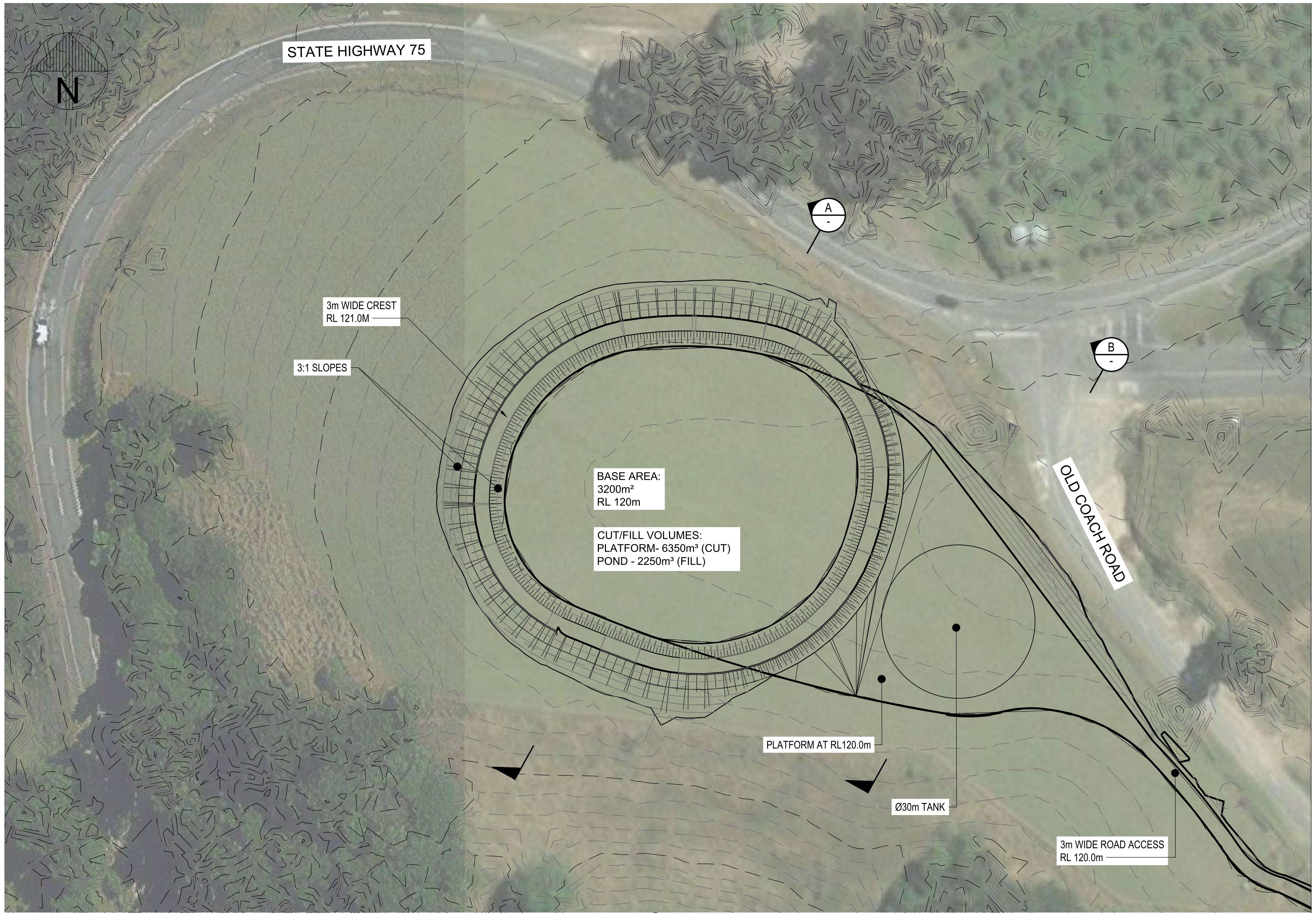
CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C151

PROJECT TITLE
AKAROA TREATED WASTEWATER
IRRIGATION SCHEME

DRAWING TITLE
OPTION 5 - PLATFORMS, CUT DISPOSAL & ACCESS ROADS

CONTRACT NUMBER
ORIGINAL SHEET SIZE A1
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
SCALES
SHEET C151 OF

Christchurch City Council



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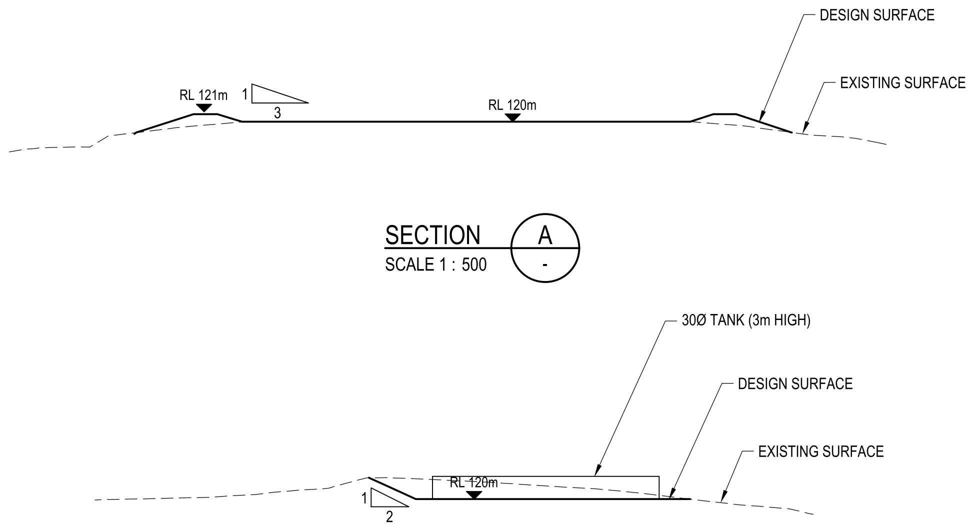


SECTION A
SCALE 1 : 500

SECTION B
SCALE 1 : 500

FOR CONSENT
NOT FOR CONSTRUCTION

ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.		DESIGNED	Steven Woods		08/21
RL		DES. REVIEW			
SURVEY		DRAWN	Tom Frowein		08/21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-SK10.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER
DATE SIGNED
FOR CONSTRUCTION
DATE SIGNED

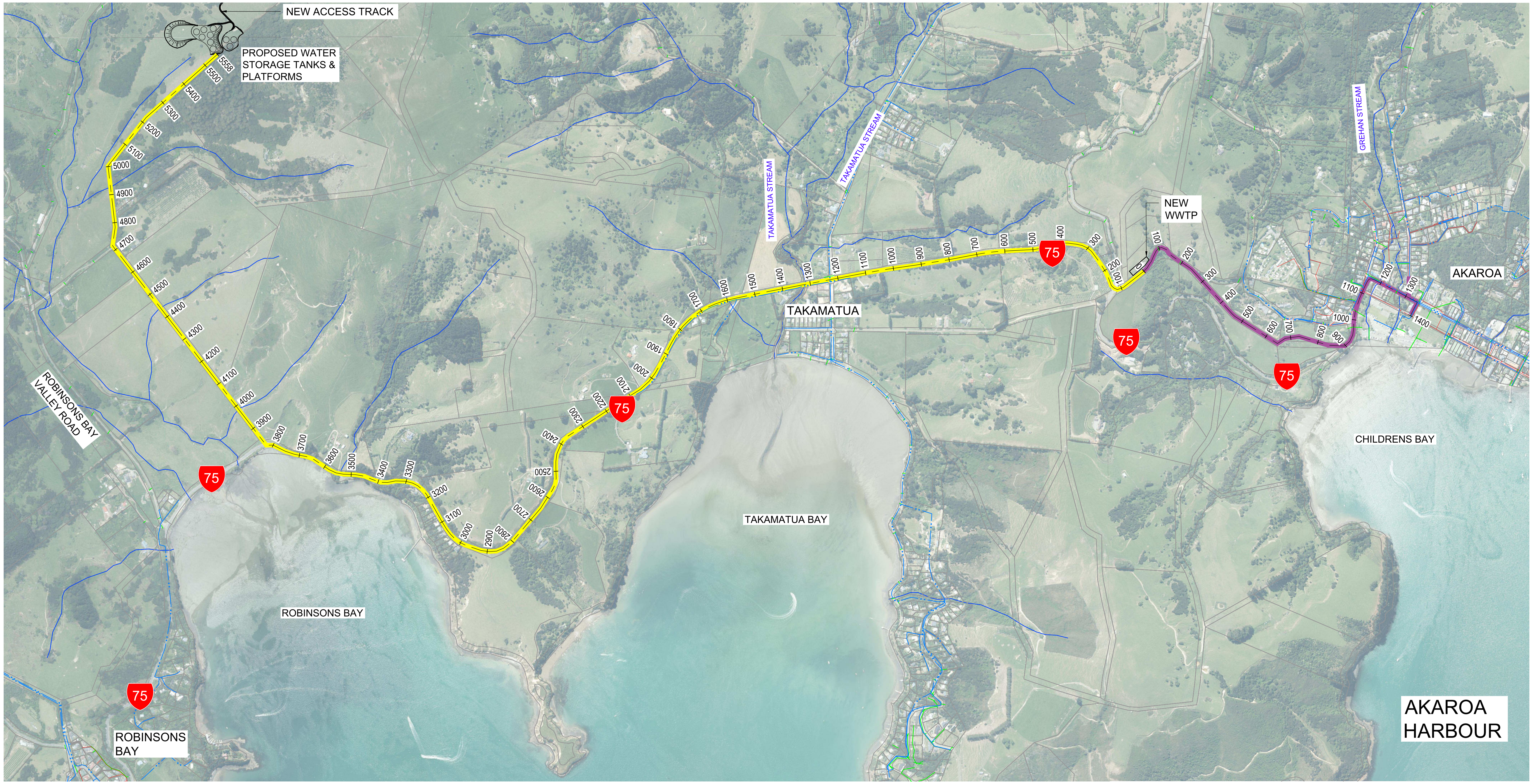
CONSULTANT
Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-SK10

PROJECT TITLE
AKAROA RECLAIMED WATER & REUSE SCHEME

DRAWING TITLE
WETLAND CONCEPT SITE PLAN

CONTRACT NUMBER
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
SHEET SK10 OF

Plan CRCXXXXXXC



WATER STORAGE TANKS & PIPELINE ROUTE - OVERVIEW PLAN

SCALE 1 : 7500

LEGEND :

- RIVER / STREAM
- WWTP DISCHARGE PIPELINE
- PURPLE PIPE SCHEME
- EXISTING COUNCIL WASTEWATER
- EXISTING COUNCIL STORMWATER
- EXISTING COUNCIL POTABLE WATER

NOTES:

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FOR CONSENT
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ISSUE	AMENDMENTS	SIGNED	DATE
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A	INITIAL DRAFT		

Christchurch City Council

			NAME	SIGNED	DATE
DATUM	C.D.D.				
BENCH MK.	NZTM	DESIGNED	Mark Ridge		12.21
RL		DES. REVIEW			
SURVEY		DRAWN	Blair Timblick		12.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C200.DWG			
SAP WBS		PRINTED ON 6-Jul-22	BY Frowein, Tom		

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FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C200

PROJECT TITLE: AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE: WATER STORAGE TANKS & PIPELINE ROUTE OVERVIEW PLAN

CONTRACT NUMBER:
CAD DRAWING FILE REF. 310103534-01-001
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
TSD PROJECT FILE NUMBER:
SHEET C200 OF

Appendix X – Proposed Conditions: Land Use (CCC)

Applicant: **Christchurch City Council**

Consent Application: **RMAXXXXXXXX**

Land Use Consent (s9) to use land to construct, maintain and operate infrastructure and structures associated with the Akaroa Treated Wastewater Irrigation Scheme.

Location: **Akaroa Area**

Consent Duration: **Not Limited**

Attachments:

Plan RMAXXXXXXXXA – Robinsons Bay Valley Irrigation Area

Plan RMAXXXXXXXXB – Old Coach Road Site

1. This consent authorises the use of land to construct, maintain and operate infrastructure and structures for storing wastewater associated with the Akaroa Treated Wastewater Irrigation Scheme in general accordance with the application for resource consent dated [DATE].

2. The following structures shall be located and built as described in the application and the attached plans:
    a. Up to ten storage tanks and associated infrastructure on the Robinsons Bay Valley irrigation site, 11 Sawmill Road, Robinsons Bay Valley, Akaroa, on land legally described as Lot 2 DP 82749 (CT CB47D/512) as shown on Plan RMAXXXXXXXXA; and
    b. A storage tank, subsurface wetland and associated infrastructure on the Old Coach Road site, Old Coach Road, Akaroa, on land legally described as Lot 7 – 10 DP 7273 (CT CB3C/568) as shown on Plan RMAXXXXXXXXB.

3. The storage tanks referred to in Condition (2) shall be finished in recessive colours sympathetic to the setting, using materials with a maximum Light Reflective Value (LVR) rating no greater than 40%.

<u>Old Coach Road site</u>

4. The development of the site at Old Coach Road, Lot 7 – 10 DP 7273 shall be undertaken in general accordance with the concept shown on Plan RMAXXXXXXXXB attached to and forming part of this consent.

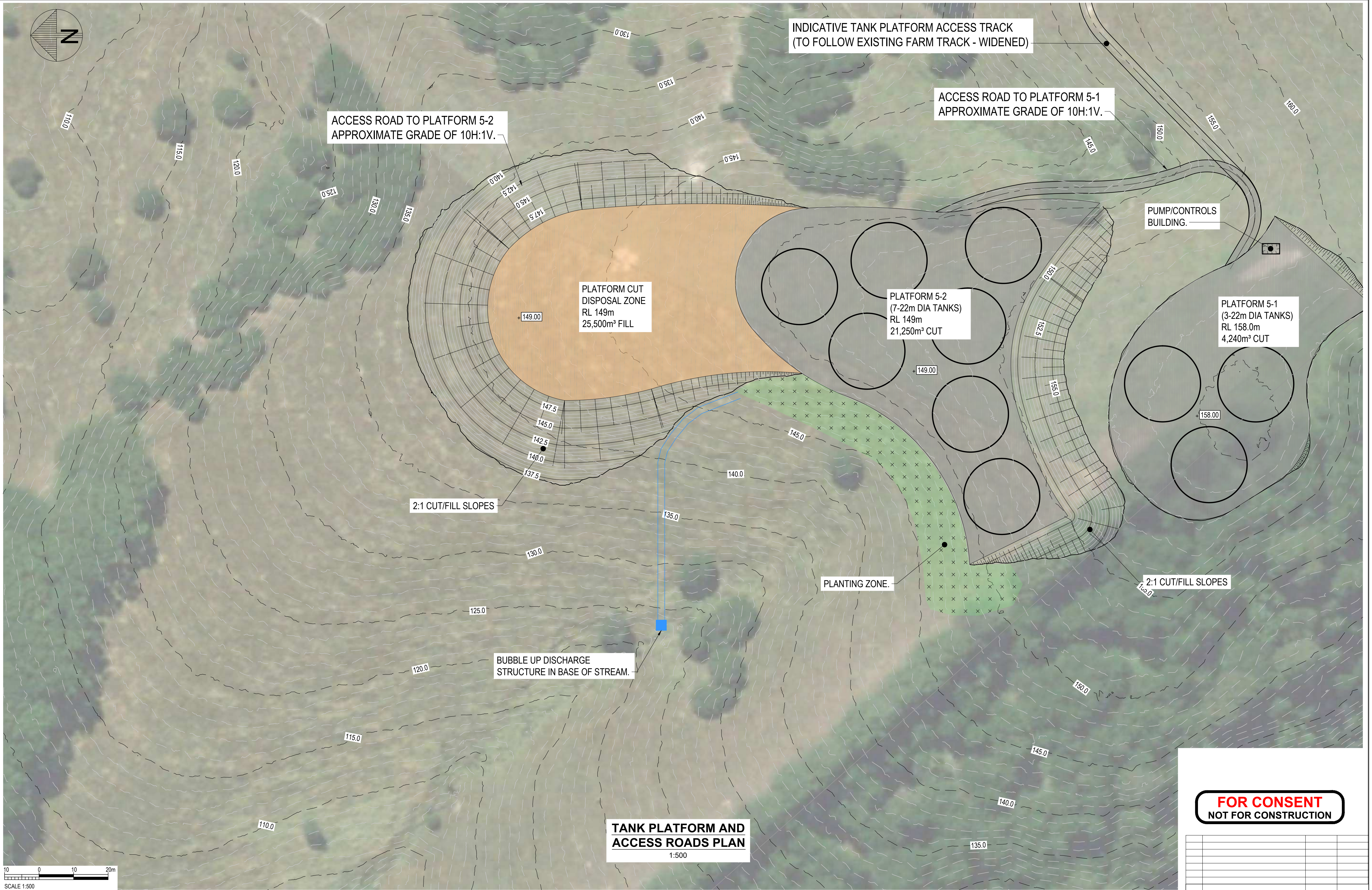
5. All vegetation on the Old Coach Road storage site required to visually screen structures from off-site shall be maintained for the term of this consent, with any dead, damaged or diseased plants

being removed and replaced with appropriate species as soon as practicable, but within one growing season of their removal.

Administration

6. The lapsing date for the purposes of Section 125 shall be [eight] years from the commencement of this consent.

7. Pursuant to Section 128 of the Resource Management Act 1991 the Council may review the conditions of consent by serving notice on the consent holder within a period of one month of any 12 month period following the date of this decision, in order to deal with any adverse effects on the environment which may arise from the exercise of this consent and which it is appropriate to deal with at a later stage.



TANK PLATFORM AND ACCESS ROADS PLAN
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FOR CONSENT
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ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
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RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C151.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED

FOR TENDER	
DATE	SIGNED
FOR CONSTRUCTION	
DATE	SIGNED

CONSULTANT: Stantec

CONSULTANT PROJECT REF. 310103534

CONSULTANT FILE REF. 310103534-01-001-C151

PROJECT TITLE

AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE

OPTION 5 - PLATFORMS, CUT DISPOSAL & ACCESS ROADS

CONTRACT NUMBER

CAD DRAWING FILE REF. 310103534-01-001

ORIGINAL SHEET SIZE A1

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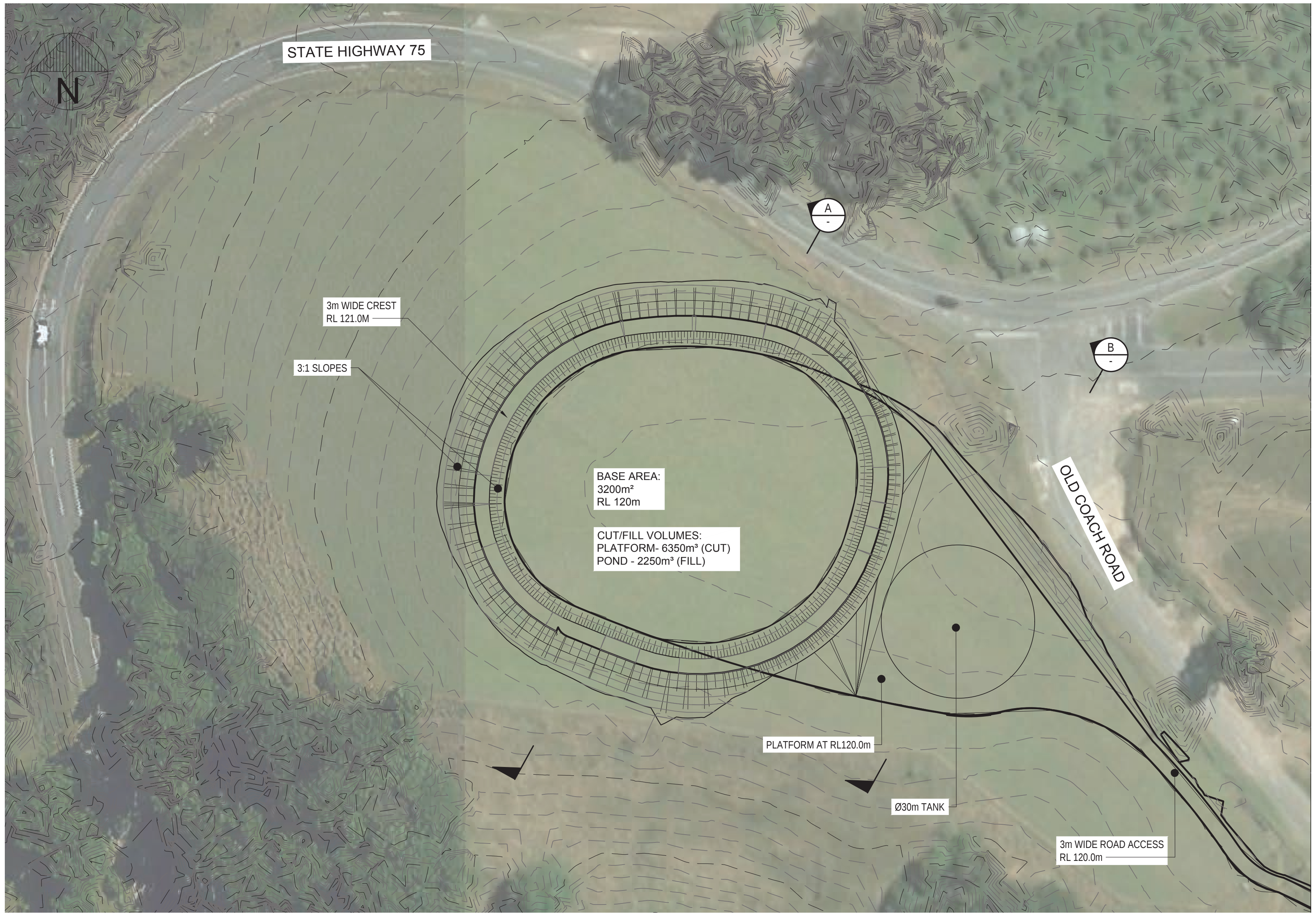
SHEET C151 OF



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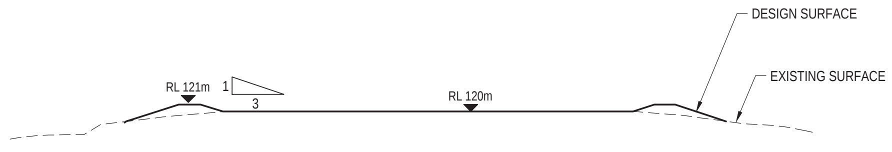

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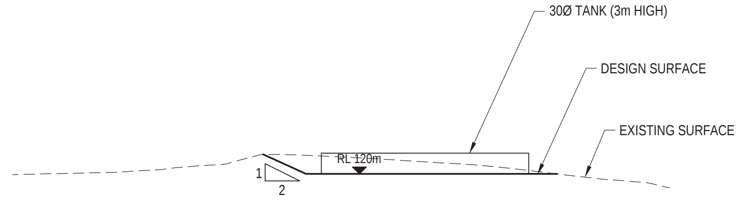

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FOR CONSENT
NOT FOR CONSTRUCTION

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Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.		DESIGNED	Steven Woods		08/21
RL		DES. REVIEW			
SURVEY		DRAWN	Tom Frowein		08/21
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APPROVED
FOR TENDER — DATE / SIGNED
FOR CONSTRUCTION — DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-SK10

PROJECT TITLE
AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE
WETLAND AND STORAGE CONCEPT SITE PLAN

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
TSD PROJECT FILE NUMBER
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
SHEET SK10 OF

Appendix X – Proposed Conditions: Earthworks (CCC)

Applicant:	**Christchurch City Council**
Consent Application:	**RMAXXXXXXXX**
	Land Use Consent (s9) to undertake earthworks associated with the construction of the Akaroa Treated Wastewater Irrigation Scheme.
Location:	**Akaroa Area**
Consent Duration:	**Not Limited**
Attachments:	*Plan RMAXXXXXXXXA – Robinsons Bay Valley Irrigation Area Plan*
	Plan RMAXXXXXXXXB – Old Coach Road Site
	Plan RMAXXXXXXXXC – Pipeline Routes

1. This consent authorises the use of land earthworks associated with the Akaroa Treated Wastewater Irrigation Scheme, undertaken in general accordance with the earthworks described in application for resource consent dated [DATE], and with the plans attached to and forming part of this consent.

<u>Erosion Dust Sediment Control Plan</u>

2. All earthworks shall be carried out in accordance with a site-specific Erosion, Dust and Sediment Control Plan (EDSCP) prepared by a suitably qualified and experienced professional to ensure that erosion, dust, stormwater and sediment risks and associated effects are appropriately minimised. The EDSCP must follow the best practice principles, techniques, inspections and monitoring for erosion and sediment control contained in Environment Canterbury's Erosion and Sediment Control Toolbox for Canterbury http://esccanterbury.co.nz/.

3. The EDSCP must be submitted to the Christchurch City Council's resource consent monitoring team via email to rcmon@ccc.govt.nz at least ten (10) working days before commencing earthworks. A design certificate (Appendix IV in IDS Part 3) shall be submitted with the EDSCP for acceptance. No works shall commence prior to formal acceptance of the EDSCP by Christchurch City Council (via email to rcmon@ccc.govt.nz).

   <u>Advice Note:</u>

   > *Notwithstanding Condition (2), if the consent holder has not received written confirmation within ten working days of the Christchurch City Council receiving the EDSCP, the works may commence.*

4. The EDSCP shall include (but not be limited to):

   a) A site description and locality map of each site where earthworks will occur (e.g. specifying topography, vegetation cover, soil type, proximity of sensitive receptors such as waterways and land use activities);

   b) The identification of environmental risks including areas of erosion, dust, stormwater and sediment generation risk, storage areas for construction-related hazardous substances (e.g. fuel, lubricants, hydraulic fluids), materials stockpile areas, and any construction-phase stormwater management facilities;

   c) A description of the proposed earthworks, including scale, volume, height / depth, stockpiling and sequencing, and a programme including a proposed timeframe and completion date;

   d) A description of the methods to be used to minimise the area of soil disturbed and exposed at any time, including the retention of existing vegetation to the extent practicable;

   e) The methods and programme for earthworks and associated monitoring of EDSC measures, including frequency of monitoring and reporting;

   f) Drawings showing the location of the earthworks on the site and the type and location of erosion and sediment control measures, including on-site catchment boundaries and off-site sources of run on/runoff;

   g) Emergency response and contingency management procedures, including contact people and numbers, a description of triggers for corrective actions, what those actions may be relative to the effect, recording and reporting processes, and response processes to update the EDSCP and actions if necessary;

      Advice Note:

      Any changes to the accepted EDSCP must be to respond to adverse effects from the activity and / or updated best practice or to improve the efficacy of the erosion and sediment control measures. The amended EDSCP must be submitted to the Council in writing via email to rcmon@ccc.govt.nz. The changes must be accepted by the Council prior to being implemented other than where immediate implementation is required in response to an emergency.

      Notwithstanding the above, if the consent holder has not received written confirmation within ten working days of the Christchurch City Council receiving an amended EDSCP, the works may commence in accordance with the amended plan.

5. The accepted EDSCP referred to in condition (2) shall be implemented prior to commencing construction, and maintained for the duration of the construction phase. No vegetation clearance, enabling works or earthworks shall commence on site until:

   a) The erosion and sediment control measures required by the EDSCP for each active phase are operational;

b) An Engineering Completion Certificate (Appendix VII in IDS Part 3) signed by an appropriately qualified and experienced engineer has been submitted to the Christchurch City Council certifying that the measures have been installed in compliance with the accepted EDSCP;

c) The Council has been notified (via email to rcmon@ccc.govt.nz) of the start date no less than three (3) working days prior to commencing earthworks, and of the names and contact details of the key personnel responsible for environmental management and compliance.

d) The contractor and any subcontractors have received a copy of all relevant resource consents relating to the works authorised by this consent and have received all necessary training and briefings specific to the work and the site(s).

General Conditions

6. No permanent unsupported cut or batter shall be formed steeper than 26 degrees in loess soil unless approved by a chartered professional engineer. Cut and batter faces shall be contoured to integrate with the surrounding natural landform to the extent practicable.

7. No earthworks will occur in, or within 10 m of a natural wetland identified by a suitably qualified and experienced terrestrial ecologist.

8. Construction plant and machinery shall not pass through, work in or from within any watercourse where water is present.

9. Any cut material remaining on site at the completion of works shall be removed from the site, or distributed and contoured on site in a manner that:

   a) integrates with the contours of the surrounding landscape; and

   b) minimises the potential for soil migration from disturbed areas into watercourses or across site boundaries.

10. The consent holder shall ensure that no sediment or vegetative debris:

   a) enters a stream, river or wetland;

   b) is positioned in a location where it may reasonably be entrained by flood waters; or

   c) is positioned in a location that results in sediment-laden water flowing beyond the legal boundary of the properties to which this consent applies.

   Advice Note:

   For the purpose of this condition 'sediment-laden water' is defined as water with a total suspended solid (TSS) content greater than 50mg/L.

11. All disturbed areas shall be stabilised as soon as practicable but no later than 14 days following completion, or if they are not to be disturbed for a period of five (5) consecutive days or more during works.

Sites of Heritage and Cultural Significance

12. At least ten (10) working days prior to any earthworks commencing in an area described as a Site of Ngāi Tahu Cultural Significance and identified in Appendix 9.5.6 of the Christchurch District Plan, the consent holder shall contact representatives of Ōnuku Rūnanga via Mahaanui Kurataiao Ltd (email mkt.admin@ngaitahu.iwi.nz or phone 03 377 4374) to advise of the works, and to allow a rūnanga representative trained in the recognition of archaeological deposits the opportunity to be on site during works to observe earthworks and provide cultural insights/advice as necessary.

13. In the event of the discovery/disturbance of any archaeological material or sites, including taonga (treasured artefacts) and koiwi tangata (human remains), the consent holder shall immediately:

    a) Cease earthmoving operations in the affected area of the site; and

    b) Cordon off the area as necessary to effectively protect it from further disturbance; and

    c) Advise the Council of the disturbance via email to rcmon@ccc.govt.nz; and

    d) Advise appropriate agencies, including Heritage New Zealand Pouhere Taonga and representatives of Ōnuku Rūnanga of the disturbance.

    Works shall not continue in the affected area without confirmation from the Christchurch City Council's resource consent monitoring team via email to rcmon@ccc.govt.nz.

Traffic Management

14. All works within formed legal road will be subject to a site-specific Traffic Management Plan (TMP) to be prepared by a suitably qualified and experienced person. No works are to commence until the measures specified in the TMP have been implemented relative to the location of active works.

15. The TMP(s) referred to in Condition (15) shall identify the nature and extent of works within legal road, and the temporary traffic management methods to be used in each location. The TMP(s) must comply with the Waka Kotahi Code of Practice for Temporary Traffic Management (CoPTTM) and / or the relevant Road Controlling Authority's Local Operating Procedures.

16. The TMP(s) shall be submitted through the web portal www.myworksites.co.nz along with a Corridor Access Request (CAR). A copy of the TMP and CAR shall be forwarded to the Christchurch City Council's resource consent monitoring team via email to rcmon@ccc.govt.nz no less than five (5) working days prior to commencing earthworks within legal road.

Noise Management

17. Earthworks involving mechanical equipment shall not occur outside the hours of 07:00 and 22:00 Monday to Saturday. No earthworks shall occur on Sundays or public holidays unless in response to an emergency or to urgently address an unanticipated adverse effect.

<u>Advice Note:</u>

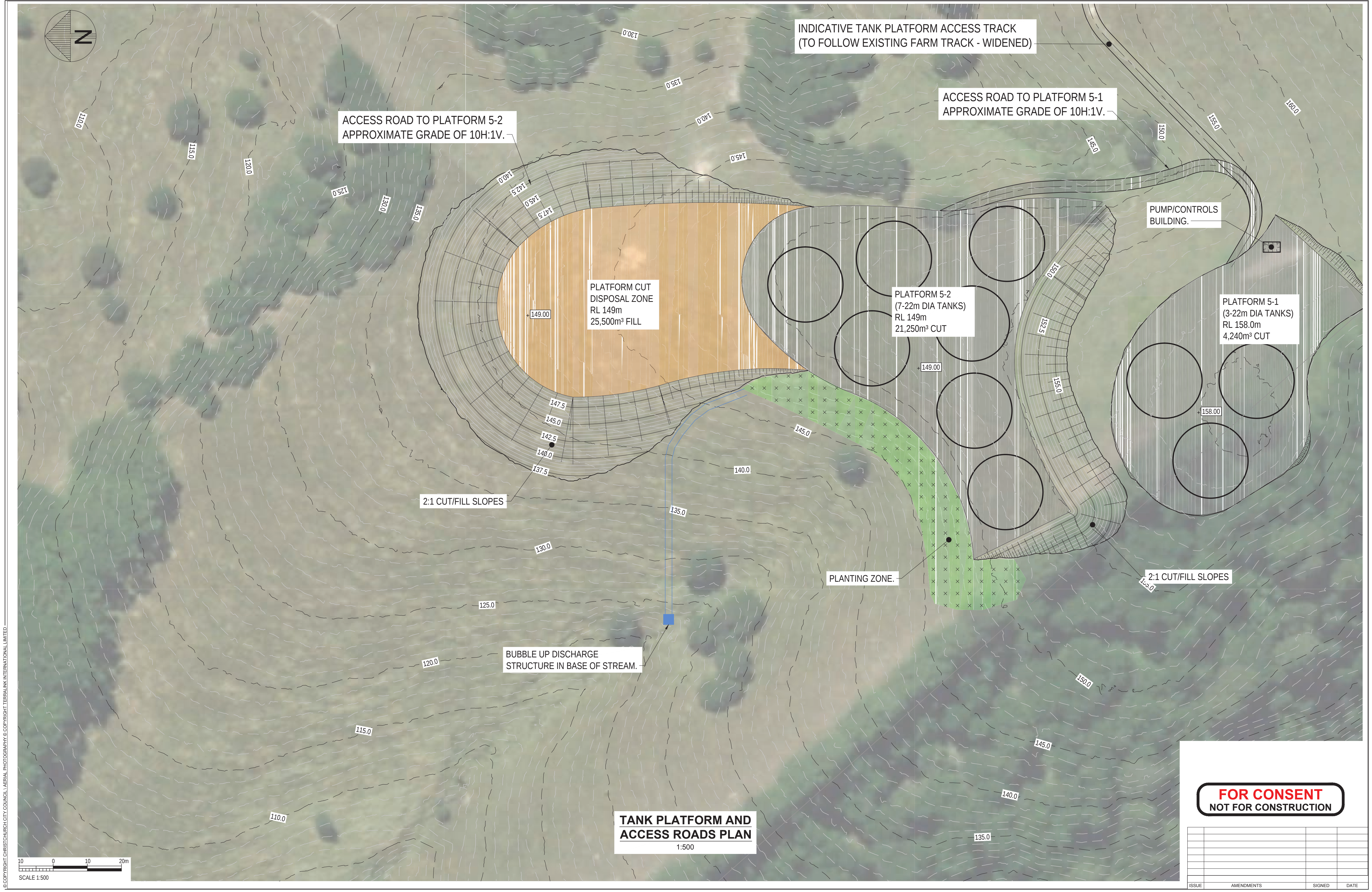
> *It is the consent holder's responsibility to ensure that the activity, including where carried out by contractors on their behalf, complies with the Christchurch District Plan standard specified below - failure to do so may result in enforcement action and the need for additional land-use consent:*
>
> *Rule 6.1.6.1.1 P2 - All earthworks related construction activities shall meet relevant noise limits in Tables 2 and 3 of NZS 6803:1999 Acoustics - Construction Noise, when measured and assessed in accordance with that standard. Earthworks shall comply with NZS 6803:1999 at all times.*

<u>Administration</u>

18. The lapsing date for the purposes of Section 125 shall be [eight] years from the commencement of this consent.

19. Pursuant to Section 128 of the Resource Management Act 1991 the Council may review the conditions of consent by serving notice on the consent holder within a period of one month of any 12 month period following the date of this decision, in order to deal with any adverse effects on the environment which may arise from the exercise of this consent and which it is appropriate to deal with at a later stage.

Plan RMAXXXXXXXXA



TANK PLATFORM AND ACCESS ROADS PLAN

1:500

FOR CONSENT
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ISSUE	AMENDMENTS	SIGNED	DATE

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.	Mt PLNT GD2000	DESIGNED	Steve Woods		10.21
RL		DES. REVIEW			
SURVEY		DRAWN	Brent James		11.21
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CPMS		FILE LOCATION			
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CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C151

PROJECT TITLE
AKAROA TREATED WASTEWATER
IRRIGATION SCHEME

DRAWING TITLE
OPTION 5 - PLATFORMS, CUT DISPOSAL & ACCESS ROADS

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
ORIGINAL SHEET SIZE A1
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TSD PROJECT FILE NUMBER
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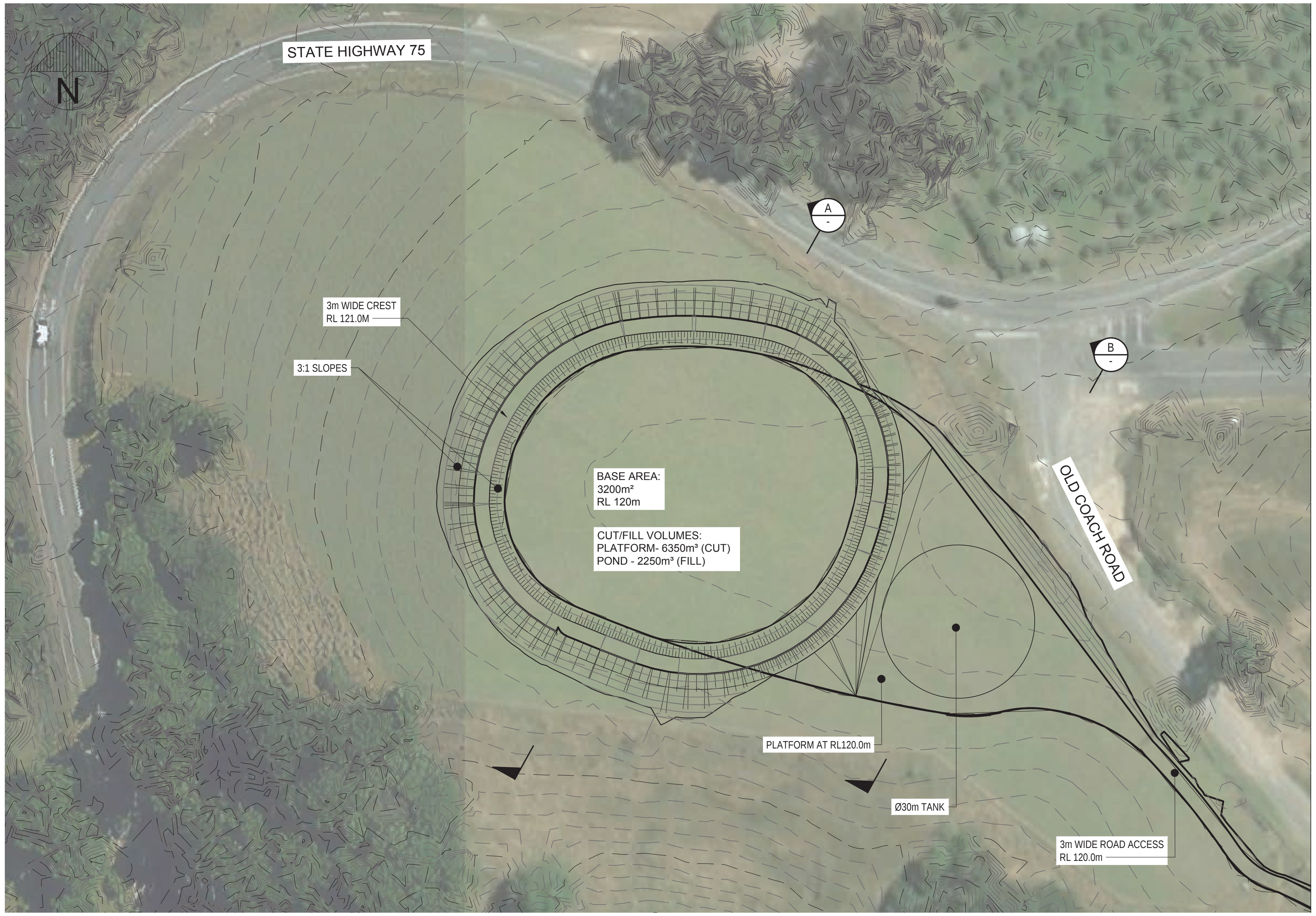

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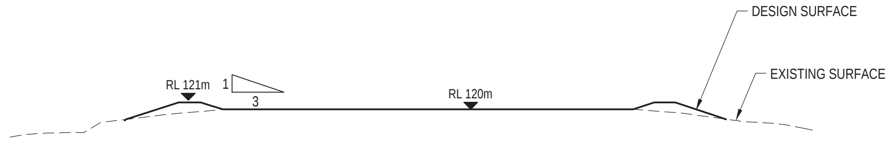

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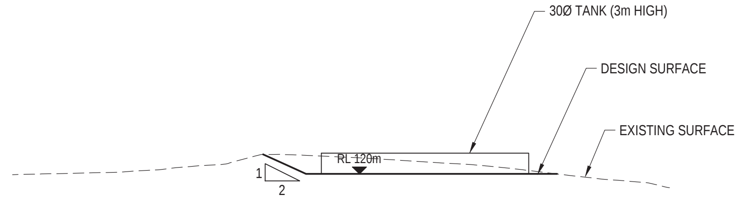

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RL		DES. REVIEW			
SURVEY		DRAWN	Tom Frowein		08/21
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CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-SK10.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED	
FOR TENDER	
DATE	SIGNED
FOR CONSTRUCTION	
DATE	SIGNED

CONSULTANT
Stantec

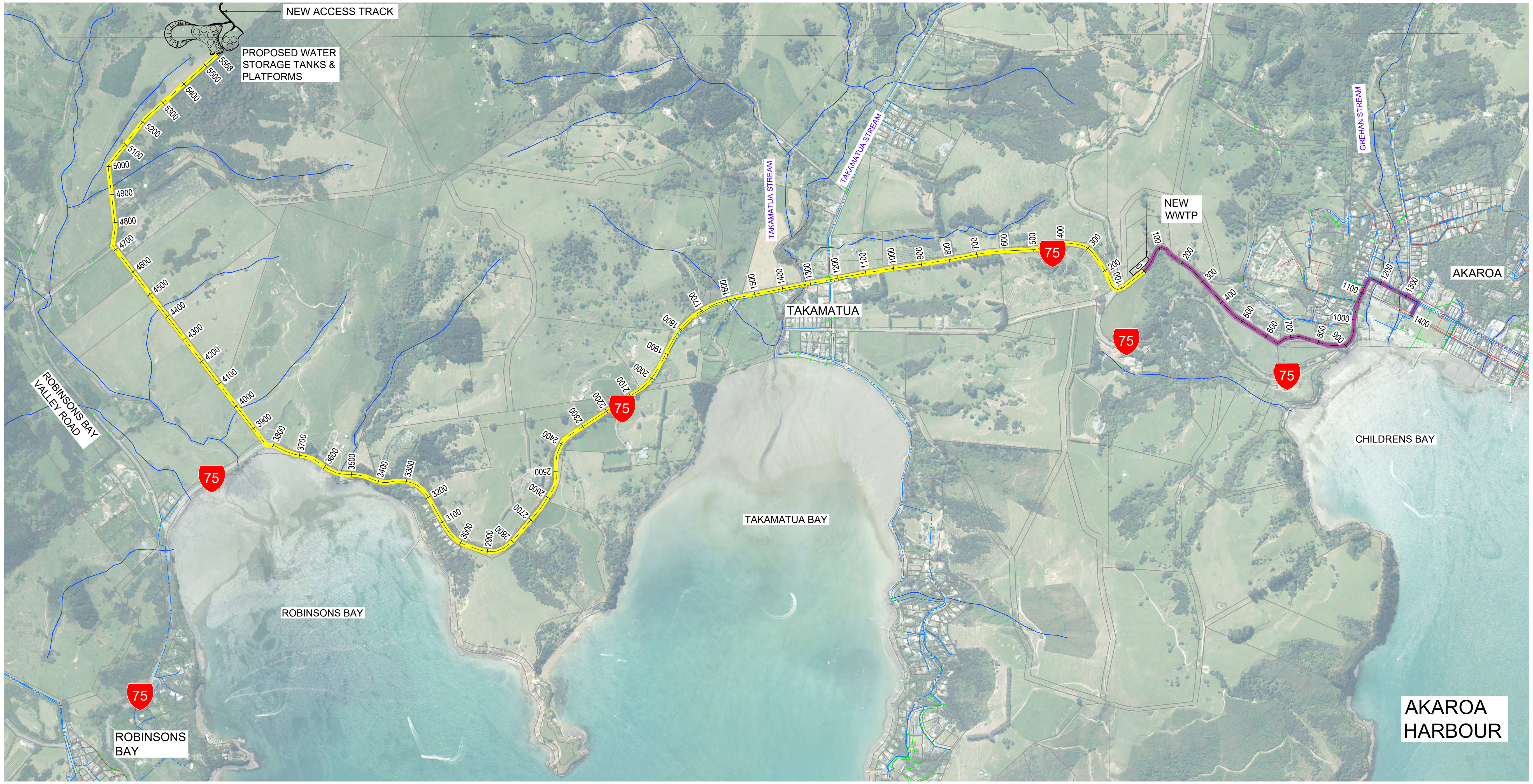
CONSULTANT PROJECT REF.	CONSULTANT FILE REF.
310103534	310103534-01-001-SK10

PROJECT TITLE
AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE
WETLAND AND STORAGE CONCEPT SITE PLAN

CONTRACT NUMBER	ORIGINAL SHEET SIZE	SCALES
	A1	AS SHOWN
CAD DRAWING FILE REF. 310103534-01-001		
TSD PROJECT FILE NUMBER		SHEET SK10 OF

Plan RMAXXXXXXXXC



WATER STORAGE TANKS & PIPELINE ROUTE - OVERVIEW PLAN

SCALE 1 : 7500

LEGEND :

- RIVER / STREAM
- WWTP DISCHARGE PIPELINE
- PURPLE PIPE SCHEME
- EXISTING COUNCIL WASTEWATER
- EXISTING COUNCIL STORMWATER
- EXISTING COUNCIL POTABLE WATER

NOTES:

1. DRAWING BASE DATASETS SHOWING INFORMATION SOURCED FROM LINZ. CROWN COPYRIGHT RESERVED.
2. CONTAINS SERVICE DATA SOURCED FROM CHRISTCHURCH CITY COUNCIL.
2. BASE DATASETS CREDITS: SOURCED FROM THE LINZ DATA SERVICE AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL
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FOR CONSENT
NOT FOR CONSTRUCTION

100 0 100 200 300m
SCALE 1:7500

ISSUE	AMENDMENTS	SIGNED	DATE
B	UPDATED ACCESS TRACK	MR	07.06.22
A	INITIAL DRAFT		

Christchurch City Council

DATUM	C.D.D.		NAME	SIGNED	DATE
BENCH MK.	NZTM	DESIGNED	Mark Ridge		12.21
RL		DES. REVIEW			
SURVEY		DRAWN	Blair Timblick		12.21
SURVEY LB		DRW. CHECK			
CPMS		FILE LOCATION			
DRAIN. REF.		310103534-01-001-C200.DWG			
SAP WBS		PRINTED ON 6-Jul-22 BY Frowein, Tom			

APPROVED
FOR TENDER: DATE / SIGNED
FOR CONSTRUCTION: DATE / SIGNED

CONSULTANT: Stantec
CONSULTANT PROJECT REF. 310103534
CONSULTANT FILE REF. 310103534-01-001-C200

PROJECT TITLE
AKAROA TREATED WASTEWATER IRRIGATION SCHEME

DRAWING TITLE
WATER STORAGE TANKS & PIPELINE ROUTE OVERVIEW PLAN

CONTRACT NUMBER
CAD DRAWING FILE REF. 310103534-01-001
ORIGINAL SHEET SIZE A1
SCALES AS SHOWN
TSD PROJECT FILE NUMBER
SHEET C200 OF

DESIGN WITH COMMUNITY IN MIND

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of place and of belonging. That's why at Stantec, we always design with community in mind.

We care about the communities we serve—because they're our communities too. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

Stantec trades on the TSX and the NYSE under the symbol STN.
Visit us at stantec.com or find us on social media.

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