Duvauchelle Wastewater Summary of Disposal and Reuse Options 2022

Report

Prepared for Christchurch City Council
Prepared by Beca Limited

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Revision History

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Executive Summary

The Duvauchelle Wastewater Treatment Plant (WWTP) currently disposes treated wastewater to the Akaroa harbour via an ocean outfall. The consent for this discharge is soon to expire. The purpose of this report is to document the review of long term options and the final shortlisting exercise for Duvauchelle wastewater management options, to inform stakeholder and community consultation.

A notable feature at Duvauchelle is the Council-owned golf course land (the Akaroa Golf Club) which is sufficient to irrigate 100% of local wastewater flows. The Council adopted irrigation of the golf course land at an early stage as the baseline option for beneficial reuse of Duvauchelle wastewater. Following development of options using the golf course site, the options assessment was extended to assess the feasibility of land disposal to site in the wider area. An evaluation of the longlisted options was undertaken based on the four well-beings: Cultural, Social, Economic and Environmental.

The submissions of the Ngāi Tahu parties show potential for significant adverse cultural impacts from continuing discharge of treated wastewater to the Akaroa Harbour. These effects are multi-dimensional and include the impact on food gathering, on the mahinga kai, and on the mauri of the Akaroa Harbour. They provide strong direction for the Council to develop and implement a land-based treatment scheme through which all wastewater has its mauri restored before entering water. National and regional policies for water management also support this direction.

A wide range of options have been considered for treatment and disposal or reuse of wastewater from the Duvauchelle community. This assessment is effectively a summary of a range of investigative work conducted and reported on separately. The recommended shortlist to council, submitted in April 2022, and the final decision of council on options to be carried forward for public consultation, is summarised below.

It is important to note that extensive engagement with stakeholers including Ōnuku Rūnanga has been ongoing throughout the development and refinement of the options. Ōnuku Rūnanga has issued a letter to Council on 5th of April supporting the two preferred schemes, namely Options A4 and B3 as shown below.

Ref.	Option	Shortlisting Recommendation to Council	Final Shortlist by Council
A1	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and add a wetland	Not recommended due to very high costs, nutrient impacts on stream and difficult to consent	Excluded
A2	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and also irrigate margin areas	Not recommended as similar to A1 and even higher costs	Excluded
A3	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course plus margin areas and neighbouring land	Not recommended as similar to A1 and even higher costs, but does not discharge to water.	Excluded
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions, irrigate planted course margins including upslope area year round	Recommended due to moderate cost and community stakeholder support for reuse benefits	Included
B1	Irrigate planted course margins including upslope area – retain 18 holes with storage on the golf course	Not recommended due to risk of cultural and environmental effects. However – subject to option improvements through I&I reduction, or increase to land / storage / irrigation rate	Excluded
B2	Irrigate planted course margins including upslope area – reduce course to 12 holes with storage on the golf course	Not recommended due to community opposition compared to other golf course options. However – opportunities could arise if site Master Plan redeveloped	Excluded
B3	Irrigate planted margins including upslope area – retain 18 holes, and also irrigate	Recommended due to favourable balance of costs and benefits and greater operational	Included

Ref.	Option	Shortlisting Recommendation to Council	Final Shortlist by Council
	other land on golf course or beyond the boundary of the site. Storage on golf course or other land	flexibility. Final confirmation of irrigated land area will be influenced by landowner negotiations	
C1	Dis-establish golf course and irrigate wastewater onto trees on the golf course land	Not recommended due to significant community impact.	Excluded
D1	Irrigate wastewater onto land at the Head of the Bay	Not recommended as other options available with similar outcome for lower cost and avoid Silent File issue	Excluded
D2	Irrigate land elsewhere on the western side of Akaroa Harbour Basin	Not recommended as other options available with similar outcome for lower cost	Excluded
D3	Irrigate land in Robinsons Bay (separate to Akaroa Scheme land)	Not recommended due to high costs and likely strong opposition by local community.	Excluded
E1	Discharge to harbour	Difficult to consent due to cultural concerns and legal and policy settings.	Excluded

The final two shortlisted options are A4 – irrigate treated wastewater onto playing areas within the existing 18 hole golf course and planted course margins, and B3 – irrigate only the planted margins + additional land on the golf course property or beyond the property. Requirements to upgrade the treatment plant for options A4 and B3 are summarised in the table below.

Wastewater Management Option	Wastewater Reuse/Disposal	Treatment Upgrade Requirement
A4	Publicly accessed land, spray irrigation	Major upgrade (e.g. membranes and UV) to achieve 4 or 5 accredited log reductions to address public health and environmental risks.
B3	Managed public access, drip irrigation	Minor upgrade involving filtration to 130 microns to prevent dripper blockage. Pathogen exposure risk is managed by the method of wastewater application and by controlling public access to planted irrigation areas.

The cost estimates for the final short-listed options are summarised below.

Option	Description	Concept Cost Estimate	Annual Operating Cost Estimate	35yr Net Present Value Estimate
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions, irrigate planted course margins including upslope area year round	$13,100,000	$240,000	$17,080,000
B3	Irrigate the course margins and upslope area – maintain 18 holes, and also irrigate other land on golf course margins or beyond the boundary of the site	$8,200,000	$200,000	$11,770,000

The net carbon impact of shortlisted options is summarised below:

Parameter	Net Emissions over 35 years (tCO_2-e)	
	A4	B3
Capital Emissions	705	348
Operational Emissions	1,058	660
Carbon Sequestration	-5,226	-5,010
Net emissions over useful life of asset (35 years)	-3,463	-4,002

1 Introduction

1.1 Background

The Duvauchelle Wastewater Treatment Plant (WWTP) currently disposes treated wastewater to the Akaroa harbour via an ocean outfall. The consent for this discharge is soon to expire. Christchurch City Council (Council) is investigating an alternative discharge option which involves irrigation of treated wastewater from the WWTP onto land at the Akaroa Golf Course in Duvauchelle. Beca Limited (Beca) has been commissioned by the Council to develop scheme options, concept designs and prepare an assessment of effects (AEE) for the preferred scheme.

Phase 1 of the project was summarised in the CH2M Beca report *Duvauchelle Wastewater Irrigation Feasibility Assessment, Rev B, November 2017* which included initial concept design options and cost estimates. The concepts were further developed in the Beca Ltd report *Duvauchelle Wastewater Irrigation Option Concept Report, Rev B, March 2019.* The Beca Ltd report *Duvauchelle Wastewater Summary of Disposal and Reuse Options, Rev A, September 2020* summarised Beca's findings from further investigations, design and assessments of options for treated wastewater disposal. The design revisions canvassed in this report are largely driven by new proposals to redevelop the golf course. These proposals have been put forward by RBT Design Ltd, a golf course design company, commissioned separately by Christchurch City Council for this task. In 2021 further investigations, assessment and modelling were completed to extend the long list of options considered, to enhance Council's feasibility assessment against the four well-beings.

The purpose of this report is to document the outcomes from an assessment of options for treatment, disposal and reuse of treated municipal wastewater at Duvauchelle. This report is intended to provide a summary of the longlist and shortlisting process, for the purpose of progressing with Council, stakeholder and community consultation on those shortlisted options.

1.2 Scope

The scope of this report includes investigations into land-based disposal and reuse of treated wastewater from Duvauchelle that have been investigated since 2017.

A notable feature at Duvauchelle is the Council-owned golf course land (the Akaroa Golf Club) which is sufficient to irrigate 100% of local wastewater flows. The Council adopted irrigation of the golf course land at an early stage as the baseline option for beneficial reuse of Duvauchelle wastewater. Thus specific development of scheme options for that site including investigations, technical assessments, concept designs, cost estimates, risk assessment, stakeholder engagement and decision-making processes have been undertaken.

Following development of options using the golf course site, the options assessment was extended to assess the feasibility of land disposal to site in the wider area. An evaluation of the longlisted options was undertaken based on the four well-beings: cultural, social, economic and environmental.

1.3 Information Received

The following information was received from the Council:

- EcoEng Irrigation of Treated Domestic Wastewater, Duvauchelle, Preliminary Report, Evaluation of Site Options, March 2013
- CRC102952 Duvauchelle Wastewater Treatment Plant Monitoring Data Lab Results (31 January 2011 – 31 July 2020)

- Discharge flow from the Duvauchelle Wastewater Treatment Plant (01 December 2017 – 31 August 2019), then extended to 21 October 2020
- Rainfall data from the Akaroa EWS station for the same period
- Akaroa Golf Course fairways map
- Akaroa Golf Course drone and LiDAR survey data (mesh, point cloud, contour plan, aerial photo mosaic, and flyover video)
- A site visit was undertaken with the Akaroa Golf Club 04 December 2017 to review the site condition and discuss design options
- RBT Design Akaroa Golf Club Developed Design, 07 August 2020
- Duvauchelle Outfall Inspection Reports 2006, 20210, 2011, 2013
- Duvauchelle Wastewater Treatment Plant Clarifier Outlet Water Quality during 2019-20 Summer Sampling Programme at Duvauchelle WWTP
- Duvauchelle Wastewater Pump Station flow data November 2018 to July 2019, then extended to 21 October 2020
- A field trial to determine the effect of the land application of treated municipal wastewater onto selected NZ-native plants on Banks Peninsula, Robinson B. and Meister A, 2020
- RBT Design Akaroa Golf Club reduced design options correspondence, May 2021
- Letter from Ōnuku Rūnanga to Council on their views on the options, 5 April 2022.

1.4 Statutory Overview

The Council has been investigating long term options for management of Duvauchelle for the past 12 years. Beca was commissioned in 2017 to develop concepts and costs for a land-based irrigation scheme focussing on land at the golf course at Duvauchelle.

Duvauchelle wastewater is currently treated in a secondary treatment process with tertiary UV disinfection and disposed to Akaroa Harbour through a 1.6 km long outfall. The Duvauchelle wastewater discharge consent expires in January 2023. The Council is reviewing options for future management of Duvauchelle wastewater and this process has been informed by separate but related wastewater planning activities at Akaroa, located 7 km distant and within the same harbour basin.

Resource consents to discharge treated wastewater from Akaroa to the harbour were declined in 2015 because of the cultural effects of a direct discharge to the harbour and because alternatives to a harbour outfall had not been sufficiently investigated. The Council spent the following five years exploring land-based alternatives to a harbour discharge from Akaroa. In 2020, it undertook public consultation on four options, three of which involve irrigating native trees with wastewater and a fourth option of a harbour outfall. The Council decided on the option to irrigate new areas of native trees in Robinsons Bay and Takamātua and parks in Akaroa, and to explore non-potable reuse within Akaroa.

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

For the Duvauchelle Wastewater Project, the Council will be making a Local Government Act 2002 (LGA) decision on which wastewater discharge option it will pursue. Under section 14.1 of the LGA:

> *(c) when making a decision, a local authority should take account of—*

(i) the diversity of the community, and the community's interests, within its district or region; and

(ii) the interests of future as well as current communities; and

(iii) *the likely impact of any decision on each aspect of well-being referred to in section 10:*

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

(h) in taking a sustainable development approach, a local authority should take into account—

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

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

(iii) *the reasonably foreseeable needs of future generations.*

Under Section 77 of the LGA:

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

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

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

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

The option must also be consentable as sustainable management under the Resource Management Act 1991 (RMA).

The Council has been working with the Duvauchelle Wastewater Working Party, which was set up by the Banks Peninsula Community Board in 2011 to assist the Council in exploring land-based alternatives to a harbour outfall. The wastewater working party includes members representing Ōnuku Rūnanga and Te Rūnanga o Ngāi Tahu, Environment Canterbury, the Akaroa Golf Club, the Banks Peninsula Pony Club, the Duvauchelle A&P Showground committee, and the Duvauchelle public. The working party has provided invaluable input, guidance and feedback on various proposals over the duration of the scheme investigations.

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

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

a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.

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

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

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

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

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

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

8.3.9 Direct discharge of sewage into the coastal marine area

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

> *1. Alternative methods, sites and routes for undertaking the discharges have been considered; and*
>
> *2. There has been consultation with Ngāi Tahu as tāngata whenua and particular regard had for their values and the effects of discharges on those values; charges on those values;*
>
> *the human sewage is treated in a manner appropriate to the receiving environment.*

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

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

> *a. the discharge better meets the purpose of the Act than disposal through land or a wetland outside the Coastal Marine Area; and*
>
> *b. there has been consultation by the applicant with Tāngata whenua in accordance with Tikanga Māori and due weight has been given to sections 6, 7 and 8 of the Act; and*
>
> *c. there has been consultation by the applicant with the community generally; and*
>
> *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.*

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

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

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

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

The submissions of the Ngāi Tahu parties show potential for significant adverse cultural impacts from continuing discharge of treated wastewater to the Akaroa Harbour. These effects are multi-dimensional and include the impact on food gathering, on the mahinga kai, and on the mauri of the Akaroa Harbour. They provide strong direction for the Council to develop and implement a land-based treatment scheme through which all effluent makes contact with Papatūānuku before entering water. The regulatory policies set out above also support this direction.

1.5 Design Flows and Loads

1.5.1 Wastewater Flows

The design basis wastewater flows are set out in Table 1-1, refer to Appendix F3 for details on the modelling. Note that the flows referenced below and in Appendix F3 exclude a 10 m^3/day allowance for backwash from the Duvauchelle Water Treatment Plant, that was previously included. This change takes account of a project to treat and dispose of water treatment plant backwash separately.

Table 1-1 Duvauchelle Wastewater Scheme Design Basis Flows

Design Parameter	Flow monitoring data(1)	2021 modelled flow	2053 modelled flow
Average flow (m^3/day)	69	75	73
Median flow (m^3/day)	60	54	54
Maximum flow(2) (m^3/day)	769	667	545

Notes.

(1) Monitoring data for pump station from 22/11/2018 to 21/10/2020. Earlier monitoring data for 1/12/2017 to 21/11/2018 has been adjusted to correct for a flow monitoring error identified in late 2018

(2) The modelled flow for the maximum rainfall day over a 47 year time series

1.5.2 Wastewater Quality

Wastewater quality data for 2014 – 2019 is presented in Table 1-2 (refer to Appendix D for dataset). Samples are taken weekly in summer and monthly for the remainder of the year. Samples are taken at the outlet of the treatment plant post-UV disinfection.

Table 1-2 Treated Wastewater Quality (data from 8/01/2014 to 3/10/2019[3])

	BOD_5 (g/m^3)	Suspended Solids (g/m^3)	Faecal Coliforms (CFU/100mL)	Enterococci (MPN/100mL)	Dissolved Reactive Phosphorus (g/m^3)	Ammoniacal Nitrogen (g/m^3)	Total Nitrogen (g/m^3)
Minimum	1.0	3.0	1	10	0.6	0.0	5.6
Median	5.8	17.0	10	10	3.9	1.2	26.0
Mean[3]	7.6	18.3	18[2]	13[2]	4.6	6.8	35.2
95%ile	13.0	28.0	60	29	6.8	15.4	48.1
Maximum	21.0	38.0	52,000[1]	2,300	7.4	38.0	60.0

(1) There are a number of outlier values of faecal coliform count in the data. Recent high values do not appear to be related to high rainfall events and may be related to a plant bypass or UV fault.

(2) The data values reported for faecal coliforms and enterococci are geometric means. Other parameters are arithmetic means.

(3) Reported mean (average) range includes from 5/12/2017 to 6/11/2019 only (reflecting the period of available data).

The average total nitrogen leaving the plant over the time period from 5/12/2017 to 6/11/2019 is 35.2 g/m^3, whereas the ammoniacal nitrogen (NH_4-N) is significantly less at 6.8 g/m^3. In raw wastewater, the NH_4-N is expected to be at least 60% of the total nitrogen (and of the Total Kjeldahl Nitrogen (TKN)), as nitrate and nitrite are not expected to be present) (Metcalf & Eddy, 2014). As the average NH_4-N in the treated effluent is only 19% of the total nitrogen, this indicates that nitrification is occurring during the treatment process where NH_4-N is converted to nitrate and nitrite.

As part of this project, a summer sampling programme was recommended to better characterise the operation of the plant under peak summer loads. The results of the monitoring programme conducted in the 2019 – 2020 summer period are summarised in Table 1-3 along with comparative historical data. None of the parameters (faecal coliforms, total suspended solids (TSS) or BOD_5) measured over the summer exceeded the historical maximum. The minimum pH recorded was 6.9

Table 1-3 UV Outlet Water Quality - 2019-20 Summer Sampling Programme and Historical Water Quality (2014 – 2019)

		BOD_5 (mg/L)	TSS (mg/L)	Turbidity (NTU)	Faecal Coliforms (CFU/100mL)	pH
2019-20 Summer Sampling – UV Outlet[1]	Mean[2]	8.2	20.9	10	70	7.3
	Median	8.8	20.5	9.1	90	7.4
	Maximum	9.4	30.0	13	660	7.5
Historical Data	Mean[2]	6.5	17.0	N/A	18.1	N/A
	Maximum	21.0	38.0	N/A	52,000	N/A

(1) All samples collected at the plant outlet downstream of the UV disinfection unit

(2) The data values reported for faecal coliforms are geometric means. Other parameters are arithmetic means.

1.5.3 Data Confidence

The accuracy of the synthetic flow record depends on the quality of the flow monitoring data. A number of issues with flow monitoring data accuracy have been identified and progressively resolved. In late 2018 a water spray on the treatment plant clarifier that operates for most of the time was identified as causing an error in plant flow monitoring (i.e. as some water was recirculated back through the plant, actual outflow was lower than measured). This error was corrected and the flow modelling and design basis in this report is based on the following:

- Monitoring data for pump station from 22/11/2018 to 21/10/2020.
- Earlier monitoring data for 1/12/2017 to 21/11/2018 has been adjusted to correct for the water spray error

It is assumed that the average dry weather flow from the limited measurement period is representative of the whole year, and that 2018 is a representative year. The model calculates inflow and infiltration (I&I) based on the relationship of rainfall vs. flow for the measured period. Due to the limited number of data points, this relationship should only be considered as approximate.

We recommend that flows and rainfall continued to be recorded, and used to re-run the flow model as the work progresses to allow the design basis to be refined as part of detailed design.

1.6 Irrigation to Land Option Development

1.6.1 Option Development

Potential sites for irrigation and wastewater storage outlined in this report were selected using a GIS (geographical information system) model that was developed by CH2M Beca in 2017. The GIS model employs a range of criteria incorporated into an algorithm to initially screen potentially irrigable land to avoid impacts on surrounding properties, public roads, waterways, the coastline and other sensitive features. One of the most important criteria is land slope. Steeper land poses higher risks for wastewater irrigation due to the potential for land to be destabilised by the application of wastewater, and also for wastewater to runoff across the land surface.

The basic requirement is for land slope or 15 degrees or less for irrigation of pasture, or 19 degrees or less for irrigation of trees. These criteria are set out in the USEPA Process Design Manual for Land Treatment of Municipal Wastewater 2011. Irrigation of pasture (e.g. golf course playing areas) and irrigation of trees (planted margins) are both under consideration for the Duvauchelle Wastewater Scheme. It is assumed for the initial specification of setbacks that golf course playing areas will be spray irrigated and that trees (planted margins) will be dripper irrigated. A summary of all GIS criteria is set out in Table 1-4 below. The results of the GIS mapping are attached in Appendix A.

Table 1-4 Irrigation Site Selection Criteria

Selection Criteria	Spray irrigation of golf course playing areas	Dripper irrigation of planted margins
Land Stability[1]	Exclude land with slope > 15 degrees and land with downslope slope > 15 degrees Exclude land with instability within or downhill of area Exclude land that, if it became unstable, could pose risk to downslope infrastructure	Exclude land with slope of > 19 degrees and land with downslope of > 15 degrees Exclude land with instability within or downhill of area Exclude land that, if it became unstable, could pose risk to downslope infrastructure
Erosion zones	Tonkin & Taylor (T&T) instability zones excluded	
Residential setback	Potentially irrigable land within 25 m of boundary is excluded.	Potentially irrigable land within 5 m of boundary is excluded.
Stream setback	25 m to centreline of continuous flowing streams. 10 m setback to ephemeral streams	
Coastline setback	25 m	

Note 1 In accordance with Process Design Manual for Land Treatment of Municipal Wastewater (USEPA, 2011).

It is important to note that the GIS model is used for initial screening of land, and does not preclude irrigation of any specific land parcel subject to a site-specific investigation. Site-specific geotechnical investigation reports are included in Appendix C and contaminated land reports in Appendix G. In the case of the golf course land, initial screening ruled out a significant upper slope area on the northern perimeter of the golf course as it was steeper than 19 degrees. Subsequent further study of this land by a Beca geotechnical engineer and also wastewater irrigation specialist, including a site walkover, resulted in portions of this land being re-assessed as suitable. GIS analysis also confirmed that the land slope is only slightly outside the prescribed range (about 20 – 21 degrees). As a result of this further work, part of the upper slope area was added back in as viable irrigation area. To assess the storage requirement the model compares the daily wastewater flow to the volume that can be irrigated for every day in the time series. For any day when not all of the wastewater is able to be irrigated, the surplus wastewater goes to storage. The stored volume typically increases in the winter and as a result of heavy rainfall.

Storage can be provided in ponds or tanks. Development of concept designs for storage needs to consider resilience requirements and risks. This includes seismic design and also the risk of inundation of downgradient areas in the event of storage failure (dam break analysis). Unless otherwise specified within this report, ponds are assumed to be uncovered (will receive rainfall) and tanks are assumed to be covered.

Where the golf course playing surface itself either forms part of the irrigation to land scheme, or is bounding irrigated areas, the effects on the course and opportunities to enhance it have been assessed. Golf course specialists (initially RBT Design, then NKLA Ltd) were engaged to provided inputs at the developed design stage, these are attached in Appendix E.

1.6.2 Irrigation Model

The irrigation scheme design is based on a soil moisture water balance model (SMWBM). This model incorporates a 47 year synthetic (synthetic refers to the record being developed from the data and assumptions noted below, rather than a historic record of actual flows) flow record from 1972 – 2019 and models soil moisture water levels for each day over that time series using Python software. The irrigation model uses input data including soil properties, rainfall, potential evapotranspiration (PET) and the treated

wastewater flow. The model uses this input data to calculate irrigation application, infiltration, runoff, drainage and storage.

Long term rainfall and potential evapotranspiration data was obtained from NIWA's Virtual Climate Network Station (VCNS 20116) and Onawe Duvauchelle Bay weather station (Station 327901):

- Onawe Rainfall from 1972 to 2012
- VCN20116 Rainfall from 2013 to 2019 (reduced by 23%) and to fill in gaps in Onawe between 1972 and 2012
- VCN20116 evapotranspiration (PET) from 1972 to 2019.

Key soil moisture water balance modelling assumptions are as follows:

- Treated wastewater flow: long term synthetic flow estimate including future population, 20% reduction in ground water infiltration (GWI) and 20% reduction in rainfall derived inflow and infiltration (RDII)
- Rainfall: Onawe (1972 to 2012), adjusted NIWA VCN20116 (2013 to 2019)
- Rainfall cut off: no irrigation if rainfall = 30 mm/day
- Potential evapotranspiration (PET): NIWA VCN20116
- Irrigation demand threshold: varies depending on option
- Irrigation efficiency 85% efficiency.

Appendix F contains reports from the various scheme option modelling. Note that as options developed the design flows and modelling methodology also evolved and older modelling results will not be directly comparable to the latest results presented within this report. Model results and therefore design elements for each option are sensitive to I&I and flow basis assumptions, storage volumes and covered/uncovered storage assumptions, irrigation application rates, and irrigable land areas.

2 Longlist Options

2.1 Long list screening

A wide range of options were considered for treatment and disposal or reuse of wastewater from the Duvauchelle community. Several opportunities and constraints were identified at the start of the scheme investigation, including the following:

- The existing Duvauchelle Wastewater Treatment Plant could potentially be retained in the long term, as it operates reliably and produces a good quality secondary treated wastewater.
- Wastewater should ideally be reused/disposed via irrigation onto land in order to avoid discharging to water. This policy is informed by engagement with stakeholders over the Akaroa Wastewater Scheme where cultural values associated with Akaroa Harbour were identified as a key concern.
- There could be potential to irrigate the golf course at Duvauchelle where the land is owned by Christchurch City Council and the golf course is operated by the Akaroa Golf Club.

From this starting point a range of options have been progressively scope and developed and discussed with stakeholders. The wastewater management options essentially fall into five categories as follows:

- Irrigate the golf course playing area (spray irrigation of public spaces and corresponding major upgrade to treatment plant to achieve a treated wastewater quality suitable for this use) and, in some sub-options, additional land either within the golf course site or elsewhere (A schemes)
- Irrigate the golf course margins, but not the playing area itself (B schemes), and, in some sub-options, additional land either within the golf course site or elsewhere
- Dis-establish the golf course and plant and irrigate trees on the golf course land (C schemes)
- Irrigate other land (D schemes)
- Discharge to harbour (E scheme)

A summary of the long list scheme options that have been investigated and reported on from 2017 to 2022, and grouped into the above categories, is set out in Table 2-1. Schematics of the key options are attached in Appendix B.

Table 2-1 Duvauchelle Wastewater Scheme Longlist of Options

No.	Option	Description
A1	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and add a wetland	Redevelop the golf course to provide sand layers, improve drainage and make the course playable all year round, and reduce the course to 12 holes. Spray irrigate about 3.6 ha of tees, greens and approaches. Provide 5000 m^3 of pond storage and a 1 ha sub-surface wetland to treat regular drainage flows prior to discharge to receiving waters (either Pawsons Stream or the harbour). Major upgrade to the treatment plant is needed to meet pathogen limits for spray irrigation.
A2	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and also irrigate margin areas	Redevelop the golf course to provide sand layers, improve drainage and make the course playable all year round, and reduce the course to 12 holes. Spray irrigate about 3.6 ha of tees, greens and approaches. Also irrigate 9.6 ha of planted margins to achieve a 1:5 year wastewater overflow frequency. Major upgrade to the treatment plant to meet pathogen limits for spray irrigation. Also provide 5000 m^3 of pond storage.
A3	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and irrigate margin areas plus	Redevelop the golf course to provide sand layers, improve drainage and make the course playable all year round, and reduce the course to 12 holes. Spray irrigate about 3.6 ha of tees, greens and approaches, and reduce the course to 12 holes. A major upgrade of the treatment plant for spray irrigation

No.	Option	Description
	neighbouring land to reduce overflow frequency	is required. Also irrigate 15.6 ha of planted margins to achieve no overflows to Pawsons Stream. Provide 5000 m^3 of pond storage.
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions. Irrigate planted course margins including upslope area year round	Maintain the existing 18 hole golf course layout. Extend plantings within course margins to provide a total of 8.2 ha of irrigable area. Irrigate the playing areas (7.5 ha) in dry conditions (likely summer) and the planted margins throughout the year. A major upgrade of the treatment plant for spray irrigation is required. Also provide 3,750 m^3 of covered storage.
B1	Irrigate the course margins and upslope area – retain 18 holes with storage on the golf course	Retain the 18 hole layout and drip irrigate 6.2 ha of existing/historically tree planted course margins. Provide a minor upgrade of the treatment plant and 5,000 m^3 of covered storage on the golf course in tanks. Modelling shows that the scheme achieves no overflows, but this is sensitive to assumptions.
B2	Irrigate the course margins and upslope area – reduce the course to 12 holes with storage on the golf course	Reconfigure the course as 12 holes, improve course drainage, and drip irrigate 9.4 ha of course margin area. Provide about 3,200 m^3 of covered storage in tanks. Minor upgrade to the treatment plant. Scheme achieves no overflows and is more flexible/resilient than B1 due to increased irrigation area.
B3	Irrigate the course margins and upslope area - retain 18 hole, and also irrigate other land on golf course margins or beyond the boundary of the site. Storage on golf course or other land.	Retain the 18 hole layout, and drip irrigate 6.2 ha of golf course margins and upslope area. Provide an additional 2.0 - 3.1 ha of irrigation and 3,200 m^3 of covered storage within further course margins or on other privately owned land. Minor upgrade to the treatment plant. Scheme achieves no overflows and is more flexible/resilient than B1 due to increased irrigation area.
C1	Irrigate wastewater onto trees planted on the golf course land	Dis-establish the golf course and plant native trees within irrigable areas of the golf course site. Provide a covered storage tank (2,000m^3) and irrigate wastewater onto the trees all year round. Minor upgrade to the treatment plant. Scheme achieves no overflows.
D1	Irrigate wastewater onto land at the Head of the Bay	Irrigate a different site and do nothing at the golf course. The identified irrigable land is 8.0 ha on a promontory that forms part of Onawe Peninsula. Provide about 4,500 m^3 of covered storage. Minor upgrade to the treatment plant. Scheme achieves no overflows.
D2	Irrigate land elsewhere on the western side of Akaroa Harbour Basin	Irrigate on the western side of Akaroa Harbour Land will be greater distance from treatment plant than other options.
D3	Irrigate land in Robinsons Bay (separate to the Akaroa Wastewater Scheme land)	Pump wastewater to Robinsons Bay and irrigate 11 ha of land in the lower valley, separate from the irrigation area set aside for the Akaroa Wastewater Scheme. Storage requirements and overflow frequency to be confirmed.
E1	Discharge to harbour	Discharge wastewater from the existing or upgraded wastewater treatment plant to Akaroa Harbour via a harbour outfall. This would be a continuation of the current wastewater disposal arrangement.

The longlist options identified above were assessed using the four well-beings set out in Section 10 of the Local Government Act 2002. This assessment is effectively a summary of a range of investigative work conducted and reported in separately. This comparative assessment was done using traffic lights according to the method set out in Table 2-2.

Table 2-2 Longlist Assessment Methodology

Traffic Light Assessment of Longlist Options		
Comparatively unfavourable or “fatally flawed“ denoted as red	Moderate performance denoted as orange	Comparatively favourable denoted as green

The evaluation of cultural and social well-beings has been dealt with as follows:

- Mana whenua should be consulted on cultural well-beings in relation to specific scheme options. The cultural performance of options described here is a notification of a viewpoint that has been expressed by Ōnuku Rūnanga for that particular option. Where no viewpoint has been expressed about an option this is denoted as “ unspecified” in Table 2-1.
- Social wellbeing for wastewater options has not been assessed using formal tools such as social impact assessment. The attributes noted in the table represent a summary of the viewpoints expressed by local stakeholders and the Duvauchelle Wastewater Working Party to Council as a result of engagement activity and where these viewpoints provide a clear position. Where no views have been sought or expressed the attribute is denoted as “unknown”.
- Further ongoing engagement with stakeholders is recommended to provide confidence that shortlisted options are suitable and meet the needs of the community.

The longlist of options and the evaluation of the four well-beings as presented to Councillors at a meeting on 6 April is shown in Table 2-3.

Table 2-3 Duvauchelle Wastewater Scheme Longlist Assessment and Recommendations to Council

Ref.	Option	Plant Upgrade	Irrigation & Storage	CAPEX OPEX 35yr NPV	Net Carbon Emissions (35 years)	Cultural Wellbeing	Social Wellbeing	Economic Wellbeing	Environmental Wellbeing	Staff suggestion for consultation shortlist
A1	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and add a wetland	Major upgrade to meet spray irrigation standard	3.6 ha plus fairways and surrounds, 1 ha wetland + 5,000 m³ storage	≈$25M		May be acceptable to Ngāi Tahu depending on wetland performance	Initially favoured by golf club (no longer) but impacts the A&P Showground which would have to move	Very high costs	Potential impacts on water quality and ecology as regular overflows to stream winter. Difficult to consent	**Not recommended** due to very high costs, nutrient impacts on stream (NPSFM) and difficult to consent.
A2	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and also irrigate margin areas	Major upgrade to meet spray irrigation standard	3.6 ha fairways plus 9.6 ha of planted margins + 5,000 m³ storage	≈$25M ≈$380K ≈$30M		May have a cultural challenge due to 1 in 5 year overflow of treated storage to harbour	Initially favoured by golf club (no longer) but impacts the A&P Showground. Course upgrades may offset the loss of holes.	Very high costs due to need for additional land and golf course upgrades	Likely minimal impacts on water resources + carbon benefits. Has a 1 in 5 year overflow frequency	**Not recommended** as similar to A1 and even higher costs
A3	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course plus margin areas and neighbouring land	Major upgrade to meet spray irrigation standard	3.6 ha fairways plus 15.6 ha of planted margins plus neighbouring land + 5,000 m³ storage	≈$26M ≈$380K ≈$31M		Likely favoured by Ngāi Tahu as no discharge to water	Initially favoured by golf club (no longer) but impact the A&P Showground. May be concern in community around irrigating neighbouring land.	Very high costs due to need for additional land and golf course upgrades	Minimal impacts on water resources	Not recommended as similar to A1 and even higher costs **However - subject to review by Councillors.**
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions, Irrigate planted course margins including upslope area year round	Major upgrade to meet spray irrigation standard	Approx. 8-9 ha of trees plus approx. golf course playing surface + 3,750 m³ storage	≈$13M ≈$240K ≈$17M		Likely favoured by Ngāi Tahu as no discharge to water	Favoured by golf club; beneficial reuse and benefit to golf club thus community. No obvious problems but need to select a storage location	Moderate cost due to need for major upgrade to Plant and additional irrigation and drainage infrastructure	Likely minimal impacts on water resources + carbon benefits. Irrigation for golf course reduces stream water take	Recommended due to moderate cost and community stakeholder support for reuse benefits. **Recommended by staff**
B1	Irrigate planted course margins including upslope area – retain 18 holes with storage on the golf course	Minor upgrade	6.2 ha of trees + 5,000 m³ storage	≈$9M ≈$200K ≈$13M		May have a cultural challenge due to limitations in irrigated land and storage causing risk of 1 in 5 year overflow of treated storage to harbour	No obvious problems but need to select a storage location	Comparatively lower cost	Likely minimal impacts on water resources + carbon benefits. Risk of insufficient irrigable land or storage	Not recommended due to risk of Cultural and Environmental effects. **However – subject to option improvements through I&I reduction, or increase to land / storage / irrigation rate**
B2	Irrigate planted course margins including upslope area – reduce course to 12 holes with storage on the golf course	Minor upgrade	9.4 ha of trees + 3,200 m³ storage	≈$13M ≈$320K ≈$19M		Likely favoured by Ngāi Tahu as no discharge to water	Golf course reduced to 12 holes, has impact on player experience so golf club no longer in favour. Land-sharing to offset with A&P Showground and Pony Club not favoured by parties.	Comparatively lower cost	Likely minimal impacts on water resources + carbon benefits	Not recommended due to community opposition compared to other golf course options. **However – opportunities could arise if site Master Plan redeveloped**
B3	Irrigate planted course margins including upslope area –retain 18 holes, and also irrigate other land on golf course margins or beyond the boundary of the site. Storage on the golf course or other land	Minor upgrade	8.2-9.4 ha of trees + 3,200 m³ storage	≈$8M ≈$200K ≈$12M		Likely favoured by Ngāi Tahu as no discharge to water	No obvious problems but need to select a storage location	Comparatively low, but extra cost for additional land. Provides more capacity for growth.	Likely minimal impacts on water resources + carbon benefits	Recommended due to favourable balance of costs and benefits and greater operational flexibility. **Recommended by staff. Dependant on land owner negotiations**
C1	Dis-establish golf course and irrigate wastewater onto trees on the golf course land	Minor upgrade	19.1 ha of trees + 2,000 m³ storage	≈$8M ≈$220K ≈$11M		Not favoured by Ngāi Tahu due to social impacts, albeit favoured for no discharge to water	Will be strongly opposed by golf club and wider community	Comparatively lower cost	Likely minimal impacts on water resources + carbon benefits	Low cost and positive environmental outcomes. Significant community impact. Alternative recreational use of site would have to be developed. **Recommendation subject to review by Councillors**
D1	Irrigate wastewater onto land at the Head of the Bay	Minor upgrade	8.0 ha of trees + 4,500 m³ storage			Ngāi Tahu have expressed concerns due to Silent File but would discuss further if only land-based option available	Neutral – on private land	While the land is not for sale the owner may consider irrigation of native trees on site	Likely minimal impacts on water resources + carbon benefits	**Not recommended** as other options available with similar outcome for lower cost and avoid Silent File issue
D2	Irrigate land elsewhere on the western side of Akaroa Harbour Basin	Minor upgrade	Various			Unspecified as no consultation with Ngāi Tahu about this option	Unknown – no further sites of interest identified	Significantly higher cost due to additional conveyance (>distance to irrigation area) and land purchase costs	Likely minimal impacts on water resources + carbon benefits	**Not recommended** as other options available with similar outcome for lower cost
D3	Irrigate land in Robinsons Bay (separate to Akaroa Scheme land)	Minor upgrade	Approx. 11 ha of trees	≈$10M ≈$210K ≈$13M		Favourable over discharge to harbour	Would receive significant community protest.	Potentially higher costs but further study needed	Likely minimal impacts on water resources + carbon benefits	Not recommended by staff – due to high costs and likely strong opposition by local community. **However - subject to review by Councillors**
E1	Discharge to harbour	Major upgrade to meet discharge to water standard	N/A	≈$5M ≈$130K ≈$7M		Culturally unacceptable to Ngāi Tahu	No stakeholder feedback. Minor risk of public health impacts	Comparatively lower cost	Minor impacts on water quality and ecology	Difficult to consent due to cultural concerns and legal and policy settings **However - subject to review by Councillors**

3 Shortlisted Options

3.1 Shortlisted Options Summary Table

The shortlisted options to be taken to the public for consultation were confirmed by the Three Waters Infrastructure and Environment Committee at a meeting on 6 April 2022. These are shown in in Table 3-1. .

Table 3-1 Final Shortlisted Options following Councillor Decision on 6th April 2022

Ref.	Option	Shortlisting Recommendation to Council	Final Shortlist by Council
A1	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and add a wetland	Not recommended due to very high costs, nutrient impacts on stream and difficult to consent	Excluded
A2	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course and also irrigate margin areas	Not recommended as similar to A1 and even higher costs	Excluded
A3	Irrigate wastewater onto tees, greens and approaches on a redeveloped 12 hole golf course plus margin areas and neighbouring land	Not recommended as similar to A1 and even higher costs, but does not discharge to water. However - subject to review by Councillors	Excluded
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions, irrigate planted course margins including upslope area year round	Recommended due to moderate cost and community stakeholder support for reuse benefits	Included
B1	Irrigate planted course margins including upslope area – retain 18 holes with storage on the golf course	Not recommended due to risk of Cultural and Environmental effects. However – subject to option improvements through I&I reduction, or increase to land / storage / irrigation rate	Excluded
B2	Irrigate planted course margins including upslope area – reduce course to 12 holes with storage on the golf course	Not recommended due to community opposition compared to other golf course options. However – opportunities could arise if site Master Plan redeveloped	Excluded
B3	Irrigate planted margins including upslope area – retain 18 holes, and also irrigate other land on golf course or beyond the boundary of the site. Storage on golf course or other land	Recommended due to favourable balance of costs and benefits and greater operational flexibility. Recommended by staff. Dependant on landowner negotiations	Included
C1	Dis-establish golf course and irrigate wastewater onto trees on the golf course land	Not recommended due to significant community impact. Subject to review by Councillors	Excluded
D1	Irrigate wastewater onto land at the Head of the Bay	Not recommended as other options available with similar outcome for lower cost and avoid Silent File issue	Excluded
D2	Irrigate land elsewhere on the western side of Akaroa Harbour Basin	Not recommended as other options available with similar outcome for lower cost	Excluded
D3	Irrigate land in Robinsons Bay (separate to Akaroa Scheme land)	Not recommended due to high costs and likely strong opposition by local community. Subject to review by Councillors	Excluded
E1	Discharge to harbour	Difficult to consent due to cultural concerns and legal and policy settings. Subject to review by Councillors	Excluded

The remainder of this report focuses on the final shortlisted options – namely A4 and B3 (referred to as Options 1 and 2 respectively in the consultation document). No further discussion on other options is provided as they have all been eliminated.

3.2 Wastewater Treatment Plant Upgrade Requirements

Requirements to upgrade the treatment plant are influenced by the method and location of ultimate disposal of the wastewater. There are essentially two main upgrade scenarios and each of these two options is aligned with the sub-group of shortlisted wastewater options as shown in Table 3-2.

Table 3-2 Treatment Upgrade Requirements for Shortlisted Options

Wastewater Management Option	Wastewater Reuse/Disposal	Treatment Upgrade Requirement
A4	Publicly accessed land, spray irrigation	Major upgrade (e.g. membrane filtration and UV disinfection) to achieve 4 or 5 accredited log reductions[1] in pathogens to meet relevant policies and standards. This is required to address public health and environmental risks.
B3	Managed public access, drip irrigation	Minor upgrade involving filtration to 130 microns to prevent dripper blockage. Pathogen exposure risk is managed by managing public access to irrigation areas or, for areas with public access such as walking trails, by provision of a 1.8m exclusion zone at the edge of the walking trail.

Note 1. Accredited in accordance with the Australian Guidelines for Water Recycling (AGWR) 2006.

3.2.1 Public Access, Spray Irrigation – Option A4

The WWTP upgrade requirements are significant for spray irrigation of treated wastewater to publicly accessed pasture land (i.e. the golf course playing surfaces). This was previously assessed in the report (Duvauchelle WWTP Upgrade Options - Design Feasibility Report, Beca, 5 June 2020) included in **Appendix D,** using the Australian Guidelines for Water Recycling (AGWR) as the basis for the assessment. The selected option for a disposal scenario with no restrictions on public access was installation of ultrafiltration membranes and validated UV disinfection. A membrane-only option could be feasible if additional restrictions were placed on public access (i.e. no public access during irrigation, and withholding periods/no access until dry).

3.2.2 Managed Public Access, Dripper Irrigation – Option B3

For irrigation of treated wastewater to trees and managed access land via drip irrigation, the WWTP upgrade requirements are a lot simpler. The upgrade requires a simple 130 micron filter (e.g. Arkal Spin Klin type filters as shown in Figure 3-1) to remove additional solids after the secondary treatment process (to prevent blockage of the dripline). Under AS/NZS 1547 Onsite Domestic Wastewater Management, the effluent must also meet the effluent requirements of BOD < 20 mg/L, and TSS < 30 mg/L. This BOD limit is already met with the existing secondary treatment process, and the TSS limit is typically met at present with the 130 micron filters expected to provide greater certainty of this. The existing UV disinfection at the plant would be retained. There are no specific requirements around levels of disinfection for drip irrigation under AS/NZS 1547 (although it does note some regulatory authorities require disinfection prior to disposal via covered surface drip). Under the AGWR, for landscape irrigation of trees with no public access, either disinfection or an E. coli limit of <1000 cfu/100 mL is recommended. The current plant effluent data (Table 1-2) shows that 95% of E. coli samples are below this limit. Therefore a new UV unit has was not included in this option.

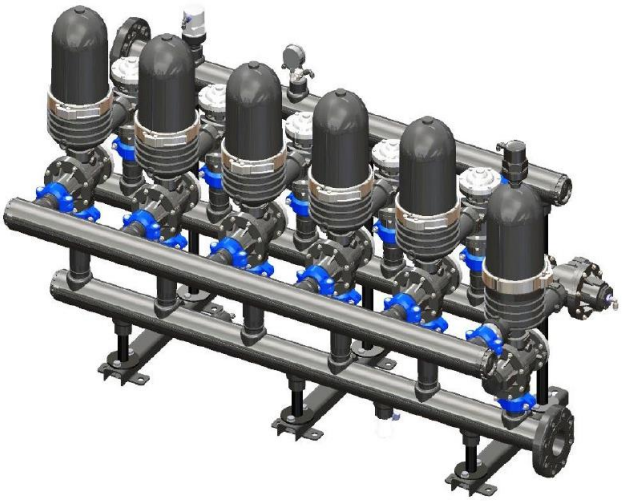

Figure 3-1 Arkal Spin Klin Filters for Tertiary Filtration (Source: 2016 Amiad Water Systems Ltd)

This applies to shortlist option B3.

3.3 Golf Course Irrigation - Option A4

3.3.1 Overview

Golf course irrigation Option A4 involves retaining the existing 18 hole golf course and spray irrigating part of the playing area as beneficial reuse plus dripper irrigation of 8.2 ha of planted margins within the golf course property. The planted margins will include a mix of exotics (pines and eucalypts, where they already exist) and new areas planted in native trees.

Spray irrigation of the golf course playing areas represents beneficial reuse of the treated wastewater as the nutrients in the wastewater will be taken up in grass growth. This will allow a reduction in the amount of chemical fertiliser used and will also support improved grass growth in the height of summer when irrigation water is scarce. Currently golf course irrigation water is supplied from Pawsons Stream; use of treated wastewater will result in a significant reduction of the water take from the stream.

The wastewater treatment plant will be upgraded in accordance with the Australian Guidelines for Water Recycling to provide 5 log removal of viruses. In accordance with the guidelines, and based on this standard, uncontrolled access to the spray irrigated playing areas will be available at all times. The same quality wastewater will be applied to the planted margins via dripper irrigation.

The purpose of retaining the exotic trees in certain areas is to maximise the soil water uptake by vegetation and also maximise the interception of rainfall, to optimise the overall irrigation performance. Exotic trees are generally considered to be superior to natives in both soil water uptake and rainfall interception, however their biodiversity values are lower. This approach applies specifically to the upslope area already planted in exotic trees. As part of the scheme implementation some of the mature exotic trees may be removed and new saplings planted. Gaps in the canopy will also require new exotic tree plantings.

Other irrigation zones within the site are generally closer to the golf playing area. In these areas, native trees and shrubs will be used as these plants are less obstructive to golf play, are slower growing, and offer eco-restoration benefits.

Drainage upgrades will also be provided to the golf course to address longstanding issues with stormwater management that cause operational problems and reduce playability in the winter and spring. The drainage upgrades mainly involve diverting water that flows onto the golf course property from surrounding areas including private property and the Pawsons Valley Road corridor. Drainage work will also reinstate cut-off

drains within the site to further optimise the utility of the playing area. Where internal cut-off drainage water has potential to be contaminated by irrigated wastewater then minor additional features such as small, localised wetlands may be added to mitigate any risks to the receiving environment (e.g. Pawsons Stream). In general, it is considered that these risks are low due to the conservative approach taken to irrigation area sizing, carefully managed application rates, the cessation of irrigation during rainfall, and the use of selected plantings (both exotic and native) to manage soil moisture throughout the year. Refer to Appendix E3 for the proposed drainage upgrade concepts. It is envisioned that minor golf course playing surface upgrades (to irrigation system and minor earthworks) and in particular the creation of native wetland planting areas will be undertaken to improve the ability of the course to benefit from irrigation and drainage upgrades. NKLA Ltd are liaising with the golf club to design these features, and a cost allowance has been made in Option A4 for these.

Option A4 reduces modelled peak wet weather overflows from a return interval of 1:5 years (in the previous A schemes) to no overflows. (Note that the previous A schemes also included use of wetlands, discussion on the performance of wetlands with respect of environmental discharges, consentability and cultural well-being is included in Appendix H). Wastewater storage of 3,750 m^3 would be provided, most likely in covered storage tanks located within the golf course site, either at the location of the existing storage pond (preferred) or at the very top of the site above the irrigated upslope area (not preferred due to access difficulties).

The capital cost of Option A4 including upgrading the treatment plant, provision of irrigation system, drainage improvements and tree planting is $13M and the annual operating cost is $240,000. The net present value (NPV) of the scheme over 35 years is $17M. Details of cost estimates are provided in Appendix J – Cost Estimates.

3.3.2 Planning Evaluation

A preliminary planning assessment has been undertaken for land-based disposal at the golf course site; refer to Appendix I for the full assessment.

The relevant plans are:

- National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health (NESCS);
- The Canterbury Air Regional Plan (CARP)
- The Land and Water Regional Plan (LWRP)
- The Christchurch District Plan (CDP).

A preliminary assessment of effects on the environment of land based disposal has identified potential adverse effects that will be required to be addressed include visual impacts, odour, and effects on surface water and groundwater.

The site is located in proximity to some sensitive receptors including residences, the Plunket rooms, Duvauchelle School and Akaroa Harbour and waterways. Appropriate design will be required to address and mitigate any potential risks to local sensitive sites. The site is also located in a Silent File area so consultation with Ōnuku Rūnanga will be also required. Potentially, earthworks associated with drainage works or other aspects within the site could result in a requirement to apply for an Archaeological Authority, particularly as the site is identified as being in a Silent File Area.

A number of resource consents for the proposal will be required from both Christchurch City Council and Environment Canterbury including use of the site for wastewater disposal, setbacks for buildings, the discharge of wastewater to land, potential earthworks and discharge to air. Overall taking a bundling approach, resource consent is likely required from Canterbury Regional Council as a discretionary activity, and resource consent is likely required from Christchurch City Council as a discretionary activity, although if

vegetation clearance under Rule 18.4.1.5 is considered sufficiently related to the overall project, resource consent is required as a non-complying activity.

District Plan

The zoning of site area is Open Space Community Parks (OCP). Part of the site is located within the Coastal Environment Overlay and the Coastal Environment "Other Area of Natural Character in Coastal Environment" (NCCE 1.0) Overlay. The site is located within Silent File Area 10a. There are two "Environmental Asset Waterways" (streams) on the site.

The proposed activities associated with wastewater disposal are considered to be a "utility" under the Christchurch District Plan. Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator are permitted activities provided the activity complies with the Built Form Standards for the OCP.

In respect of the Built Form Standards for the OCP Zone, standard for site coverage or the building footprint of the storage tanks or pond is unlikely to be met

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

Based on current options none of the overlays/notations trigger specific resource consents other than those identified above.

Regional Plan

In terms of the relevant Environment Canterbury planning documents the following is of relevance to the proposed Option A4:

- The use of land for a community wastewater treatment system and discharge of treated sewage effluent from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP, which includes the irrigation of wastewater to land.
- The western part of the site is identified as "High Soil Erosion Risk" in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171. However it is noted that Rule 5.170 does not apply to works for which a building consent from Christchurch City Council has been obtained so any earthworks associated with a building are exempt from this rule.
- The southern part of the site is identified as overlying an unconfined or semi-confined aquifer. Rule 5.75 of the LWRP requires any excavation to maintain 1 m between any excavation and the aquifer and 50m separation from a waterbody. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.
- It is assumed that the storage ponds (if utilised instead of storage tanks) will have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds will not occur. If there is a discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.
- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond/tanks and irrigated areas is a discretionary activity under Rule 7.63 of the CARP given that Rules 7.50-7.52 cannot be complied with.

3.4 Golf Course Margin + Other Land Irrigation - Option B3

3.4.1 Overview

Golf course margin irrigation Option B3 is based on irrigating the edges and margins of the golf course land as well as additional land on a nearby site or within the golf course property, but not the golf playing area. A

key benefit of this approach is that dripper irrigation of trees in the margins minimises risks of human exposure to wastewater pathogens and, as result, avoids the need for a major upgrade of the treatment plant.

The planted margins will include a mix of exotic trees (pines and eucalypts, where they already exist) and new areas planted in native trees in the same arrangement as Option A4.

The wastewater treatment plant will receive a minor upgrade to provide filtration to 130 microns to prevent blockage of irrigation drippers. No other improvements to the treatment plant are required.

The purpose of retaining the exotic trees in certain areas is to maximise the soil water uptake by vegetation and also maximise the interception of rainfall, to optimise the overall irrigation performance. Exotics are generally considered to be superior to natives in both soil water uptake and rainfall interception however their biodiversity values are lower. This approach applies specifically to the upslope area. As part of the scheme implementation some of the mature exotic trees may be removed and new saplings planted. Gaps in the canopy will also require new exotic tree plantings.

Other irrigation zones within the site are generally closer to the golf playing area. In these areas native trees and shrubs will be used as these plants are less obstructive to golf play, are slower growing, and offer eco-restoration benefits. Irrigated areas beyond the boundary will be planted in natives.

No specific upgrades to the golf course playing surface or irrigation are proposed. Provision of increased planted irrigation area, including irrigation of land beyond the boundary of the site, means that the golf playing area will be largely unaffected by the application of treated wastewater. However some improvements to drainage are proposed, to address current drainage problems in the adjoining margin areas.

In terms of other land to be irrigated, a possible site located in Duvauchelle (referred to within this report as ‘Site B’) is currently under investigation. This site is very steep and does not conform to standard criteria that have been employed for selection of potentially irrigable land including a maximum slope criteria of 19 degrees. The potential irrigation areas at Site B vary in slope but are consistently much steeper than 19 degrees (typically 23 – 25 degrees or steeper). Increased slopes in this range pose significantly higher risks of wastewater runoff as well as higher risks of increased land instability. The potential irrigable land identified within Site B is 1.7 ha. This irrigation area is considered minor in terms of its contribution to the total irrigation area. A similar-sized additional area may be obtained by adjusting the margins of planted areas with the golf course to slightly increase their size. This would bring the irrigable area within the golf course for Option B3 up to that proposed for Option A4 (8.2 ha). Further discussions are needed with the golf club to assess the suitability of increasing the planted areas within the golf course for Option B3. For the purposes of Option B3 “other land” could be extra land within the golf course, or other land beyond the site boundary such as Site B.

Option B3 reduces peak wet weather overflows from a return interval of 1:5 years (in the previous A schemes) to no overflows. Wastewater storage of 3,200 m^3 would be provided, most likely in covered storage tanks located within the golf course site, either at the location of the existing storage pond (preferred) or at the very top of the site above the irrigated upslope area (not preferred due to access difficulties). Storage may also be sited within other land (e.g. 38 Pawsons Valley Road).

The capital cost of Option B3 including upgrading the treatment plant, provision of irrigation system, and tree planting is $8.2M and the annual operating cost is $200,000. The net present value (NPV) of the scheme over 35 years is $11.8M. Details of cost estimates are provided in Appendix J – Cost Estimates.

3.4.2 Planning Evaluation

District Plan

The zoning of site area is Open Space Community Parks (OPC). Part of the site is located within the Coastal Environment Overlay and the Coastal Environment "Other Area of Natural Character in Coastal Environment" (NCCE 1.0) Overlay. The site is located within Silent File Area 10a. There are two "Environmental Asset Waterways" (streams) on the site.

The proposed activities associated with wastewater disposal are considered to be a "utility" under the Christchurch District Plan. Construction or operation of structures for the conveyance, treatment, storage or retention/detention of water, wastewater and stormwater by the Council or a network utility operator are permitted activities provided the activity complies with the Built Form Standards for the OCP.

In respect of the Built Form Standards for the OCP Zone, standard for site coverage or the building footprint of the storage tanks or pond is unlikely to be met.

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

Based on current options none of the overlays/notations trigger specific resource consents other than those identified above.

Regional Plan

In terms of the relevant Environment Canterbury planning documents the following is of relevance to the proposed options:

- The use of land for a community wastewater treatment system and discharge of treated sewage effluent from a community wastewater treatment system is a discretionary activity under Rule 5.84 of the LWRP, which includes the irrigation of wastewater to land.
- The western part of the site is identified as "High Soil Erosion Risk" in the LWRP. Earthworks associated with any development may require resource consent as a restricted discretionary activity under Rule 5.171. However it is noted that Rule 5.170 does not apply to works for which a building consent from Christchurch City Council has been obtained so any earthworks associated with a building are exempt from this rule.
- The southern part of the site is identified as overlying an unconfined or semi-confined aquifer. Rule 5.75 of the LWRP requires any excavation to maintain 1 m between any excavation and the aquifer and 50m separation from a waterbody. Earthworks in this area therefore may require resource consent under Rule 5.76 as a restricted discretionary activity.
- It is assumed that the storage ponds will have an impermeable liner and accordingly the discharge of treated effluent through the base of the storage ponds will not occur. If there is a discharge, resource consent as a discretionary activity under Rule 5.84 of the LWRP is required.
- The discharge of contaminants to air from the disposal of human sewage effluent including the storage pond/tanks and irrigated areas is a discretionary activity under Rule 7.63 of the CARP given that Rules 7.50-7.52 cannot be complied with.

4 Evaluation of Options and Recommendations

4.1 Cost Estimates

The cost estimates for the short-listed options are summarised in Table 4-1.

Table 4-1 Cost Estimate Summary

Option	Description	Concept Cost Estimate	Annual Operating Cost Estimate	35yr Net Present Value Estimate
A4	Irrigate wastewater onto tees, greens and fairways on existing 18 hole golf course during dry conditions, irrigate planted course margins including upslope area year round	$13,100,000	$240,000	$17,080,000
B3	Irrigate the course margins and upslope area – maintain 18 holes, and also irrigate other land on golf course margins or beyond the boundary of the site	$8,200,000	$200,000	$11,770,000

The estimate breakdowns can be found in Appendix J. Please note all cost estimate values in this report are exclusive of GST. The estimate is based on concept design information as outlined in this report and shown on the sketches. Please refer to the clarifications, assumptions, exclusions and risk items that are outlined within the body of this report.

4.1.1 Cost Estimate Notes

Note 1: **Main Contractor Preliminary and General (P&G)** is also known as On-site Overhead costs and covers the cost of on-site overheads such as site supervision / management, site offices, stores, hoardings, amenities, plant, cranes, temporary works etc. The estimate generally includes an allowance of 20-25% of Net Construction costs for On-site Overheads, including a location factor allowance of 2%. This is to allow for the additional cost of cartage and travel associated with working in Duvauchelle.

Note 2: **Main Contractor Margin** is also referred to as Off-site Overheads and profit (OH&P) and covers the cost of contributions to cover the Main Contractors business operational costs, i.e. off-site overhead costs such as executive management, accounts, quality and health & safety systems and company profits. The estimate includes an allowance of 5% of Net Construction costs for Off-site Overheads and Margin.

Note 3: The **Design Development Allowance** is integral to the estimate total and is a general allowance for residual cost risk including design development, omissions, sundry unmeasured items and assumptions made for construction details not shown based on the current project scope. This is not a project / contract contingency which is expected to be held in addition to this estimating contingency. Please refer to figure 4-1 which shows the typical relationship between the design development allowance, the design stages, and design progression (for illustrative purposes only). The estimate is based on concept design information and includes an allowance of 10% for remaining design development.

Note 4: **Construction Contingency** is a risk contingency to cover the cost of variation claims made by the contractor during the construction phase of the project. This contingency is integral to the estimated outturn cost and should be separately monitored during the construction phase. It is estimated based on the current project scope, exclusive of any client driven scope changes. The estimate includes an allowance of 10% for construction contingency.

Note 5: **Client Scope Change Risk** - This allowance is **excluded from our estimate**. It is for use during both design and construction processes to provide for any client driven changes. It is excluded from our

estimate and is a separate budget we recommend the client hold, if there is the potential for client scope changes to influence the outturn cost of the project.

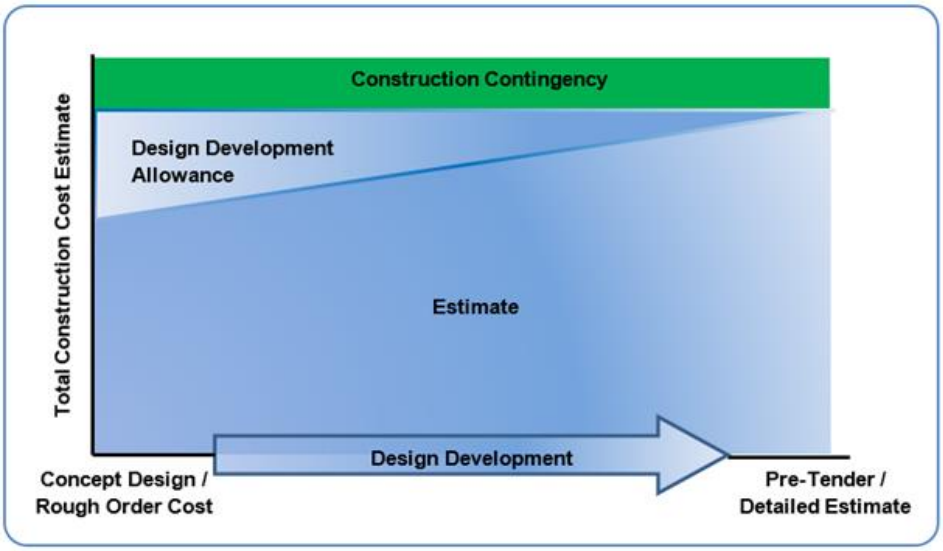

Figure 4-1 Design Development Allowance

4.1.2 Expected Accuracy Range

Estimate range is an indication of the degree to which the final cost outcome for a given project will vary from the estimated cost – it is not an additional Contingency. Range is often expressed as a +/- percentage range around the point of estimate after the application of contingency, with a stated level of confidence that the actual cost outcome would fall within this range. As the level of project definition increases and the tender date draws nearer, the expected range of the estimate tends to improve, as indicated by a tighter +/- percentage range.

The expected estimate range highlights the unknown risks that can impact the project that are difficult to predict or value. As the project gets closer to tender this range will reduce to reflect the level of confidence in the design and information available and level of risk. These risks could include:

Procurement routes

- Major fluctuations in the market
- Labour and material shortages
- Health and safety hazards
- Unexpected ground and site conditions
- Exceptionally adverse weather

The estimates are based on concept level design information. The estimates are deemed to be Class 4 estimates in terms of the AACE Cost Estimate Classification System guidelines. The probable accuracy range of the estimates is likely to be around +/-30%.

4.1.3 Cost Estimate Assumptions and Clarifications

All quantities and dimensions in the estimate are approximate and subject to design development.

- We assume that a competitive tendering process will be followed as part of the Council procurement process.

- We assume that all of the work will be undertaken by a single 'Main Contractor' through a single contract for the project.
- We assume that all of the work will be carried out in a single phase. The estimate does not include an allowance for staging of phasing of the works.
- We assume that all works are carried out during normal daytime working hours.
- The estimate assumes continuity of work and unobstructed access to site.
- Elements of cost included within this estimate are based on costs from similar projects and other Beca cost benchmarks.
- The costs for the wastewater treatment plant (WWTP) upgrade are based on either a more intensive treatment (membrane filtration and UV disinfection) or basic treatment (filtration).
- Storage tank cost are based on indicative budget supply and installation cost from Kliptank received by email on 13/12/2021 plus additional allowances for site preparation and a concrete foundation.
- The allowance for Professional Fees assumes a single design from preliminary design through to completion and excludes concept design stage costs.
- The allowances for Professional Fees are typical allowances included for comparative purposes - a work breakdown or fee estimate has not been prepared.
- The allowances for CCC client-owned project costs are typical allowances included for comparative purposes and are to be confirmed by CCC.
- These estimates are a revision and refinement of the previous August 2020 Concept estimates. All estimate values are based on the August 2020 Concept Estimates unless stated otherwise. We have included a separate allowance for general cost escalation from 2020 to 1st quarter 2022. No allowance for future cost escalation has been included.
- All values are exclusive of Goods and Services Tax (GST).

4.1.4 Cost Estimate Exclusions

a. General Estimate Exclusions

The following general items are excluded from the cost estimates:

- Goods and Services Tax (GST).
- Incurred costs to date e.g. options, concept design, internal CCC costs to date.
- Construction cost escalation beyond the date of the report.
- Fast track / accelerated programme.
- Work outside normal working hours.
- Routine or deferred maintenance, including other works to the WWTP or network I&I reduction.

b. Specific Estimate Exclusions

The following specific items are excluded from the cost estimates:

- Akaroa Golf Club project-related costs.
- Compensation for loss of income for Akaroa Golf Club during construction.
- Contractor temporary accommodation costs. The estimate includes a location factor allowance of 2% for remote location.
- Archaeological attendance and oversight during construction.
- Relocating existing services.
- Power supply upgrades - we assume that the power supply to site has sufficient capacity for the proposed electrical works.
- Treating and handling contaminated soil and hazardous materials.
- Cartage of excavation spoil - all excavation spoil is assumed to be disposed of on site in a balanced cut to fill.
- No allowance has been made for the impacts of extraordinary global events (such as the current COVID-19 outbreak) within the base estimate.

- Opex estimates for A4 or B3 do not include allowances for golf course upgrades (equipment and facilities), operational golf club costs (mowing, fertilizer, existing irrigation), or labour costs.

4.1.5 Cost Risks

Risk items with a potential cost effect include:

- Design development.
- Local community acceptance.
- Ground and soil conditions e.g. ground water, underground obstructions, etc.
- Local market conditions and contractor availability.
- Lead times for supply of materials, especially WWTP equipment sourced from overseas.
- Cost escalation and foreign exchange rates.
- Contaminated soil and hazardous materials.
- Costs of impacts associated with extraordinary global events (such as the current COVID-19 outbreak).

We have not carried out quantitative risk analysis during this early-stage concept design phase. In addition to the design development and construction risk allowances, we have included an additional 5% for Funding Risk Contingency. This is an additional provision for known/unknown risks between the expected and 95th percentile estimates. There may be other risks and opportunities that are not listed above and which could affect the final out-turn cost. We recommend that further cost estimation and risk analysis is carried out at the next stage of design.

4.1.6 Cost Estimate Considerations and Limitations

The estimates are solely for our Client's use for the purpose for which they are intended in accordance with the agreed scope of work. They may not be disclosed to any person other than the Client, and any use or reliance by any person contrary to the above, to which Beca has not given its prior written consent, is at that person's own risk.

These are comparative concept level cost estimates and have been developed solely for the purpose of comparing and evaluating competing options. They are sufficiently accurate to serve this purpose. We do not recommend that they are used for budget-setting purposes as common elements between options may have been omitted and/or the works not fully scoped. A functional design should be undertaken if a budget estimate is required.

The concept cost estimates presented in this section are typically developed based on extrapolation of recent similar project pricing, budget quotes for some equipment items, industry unit rates and Beca's general experience. The estimates are based on incomplete design information. A functional design should be undertaken if a more reliable estimate is required.

4.2 Stakeholder Engagement

The Council has been working with Duvauchelle Working Group including representatives from Ōnuku Rūnanga and Te Rūnanga o Ngāi Tahu, Environment Canterbury, the Akaroa Golf Club, the Banks Peninsula Pony Club, the Duvauchelle A&P Showground committee, and the Duvauchelle public. The working group has provided input and feedback on the long list of options, and assisted to find a suitable and acceptable land-based alternative to a harbour discharge from the Duvauchelle Wastewater Treatment Plant for about 12 years.

The next step is to undertake public consultation on the two shortlisted options and use stakeholder engagement and feedback to decide on a preferred scheme.

4.3 Carbon Assessment

4.3.1 Overview

A high-level assessment of the greenhouse gas (GHG) emissions has been completed to assist with decision making and selection of a preferred wastewater scheme. All figures are presented in tonnes of carbon dioxide equivalent (tCO2-e), a standard metric to account for the relative warming impact of different GHG sources. The assessment considers the emissions generated in creating the asset (capital emissions) and in operating the asset (operational emissions).

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

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

The full methodology, assumptions and results relating to the carbon assessment is attached as a separate report in Appendix K; *Carbon Assessment - Duvauchelle Wastewater Options, Beca 2021.*

4.3.2 Sequestration

For all of the irrigation to trees options, an estimate of carbon sequestered by the native and eucalypt trees over 35 years was made based on default lookup tables provided by the Ministry for Primary Industries (2017) for forests under 100 hectares. MPI assumes carbon sequestration of native trees until 50 years of growth. With this in mind sequestration from the native areas will continue beyond the modelled 35 years.

Key assumptions include:

- The MPI method assumes natives are equivalent to a regenerating natural forest (shrubland of manuka-kānuka, with potential to reach forest), and the associated carbon sequestered is low relative to planting of exotic species (e.g. eucalypts).
- The estimate assumes crown coverage of at least 30% per hectare at the tree's maturity.
- It does not include any changes to the carbon embodied in local soil as a result of discharge of wastewater to land.
- It is central to the carbon sequestration assumption that the trees remain in the ground indefinitely for the benefits to remain.
- Many factors can influence actual carbon sequestered compared to the national averages used for the MPI factors, including growth conditions (temperature, soil moisture) and thinning regime. Different sources (e.g. MfE) will also provide different sequestration estimate numbers. This is an indicative estimate only.

The sequestration calculation is based on the total hectares of trees being planted for each disposal option (refer Table 4-1).

Table 4-1 Summary of Tree Area Available for Sequestration

	A4	B3
Native trees (ha)	**1.7**	**4.0**
Eucalypt trees (ha)	**6.5**	**5.3**
Total (ha)	**8.2**	**9.3**

4.3.3 Net Emissions Summary

Both shortlisted options A4 and B3 are net carbon sinks over a 35 year lifetime (i.e. indicating that the trees are able to sequester more than the initial capital emissions associated with the upgrade, and the ongoing emissions from operation of the WWTP (e.g. process, disposal and electricity emissions). The Ministry for Primary Industries estimates that over 35 years native trees could sequester approximately 286 tCO_2-e per hectare. This could increase to approximately 323 tCO2-e per hectare by time the trees have reached maturity. Eucalypt trees offer more sequestration potential than natives on a per hectare basis; approximately 729 tCO2-e per hectare over 35 years (based on the MPI 2017 factors).

The option with the largest sequestration potential with native and eucalypt trees for irrigation is Option A3 (15.6 ha total of trees). Therefore, this option is estimated to offer the most positive impact towards reducing the impacts of global heating and contributing to the Council's net zero operational carbon emissions by 2030 target and New Zealand's Net Zero 2050 target.

A summary of the net emissions for each option is provided in Table 4-2, with the cumulative emissions shown in Table 4-2 and **Error! Reference source not found.**. In summary:

- The larger capital emissions for some options (A2, A3, and B2) is primarily due to the major golf course upgrade
- The larger operational emissions for some options (A2, A3, A4) is primarily due to the electricity associated with the more complex WWTP upgrade, as well as additional mowing/maintenance fuel for the golf course
- The carbon sequestration is directly related to the total area of native and eucalypt trees. This dominates the whole of life emissions total.

Table 4-2 Summary of Net Emissions per Option

Parameter	Net Emissions over 35 years (tCO_2-e)	
	A4	B3
Capital Emissions	**705**	**348**
Operational Emissions	**1,058**	**660**
Carbon Sequestration	**-5,226**	**-5,010**
Net emissions over useful life of asset (35 years)	**-3,463**	**-4,002**

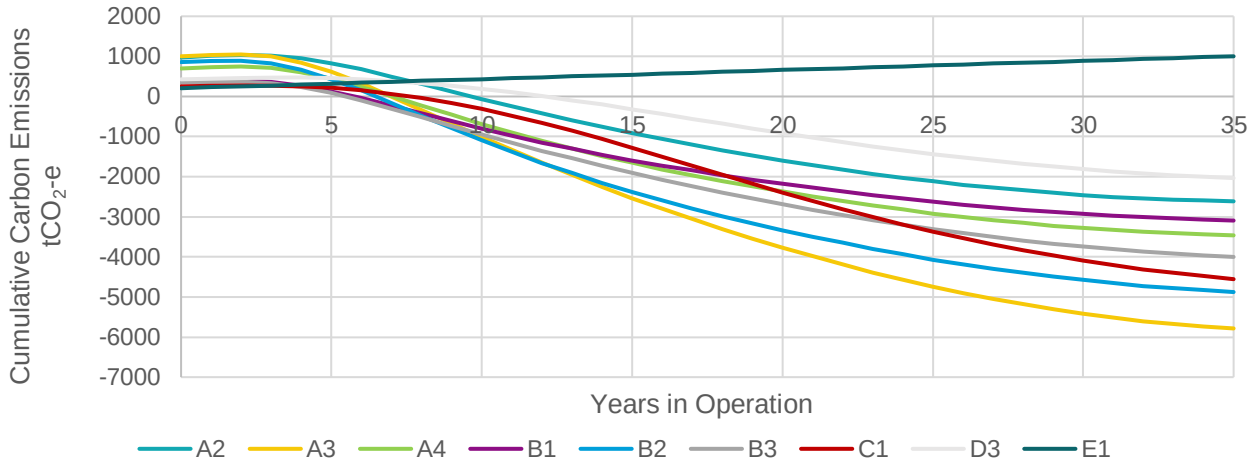

Figure 4-1 Summary of Approximate Cumulative Emissions by Option

4.4 Safety in Design, Climate Change, Risk Assessment

4.4.1 Safety in Design

Safety in Design is a key consideration in the development of a wastewater disposal and reuse design scheme. An initial Safety in Design assessment was completed by the project team for both irrigation to the golf course, and the wastewater treatment plant upgrade, and these are attached in Appendix L. These are intended to be a non-exhaustive list of some of the safety considerations required for constructing and operating the scheme. It is recommended Safety in Design principles be reviewed at different phases of design as the scope of the project is further defined. A full Safety in Design and HAZOP workshop will be required in later stages of design.

Some Safety in Design issues highlighted in this study are noted below.

Key Design Actions:

- Archaeological assessment
- Consenting and statutory approvals
- Refinement of storage tank design (seismic and structural resilience, inspection maintenance and replacement methodology, consideration of overland flow paths)
- Odour/mosquito/bird attraction risks to be evaluated
- Detailed design to consider storage, treatment plant and pump station operational features
- Review overall wastewater system with respect to how a bypass / emergency discharge would operate, consider if existing outfall should be retained
- Detailed design to consider costal erosion/inundation including tsunami and sea level rise risks (refer to section 4.4.2).

Key Construction / Operational Risks:

- Construction timing important (with respect to wet weather, golf course operations, and the A&P Show)
- Wet weather introduces hazards during construction
- Presence of existing service/utilities
- The construction site will be within public domain/an active golf course: management of access, communications and traffic will be important
- The WWTP construction site has an existing rockfall risk to be considered
- The operational, ergonomic, and maintenance requirements of new WWTP process equipment to consider safety including adequate space around membranes and UV equipment.

4.4.2 Climate Change

Christchurch City Council has a target to be carbon neutral for its operations by 2030 and carbon emissions assessments and identification of options for reduction of the carbon footprint should be considered through all design stages. Refer to Section 4.3 for the details of our initial carbon assessment.

The Duvauchelle WWTP area, as with most of the Akaroa Harbour, is exposed to erosion and tsunami hazards, and the WWTP and site access from SH75 is very close to sea level. The coastal inundation prediction map in Figure 4-2 shows the RCP 8.5+ scenario in 2120 encroaching on the accessway to the wastewater treatment plant, based on a sea level rise projection of 1.36 metres. The Duvauchelle WWTP site is very close to the coastal erosion hazard zone and coastal inundation hazard zone areas for 2065 onwards (see the Coastal Hazard Maps https://ccc.govt.nz/environment/land/coast/coastalhazards/).

The map shows the harbour zone erosion is expected to encroach near the treatment plant site which has potential to cut off access via the road (SH75) (see Figure 4-2). This is a significant project risk. As the access road is also a state highway it is anticipated that NZTA will carry out remedial works over time to protect this road corridor which is the primary access route to Akaroa township. Estimated from Google Maps, SH75 outside the WWTP is 1 m above sea level, and the existing WWTP site ranges from this level to approximately 8 m above sea level. . The RCP 8.5+ 2120 sea level rise projection is 1.36 metres. Mitigations within the treatment plant site could include building new process equipment at a higher level and/or bunding and drainage improvements around the plant.

Moving the treatment plant to a different site has not been considered as part of this project. This would be a costly alternative.Any moves to relocate the plant should include discussions with NZTA about their intentions to maintain access along State Highway 75.

Figure 4-2 2120 Coastal Inundation Map (Source https://ccc.govt.nz/environment/land/coast/coastalhazards/)

RCP = Representative greenhouse gas Concentration Pathway

4.4.3 Risk Assessment

The key risks are summarised in Table 4-3. With regard to the potential for cultural impacts, Ōnuku Rūnanga has been consulted during the finalisation of scheme options and has submitted a letter in support of council proposals to irrigate wastewater to land and specifically Options B3 and A4.

Table 4-3 Initial Assessment of Key Risks

Key Risk Issues	Risk Mitigation
Potential for cultural impacts	The Ōnuku Rūnanga are supportive of irrigation of wastewater to land and specifically Options B3 and A4, and has submitted a letter of support to Council on 5th of April 2022. Ngāi Tahu is strongly opposed to wastewater disposal to the harbour, and continued use of the existing harbour outfall option would have significant cultural impacts. Cultural impact assessments for specific scheme options will be required and will assist in acknowledging and managing cultural concerns.
Scheme affordability	Well-developed capital and operational cost estimates to be prepared by qualified quantity surveyor, with staged development and accuracy defined based on the level of effort. Scheme costs should be communicated to the Council and other stakeholders for consideration in decision making.
Climate change, resilience to natural hazards, sustainability	Incorporate allowances for climate change into the design basis including sea level rise, tsunami risks and extreme rainfall events. Resilience of land irrigation options is linked to site selection and design, management and maintenance of storage and irrigation infrastructure. The pipeline from the treatment plant to irrigation site is along state highways and properly designed infrastructure corridors will be more resilient than via secondary and minor roads. Develop greenhouse gas emissions inventory for all options and take into account in decision making. High level assessment of potential environmental effects to be conducted at concept development stage. This should be taken through into detailed assessment of effects, with avoidance and mitigation measures incorporated, for preferred wastewater scheme.
Project governance risks	Long timeframe for scheme genesis poses risks around loss of important background and development context within governance group when final scheme selection decisions are made. Mitigation involves effective briefing by Council officers.
Programme	Failure to meet existing consent expiry date due to programme slippage or failure to consent. Timely and efficient delivery of design required. Overall project programme (high level) developed to show all stages. Short term consent being sought from Environment Canterbury for the transitional period of current scheme operation while the new scheme is built.
Wastewater irrigation to land – irrigation performance	Adoption of suitable irrigation criteria and golf course development with engagement of specialist golf course designers, agronomist, and turf design specialists. Physical testing of soil infiltration characteristics has been undertaken.
Wastewater irrigation to land – storage risks	Wastewater storage pond and tank concepts to be developed taking into account break risk and consequences. Risks around building storage facilities in loess will require careful consideration and peer review in detailed design. For storage tanks, Council have supplied inputs from Akaroa Scheme design in progress by others.
Wastewater irrigation to land - impacts	Treatment of wastewater to very high standard. Beneficial reuse of wastewater in golf course irrigation or supporting tree growth. Adoption of boundary setback criteria for storage and irrigation area to avoid impacts on surrounding properties, public roads,

Key Risk Issues	Risk Mitigation
on surrounding area	ephemeral and permanent waterways, the coastline, and other sensitive features, or specific mitigation design. Divergence from the general criteria requires specialist assessment and evaluation.
Social impacts	Strong community engagement via wastewater working party and other forums to raise awareness and provide for well-informed position and feedback from community on respective options. Using feedback received from the community, including specific stakeholder groups such as the Akaroa Golf Club, to modify and refine the scheme options to mitigate concerns and potential impacts.
Wastewater quality poses risks to receiving environment	Treatment of wastewater to a very high standard using ultrafiltration membranes, and UV disinfection for spray irrigated public accessed land based options, for all flows up including wet weather events, with a bypass for emergencies (>47 year modelled event) to be incorporated.
Consenting risks	Selection of preferred wastewater scheme through well-structured and transparent process with strong community engagement. Incorporation of regional and district planning requirements from early stages. Thorough investigation and assessment of potential environmental effects and documentation within Assessment of Environmental Effects to accompany application for consents for selected scheme

4.5 Recommendations

Suggestions for further work to progress the scheme are as follows:

- Public consultation and stakeholder engagement (including with private land owners and golf course design specialists) undertaken and used for further development and refinement of shortlisted options
- The Council to then decide on a preferred scheme based on the option design and taking into account consultation and stakeholder engagement and feedback
- The Assessment of Effects and consent applications can then be prepared and lodged
- The procurement approach for the detailed design and consultation (including any staging) can then be refined and implemented.

To address key risks the following activities are recommended:

- Flow uncertainty: recommend the Council continues to collect wastewater flow metering records, and complete flow measurement calibration and validation of the plant discharge flow data for use in detailed design. I&I reduction activities currently are being progressed by Council, review and assessment on their effectiveness will assist in refining the future flow design basis.
- Consultation and communications: ongoing updates and sharing of knowledge and learning from Akaroa Scheme project and Duvauchelle project stakeholders suggested
- Modelling assumptions: Review and refine flow and soil moisture water balance assumptions as improved data comes to hand including from any further physical investigations.
- Engage with Waka Kotahi over any plans to address the resilience of State Highway 75 where it passes the Duvauchelle Wastewater Treatment Plant site. Also, further assess the specific vulnerabilities of the site and take these considerations into account in long term planning of management options for Duvauchelle wastewater.