Sensitivity: General

Kaitaia Wastewater Treatment Plant

Land Disposal Options Assessment

March 2021

REPORT INFORMATION AND QUALITY CONTROL

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Executive Summary

This report provides the results of an assessment to identify potential sites for land disposal of treated wastewater from the Kaitaia wastewater treatment plant (Kaitaia WWTP). The work has been completed using geographic information systems (GIS) to identify potentially suitable sites along with a multi-criteria analysis to shortlist potentially suitable sites for a future detailed assessment.

This report assumes an average annual wastewater flow to the WWTP of 2827 m^3/day in 2025 which is the estimated year of commissioning of any land-based disposal infrastructure. An average hydraulic loading rate of 2.6 – 5.6 mm/day was determined based on the soil drainage classes present in Kaitaia and the indicative permeability rate associated with the clay loam soils. Based on these assumptions, a minimum total area of 63.3 hectares of land is required for 100% disposal to land which includes a 25% buffer to allow for future growth and a storage pond.

GIS mapping using data sets from FNDC, Northland Regional Council (NRC) and other online sources were used. Based on these data sets, it can be confirmed that there are numerous feasible options for land disposal within 10 km of the WWTP. The sites identified as a shortlist were all located along the west coast inside the area of interest where the high drainage soils are present.

The top three options found in this report are all within 4 km of the Kaitaia WWTP and hold enough area to discharge to land and hold a storage pond for wet winter months when soils are high in water content.

Due to the similarities between land disposal assessments, the high-level economic analysis developed by Beca for Kaikohe land disposal has also been used as an approximate costing for land disposal in Kaitaia. This economic analysis was conducted using assumptions based on the Kaikohe assessment and will therefore have some limitations in its use for Kaitaia. Increased outflow from the Kaitaia WWTP will likely mean it sits in the +50% range of the analysis due to the general size increase needed for disposal.

1. Introduction

The Kaitaia WWTP discharges treated wastewater into the Awanui River. FNDC is currently in the process of renewing the resource consent authorising the discharge, which expires in November 2021. Policy D.4.3 of the Proposed Regional Plan for Northland (Appeals Version – August 2019) sets out that an application for resource consent to discharge municipal wastewater to water will generally not be granted unless, among other things, a discharge to land has been considered and found not to be economically or practicably viable.

The purpose of this report is to provide an initial desktop feasibility assessment and cost estimate of land disposal of wastewater from the Kaitaia WWTP to enable a determination of land disposal practicability and feasibility in accordance with Policy D.4.3.

2. Methodology

In order to establish the feasibility of land disposal areas, GIS software was used to initially screen site suitability by excluding land areas that failed critical criteria. This first-class exclusion zone was initially developed for the area of interest (AOI) based on the following criteria:

- 20m proximity from all lakes and rivers.
- 20m proximity from all land not designated rural production, general coastal or minerals.
- Total area for land designated as minerals.
- Total area for flood susceptible land.
- Slope > 12°.
- Soil drainage classes 0 – 1.

These criteria were developed based on established best practice, considering previous similar studies in the Far North [note reference] and engineering advice provided by Beca as part of a pre-draft review process.

A long list of sites was then created by ranking each site using the criteria and weighting shown in Table 1 below.

Table 1: Long List Criteria

Criteria	Weighting
Highest Average Drainage Class	33.3%
Highest Average Hydraulic Loading Rate	33.3%
Lowest Average Slope	22.2%
Highest Regularity Score	11.1%

Lastly, the long list underwent a multi-criteria analysis (MCA) process in which qualitative measures are assessed as shown in Table 2 below. This process allows for the remaining sites to be ranked based on their suitability for land disposal so that the highest ranked can be taken forward for further analysis.

Table 2: MCA Criteria

Criteria	Weighting
Long List Rank	35%
Potential effects on Maori cultural sites (impacts on cultural values and sites)	35%
Distance to WWTP	20%
Existing Land Use (Land Cover, Statutory Considerations, SNA's)	10%

The analysis was achieved using the datasets found in Table 3 in order to conduct the exclusion zones and criteria analysis referenced above.

Table 3: Spatial Data Sets used to Identify Land Disposal Constraints

GIS Dataset	Source
District Plan Zones	Far North District Council
Slope	LENZ[2]
MfE river flows	LINZ[1]
Northland Flood Susceptible Land	Northland Regional Council
Marae	Te Puni Kokiri Maps
NZAA Registered Sites	Far North District Council
SNA's	Far North District Council
Bore sites	Northland Regional Council
Parcel Search (Property Ownership Type)	Far North District Council
NZLRI SOIL	LRIS Portal[3]
LCDB v5.0	LRIS Portal

1 LINZ topo1:50,000 map data
2 Slope data layer used in the creation of Land Environments of New Zealand (LENZ) classification
3 Identified as the same layer used in NRC Soil Map Viewer

3. Land Disposal Methods

The work of Tonkin + Taylor (2019) in Ahipara suggests that the methods for land disposal from wastewater treatment plants are limited by volume, soil quality, and level of treatment prior to disposal.

Four potential land disposal methods have been identified for consideration:

- Soil Aquifer Treatment (SAT)
- Soil Moisture Discharge Methods (SM)
- Slow Rate Irrigation (SR)
- Combined Land and Water Discharge (CLWD)

Soil Aquifer Treatment (SAT)

According to the USEPA Process Design Manual for Land Treatment of Municipal Wastewater Effluents, (2006) soil aquifer treatment allows for higher loading rates than the other options which would significantly reduce the area required for disposal. However, this method requires sandy soils which are free draining and have a fine level of pre-disposal filtration in order to operate effectively.

The area surrounding the Kaitaia WWTP contains recent and mature sands along the coastline before becoming alluvial soils in the center of the AOI, and semi-volcanic further inland. This can be seen in Section 5 of this report which shows the drainage classes within the AOI where the sands and semi-volcanic soils supply a higher drainage level than the alluvial. The most viable options found as a result of this assessment are all located in either recent/mature sands or semi-volcanic soils. Those options found in the recent/mature sands may be suitable for SAT, however, further investigation would be required on-site to determine viability.

Effluent exiting the Kaitaia WWTP also contains algae and other solids which can lead to clogging of the disposal system and result in runoff. For SAT to be viable, the pre-disposal treatment would need to meet a suitable standard to prevent clogging and runoff from occurring. Current pre-disposal treatment would not meet this standard and therefore SAT would only be considered in combination with upgrades to the treatment process.

Investigation into treatment requirements and costing of upgrades required to reach those requirements would need to be completed before SAT disposal could be considered. It is recommended that this is done should land disposal be carried forward as an option following this report.

Soil Moisture Discharge Methods (SM)

Soil moisture discharge methods are designed to minimize losses to groundwater following the disposal to land. This method requires a significantly larger land area than other disposal methods. Given the flow volumes from the Kaitaia WWTP, this method of disposal is deemed impracticable.

Slow Rate Irrigation (SR)

Slow rate irrigation is a method where treated wastewater effluent is applied at a low loading rate over an extensive area of land as determined by USEPA (2006). Application rates typically vary between 3 and 5 mm/d according to Tonkin + Taylor (2019). The effluent applied will soak into the upper soil layers where some is lost to evapotranspiration. When the storage capacity of moisture in the soil is exceeded, the effluent will percolate and be lost via soakage. Application methods for SR are spray irrigation (fixed sprinkler or k-line system), and pressure compensating drip irrigation, either laid on the surface or buried within the topsoil layer (100 to 150 mm depth).

Effluent from the Kaitaia WWTP is not suitable for the pressure compensating drip irrigation system due to the required small diameter effluent emitters. The wastewater being discharged contains algae that will quickly clog the emitters and compromise the operation. This was the reason the system was not further considered for the Ahipara WWTP land disposal options assessment (Tonkin + Taylor, 2019). For this reason, drip irrigation would only be considered if pre-disposal treatment was improved.

SR systems need to be developed to avoid run-off from the disposal area with all effluent being disposed of via soakage or evapotranspiration. Therefore, irrigation will need to cease during times of high soil moisture content when chances of runoff are high. Detailed investigations would be required to determine when irrigation should cease for each site. Effluent produced at such a time would need to be stored in a storage pond. Comparison sites indicate a requirement of 3 – 6 months of storage capacity is required if 100% discharge to land is pursued. Whangamata which uses a precipitation index irrigation scheme requires a 3-month storage pond, whilst a land disposal system in Mangawhai requires 6 months of storage.

SR is most suitable on land slopes up to 10° however, it can work on slopes up to 20° if drainage class is suitable. The drainage class within the area of interest allows slopes greater than 10° to be considered, however the additional runoff risk requires further investigation. For the purpose of this analysis sites with less than 12° have been considered for disposal in accordance with the land disposal report for Kohukohu by Daniel, J. (2020). This report identified that slopes above 12° pose a greater risk of runoff and erosion issues.

Most contaminants within wastewater effluent are removed in the first few meters of soil, with finer soils resulting in a greater removal rate. Some nitrogen may be removed through nitrification on the surface of the soil, however, once it has entered the soil will move freely through the soil profile when it becomes entrained with water. This can lead to nitrogen loading downstream, the effects of which should be considered when finding an appropriate site for land disposal.

Slow rate irrigation is considered the most appropriate method for this desktop analysis.

Combined Land and Water Discharge (CLWD)

Using SR in a combined land and water discharge should also be considered where the land disposal would be considered as a 'side-stream' treatment to the current set-up; that is, flows that are to be directed to land disposal would undergo a separate treatment process to the flows that would be discharged to water. The benefits of a side-stream arrangement are that the capital investment required for land disposal can potentially be reduced owing to the differing treatment requirements for land disposal discharge to water. This would allow for discharge to water when the land discharge site is unable to accept treated wastewater due to soil moisture conditions. It is also noted that at least 20% of the flow is required to go through the ponds in order to keep them 'alive'. Therefore, it would be ideal for the wastewater to flow through the current system before either being discharged to land or surface water depending on soil moisture conditions.

4. Flow Summary:

Flow data for the period between January 2017 and March 2019, which includes both residential and industrial wastewater, has been collated for analysis. Table 4 below identifies the average, median, 90th percentile, maximum, and average dry weather flows for 2020 (current year), 2025 (estimated first year of operation should the option be taken forward), and 2055 (final year of maximum consent duration).

This analysis was taken from Harrison Grierson (2020) whom have been tasked with identifying treatment upgrade options at the Kaitaia WWTP. Using this data allows for consistency across the potential options.

Table 4: Kaitaia Wastewater In-Flows (Jan 2017 – Mar 2019)

Parameter	2020	2025	2055
Average Flow (m3/day)	2,673	2,827	3,752
Median Flow (m3/day)	2,330	2,464	3,271
90th Percentile Flow (m3/day)	3,964	4,193	5,565
Maximum Flow (m3/day)	10,417	11,018	14,621
Average Dry Weather Flow (m3/day)	2,277	2,408	3,196

For their analysis of the flows Harrison Grierson used the inflow to Kaitaia WWTP rather than the outflow. The existing pond will offer storage, however there is likely to be times in summer when evaporation causes the outflow to be less than the inflow. This means that there is some uncertainty in sizing a land disposal system based on inflow data.

Investigation was undertaken of the outflow for the same period assessed by Harrison Grierson as above to understand the level of uncertainty. The results we largely similar as seen in Table 5 below. The main difference is in the maximum flow and 90th percentile flow which is due to periods of heavy rainfall and infiltration.

Table 5: Kaitaia Wastewater Out-Flows (Jan 2017 – Mar 2019)

Parameter	2020
Average Flow (m3/day)	2673
Median Flow (m3/day)	2352
90th Percentile Flow (m3/day)	4555
Maximum Flow (m3/day)	15534
Average Dry Weather Flow (m3/day)	1735

This will give a better estimate for the maximum flow which need to be considered for design aspects such as pump sizing. As the outflows are largely consistent with the inflows, the results found in Table 4 were carried through for use in sizing of the land disposal system.

5. Soil Drainage Class

Drainage classification is of fundamental importance to land disposal at a high level. It allows for an indicative soil permeability to be determined based on the preliminary soil permeability as per the guidelines of NZS1547 (2012).

In order to compare the potential sites with the underlying soil, a drainage class assessment was undertaken using the following method:

- NZLRI Soil (2010) layer imported from LRIS portal. This layer forms the basis for the Northland Regional Councils (NRC) soil viewer.
- Using the soil factsheets supplied by NRC, the types of soils found in the AOI were assigned with a drainage class between 0 (No drainage) – 5 (Very well drained). Some of these soils had a range of drainage classes that were averaged out so that a single value could be attributed to them. (e.g. Omu Clay Loam (OM) has a drainage class between 2 – 4 so would become a 3).
- The assigned drainage classes were then applied to the imported layer which exists as polygons on the map. These polygons often had 2 – 3 soils attributed to them and so an average drainage class was used with it being rounded to the nearest whole number.

The output from the above assessment is set out in Figure 1 below.

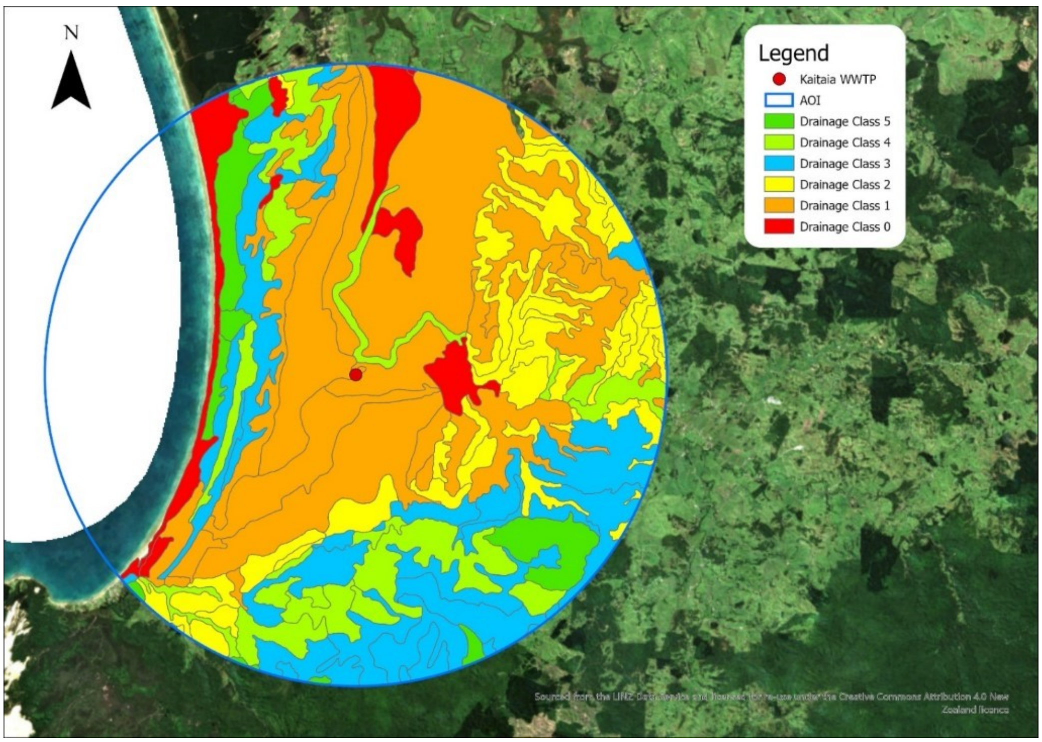

Figure 1: Soil Drainage Classes

For the purposes of this analysis a high-level approach was used to give an indicative drainage class that could be associated with the underlying soil as a comparison tool for potential sites. On-site testing to confirm the drainage of the soil would need to be carried out in the event any options are taken forward for further consideration.

6. Groundwater considerations

The study area contains the Aupouri aquifer which is located north of Kaitaia and covers approximately 788 square kilometers along the Aupouri Peninsula as shown in Figure 2 below. The aquifer is largely a deep sandy coastal system that has formed as a tombolo between islands of basement rock. Although it is a sandy aquifer, it also contains a significant proportion of clay and peat deposits that have formed between sand dunes according to Wilson (2015).

There is an extensive horizon of low permeability soil at approximately sea level, which acts as a confining layer to the deeper sediments. Most boreholes tap the more permeable shell-rich marine sands found at the base of the aquifer, although almost all the water for these bores is provided by leakage from the overlying sands during pumping. The shallow unconfined part of the aquifer is quite dynamic, and most of the rainfall recharge is routed towards the sea within this layer.

The leaky-confined part of the aquifer that is found below sea level is relatively stagnant. Dating of groundwater samples from the top of the leaky-confined aquifer indicate a mean residence time of over 50 years, while deeper samples are over 200 years, which is older than the limits of the tritium dating method. Despite its age, the quality of the groundwater in the aquifer is very good.

Using information supplied by NRC (2012) the following is known about the Aupouri aquifer:

- Predominantly quartz and feldspar sands overlying limestone/sandstone/mudstone
- Aquifer type: semi-confined to confined
- Recharge estimate: 10 – 30% for sands, 1 – 10% for underlying sandstone. Low reliability for both.
- Saturated thickness: 12 - 90 m
- Transmissivity: 12 – 850 m^2/day

The semi-confined status for part of the aquifer could mean additional considerations are required for the implementation of land disposal which has not been included in this report. Should an option be taken forward then consideration to avoid adverse effects on the Aupouri aquifer will be investigated further.

Figure 2: Aupouri Aquifer

7. Hydraulic Loading Rate Design Basis

Following the method used by Jacobs (2020) the hydraulic loading rate has been determined based on an estimated percolation rate, average annual rainfall, and the average annual evapotranspiration for Kaitaia. Annual rainfall and evapotranspiration data used is NIWA Cliflo data from the Kaitaia Observatory (Station 1041).

The preliminary design for soil permeability is determined using NZS1547 (2012) which provides a broad estimate of between 60 – 120 mm/day for massive clay loam land disposal systems. This range was used to differentiate the drainage classes being considered (2 – 5) as in Table 6 below.

Table 6: Soil Permeability

Drainage Class	Preliminary Soil Permeability (mm/day)
2	60
3	80
4	100
5	120

An example of this method can be found in Table 7 below which finds a hydraulic loading rate of 5.59 mm/d for areas with a drainage class of 5. Therefore, this result is the best possible case for the area of interest and is only slightly outside the range of 3 – 5 mm/d suggested by Tonkin + Taylor (2019) for land disposal for the Ahipara WWTP. Kaitaia holds a greater maximum drainage due to a low rainfall to evapotranspiration ratio.

The hydraulic loading rate found for drainage class 2 is 2.6 mm/day which is also outside the range considered by Tonkin + Taylor (2019). Due to the imperfectly draining nature of the class this was considered appropriate.

Table 7: Hydraulic Loading Rate Example

Parameter	Units	Value	Comment
Soil Type	-	Clay Loam	NRC Managing NZ Soils Fact Sheet Viewer
Soil Permeability (Preliminary Design)	mm/day	120	Category 4, Table 5.2 NZS1547 (2012)
Design Safety Factor	%	5	USEPA (2006)
Design Annual Percolation Rate	mm/day	6	Soil Permeability x Design Safety Factor
Annual Rainfall	mm/year	1411	NIWA (Average from past 5 years)
Annual Evapotranspiration	mm/year	1260	NIWA (Average from past 5 years)
Hydraulic Loading Rate	mm/day	5.6	Percolation – Rainfall + Evapotranspiration

8. Land Disposal Design Basis

Using the values reported for the average daily flow and the hydraulic loading rate, total land disposal area requirements can be calculated. These land area requirements are reported in Table 8 for drainage class 2 and 5 to show the range considered for sizing the land disposal system. The total land requirement includes a 25% buffer to account for a storage pond, and potential growth of irrigated area. A comparison has also been included in Table 8 below to show the difference between 2025 and 2055 requirements based on assumed wastewater flows in 2055.

The 25% buffer is added in addition to the exclusion zones applied as detailed in section 9 of this report.

Table 8: Total Area Required for Land Disposal

Parameter	Units	Drainage Class 2	Drainage Class 5
Average Daily Flow (2025)	m^3/day	2827	2827
Average Daily Flow (2055)	m^3/day	3752	3752
Hydraulic Loading Rate	mm/day	2.6	5.6
Irrigated Area (2025)	Ha	109.3	50.6
Irrigated Area (2055)	Ha	145.1	67.2
Irrigation Application Method		Spray	Spray
25% Buffer Area (2025)	Ha	27.3 (0.25 * (Irrigated Area))	12.7 (0.25 * (Irrigated Area))
25% Buffer Area (2055)	Ha	36.2 (0.25 * (Irrigated Area))	16.8 (0.25 * (Irrigated Area))
Total Land Area Required (2025)	Ha	136.6	63.3
Total Land Area Required (2055)	Ha	181.3	84

9. First-class Exclusion Process

A first-class exclusion zone has been initially developed in Arc GIS Pro for the area of interest based on the following criteria:

- 20 m proximity from all lakes and rivers.
- 20 m proximity from all land not designated rural production, general coastal or minerals.
- Total area for land designated as minerals.
- Total area for flood susceptible land.

- Slope > 12°.
- Soil drainage classes 0 – 1.

Based on these criteria, a desktop GIS analysis was conducted by first creating a 10 km buffer boundary around the Kaitaia WWTP. FNDC District Plan zones were included in order to determine the zoning associated with the AOI. Figure 3 below shows the area of the zones being excluded from further analysis as according to the criteria above.

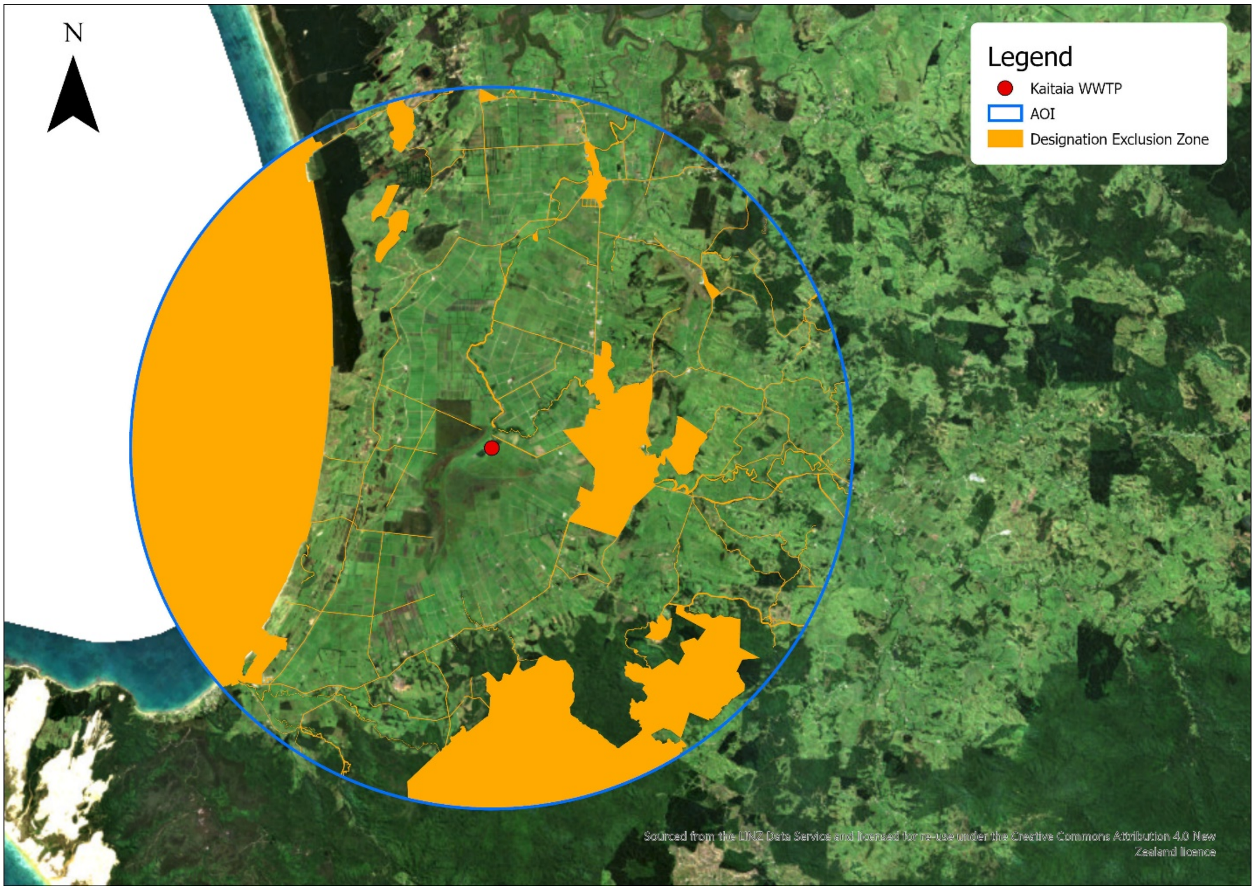

Figure 3: Land Designation

Using this zoning data, all land not zoned as either rural production or general coastal was given a 20m buffer which acts as the designation exclusion zone. The exception to this rule was the minerals zone as it was deemed that this zoning does require the same degree of separation due to the anticipated land use not being sensitive to the land disposal activity.

The lines stretching across the AOI is land designated as roads which have also been considered part of the exclusion zone.

River lines were then produced using data from LINZ TOPO50 NZ River Centerlines and given a buffer of 20 m as per the exclusion criteria. The output is depicted in Figure 4 below. Rivers/streams are widespread over the AOI and act as a considerable constraint compared to the other exclusion criteria.

The flood plains were also considered a total exclusion zone and have been included in Figure 4. Because no flood modeling has been completed within the surrounding catchment, the Northland Regional Council

Flood Susceptible Land data was used to demarcate 100-year floodplains. It has been used as an exclusion zone due to the potential damage/contamination that could be caused in the event of a flood.

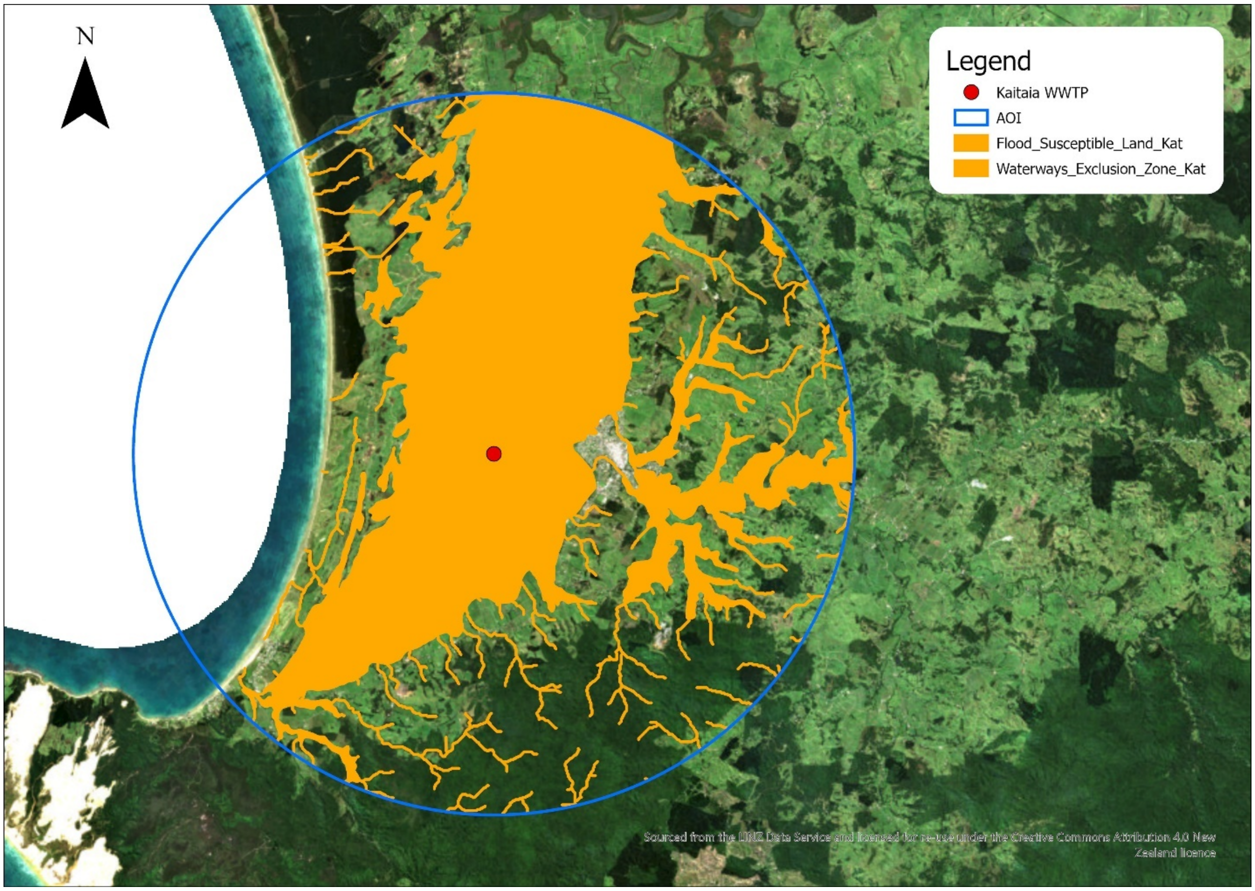

Figure 4: River, Lake, and Flood lands Exclusion Zone

Flood susceptible land takes up a large amount of the AOI. This is predominantly because of the Awanui River which travels through the center of the AOI in combination with the low drainage alluvial soils in the area. Alluvial soils are soils deposited by surface water and are therefore frequently found in flood plains and alongside rivers. This is evident in Figure 6 which shows that the soil drainage exclusion zone is very similar to the flood susceptible land shown in Figure 4.

Slopes greater than 12° have been added as an exclusion zone due to the propensity for runoff to be produced from these slopes. Data from LENZ was used first to project the slope data based on a 25m digital elevation model fitted to 20m digital contour data as seen in Figure 5 below. Following this, the areas above 12° were added to the exclusion zone.

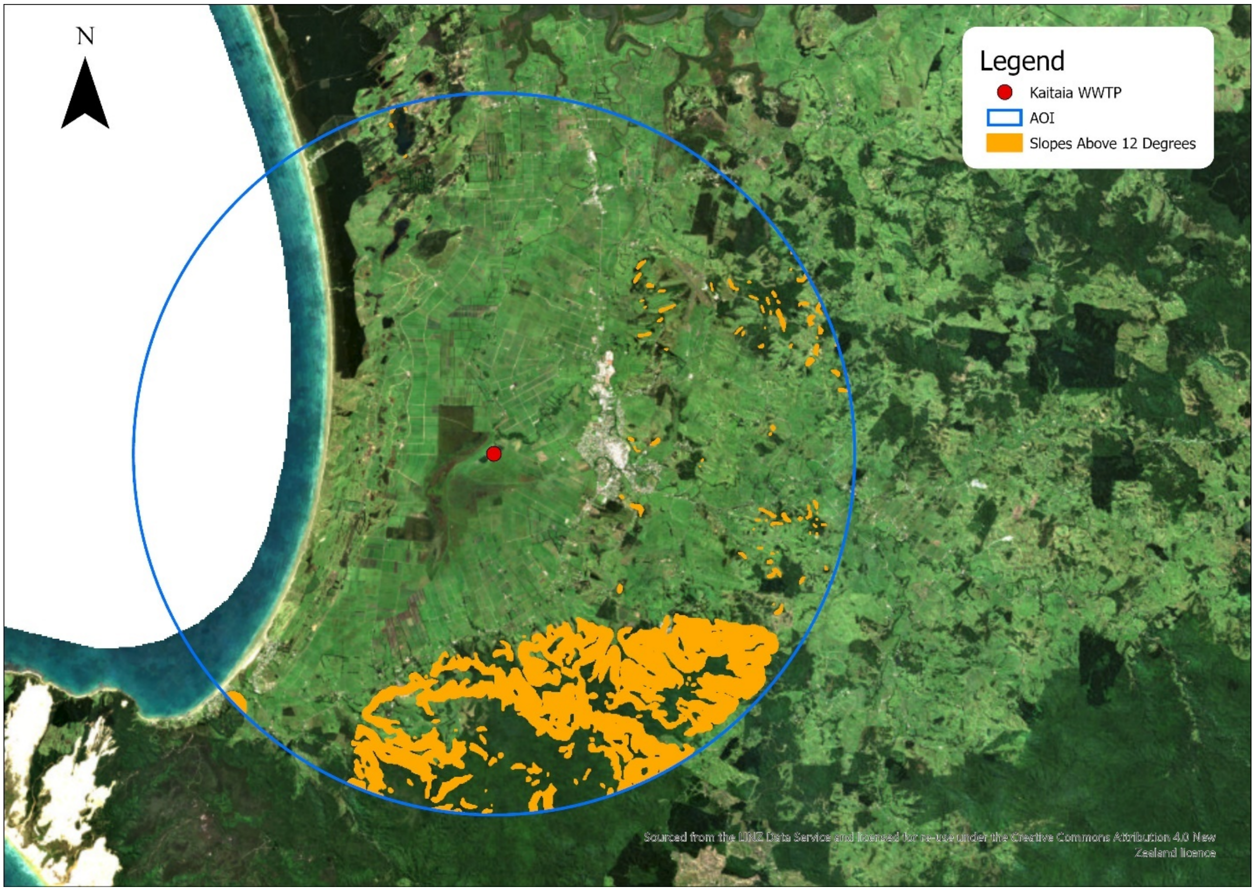

Figure 5: Slope Exclusion Zone

Slopes greater than 12° were found along the southern border of the AOI with sporadic cases to the east and north.

As can be seen in Section 5 of this report, the soil drainage map allows for classes 0 – 1 to be excluded from further consideration. This is shown as an exclusion zone in Figure 6 below which matches well with the flood susceptible land due to the alluvial soils found in that area.

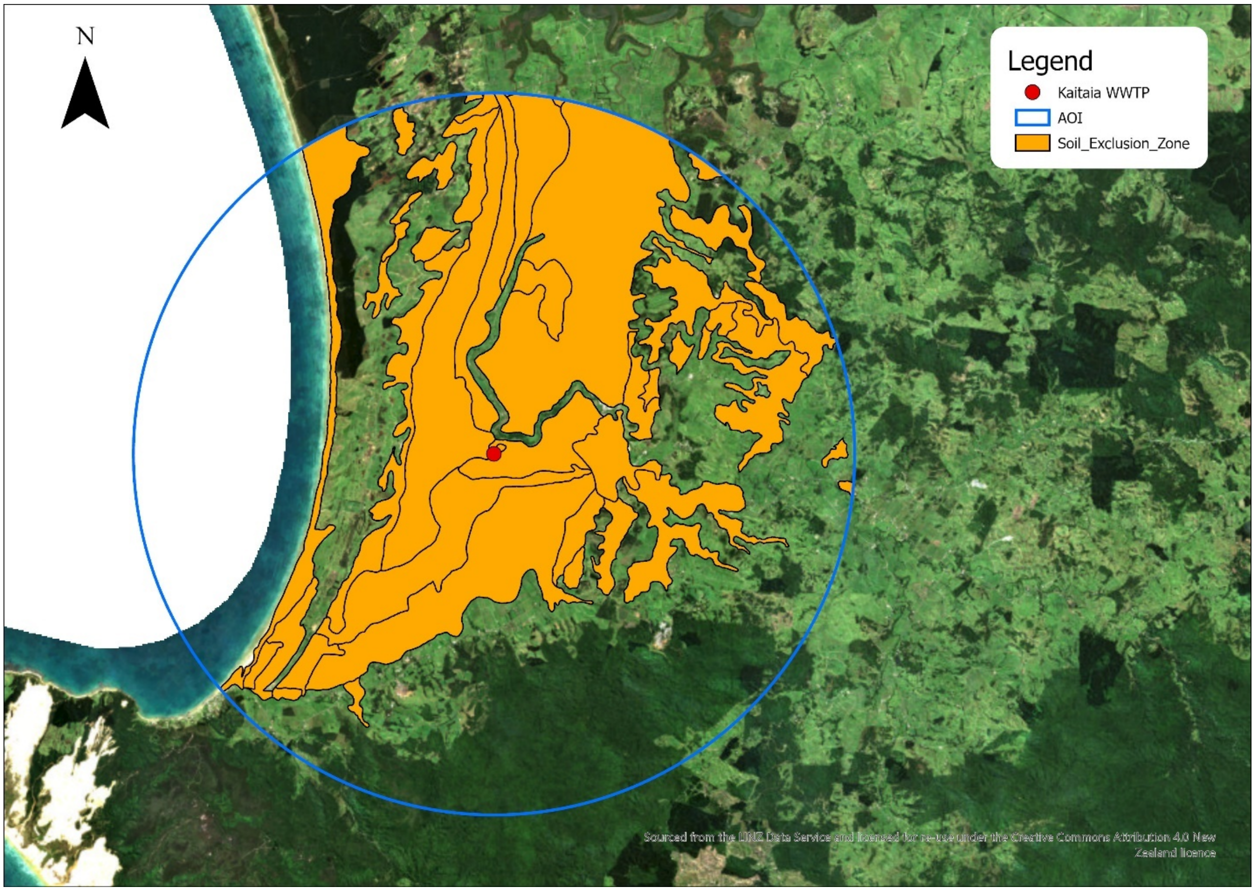

Figure 6: Soil Exclusion Zone

Based on all the first-class exclusions a complete exclusion zone could then be formed as per Figure 7 below.

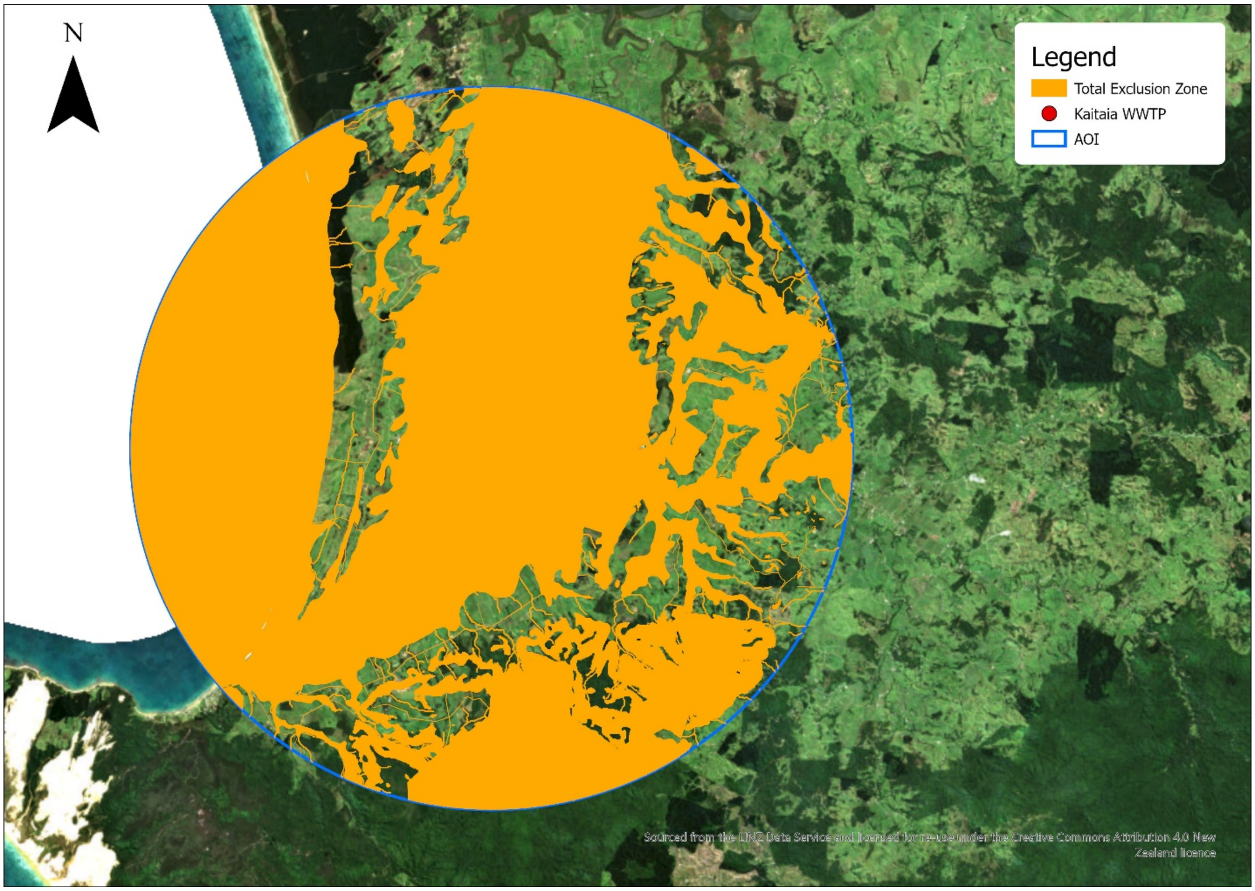

Figure 7: Total Exclusion Zone

Using the total exclusion zone layer, the available land is shown in Figure 8 below.

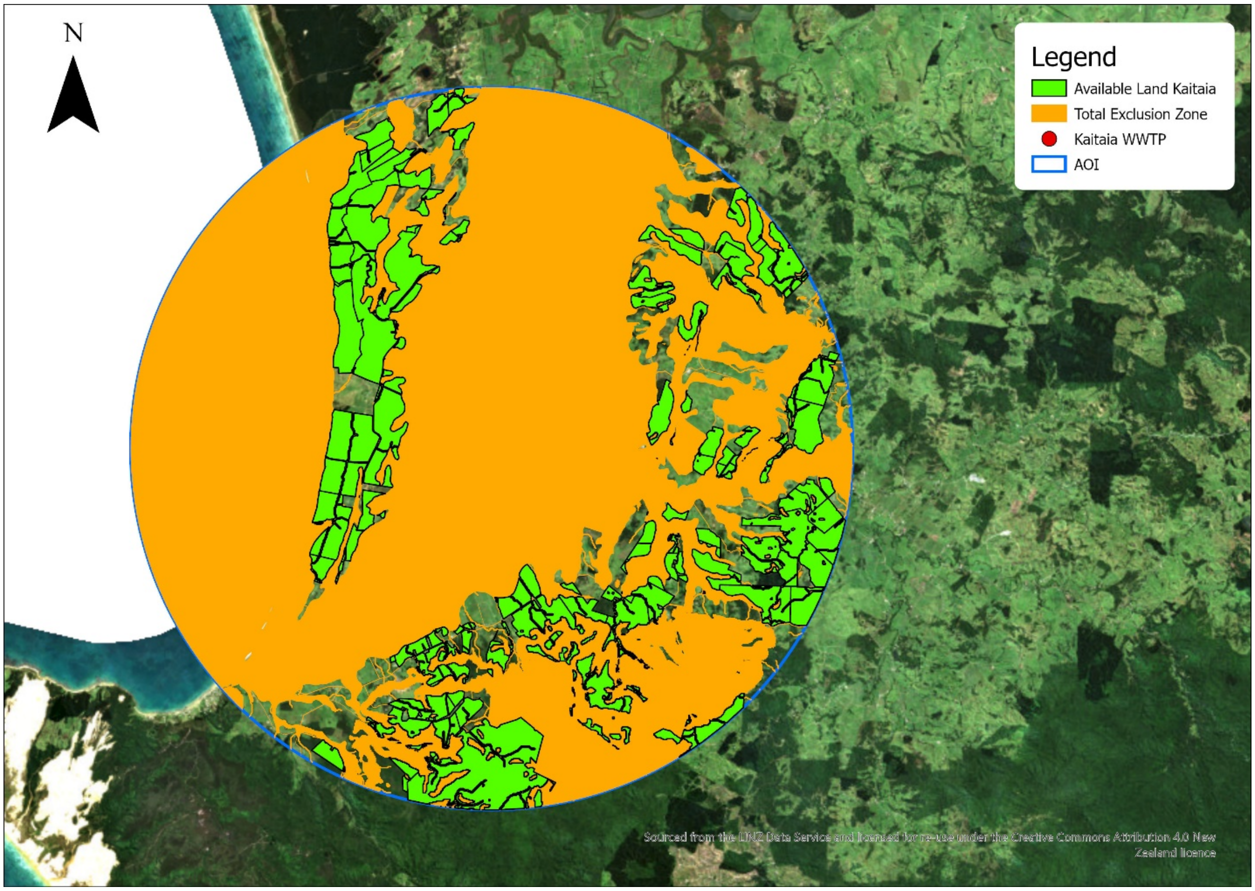

Figure 8: Available Land

The land parcels located outside the exclusion zone were processed using GIS software (ArcMap Pro) to remove small parcels and those that are deemed unusable, in addition to merging land parcels in common ownership. The methodology for this processing is outlined below:

- Available land data initially cleaned of any land parcel area below 1 Ha.
- Additional cleaning of remaining data with parcel intents labelled ROAD, HYDRO, etc. which hold unusable land for disposal.
- Parcel properties are merged based on ownership and proximity. This is done so that total land available from a single owner/ownership group can be used providing that the parcel properties are close together.
- Any land remaining with less than 31.6 Ha is excluded due to being less than half of the lowest disposal area requirement calculated.

This process has provided an extended list of options which can be further considered for their potential as land disposal sites. In this case there were 60 remaining sites of interest. The number of sites is further refined into a long list using the qualitative method detailed in section 10 of this report.

10. Long List Development

The long list was created using the criteria shown in Table 9 below. This initial method of ranking the potential sites was purely quantitative in nature.

Table 9: Long List Criteria

Criteria
Total Available Area
Average Hydraulic Loading Rate
Average Slope
Regularity Score

The long list criteria were determined as follows:

- The resulting 60 sites found in the first-class exclusion process were joined with the underlying soil drainage data using the union tool in Arc GIS Pro. This allowed for the drainage classes of each option to be analyzed.
- Multiple soil drainage class polygons underlined each option and therefore a percentage was developed to show how much of each option contained each drainage class. In order to achieve this analysis, the available land area information was extracted from Arc GIS Pro and transferred to Excel. Here, the total area of each option was first found by summing the areas for all associated drainage class polygons. This allowed for the area of each drainage class to be given a percentage value for the area they make up of an option in relation to its total area.
- In order to come up with a numerical field that can be ranked, the percentage values of each drainage class are multiplied by its associated hydraulic loading rate (as calculated in section 6 of this report). This gives each option an indicative hydraulic loading rate which can then be used to score the drainage level of each option.
- The average slope of each option was calculated in Excel using the AVERAGE function for all soil polygons found within an option. This gives an indicative value for the slopes on-site for each option and allows for them to be scored against each other to find the options with the lowest average slope.
- Lastly, the regularity is calculated by using the ratio AREA:Perimeter^2. This means that cuts within the available areas produced from exclusion criteria result in a lower regularity as they raise the perimeter of the polygons in Arc GIS Pro.

Using the output from the above analysis, scores can be set up for each of the long list criteria based on where an option sits for a certain criterion in relation to the other options. Percentiles were then used to create 10 possible scores for each criterion based on the results found for all 67 options. An example of this is shown in Table 10 below which details how options are scored for their total available area.

Table 10: Total Available Area Scoring

Percentile	Score
Below 10%	1
Below 20%, Above 10%	2
Below 30%, Above 20%	3
Below 40%, Above 30%	4
Below 50%, Above 40%	5
Below 60%, Above 50%	6
Below 70%, Above 60%	7
Below 80%, Above 70%	8
Below 90%, Above 80%	9
Above 90%	10

The scoring for each of the criterion were then used to develop the long list using the weightings shown in Table 11 below. Total available area and hydraulic loading rates were considered the most important factors for considering land disposal and therefore got a higher weighting. As slopes above 12° were excluded earlier this was deemed a less important criterion though it is noted that the lower the slope on-site, the better it is for land disposal and therefore it was included. Lastly, the regularity has the lowest weighting as it is only being used so that the most irregular sites are not considered. The building constraints exhibited in those options would make implementation difficult.

Table 11: Long List Weighting

Criteria	Weighting
Highest Total Available Area	33.3%
Highest Average Hydraulic Loading Rate	33.3%
Lowest Average Slope	22.2%
Highest Regularity Score	11.1%

The weightings for each of the criteria were then multiplied by the associated score for each option to develop an overall ranking for each site. Based on this ranking, the top 10 sites were taken forward for further analysis using a multi-criteria analysis (MCA) which considered qualitative information. These 10 sites are included in Appendix B alongside the information used for the MCA. It is important to note that this does not rule out the remaining 50 options from consideration. Should the options taken forward prove unviable then additional sites from the available land list can be taken forward based on their ranking to be considered further.

Also included in Appendix B is the total available land in hectares. Many of the sites considered for Kaitaia do not meet the requirements for 100% land disposal and so it is recommended that a split between land and surface water disposal be investigated for these sites.

11. Multi-Criteria Analysis

Finally, a multi-criteria analysis (MCA) has been carried out to further rank the long list options. The MCA considers four additional criteria as shown in Table 11 below. The initial weighting of the criteria is as below, however, numerous different weighting scenarios were considered in a sensitivity analysis.

On top of the criteria listed in Table 12, bore locations and property ownership type (Public, Private, Maori) were found for each site. It was deemed that any bores onsite could be closed off before implementation of land disposal and therefore not considered in the MCA. Ownership type was excluded from the MCA and was instead set for later consideration should any sites be taken forward. However, in this case all 10 sites are on private freehold land.

Table 12: MCA Criteria

Criteria	Weighting
Long List Rank	35%
Potential effects on Maori cultural sites (impacts on cultural values and sites)	35%
Distance to WWTP	20%
Existing Land Use (Land Cover, Statutory Considerations, SNA’s)	10%

The initial long list ranking for each of the options was first recognized as a factor which needed to be considered due to its importance in site selection.

Impacts that the options could have on cultural sites and values was deemed an important consideration. This was achieved by locating all marae and NZAA sites within a range of 500 m of each site and evaluated the level of its cultural significance. An example of this is that one of the options held a marae at its center and would therefore show significant risk from a cultural perspective and would score low. However, this is an initial evaluation only, and a separate evaluation will have to be done for any sites taken beyond the scope of this report. The additional evaluation will need to incorporate an engagement process with local iwi.

Distance to the wastewater treatment plant has been included to allow for cost differences in reticulation, as cost has not been included as a criterion in the MCA. This is due to an economic analysis being conducted by BECA for the Kaikohe land disposal report which has been deemed appropriate to use for this report given the similarities between the assessments.

Lastly, the existing land use has been determined by using the land cover database (LCDB), and locations of Significant Natural Areas (SNA) in the area of interest. This was then verified using Photoblique. As with the drainage class, the land cover database is joined with the available land using a union in GIS and a percentage calculated for how much of the option is covered by certain types of land (e.g. High Production Exotic Grassland). SNA’s are found in FNDC’s geodatabase and if they cross one of the long-listed options, their impact on the usage of the site is determined and scored appropriately.

The results of this analysis can be seen below in Figures 9 – 10. Figure 9 shows the results of the chosen weighting from Table 12, where Figure 10 shows the variance exhibited by the sensitivity analysis in which differing weightings were compared. A score of 5 would represent a maximum score, whilst a score of 0 represents a minimum score for both figures.

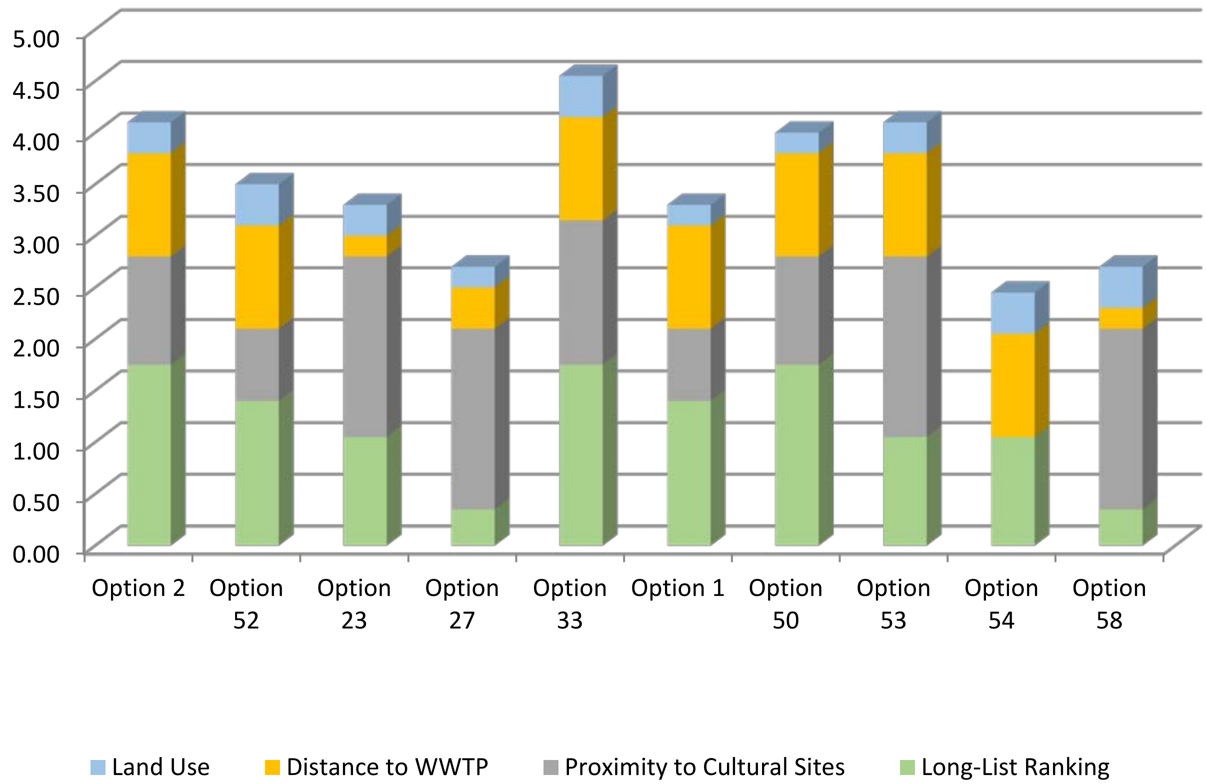

Figure 9: MCA Results

Figure 9 shows that for the chosen weighting, option 33 which is currently owned by Logan King Trustee Ltd. presents the best case for land disposal. It is noted however, that like a few other options on this list, there are wetlands on site which will need to be investigated further to understand boundaries required for implementation of the design. Following this, options 2, 50, and 53 are the next highest scoring. These sites are owned by Alma Kemp, Summit Forests NZ, and Te Waka Pupuri Putea Trust.

These options are all viable and should be considered further if the Logan King Trustee land proves to not be an option. Of these three options, the site owned by Alma Kemp is considered the best option despite being equal with Te Waka Pupuri Putea Trust in the MCA. This is due to it having greater soil drainage and less excess land that would be involved in the purchase. It should also be noted that the land owned by Alma Kemp borders the land owned by Logan King Trustee.

The next set of options include 1, 23, and 52 which are owned by Ahipara Land Co., Harrison Gillispie Trustee, and Te Runanga o Ngai Takato Custodian Trustee respectively. This set, although assessed as being weaker options for land disposal are still up for consideration should the options ranked above them not be possible.

The last set of options include 27, 54, and 58 which are owned by Jared Arthur Trussler, Te Waka Pupuri Putea Trust, and William Kenneth Jones respectively. All these options have high drainage, but low land area compared with the other options which would mean that the land disposal would likely need to occur as a side stream disposal instead of being the main disposal method.

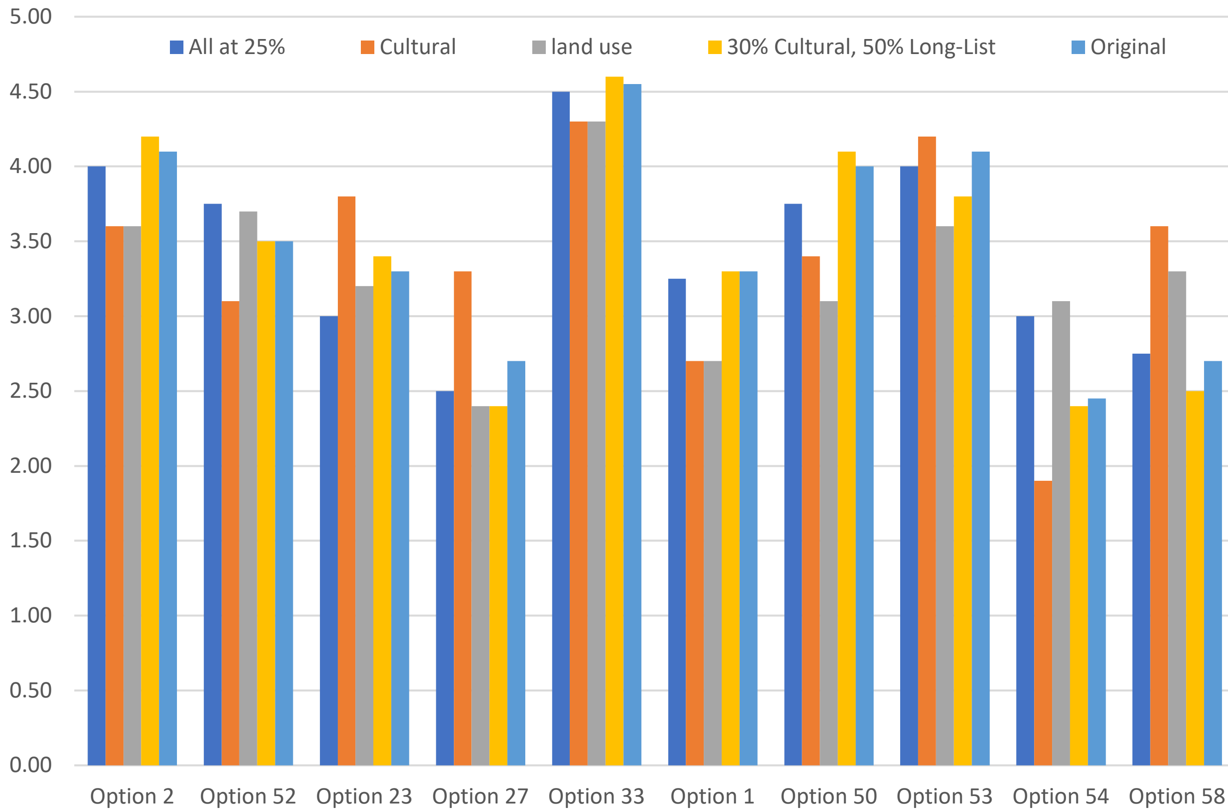

Figure 10: MCA Sensitivity Analysis

A range of weighting options has been considered for a sensitivity analysis to determine whether the top sites hold up to several different scenarios. Cultural and land-use was considered the biggest risks and so were targeted specifically for this analysis. Their specific analysis's as seen in Figure 10 use a 50% weighting with 20% weightings for land use and the other targeted criteria, leaving 10% for distance.

This sensitivity analysis shows that the options are reasonably consistent across the different scenarios which gives credence that the top options are accurately represented in the initial graph.

Should none of the sites prove viable however, the MCA will be reconducted using the next set of available land options identified in the initial ranking. This process can be completed for as many of the available land options as required until either a site has been selected or there are no available options left.

12. Closing Remarks

The Kaikohe high-level economic analysis has been included as Appendix A due to the similarities between the assumptions that guide the analysis for both assessments. The higher outflows in Kaitaia will likely mean that it resides in the +50% of the analysis due to the general size increase needed for disposal.

This analysis will be a determining factor for the potential development of a land disposal system at the Kaitaia WWTP. If the cost is too high for consideration, then the process of investigating the different options will stop here. However, if it is decided that the option is viable then negotiations will begin with the site owners. On-site testing will also be carried out to confirm the desktop analysis and investigate any unforeseen issues with the sites. This will include an assessment of potential environmental effects of the proposed treated wastewater discharge regime. Costs will also need to be revised and updated based upon the results of further technical and environmental investigations.

13. References

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Far North District Council
PO Box 752
Kaikohe 0440
New Zealand

30 October 2020

Attention: Mandy Wilson

Dear Mandy

Kaikohe WWTP Cost Estimate

As per our peer review proposal dated 27 August 2020, a cost estimate has been prepared for a high-level economic analysis of the expected land discharge costs for the Kaikohe Wastewater Treatment Plant (WWTP).

The cost estimate has been prepared based on the assumed key elements in the schematic in Figure 1, and include allowances for preliminary and general contractor costs, and fees and investigations, to give a whole-project cost estimate. This cost estimate is indicative only based off a series of high-level assumptions. No specific land sites have been identified and further concept design and costing work will be required to generate a cost estimate for specific sites and associated site-specific constraints.

The costs for options for the WWTP upgrade have been provided by others, and have not been included in this estimate.

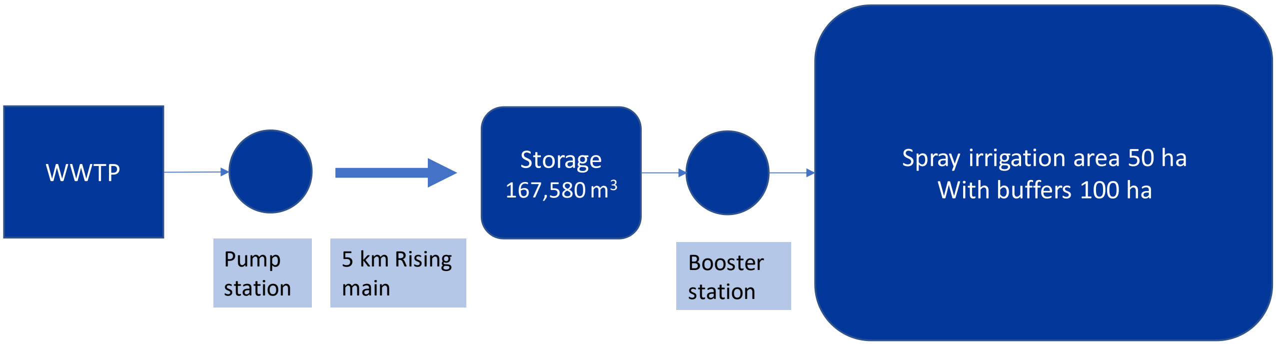


Figure 1 Schematic of high-level land discharge design used for cost estimation

Table 1 Cost estimate for land discharge scheme

Item	Cost (NZD)
Conveyance to irrigation site	$3.9M
Irrigation scheme and storage	$4.7M
Fees and investigations	$2.3M
General	$4.1M

Item	Cost (NZD)
Land Purchase	$2.0M
Total Estimated Cost (-35% to +50%) excluding GST	**$17.1M**

Estimation Notes and Assumptions

- This estimate is an order of magnitude cost with an expected accuracy range of between -35% to +50%
- 50 ha land area for irrigation is assumed to be required (based on indicative work undertaken by FNDC) plus 100% for storage, buffers and non-irrigable areas or the site and harvest stand down periods. This buffer area may be reduced following the identification of a specific site.
- Spray irrigation proposed – nozzle size allows for larger particulates, for example algae from ponds
- Three months storage of 167,580 m^3 is assumed (supplied by FNDC, appears to be based on 2020 average flow)
- Geotechnical investigations included for rising main and irrigation site
- Irrigation site is assumed to require 5 km of pipeline from the WWTP to the irrigation site
- Pump and rising main sizing has been based on schemes for WWTPs of a similar size

Exclusions

- Legal fees
- Consents
- Ground improvement works
- Goods and Services Tax
- Contingency

Limitations

It should be noted that the cost estimates provided as part of the Services are not a statement of absolute cost, rather they will have an accuracy range commensurate with various factors such as the extent of relevant information provided, the certainty of data and the level of detail available at the time of preparation.

The high level cost estimates presented in this letter are typically developed based on extrapolation of recent similar project pricing, historical quotes for some equipment items, industry unit rates and Beca's general experience. The estimates are based on incomplete design and other information and are not warranted or guaranteed by Beca. The accuracy of these estimates is not expected to be better than approximately -35% to +50% for the scope of work described in this report. Further design should be undertaken if a more reliable estimate is required.

Total Scheme Cost

A review of the short-listed options provided by Harrison Grierson in their Options Report (draft, October 2020) found that options 3, 4A and 4B are the most likely to meet consent conditions for discharge to stream when the storage pond for the irrigation is fully utilised, and irrigation is not possible. The times when a discharge to stream is potentially required is when pond-based systems are at their lowest performance levels, generally being in the wet and cold months when treatment processes produce the lowest quality treated effluent of the year, and ammonia (currently the failing determinand) is most at risk. This is based on experience with pond treatment systems in other regions using the technologies in options 1 and 2 which are not meeting compliance with their resource consents.

Potential total costs for a WWTP upgrade and land discharge scheme are presented in Table 2 below.

Table 2 Total scheme capital cost using Harrison Grierson WWTP option costs[#]

Option	HG WWTP Option cost	Total scheme cost[*]
3. IDAL	$6.5M-$8.9M	$17.6M-$34.6M
4A. side stream BNR	$15.0M-$20.6M	$26.1M-$46.3M
4B. BNR	$17.5M-$24.0M	$28.6M-$49.7M

[#]Note: Beca accepts no responsibility for the costs provided by others

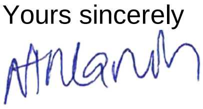
*Total scheme costs have been calculated to include the high/low range for the land discharge costs

References

Kaikohe WWTP Options Assessment, Harrison Grierson, Draft October 2020

FNDC Kaikohe WW Peer Review 01.10.20.pdf

Yours sincerely



Nicola Marvin
Senior Environmental Scientist

on behalf of

Beca Limited

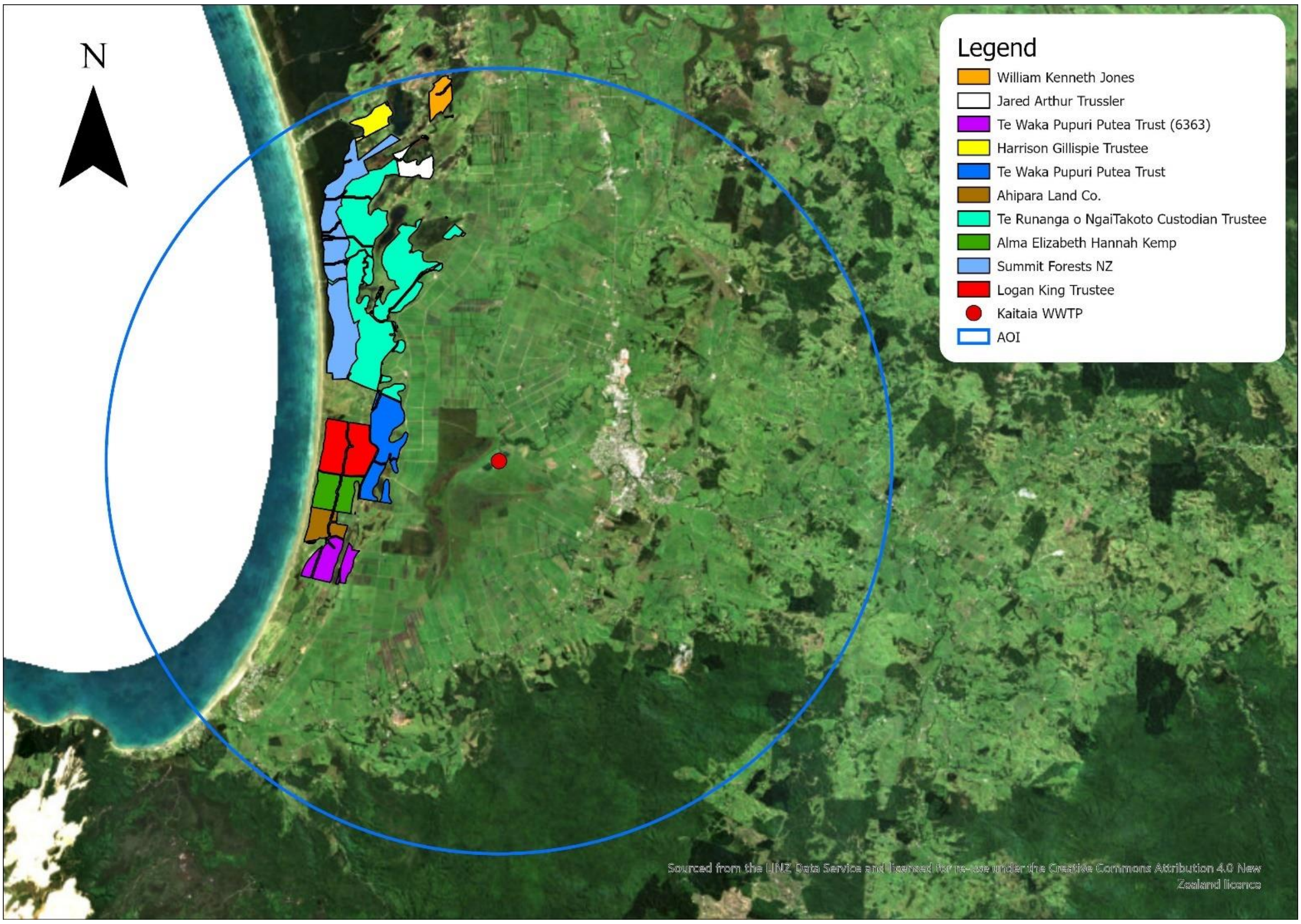
Phone Number:
Email: nicola.marvin@beca.com

Kaitaia Land Disposal Options Assessment – Appendix B

10/12/2020

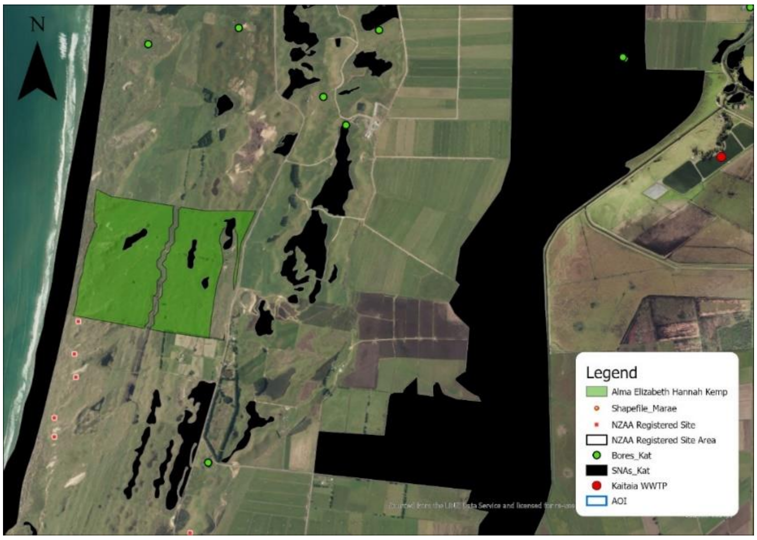
APPENDIX B – SHORT-LIST OPTIONS

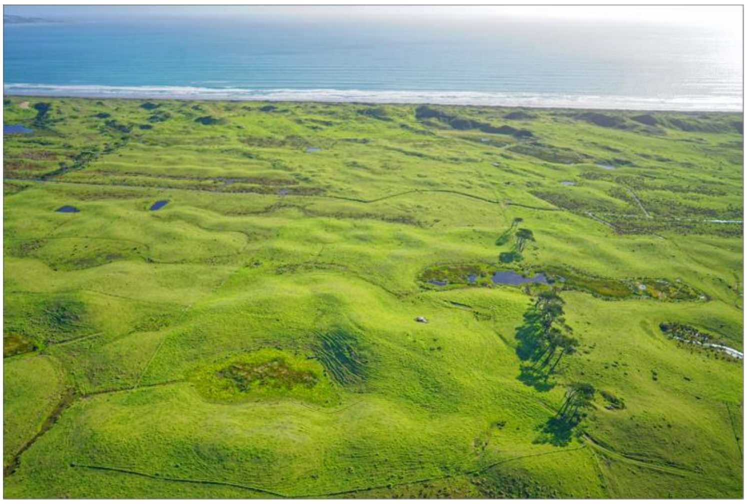
Short-listed Options



Nine of the ten options are relatively close to the sea which was a significant reason that the most viable option in the Ahipara land disposal assessment was not carried forward. It is also worthy to note that the most viable option found in that 2019 report by Tonkin + Taylor is the Te Waka Pupuri Putea Trust (6363) site. This is the only site of the short-listed options that was in the 5 km Area of Interest (AOI) used for that assessment.

Option 2 – Alma Elizabeth Hannah Kemp





Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
90.4 Ha (8/10)	4.61 mm/day (10/10)	1.1 (10/10)	0.017 (8/10)	82 (3rd)

Culturally Significant Sites: Midden/Oven to the south.

Distance to WWTP: 3.5 km

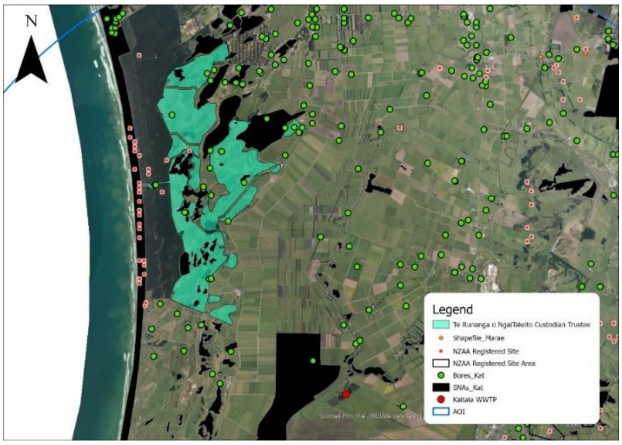
Landowner Type: DCDB – Private

Land Use:

- 75.1% High Producing Grassland
- 23.6% Low Producing Grassland
- 1.3% Herbaceous Freshwater Vegetation (wetlands)

SNA's: Kaikoura Farms Wetland (Total Size: 6.6 Ha)

Option 52 – Te Runanga o Ngai Takoto Custodian Trust



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
624.5 Ha (10/10)	4.27 mm/day (9/10)	1.4 (9/10)	0.003 (1/10)	76 (4th)

Culturally Significant Sites: Pa onsite, rest are Midden/Ovens.

Distance to WWTP: 3.7 km to nearest large area. 7.5 km to upper clear area.

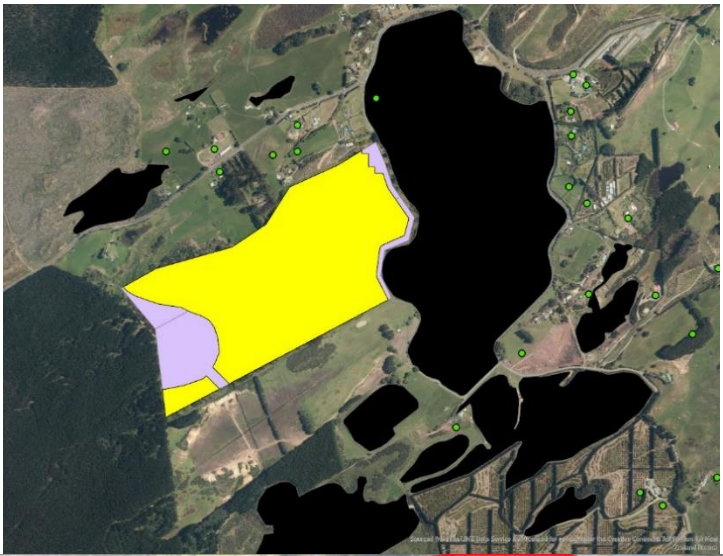
Landowner Type: DCDB

Land Use:

- 86.1% High Producing Exotic Grassland, 6.6% Herbaceous Freshwater Vegetation (wetlands)
- 3.7% Low Producing Exotic Grassland, 3% Exotic Forest, 0.4% Manuka and/or Kanuka
- 0.2% Lake or Pond

SNA's: Airstrip shrubland to East. Sweetwater Station Depressions to the south. Split Lake Wetland top middle. Mini & round lakes bottom middle. Lake Ngatu Complex top. Lake Heather, Lake Rotoroa and wetlands north between.

Option 23 – Harrison Gillespie Trustee Service Ltd.



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
44.5 Ha (5/10)	5.57 mm/day (10/10)	2.86 (8/10)	0.030 (10/10)	71 (7th)

Culturally Significant Sites: No known sites in area.

Distance to WWTP: 8.9 km

Landowner Type: Private – DCDB.

Land Use:

- 55.7% High Producing Exotic Grassland
- 41.1% Manuka and/or Kanuka
- 2.3% Exotic Forest
- 0.6% Gorse and/or Broom
- 0.4 % Orchard, Vineyard or another perennial Crop

SNA's: West Coast Road Lake to north west. Lake Ngatu Complex to the east. Both offsite.

Option 27 – Jared Arthur Trussler

Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
44.9 Ha (4/10)	4.57 mm/day (10/10)	3.02 (8/10)	0.015 (7/10)	65 (9th)

Culturally Significant Sites: No known sites in area.

Distance to WWTP: 7.5 km

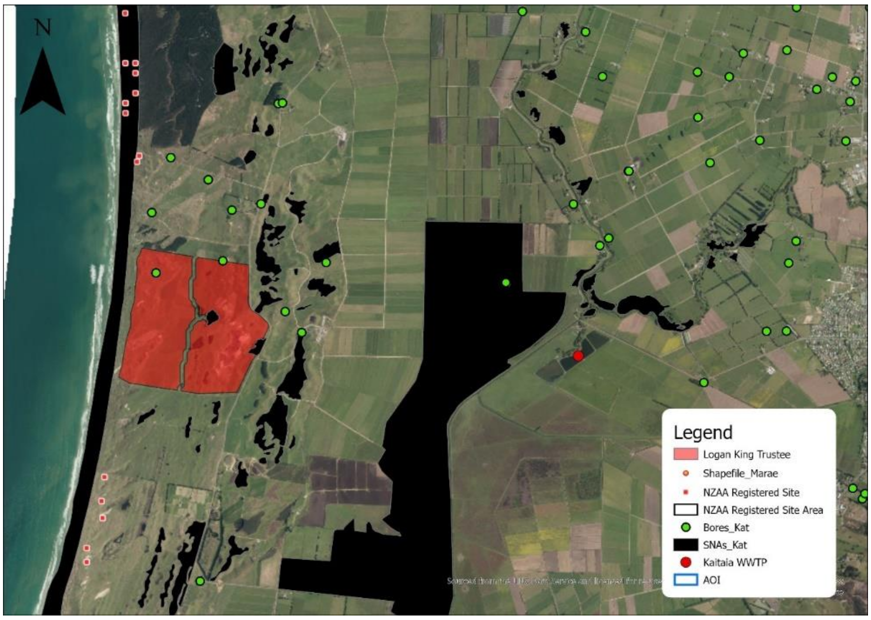
Landowner Type: Private – DCDB

Land Use:

- 91.5% Deciduous Hardwood
- 5.2% Herbaceous Freshwater Vegetation (wetlands)
- 2.5% Manuka and/or Kanuka (0.1% of which is classified as wetland)
- 0.7% High Producing Exotic Grassland
- 0.2% Forest - Harvested

SNA's: Lake Ngatu Complex (1.25 Ha, 2.9%). Lake Heather onsite south west (1.58 Ha, 3.6%).

Option 33 – Logan King Trustee Ltd.



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
157.3 Ha (10/10)	4.57 mm/day (10/10)	2.04 (8/10)	0.024 (9/10)	85 (1st)

Culturally Significant Sites: No known sites in area. Midden/ovens to far north and south.

Distance to WWTP: 3.2 km

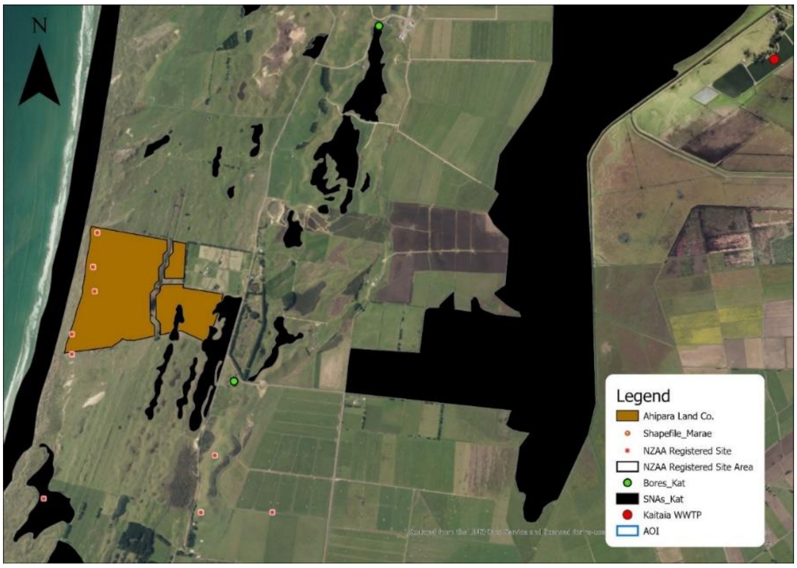
Landowner Type: Private – FSIM.

Land Use:

- 69.9% High Producing Exotic Grassland
- 27.9% Low Producing Grassland
- 1.4% Herbaceous Freshwater Vegetation (wetlands)
- 0.5% Exotic Forest
- 0.3% Lake/Pond

SNA's: Kaikoura Farms Wetland onsite and to south (1.96 Ha, 2.6%). Sweetwater station to north east, offsite. Sandhills Road Wetland No 1 to south east, offsite.

Option 1 – Ahipara Land Co. Ltd



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
58.5 Ha (6/10)	mm/day (9/10)	0.62 (10/10)	0.022 (9/10)	74 (5th)

Culturally Significant Sites: Midden/Ovens

Distance to WWTP: 4.3 km

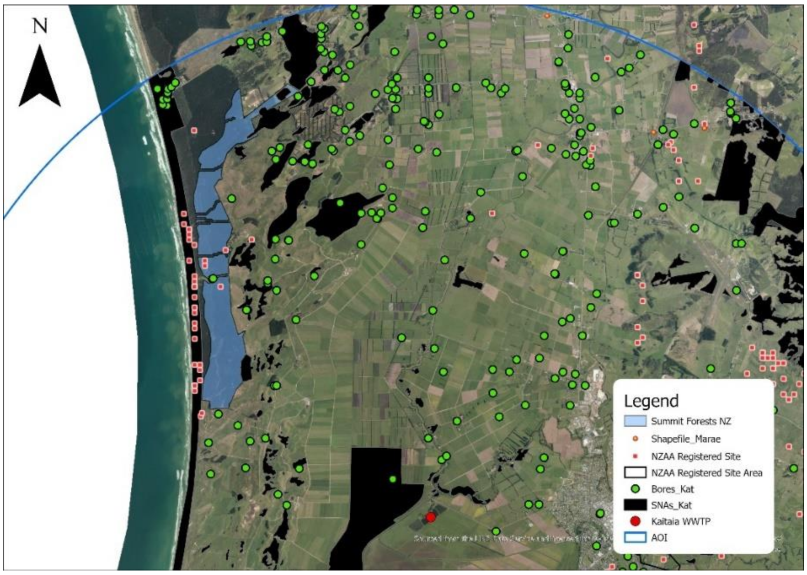
Landowner Type: DCDB

Land Use:

- 49.3% High Producing Exotic Grassland
- 47.4% Low Producing Grassland
- 2% Exotic Forest
- 1.3% Herbaceous Freshwater Vegetation (wetlands)

SNA’s: Clarke Road Wetland. Ninety Mile Beach to the East.

Option 50 – Summit Forests New Zealand Ltd.



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
326.3 Ha (10/10)	5.46 mm/day (10/10)	1.19 (10/10)	0.006 (3/10)	83 (2nd)

Culturally Significant Sites: Pa to west inside SNA. Rest are midden/ovens.

Distance to WWTP: 4.5 km to closest point. 7.9 km top portion.

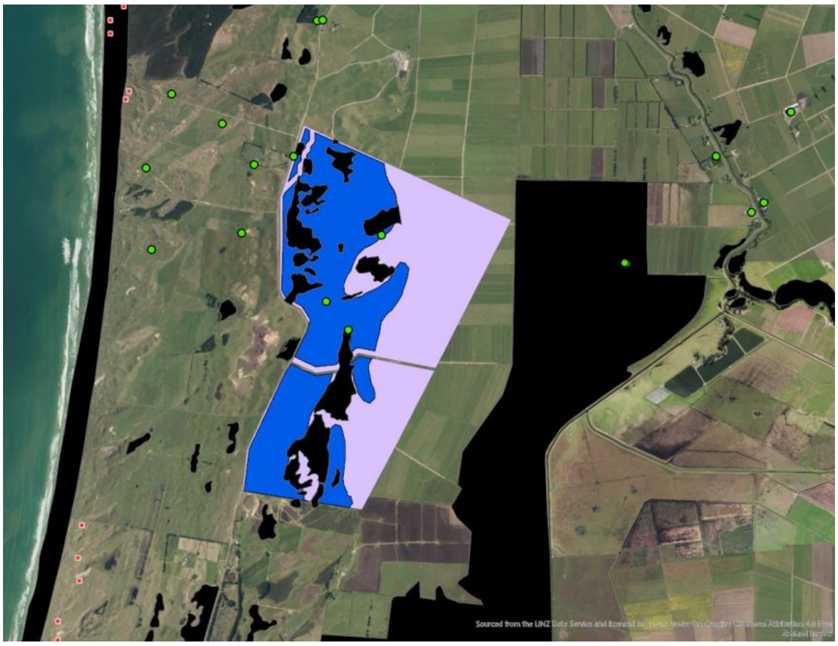
Landowner Type: Private – DCDB.

Land Use:

- 93.6% Exotic Forest
- 3.3% High Producing Exotic Grassland
- 1.4% Herbaceous Freshwater Vegetation (wetlands)
- 0.6% Manuka and/or Kanuka and 0.6% Low Producing Grassland
- 0.3% Lake or Pond, and 0.3% Gorse and/or Broom.

SNA's: Lake Ngatu Complex, onsite north east. Ninety-mile beach borders the west side. Split lake wetland and mini round lakes to the south, offsite.

Option 53 – Te Waka Pupuri Putea Trust (0647)



Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
156.5 Ha (10/10)	3.6 mm/day (7/10)	2.05 (8/10)	0.009 (5/10)	72 (6th)

Culturally Significant Sites: No known sites in the area.

Distance to WWTP: 2.4 km

Landowner Type: Private – DCDB.

Land Use:

- 83.1% High Producing Exotic Grassland
- 15.7% Herbaceous Freshwater Vegetation (wetlands)
- 1.2% Exotic Forest

SNA's: Onsite – Sweetwater station (19.81 Ha, 13.2%), Sandhills Road Wetland No 1 (5.03 Ha, 3.3%).

Option 54 – Te Waka Pupuri Putea Trust (6363)

Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
88.7 Ha (8/10)	3.97 mm/day (8/10)	1.26 (9/10)	0.009 (5/10)	71 (7th)

Culturally Significant Sites:

- Puketutu (Pa with burials) onsite.
- Pa and Pits to the south, offsite. Midden/ovens to the east, offsite.

Distance to WWTP: 4.25 km

Landowner Type: Private – DCDB.

Land Use:

- 95% High Producing Exotic Grassland
- 3.3% Gorse and/or Broom
- 0.06% Exotic Forest, 0.06% Low Producing Exotic Grassland, 0.04% Manuka and/or Kanuka

SNA's: Clarke Road Wetland on site and to north.

Option 58 – William Kenneth Jones

Total Area	Average Hydraulic Loading Rate	Average Slope (°)	Regularity	Overall Score (Overall Ranking)
43.6 Ha (4/10)	4.41 mm/day (9/10)	1.95 (9/10)	0.020 (8/10)	65 (9^{th})

Culturally Significant Sites: No known site in area.

Distance to WWTP: 8.9 km

Landowner Type: Private – DCDB, FSIM.

Land Use:

- 80.4% High Producing Exotic Grassland
- 11% Exotic Forest
- 4.8% Manuka and/or Kanuka
- 2.1% Herbaceous Freshwater Vegetation (wetlands)
- 1.6% Lake or Pond
- 0.1% Low Producing Grassland

SNA's: West Coast Road Shrubland onsite (2.5 Ha, 5.8%). Lake Ngatu Complex to the West, offsite.