Alternative Land Treatment Sites

Rotorua WWTP

Revision four: June 2015

Rotorua Lakes Council

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Issue and revision record

Revision	Date	Originator	Checker	Approver	Description
1	8 May 2015	Sven Exeter Khem Limbu	Rebecca Bibby Robert White	Kevan Brian	Draft
2	18 May 2015	Sven Exeter Khem Limbu	Rebecca Bibby		Draft
3	12 June 2015	Sven Exeter Khem Limbu	Rebecca Bibby	Rebecca Bibby	Draft
4	22 June 2015	Sven Exeter Khem Limbu	Kevan Brian	Kevan Brian	Final Draft

Information Class: Standard

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Executive Summary

Rotorua Lakes Council (RLC) engaged Mott MacDonald New Zealand Limited (Mott MacDonald) to undertake a detailed feasibility study of alternative sites for the discharge of treated wastewater from the Rotorua Wastewater Treatment Plant (WWTP). The current Land Treatment System (LTS) has been in operation at Whakarewarewa since 1991. It occupies a land area of 430ha of which approximately 240ha is suitable for irrigation. Treated wastewater from two holding ponds at the LTS is irrigated to land using above ground impact sprinklers. The existing LTS is to be decommissioned and options for the discharge to water, and/or land, are being investigated for the treated wastewater. In this study, two discharge options were investigated:

- Option 4 - Dual Discharge – Discharge to water of one third of the total treated wastewater from the Membrane Bio-reactor with the remaining flow to be discharged to land
- Option 5 – Total Discharge – Discharge of the entire treated wastewater to a new alternative land site within the catchment

The overall purpose of this study is to identify the potential alternative land sites for discharge of the wastewater from the plant. For both options, the discharge limits are set at 30T of nitrogen and 3T of phosphorus per annum. The general scope of works was as follows:

- Establish size and expected nutrient removal performance of alternative land disposal sites
- Identify location of the proposed alternative sites including current land use
- Scope disposal methodologies
- Scope and size transfer main and pumping systems
- Establish general site layouts and details of proposed wastewater and disposal system
- Prepare CAPEX and OPEX costs, and NPV for the alternative options
- Establish further detailed geological, groundwater and geotechnical investigation works to confirm the viability of the concept/options
- Identify technical, financial and environmental risks relative to each option including a brief overview of consenting risks.

The study recommends the most suitable disposal methodology, and transfer main and pumping arrangement for the three land options. The risks relating to each option as well as the construction and commissioning requirements were identified. However a wide range of further investigations and are required to support further consideration of a new LTS. The key findings from the study are summarised in the table below:

Area & Option	Loading Rate (mm/day)	Land Area Including Buffer Zones (ha)	CAPEX ($M)	OPEX ($M/Yr)	NPV ($M)	Key Risks
Area A (Option 4)	5	420	86.16	2.33	100.37	Geotechnically challenging and ability to consent the activity
	20	105	53.27	1.99	69.73	
Area A (Option 5)	5	600	106.90	3.11	127.38	
	20	150	59.91	2.62	83.62	
Area B (Option 4)	5	420	55.81	1.85	69.86	High number of streams, hilly, complex irrigation arrangement and ability to consent the activity
	20	105	33.16	1.51	47.10	
Area B (Option 5)	5	600	70.44	2.45	89.73	
	20	150	38.08	1.96	57.22	
Area C (Option 4)	5	420	60.06	1.13	63.08	Sandy soils, proximity to Lake Rotorua, likely to have relatively high land value and ability to consent the activity
	20	105	31.85	0.82	36.57	
Area C (Option 5)	5	600	77.83	1.42	80.96	
	20	150	37.52	0.97	43.10	

1 Introduction

1.1 Background

Rotorua Lakes Council (RLC) requires a detailed feasibility study to be undertaken of alternative sites for the discharge of treated wastewater from the Rotorua Wastewater Treatment Plant (WWTP) to land. The current Land Treatment System (LTS) has been in operation at Whakarewarewa since 1991. It occupies a land area of 430ha of which approximately 240ha is suitable for irrigation. Two holding ponds at the LTS provide storage from which the treated wastewater is irrigated to land using above ground impact sprinklers. The existing LTS is to be decommissioned and options for the discharge to water, and/or land, are being investigated for the treated wastewater. In this study, two discharge options were investigated:

- Option 4 - Dual Discharge – Discharge to water of one third of the total treated wastewater from the Membrane Bio-reactor with the remaining flow to be discharged to land
- Option 5 – Total Discharge – Discharge of the entire treated wastewater to a new alternative land site within the catchment

1.2 Purpose of this Study

The overall purpose of this study is to assist in identifying possible sites for the discharge of the wastewater from the Rotorua WWTP to land and costings to compare to other potential options for treatment and discharge of the Rotorua WWTP wastewater. For both options, the discharge limits are set at 30T of nitrogen and 3T of phosphorus per annum.

1.3 Scope of Works

The general scope of works is as follows:

- Establish size and expected nutrient removal performance of alternative land disposal sites
- Identify the location of the proposed alternative sites including current land use
- Identify appropriate disposal methodologies
- Scope and size transfer main and pumping systems
- Establish general site layouts and details of proposed wastewater and disposal system
- Prepare capex and opex costs, and NVP for the alternative options
- Establish geological, groundwater and geotechnical investigations to confirm the viability of the concept/options
- Identify technical, financial and environmental risks related to each option

Exclusions to scope:

- Addressing of consenting strategies or risks other than comments in section 2.2
- Any activities associated with assessing the actual availability and method of obtaining security on land use and possible arrangements that could be used in terms of sale, lease or partnerships with different types of land ownership.
- Investigation into the ownership of any land identified in this report

The study will identify both the most suitable disposal methodology, and transfer main and pumping arrangement. The risks related to each option as well as the construction and commissioning requirements for the alternative land options are also to be identified for each option.

2 Review of Existing Information

2.1 Existing Reports

The information form two previous studies were used in this study. These are:

1. Rotorua Land Treatment System – Alternative and Upgrade Options Investigation'. Scoping Report. Hydrus, August 2013)

2. Detailed Feasibility of Alternatives to Land Treatment' (Mott MacDonald, December 2014)

The Hydrus (2013) study included investigation of alternative discharge and upgrade options for the WWTP.

The Mott MacDonald (2014) study was a detailed feasibility investigation of options to upgrade the existing WWTP followed by the subsequent discharge of the treated wastewater to water. Outputs such as flow and wastewater quality from the WWTP contained within this report have been used for the design criteria for this report.

2.2 Statutory Considerations, Policies and Plans

Bay of Plenty Regional Council (BOPRC) is likely to require land application and leaching rate limits to any future resource consent relating to the land disposal of the WWTP wastewater. For now the only available information is that 3 tonne of P and 30 tonnes of N per year are allowed[1] to be leached/lost from the operation and this is one of the key assumptions for this investigation. The potential land disposal sites will have different characteristics and will need to be thoroughly assessed on a case by case basis.

The Bay of Plenty Regional Plan (BOPRP) has the following relevant objectives, policies and rules.

Objective 26 Discharges of contaminants to land are managed to:

a) Not exceed the natural treatment capacity of the soil.
b) Avoid, remedy or mitigate the adverse effects of run off to surface water.
c) Prevent the long-term contamination of the soil by hazardous substances, and safeguard the life-supporting capacity of soil.
d) Ensure that any adverse effects on high quality groundwater are no more than minor:
   i. Where there is potable water, including aquifers used for municipal water supply.
   ii. Where natural water quality has not been adversely affected by land use or point source discharges.
   iii. Where there are recharge areas of (i) and (ii)
   iv. In the groundwater catchments of the Rotorua lakes, Ohiwa and Tauranga harbours.
e) Ensure adverse effects on groundwater not otherwise addressed by (d) are avoided, remedied or mitigated.
f) Prevent adverse effects on lake water quality in relation to the TLI of the lake, where the discharge is in the catchment of a lake.

[1] Current resource consent RDC-'60739' condition 11 states: *"The wastewater treatment plant and spray irrigation disposal system shall be operated to ensure that the total sewage-derived nitrogen and phosphorus in the Waipa Stream at site 5 does not exceed 30 tonnes and 3 tonnes respectively during any 12-month period beginning on the 1st day of any 4, but not greater than the 5 week period to coincide, as close as possible, with the end of the calendar month".*

Policy 38 states that discharges of contaminants to water are to comply with various requirements. Of particular note, there shall be no net increase of nitrogen or phosphorus in lake catchments. This does not preclude the use of nutrient trading within the same lake catchment to achieve this policy. As the design flow is increasing consideration of this policy is important.

2.3 Existing Land Application Scheme

The LTS at Whakarewarewa occupies 430ha of which approximately 240ha is suitable for irrigation. From the storage ponds of the WWTP, treated wastewater is pumped 3km underground from the two 6,000 m^3 storage ponds at the WWTP to the two holding ponds at the LTS. From here it is pumped to the various spray blocks. The purpose of the Bardenpho, MBR and LTS systems was to control the discharge of nutrients to the lake. The treated wastewater is irrigated using above ground impact sprinklers.

3 Methodology

3.1 Design Criteria

The methodology used to undertake the detailed feasibility investigation of the land disposal options is presented in the following section. In this section we provide the treated wastewater quality and future average flow projections from the WWTP and the various attributes used for the selection process of suitable land for disposal. Given that the current land disposal system is by way of sprinklers to pine forest on relatively steep land of up to approximately 20^{o}, we have assumed that this is feasible and is included within the criteria.

Forestry could be located on flat land but a grass/pasture arrangement may be more practical depending on the final disposal method and other factors. Steeper land generally has less land value ($) and could be more suitable for forestry rather than grass/pasture for a range of reasons e.g. erosion mitigation, run off mitigation and nutrient uptake rates. Both options could then be analysed for a potential cut and carry or harvesting arrangements.

3.1.1 WWTP Treated Wastewater

The population, flow and nutrient load estimates for the WWTP to 2051 formed the basis of the TERAX™ and MBR projects which were reviewed and used as part of the Mott MacDonald (December 2014) study. The hydraulic and pollutant design criteria for the treated wastewater from the plant are shown in Table 3.1 below.

Table 3.1: Design Criteria – WWTP Treated Wastewater & Consent Limits

Limit - P (t/yr leached)	Limit - N (t/yr leached)	Calculated Average Wastewater Flowrate (ML/d)	MBR Mean DRP (mgP/L)	MBR Total N (mgN/L)	Bardenpho Mean DRP (mgP/L)	Bardenpho Mean Total P (mgP/L)	Bardenpho Mean Total N (mgP/L)
3	30	23.81	1.87	3.72	2.91	3.37	6.61

The design average flow of 23.81 ML/d is based on a 2051 estimated population (Strategic Plan) of 72,349 persons. The nitrogen and phosphorus loads and leaching limits are based on the existing WWTP wastewater and current resource consent conditions for the discharge from the WWTP. The design flow and current WWTP performance with 2051 flow is shown in Table 3.2 below.

Table 3.2: Current WWTP Performance with 2051 Flow

Current Performance (@2051 flows)	Flow	DRP	Part-P	NH4	NO3	Part Org N	Sol Org-N	TP (load)	TN (load)
	ML/d	g m^{-3}	g m^{-3}	g m^{-3}	g m^{-3}	g m^{-3}	g m^{-3}	t y^{-1}	t y^{-1}
Bardenpho + TERAX	16.51	2.90	0.50	0.20	3.30	1.55	1.18	20.49	37.54
MBR	7.30	1.90	0.00	0.50	2.30	0.00	0.88	5.06	9.81
Combined MBR and Bardenpho	23.81	2.59	0.35	0.29	2.99	1.07	1.09	25.55	47.35

3.1.2 GIS Constraints – Preliminary Sites Assessment

Table 3.3 shows the GIS parameters and constraints used for the initial mapping exercise. The relevant GIS metadata is shown in Appendix A. Note that we have based our initial land area requirement calculations and GIS mapping exercise on a hydraulically limited assumption rather than a nutrient limitation.

Table 3.3: GIS Mapping Constraints

Parameter	Limit/Constraint	Source	Reasons/Comments
Slope	Up to 20°	EPAV/NZRLI	Slope required to manage erosion and run off, and practicality if harvested
Soil drainage (Drainage Class)	Well to moderately drained (Class 4 and 5)	NZRLI	To reduce ponding and run-off
Rotorua Lake - flood return interval (FRI)	Not within 1:20 FRI and landward of SH30	BOPRC GIS Layer	To reduce run off and risk to operation
FRI – rivers and streams	Flood class 1 to 3 (> 1:20 FRI)	NZRLI	To reduce run off and risk to operation
Archaeological sites, significant sites, significant natural areas and outstanding natural features	Exclude these areas	RLC/LRIS	Unlikely to be purchased and/or legally feasible or desirable land due to its status.
Distance to WWTP	Within 10 km	RLC/MML	Capital costs are potentially cost prohibitive at a distance of more than 10 km which equates to a capital cost of approximately $20M to $22M
Urban areas	Exclude	Aerial photo and RLC GIS layers	Unlikely to be purchased and/or legally feasible or desirable land due to its status.
Area (Option 5)	~500 ha	RLC & MML	Based on 5mm/day average application rate
Area (Option 4)	~350 ha	RLC & MML	Based on 5mm/day average application rate

3.1.3 Land Application Area

Using the conceptual daily flow rate from the WWTP, the land area required for irrigation has been determined from the volume of treated wastewater to be discharged. While site specific design is required to determine the limiting factor and rate of application for any site, for the purpose of this assessment an average requirement land treatment regime has been adopted. The application rate of 20mm/day has not been researched to confirm its acceptance or otherwise in terms of down gradient environmental effects or long term sustainability. Specific site investigations are required to confirm if 20mm/day (or any other rate) will be sustainable in terms of soil management, runoff and nutrient removal potential. These investigations are beyond the scope of this report. Note that the current LTS has an average hydraulic loading rate of 9mm/day.

The approximate area of land required for Option 4 and Option 5 based on application rates of 5 mm/day and 20 mm/day are as follows:

- Option 4
  - Annual average daily flow = 16,510 m^3/day
  - Assuming 5 mm/day the land area requirement is 346 ha (rounded to 350 ha).
  - Assuming 20 mm/day the land area requirement is 87.5 ha

- Option 5
  - Annual average daily flow = 23,810 m^3/day
  - Assuming 5 mm/day the land area requirement is 476 ha (rounded to 500 ha)
  - Assuming 20 mm/day the land area requirement is 120 ha

An additional 20% land will be added to the above net areas to allow for buffer zones etc.

For Option 5, in order for RLC to meet the consent discharge limit (condition 11) approximately 17.35 tonnes of N and 22.55 tonnes of P per year of wastewater would need to be treated. For Option 4, this equates to 12.03 tonnes of N and 15.63 tonnes of P per year.

Phosphorus Removal

Phosphorus (P) is relatively immobile in soils compared to nitrogen (N), and application of wastewater from the WWTP at the appropriate loading rate is unlikely to result in any significant P leaching from the soil profile. Principal mechanisms by which P is retained in soils include soil adsorption/fixation and biological immobilisation. The ability of the soil to retain P depends on the amount of oxide (iron, aluminium, manganese), clay and organic matter and soil pH (i.e. increasing with higher pH).

A small portion will remain in soil solution as water soluble P and is readily available to plants or subject to loss (Sharpley et al. 2001). The P retention processes in most New Zealand soils result in a low probability of P leaching (White and Sharpley 1996). The P concentration in surface soils and subsequent loss in overland flow is where P is more likely to migrate to waterways (assuming the groundwater table is below the soil profile). As such, mitigating run off and erosion will reduce the P migrating to surface water.

The soils formed around Rotorua contain loam and volcanic ash with a clay mineral called allophane. This has an imperfect aluminosilicate structure that forms a large total surface area for adsorption of phosphate. For now, we've assumed that applying the WWTP wastewater to 'category 5 loam soils' (either covered with pasture or bare) will meet these leaching rate limits. Hence we have based our initial land area requirement calculations and GIS mapping exercise on a hydraulically limited assumption rather than a nutrient limitation.

Further work is essential as part of phase two of this project to confirm the extent of land required for treatment or disposal and the associated leaching rates.

Nitrogen

A cut and carry, coppicing or harvesting type arrangement may not be practical given that over half of the nitrogen in the treated wastewater is comprised of nitrate of which a large proportion will potentially be leached rather than taken up by plants. Moreover, given the low ammonia content in the wastewater, plant growth rates are likely to be less than that required to be cost effective. However given the groundwater mounding and nitrogen leaching issues present at the current LTS (Whakarewarewa forest) a range of nutrient removal options is further discussed in Section 4 below.

3.1.4 Irrigation System Options and Application Rates

Given the potentially different land use types i.e. flat land vs rolling hill, we have considered appropriate types of irrigation systems as detailed in Table 3.4.

Table 3.4: Irrigation System and Applications (Source: Environmental Protection Agency Victoria, 1983[2]).

System	Slope (%)	Suitable Crops	Potential Problems	Energy Requirements	Comment
Fixed Sprinkler					
Large nozzles	0.1-10	Pasture, horticulture, vegetables	Stock can damage	Medium-High	Suitable for pasture/crops
Mini-sprinkler	0.1-10	Trees (horticulture/forestry)	Needs rectangular maintenance	Low-Medium	Suitable for trees
Drip	0.1-10	Trees, vegetables, some field crops	Needs regular maintenance and efficient water filtration	Low-Medium	Suitable for trees
Travelling Sprinkler					
Big Gun	0.1-10	Pasture, some field crops, some vegetables	High labour input. Wind limits use	Very high	High risk of aerosol drift
Linear Move	0.1-5	Pasture, field crops, vegetables	Needs large uniform and rectangular areas	High	Suitable
Centre Pivot	0.1-5	Pasture, field crops, vegetables	Only irrigates a circle leaving high % of non-irrigated area	High	Suitable

The application rate for irrigation depends on the characteristics of the soil. Well-drained soils typically comprise coarse sandy soils, with poorer soils consisting of loams and heavy textured clays. Based on the fundamental soil map of the Rotorua District, a large area consists of loamy soils. As shown in Table 3.5, in order to prevent water logging and ponding, predominantly silt loams over compact subsoil only allow for irrigation application rates of 3 to 15 mm/hr. Therefore a 5 mm/day rate is considered appropriate[3] as part of the preliminary stage of identifying potential areas of land for WWTP wastewater disposal. However depending on the nutrient removal, wastewater quality, storage costs and other factors, a higher application rate may be appropriate hence a smaller area of land may be required for land disposal. Conversely if leaching rates are higher than expected or due to other factors, a larger area of land may be required.

Subsequently following the TAG meeting (28 May 2015), RLC requested that an application rate of 20 mm/day be considered as part of the assessment.

Table 3.5: Water Application Rates for Sprinkler Systems (Source: EPA Victoria, 1991[2])

Soil Texture	Application Rate (mm/hr) for slope of							
	0-5%		5-8%		8-12%		12% and over	
	With cover	Bare	With cover	Bare	With cover	Bare	With cover	Bare
Coarse, sandy soils to a 2 m depth	50	50	50	38	38	25	25	13
Coarse sandy surface soils with compact subsoil	44	38	31	25	26	19	19	10
Light sandy loams – uniform	44	25	31	20	26	15	19	10
Light sandy loams over compact subsoil	31	19	25	13	19	10	13	8
Silt loams over compact subsoil	15	8	13	6	10	4	8	3
Heavy textured clay or clay loams	5	4	4	3	3	2	3	2

[2] Environmental Protection Agency Victoria, "Guidelines for Wastewater Irrigation - Publication 168, 1983 (revised 1991).

[3] Sandy clay/loam, clay loam and silty clay loam soils are category 5 soils that have moderate to slow drainage. A maximum application rate of 15 mm/day is recommended in *'On-site domestic wastewater management'* AS/NZS 1547:2012 and Technical Publication 58 (Auckland Council, 2004). It is acknowledged that AS/NZS is based on sub-surface irrigation opposed to above ground irrigation.

3.2 Identification of Alternative Sites

Preliminary sites were identified and presented to RLC at a workshop. During the workshop RLC selected three alternative sites for further investigation with the aim of identifying viable and potential sites. This is explained further in in Section 4.

3.3 Assessment/Grading of Alternative Sites

A further set of criteria and a scoring/ranking method was considered by RLC for identification of the potential land options. Such parameters as land use attributes and engineering constraints were included. The considerations are outlined below.

The land use of any site indicates both:

- The potential for nutrient removal from the site; and
- Limitations for the establishment of a land treatment system due to the acceptability of pine forest and certain crops and land management practices receiving wastewater from a municipal source. Land use parameters considered are as follows.

3.3.1.1 Nutrient Uptake

The land cover type and land management practices adopted on site are an indicator of a sites ability to remove the applied wastewater nutrients.

3.3.1.2 Proximity to Surface Water Bodies

Surface water bodies have have not been excluded at this stage. Lakes have been excluded but some streams may still be shown along with the potential land application areas and will need appropriate buffers which should be set on a case by case basis.

3.3.1.3 Engineering capital and operational costs

As discussed in section 5.4 below, operational and capital costs are considered as part of the option analysis.

3.3.1.4 Acceptability

Food safety and public health matters may also limit the land treatment of wastewater. Further discussion with stakeholders is recommended following identification of potential locations in terms of the acceptability of wastewater application.

Note that there are restrictions on the use of human effluent wastewater and sludge on pasture or feed that is fed to dairy cows supplying Fonterra. Provisionally, these are:

- Only wastewater that meets the Californian Standard Title 22 is to be used on pasture of feed that is fed to lactating animals supplying Fonterra"
- No sewage sludge derived from the treatment of human waste many be used to grow pasture or feed that is feed to lactating animals"

3.4 Other considerations not included in this assessment

3.4.1.1 Other Potential Mapping Constraints and Technical Considerations

Other potential GIS mapping constraints that could be useful for future work and selecting suitable areas of land for land treatment are shown in Table 3.6.

Table 3.6: Other Potential GIS Mapping Constraints

Parameter	Limit/Constraint	Source	Reasons/Comments
Depth to groundwater	> 1.2m	NZRLI	To reduce leaching and ponding
Depth to restrictive layer	> 1.2m	NZRLI	To reduce ponding
P retention	Classes 1 & 2	NZRLI	Reduce P leaching
Active geothermal areas	Exclude	NIWA/GNS/BOPRC	Instability, run off and leaching

3.4.1.2 Land ownership

The ownership of the land will have implications for the feasibility of this project. Such matters are not assessed in this report but will be a key matter to consider and assess.

3.4.1.3 Public Perception

The proximity to certain land or archaeological features and waterways may attract public attention. Guideline buffers should be adopted in the detailed design phase and collaboration with relevant stakeholders to ensure that potential adverse effects on such features are mitigated or avoided.

3.4.1.4 BPO

Finally, in terms of the RMA, the best practicable option (BPO) is likely to be considered during the detailed design and consenting phase.

4 Preliminary Identification of Irrigable Areas and Alternative Sites Assessment

4.1 Preliminary Irrigable Areas

Appendix B and Figure 4.1 shows the preliminary irrigable areas based on the design criteria shown in Section 3 above. Some preliminary irrigable areas in this figure and table contain a few areas to be excluded such as urban, archaeological sites, stream buffers and significant natural features. These areas are not of significant size and do not affect the overall feasibility of the preliminary irrigable areas. Approximately 8,000 ha of land potentially suitable for wastewater irrigation is within 10 km of the WWTP.

4.2 Identification and Selection of Alternative Sites

As briefly explained in above, preliminary irrigable areas were identified and presented to RLC at a workshop. During the workshop RLC selected three alternative sites for further investigation.

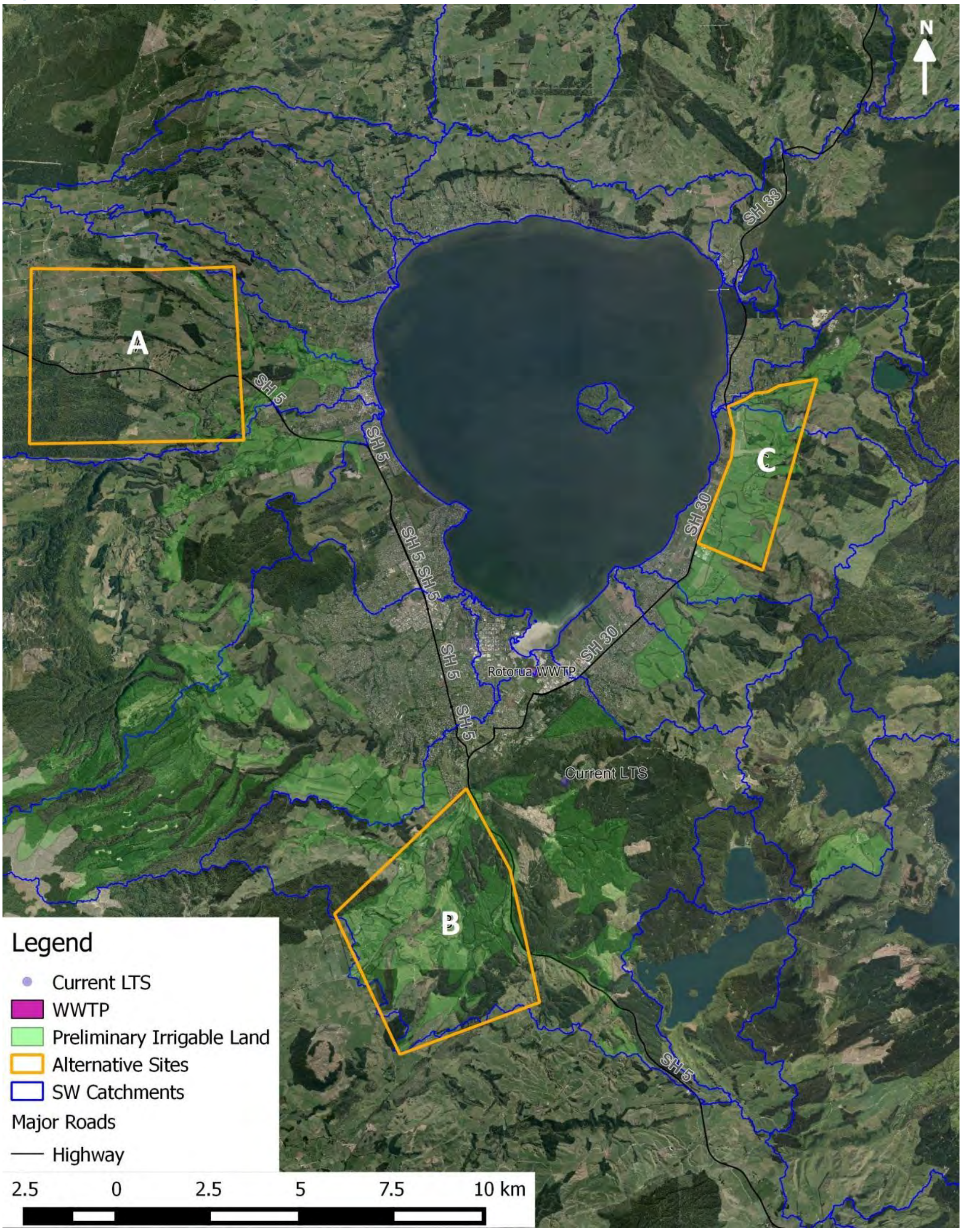
As shown in Appendix A the attributes of the preliminary irrigable areas are fairly similar. An example of a scoring system was presented to RLC during the workshop. The three attributes of P Retention Class, Depth Slowly Permeable Horizon and Drainage Class were used and each piece irrigable land (from the preliminary investigation) scored out of 15. The preliminary irrigable land scores ranged between 9 and 15. The higher the score, the more suitable the land is likely to be for wastewater irrigation. Given that the example scoring system was based on only a limited number of attributes and most pieces of land scored similarly, the example scoring system was not used for the selection of the alternative sites.

Option ‘A’ was selected by RLC due to it being potentially “available”. However Option ‘A’ did not meet the design criteria due to the majority of land being too steep and outside of the 10 km study area. It has a high number of steep volcanic rock formations which are likely to be unsuitable for pivot irrigation.

Option ‘B’ was primarily selected due to its proximity to the WWTP and the current LTS. The existing below ground pipeline infrastructure could potentially be utilised for the new LTS.

Option ‘C’ was primarily selected due to its proximity to the WWTP, relative flatness which reduces the likelihood of runoff, is suitable for pivot irrigation and reduces operational costs (i.e. electricity).

Figure 4.1: Preliminary Irrigable Areas



Source: Mott MacDonald using RLC, BOPRC and NZRLI GIS layers

4.2.1.1 Option A

Option A was considered as a potential area for land disposal in order to provide a cost comparison of sites that are relatively close to the WWTP compared to those located further away. The total area does not meet the design criteria mainly due to it being characterised by volcanic mound formations (granite) and river valleys, and is potentially too steep and difficult for practical and reasonably costing irrigation. However, approximately 300 ha of the required land appear to meet the initial design criteria.

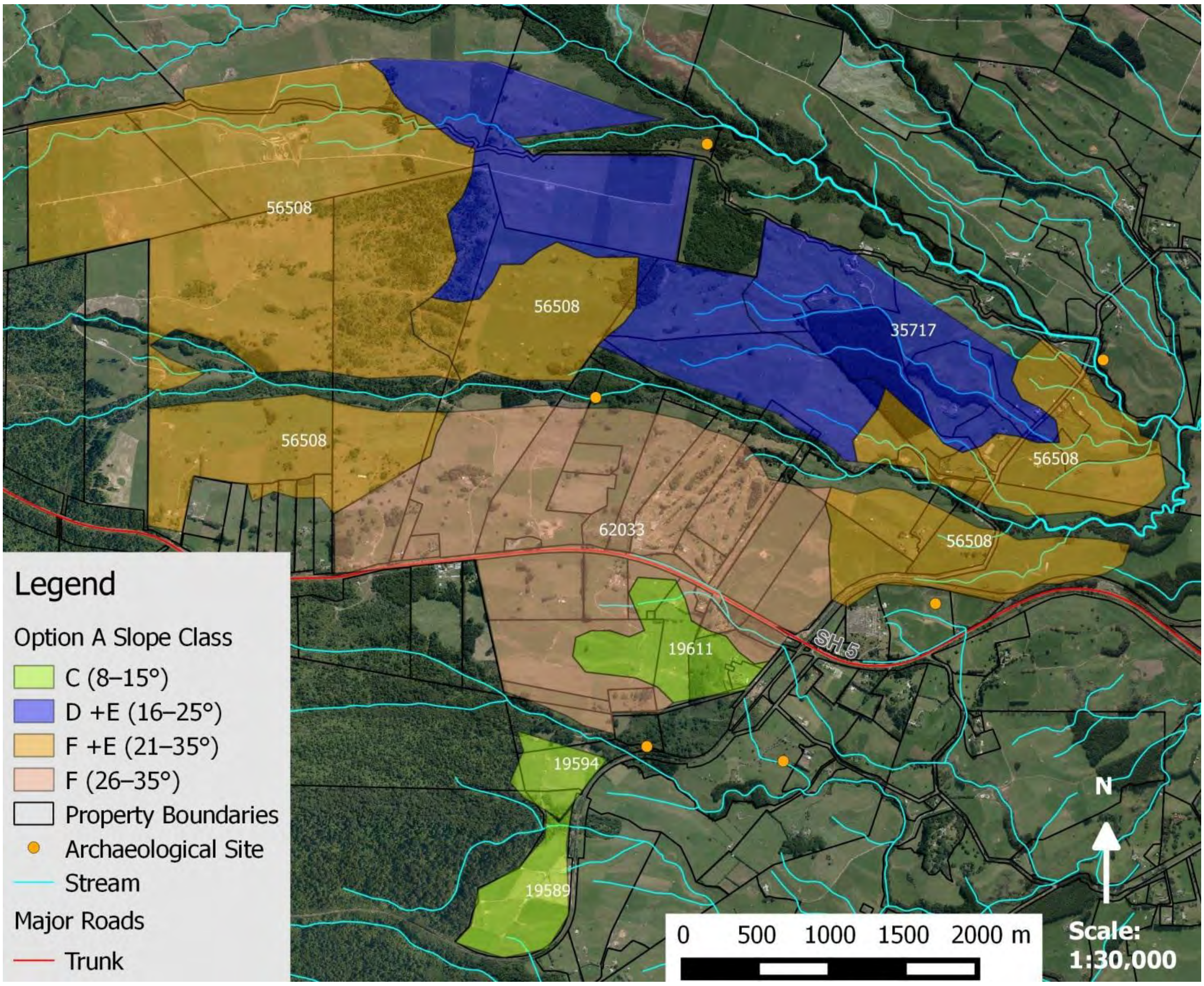
A moderate proportion of the 1,082 hectares within the Option A area could potentially be used for wastewater disposal using lower rate irrigation methods such a K-lines (pods) or other suitable methods. Consideration of whether or not pipes need to be located above or below ground (i.e. if harvesting is required for nutrient removal) is also required. The existing land use is predominately livestock farming, forestry with a golf course located within the area next to the highway. This area has also some patches of significant natural forest. A summary of the physical characteristics of the area is shown in Table 4.1 and a map showing the slope classes are shown in .Figure 4.2

Note that the object ID in the table below comes from the NZRLI GIS data layer. It has assigned each area a number. This object ID number is simply used as a label. Numerous property / parcels can be within the ‘object ID’ area.

Table 4.1: Option A Summary Table

Object ID	Soil series	Soil type	P Retention Class	DSLO Class	Drainage Class	Flood Class	Slope Class	Area (ha)
14221	Oturoa	loamy sand	1	5	5	1	D +E	83.09
14110	Mamaku	loamy sand	4	4	5	1	D +E	168.3
14127	Mamaku	loamy sand	4	4	5	1	F	267.7
14237	Ngongotaha	sandy loam	2	4	5	1	F	53.8
14294	Oturoa	sand	1	5	5	1	F	69.56
14322	Mamaku	loamy sand	4	4	5	1	F	68.81
14327	Ngongotaha	sandy loam	2	4	5	1	F +E	247.5
14383	Oturoa	loamy sand	1	5	5	1	F	55.39
14428	Mamaku	loamy sand	4	4	5	1	C	31.61
14528	Ngongotaha	sandy loam	2	4	5	1	C	12.47
14601	Ngongotaha	sandy loam	2	4	5	1	C	23.59
							Total	1082

Figure 4.2: Option A Map with Slope Classes



4.2.1.2 Option B

Option B was selected by RLC as a potential area for land disposal. Land use comprises livestock farming, dairying, forestry and scrub. This area has a high number of natural streams, two archaeological sites and some areas of significant natural forest. There is also a landfill site which will not be used for irrigation purposes and this has been excluded from the irrigation area. A summary of the physical characteristics of the area is shown in Table 4.2 with a map showing the slope classes is shown in Figure 4.3.

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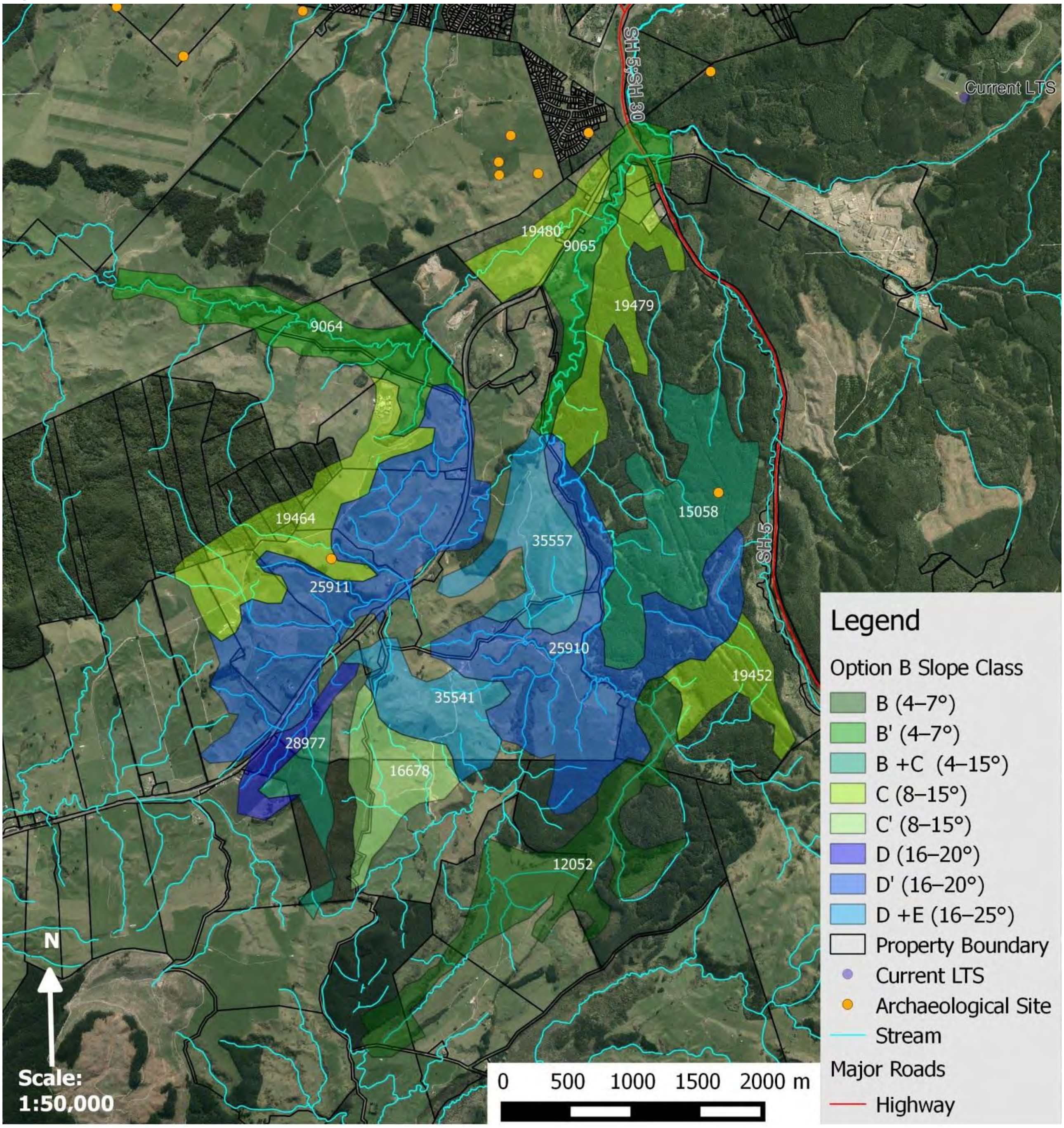
Table 4.2: Option B Summary Table

Object ID	Slope	Soil Series	Soil Type	P Retention Class	DSLO Class	Drainage Class	Flood Class	Area (Ha)
12052	B	Haparangi	sandy loam	2	5	5	1	138.5
19452	C	Ngakuru	loam	1	5	5	1	44.9
9064	B'	Haparangi	sandy loam	2	5	5	1	90
9065	B'	Haparangi	sandy loam	2	5	5	1	61.89
15051	B +C	Haparangi	sandy loam	2	5	5	1	28.3
15058	B +C	Haparangi	sandy loam	2	5	5	1	130.7
16678	C'	Haparangi	sandy loam	2	5	5	1	62.39
19464	C	Haparangi	sandy loam	2	5	5	1	105.5
19479	C	Haparangi	sandy loam	2	5	5	1	69.79
19480	C	Haparangi	sandy loam	2	5	5	1	49.62
25910	D'	Haparangi	sandy loam	2	5	5	1	210.2
25911	D'	Haparangi	sandy loam	2	5	5	1	215.2
28977	D	Haparangi	sandy loam	2	5	5	1	26.51
35541	D +E	Haparangi	sandy loam	2	5	5	1	62.38
35557	D +E	Haparangi	sandy loam	2	5	5	1	77.31
								Total 1373

Figure 4.3: Option B Map with Slope Classes



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4.2.1.3 Option C

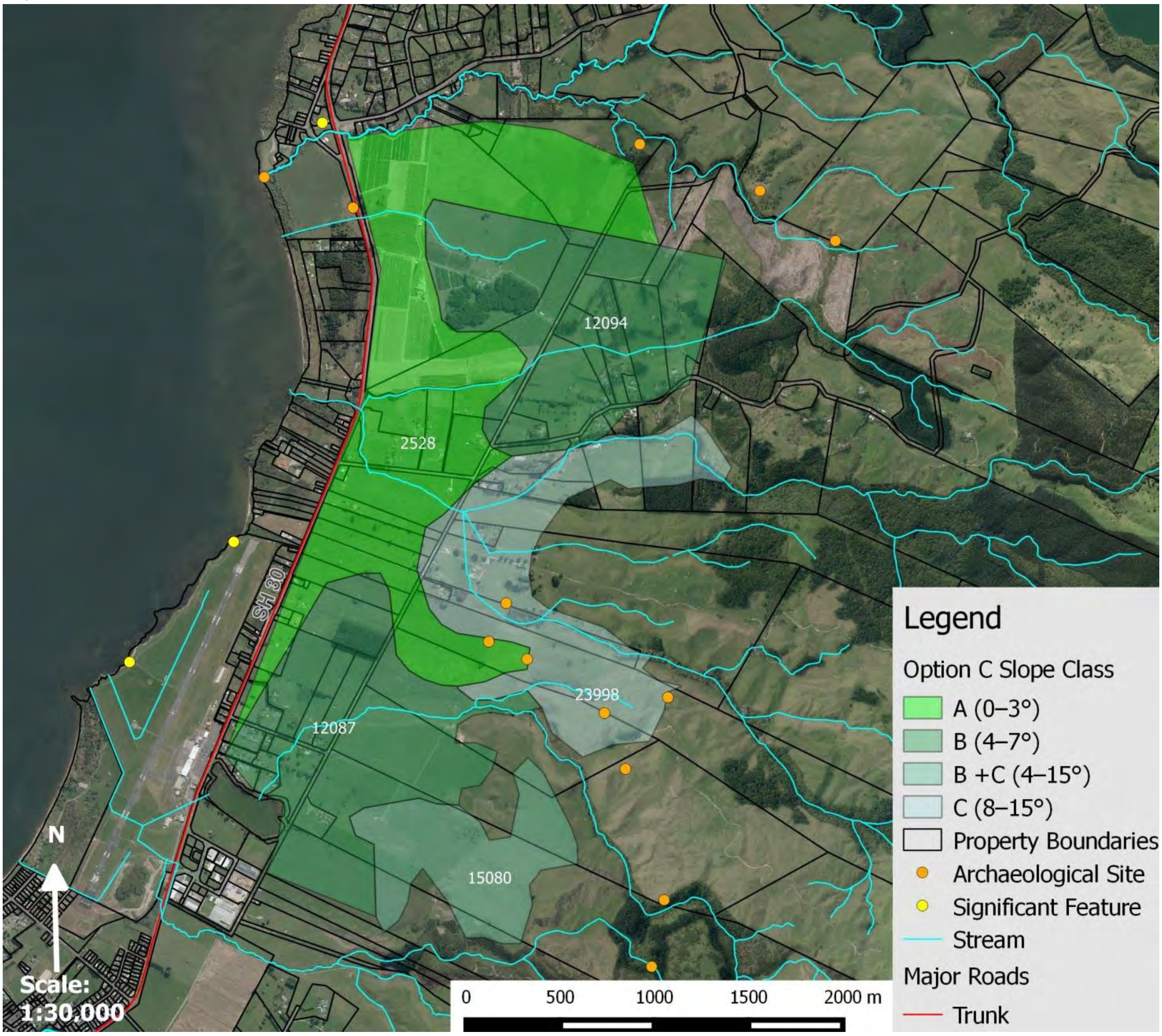
Option C was selected by RLC as a potential area for land disposal. The land use is varied with livestock farming, tree nursery and life style blocks. There are numerous houses and lifestyle blocks within the Option C irrigation area that have yet to be buffered or considered for purchase. RLC also identified two areas of lifestyle blocks which are located north and south of the Option C irrigation area which are located on the boundary of Option C. It also contains five archaeological sites. A summary of the physical characteristics of the area is shown in Table 4.3 with a map showing the slope classes are shown in Figure 4.4.

Table 4.3: Option C Summary Table

Object ID	Slope	Soil Series	Soil Type	P Retention Class	DSLO Class	Drainage Class	Flood Class	Area (ha)
12087	B	Te Ngae	loamy sand	3	4	5	1	132.7
12094	B	Te Ngae	loamy sand	3	4	5	1	75.83
15080	B +C	Rotomahana	sandy loam	3	4	5	1	60.25
23998	C +D	Tikitere	sand	4	3	4	1	124.5
2528	A	Tikitere	sand	4	3	4	1	162.5
								Total[4] 556

[4] Note: Approximately 600 ha is required for a 5 mm/day irrigation operation including buffers. Suitable land for irrigation has been identified on either side of Option C (see Figure 4.1) which can be investigated in the future to achieve the 600 ha requirement.

Figure 4.4: Option C Map with Slope Classes



4.3 Nutrient Removal Performance

Land cover and associated land management practices will influence a sites ability to remove nutrients from the WWTP discharge. In addition, the irrigation regime will affect both the amount of irrigable land required and the expected nutrient removal performance.

Table 4.4 shows average generic N leaching rates for various land uses present in the catchment. Table 4.5 describes the expected N leaching rate for each land option under the current management regime. P leaching has not been estimated for the current land use given that P leaching to groundwater is likely to be low and given that most P loss is probably more likely to be via surface runoff (i.e. P absorption to soil). Estimated P leaching rates are derived based on soil type and P retention class, land use was not considered.

Table 4.4: Nitrogen Leaching Rates for Various Land Use Activities

Land Use Type	Typical N leaching rate (kg N/ha/year)
Bush / shrub#	~3
Native Forestry#	~3
Plantation Forestry#	~3
Sheep Farm (moderately intense)*	15-18
Beef Farm (moderately intense)*	20-28
Gorse^	<385
Dairy Farm (~ = Taupō [typical)]*	~52 but up to 115
Arable/mixed cropping#	35-110

Source: *Waikato Regional Plan, #Hock et al[6] & ^BOPRC

Table 4.5: Nutrient Removal Performance for Alternative Areas

Option	Predominant Soil	Current Land Use	Current Estimated N Leaching	Potential Estimated P Leaching	Potential Estimated N Leaching
A	Loamy sand	Sheep, beef, dairy, forestry, golf course	Moderate Potentially more pumice soil rather than loam and dairying to consider so leaching may be higher	Low Allophanic soil	Moderate Due to soluble N in wastewater
B	Sandy loam	Pine forest, sheep, beef, dairying	Moderate-low Forest cover would reduce N leaching but also dairying to consider so leaching may be higher	Low Allophanic soil	Moderate-low Due to soluble N in wastewater – could be partially lower due to forest uptake
C	Loamy sand / sand	Tree nursery, arable cropping, sheep, beef	Moderate N leaching from arable cropping generally high	Moderate P retention in sandy soils less than allophanic loam	Moderate Due to soluble N in wastewater

4.3.1.1 Nutrient Removal Required

As an initial assessment to the level of nutrient removal, for N, if 100% of the current wastewater ammoniacal-N and particulate organic N was removed, and 60% of the soluble organic N was removed, then the consent limit of 30 tonnes per year of N could be achieved. We've assumed that the nitrate component of the N in the wastewater will be 100% leached. Therefore the alternative land disposal area must be able to meet this treatment requirement as a minimum. It has been assumed for the purposes of this report that the hydraulic loading rate would be limiting rather than the nitrogen loading rate. However as the hydraulic loading rate increases then nitrogen is likely to become limiting at some point. Table 4.6

[5] Some BOPRC literature states average leaching rates of gorse as high as 50 N/kg/ha/year.

[6] Hock, B. *et al*, 2009. *Recent Findings on the Environmental Impacts of Planted Forests in New Zealand*.

shows the nitrogen loading rate to the current TLS (average flow of 19ML/d) versus the loading rates at 5mm/d and 20mm/d assuming current plant performance.

Table 4.6: Nitrogen Loading Rates

Scenario	Land Area (ha)	Nitrogen Loading rate (kg/ha/yr)
Existing LTS at 9mm/d	240	180
Future LTS at 5mm/day loading rate	500	86
Future LTS at 20mm/day loading rate	120	360

Source: MM Calculations

For P, if 100% particulate inorganic P in the current wastewater was removed and 87% of soluble organic P (in the form of DRP) was removed then the 3 T per year consent limit could be achieved. As mentioned above, P is lost via leaching or overland flow as either water soluble P or bound to soil particles.

Overland flow is generally the predominant pathway for P transfer to streams and rivers however leaching may occur under saturated conditions in soils with low P retention, saturated P sorption capacity or high macroporosity. If the P load discharging from the irrigation system (Option 4 or 5) is too high then alum dosing at the WWTP could be undertaken to remove the soluble inorganic P. In this case, an additional alum chemical dose cost would be incurred. Soil conditions need to be considered for the final land application area, and modelling and field testing would need to be undertaken to verify the leaching rate. Table 4.7 shows the phosphorus loading rate as a function of land area.

Table 4.7: Phosphorous Loading Rate

Scenario	Land Area (ha)	Phosphorus Loading Rate (kg/ha/yr)
Existing LTS at 9mm/d	240	98
Future LTS at 5mm/day loading rate	500	47
Future LTS at 20mm/day loading rate	120	197

Source: MM Calculations

We have based our initial land area requirement calculations and GIS mapping exercise on a hydraulically limited assumption rather than a nutrient limitation. A comparison and balance assessment between the current and proposed land use leaching and run off rates is needed to be undertaken to ascertain whether the current allowable nutrient leaching rates and relevant regional plan policy could be met. Or should RLC have a preferred type of land treatment operation, leaching rates could be modelled to ascertain whether or not the current leaching limits could be met. At this point in time, details of the current land management regimes at the alternative sites (i.e. number of livestock, fertiliser use etc) is somewhat unknown therefore an assessment of the difference in nutrient removal/treatment performance cannot be undertaken with the required degree of accuracy.

4.3.1.2 Cut and carry

A cut and carry operation involves planting and irrigating a crop with wastewater. A crop such as ryegrass could bailed and sold to dry stock farmers as part of a sustainable reuse initiative. Ideally this crop would exported out of the catchment to other areas that do not have nutrient issues and are in need of feed. This would help ensure meeting the intent of Policy 38 (BOPRP).

As mentioned in Section 3, a cut and carry type operation (i.e. baylage or silage) may not be practical given that over half of the N in wastewater is comprised of nitrate of which a large proportion will potentially be leached rather than taken up by plants. Moreover, given the low ammonia content in the wastewater plant growth rates are likely to be less than that required to be cost effective. Further investigation would be required to ascertain the feasibility of this option.

4.3.1.3 Harvesting

This option involves the planting and irrigation of trees (usually pine) with wastewater. After approximately 25 years the trees are harvested. New trees are then planted. Staged harvesting and irrigation scheduling is likely to be required if land is required so that wastewater can continually be discharged over the long term when harvesting occurs. Further investigation would be required to ascertain the feasibility of this option.

4.3.1.4 Coppicing

A coppicing operation involves the planting and coppicing of trees. The trees are cut back to the stump, from which new tree will sprout again. Instead of harvesting the trees and re-planting, young tree stems should be regularly cut down to near ground level. This is usually done in 6 to 10 year cycles. The Whiritoa wastewater treatment plant also irrigates eucalypt trees with wastewater and proposes to coppice the trees every 7 years[7]. The coppiced wood could be used as firewood and or chipped and used as wood chip to mulch the existing areas, or sold.

Nitrogen uptake and biomass production of forest crops are generally low during the initial growth stage (1 to 2 years), rise to a maximum at canopy closure, and then decrease significantly as litter fall and decomposition supply an increasing portion of the trees' continuing needs. Irrigation of the tree plantation should not start until the trees are established[8]. Normally in pine forestry situations, trees are on a 25 year harvest rotation cycle.

However so long as eucalyptus trees remain in good health and are continuing to take up the nutrients from the wastewater then replacement may not be necessary some time the longer. Also, there is a risk that when replanting new trees, there is a high probability of damaging the irrigation lines. Normally, the tree crop should be harvested shortly after growth and net nutrient uptake rates begin to decrease however harvesting may be impractical for operational purposes.

Coppicing trees is likely to retain vigour and be near a level of optimal nutrient uptake. Wastewater irrigation carries risks to crop productivity and health. For example, irrigated trees may be more susceptible to wind throw. There will always be a percentage that do not survive and will need replacing therefore management and monitoring of tree crops should be undertaken. In this case the stumps should be left in the ground with the replacement tree being planted in new ground away from the stump. Further investigation would be required to ascertain the feasibility of this option.

4.3.1.5 Wetland

Bare or covered land could be irrigated with wastewater before or after flowing through a wetland in order to further remove nutrients. Further investigation would be required to ascertain the feasibility of this option.

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[7] Hauraki District Council (2005). Water and Sanitary Services Assessment.

[8] Land Treatment Collective, (2000). New Zealand guidelines for utilisation of sewage effluent on land, part two: issues for design and management.

5 Infrastructure Requirements

5.1 Introduction

This section presents the high level concept stage design and costing of the required transfer mains and pumping stations to convey treated wastewater from the WWTP to holding ponds at the previously identified areas (A, B and C). It also considers the irrigation systems for final discharge/disposal at each area.

Additional design and investigative work will be required at the next stage of the project, after the most suitable replacement LTS area has been selected, to develop the design and estimating accuracy.

5.2 Transfer Main and Pump stations Alignment

Plans showing the transfer main routes to Areas A, B and C are included in Appendix C. Provisional locations of the pumping stations and holding ponds for the options are also shown. All routes/locations are indicative only.

The design flows for Option 4 (66% to land) and Option 5 (100% to land) have been taken as 16.51 ML/day and 23.8 ML/day respectively. These are the Average Daily Flows (ADF) from the projected model results for 2051. The final wastewater balancing ponds at the WWTP are assumed to balance out the occasional peak outflows, therefore average daily flows have been used to size the transfer mains and pumping stations. Table 5.1 shows the infrastructure required to convey flows from the WWTP to holding ponds at each of the three areas.

It is assumed that the new transfer mains would be installed using open-cut excavations. The transfer mains would follow the most appropriate routes along existing roads to avoid the need to get possible third party agreements for construction through private land (fields). The possibility and advantages, if any, of laying in the private land could be explored further at the next stages of the project. The area around Lake Rotorua is considered likely to have a high water table as evidenced by the many water courses in the area and consideration of geothermal activity is required. Dewatering would probably be required during the construction works.

The total pump head (static and pipe losses) to each area was calculated. The pumping stations have been located in appropriate locations along the route of the transfer mains to ensure that no station would have to overcome excessive heads (maximum of 70m used as best practice). It has been assumed that the pumping stations downstream of the WWTP, if required, could be constructed within the road reserve, rather than the need to acquire private land. This would need to be investigated in more detail at the next stage of the project.

The most suitable area for constructing the new pumping station and transfer main within the WWTP is on the grassed area just to the south of the balancing ponds and to the east of the existing LTS transfer main. This may require the existing WWTP site boundary to be adjusted. It is assumed that this will not be an issue as this area is believed to be council owned land. It is proposed that the new rising main would be constructed through the strip of land south of the proposed pumping station location which is designated as a SNA (significant natural area). The existing transfer main runs through this area and it is assumed that it would not be an issue obtaining consent to lay the new transfer main through this area.

Table 5.1: Infrastructure Requirement from the WWTP to the Holding Ponds

Area & Option	Loading Rate (mm/day)	Land Area Including Buffer Zones (ha)	Flow (ML/Day)	Flow (l/s)	Total Head (m) [NB: Static + Pipe Losses]	Pumping Station (No.)	Transfer Main ID (mm)	Transfer Main Length (m)	Holding Ponds (m^3)
Area A (Option 4)	**5**	420	16.51	191	202	3	500	17,060	28,000
	20	105	16.51	191	202	3	500	17,060	28,000
Area A (Option 5)	**5**	600	23.8	275	195	3	600	17,060	40,000
	20	150	23.8	275	195	3	600	17,060	40,000
Area B (Option 4)	**5**	420	16.51	191	137	2	500	9,670	28,000
	20	105	16.51	191	137	2	500	9,670	28,000
Area B (Option 5)	**5**	600	23.8	275	133	2	600	9,670	40,000
	20	150	23.8	275	133	2	600	9,670	40,000
Area C (Option 4)	**5**	420	16.51	191	45	1	500	8,610	28,000
	20	105	16.51	191	45	1	500	8,610	28,000
Area C (Option 5)	**5**	600	23.8	275	41	1	600	8,610	40,000
	20	150	23.8	275	41	1	600	8,610	40,000

For Option 5, the holding ponds volumes at the three sites have been assumed to be of a similar size to the one to be replaced at the existing LTS i.e. approximately 40,000m^3. As for Option 4, the volumes have been adjusted to 28,000m^3.

The existing LTS would remain operational until the new system had been tested and commissioned. The new infrastructure would be constructed offline without impacting the existing system.

The decommissioning of the existing LTS system has not been considered at this time as it is outside the scope of this project.

5.3 Irrigation Systems

The most suitable irrigation systems for each of the three areas, taking into consideration the site restrictions stated in Section 3 and following consultation with irrigation contractor Waterforce Ltd, are as identified below. For Area A, a fixed sprinkler system is deemed potentially most suitable due to the area being covered with volcanic mounds. A fixed sprinkler system has been identified for Area B (located adjacent to the existing LTS area). This system is currently being used at the existing LTS and is deemed most suitable due to the terrain and wooded nature of the site. A pivot sprinkler system has been selected for area C which is relatively flat and open grassland.

5.4 CAPEX, OPEX and NVP Costs

Table 5.2 shows the CAPEX, OPEX and NPV costs for construction and operation of the infrastructure for areas A, B and C. The CAPEX costs include an estimate for land acquisition and professional fees. Note that the NPV is based on a 20 year time period at 4% inflation (consistent with the MM (2014) report).

Table 5.2: Capital and Operational Costs

	Area A (Option 4)		Area A (Option 5)		Area B (Option 4)		Area B (Option 5)		Area C (Option 4)		Area C (Option 5)	
	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day
TOTAL CAPEX + MISC ($M)	**71.53**	**44.50**	**88.62**	**49.99**	**46.61**	**27.76**	**58.79**	**31.86**	**49.64**	**26.53**	**64.23**	**31.21**
Pump Station Build Cost ($M)	1.50	1.50	1.50	1.50	1.00	1.00	1.00	1.00	0.50	0.50	0.50	0.50
Transfer Main Build Cost ($M)	20.48	20.48	20.82	20.82	11.61	11.61	11.80	11.80	10.34	10.34	10.51	10.51
Irrigation System Build Cost ($M)	14.00	3.50	20.00	5.00	14.00	3.50	20.00	5.00	10.50	2.63	15.00	3.75
Holding Ponds Build Cost ($M)	1.75	1.75	2.50	2.50	1.75	1.75	2.50	2.50	1.75	1.75	2.50	2.50
Land Purchase Cost ($M)	15.12	3.78	21.60	5.40	4.20	1.05	6.00	1.50	15.12	3.78	21.60	5.40
TOTAL CAPEX + MISC + CONTINGENCY	**86.16**	**53.27**	**106.90**	**59.91**	**55.81**	**33.16**	**70.44**	**38.08**	**60.06**	**31.85**	**77.83**	**37.52**
OPEX ($M/Yr)	**2.33**	**1.99**	**3.11**	**2.62**	**1.83**	**1.51**	**2.45**	**1.96**	**1.13**	**0.82**	**1.42**	**0.97**
Pump Station Annual Energy Cost ($M)	1.50	1.50	2.08	2.08	1.02	1.02	1.42	1.42	0.34	0.34	0.44	0.44
Irrigation System Annual Energy Cost ($M)	0.46	0.12	0.65	0.17	0.46	0.12	0.65	0.17	0.42	0.11	0.60	0.15

	Area A (Option 4)		Area A (Option 5)		Area B (Option 4)		Area B (Option 5)		Area C (Option 4)		Area C (Option 5)	
	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day	5mm / day	20mm / day
Alum Dosing Annual Cost ($M)	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Year 1 Costs ($M)	**73.86**	**46.47**	**91.72**	**52.61**	**48.45**	**29.26**	**61.23**	**33.82**	**50.77**	**27.34**	**65.64**	**32.17**
NPV ($M) [Over 20 Yrs with 4% Inflation]	**100.37**	**69.73**	**127.38**	**83.62**	**69.86**	**47.10**	**89.73**	**57.22**	**63.08**	**36.57**	**80.96**	**43.10**

The high level costs for the transfer mains, pumping stations and holding ponds were developed using our costing database for projects of a similar nature to this scheme. The approximate costs for the irrigation systems were obtained from Waterforce Ltd. The full cost estimates can be found in Appendix D.

5.5 Further Investigations Required

No further investigations are considered necessary to confirm the viability of the physical infrastructure at this stage. The following desktop/site investigations would be recommended to develop the pipeline and pump station design regardless of which area is selected for the disposal/discharge of final wastewater:

- Services/utilities information searches & physical location (pot holing)
- Geotechnical investigations
- Topographical survey
- Review of the existing pipeline performance. Treated wastewater mains can be a risk of biofilm development which reduces their flow capacities. Review of the performance of the existing pipeline will provide design criteria for any new pipeline.

5.6 Special Construction and Commissioning Requirements

The following special construction and commissioning requirements have been identified for the pipelines:

- The high geothermal activity in the Rotorua environment will potentially impact on choice of pipeline material to be used. Pipeline materials would be confirmed further to the geotechnical investigation.

6 Risks & Considerations

Technical, environmental and financial risks are shown in Table 6.1 below.

Table 6.1: Risks & Considerations

Option	Technical Considerations	Environmental Risks	Financial Risks
A	1. Transfer main – lack of space on road along route thus requiring deeper installation. 2. Watercourses – crossings may require the transfer main to be installed at a greater depth. Construction methodologies may also have to be modified to suit (trenchless construction, etc.). 3. Pumping stations downstream of WWTP – if these cannot be sited in favourable locations (protected land, unwilling third party, etc.) then redesign (e.g. larger pumps) may be required. 4. Transfer main – if the existing transfer main is found to suffer from build-up within which restricts flow capacities, the client will either have to put in place a more onerous maintenance regime or this restriction will have to be factored into the design. 5. Irrigation system – hard volcanic rock could make installation of the fixed sprinklers difficult and if so, another system or a mixture of systems (e.g. travelling/pivot irrigators) should be explored. 6. Further investigations are required into the long term sustainable hydraulic loading rate that the site soils are suitable for. This may increase or decrease land area given the actual recommended loading rate that is determined. 7. Impact of peak flows on the land area required. The option of discharging MBR effluent to water is limited by the capacity of the existing MBR system to a daily volume of 7.3ML.	1. Steep slopes and volcanic mound formations – run off 2. Proximity to streams 3. SNA area – initial transfer main length will have to cross this area. Though the existing transfer main is located in this same area, consents may be required which could cause delays and/or onerous construction conditions may have to be adhered to 4. Nutrient removal performance due to potential pumice and granite 5. Application rate and the correlation to nutrient removal performance	1. Irrigation system – installation costs could be high due to earthworks on hard volcanic rock and possible blasting/dynamite requirements. 2. Land availability in regard to ability to purchase and cost 3. Ability to consent the activity 4. Cultural acceptability 5. Capital costs (infrastructure works) could potentially be higher 6. Operational costs could potentially be higher
B	1. Transfer main – lack of space on road along route thus requiring deeper installation. 2. Watercourses – crossings may require the transfer main to be installed at a greater depth. Construction methodologies may also have to be modified to suit (trenchless construction, etc.). 3. Pumping stations downstream of WWTP – if these cannot be sited in favourable locations (protected	1. High number of streams and related potential nutrient effects 2. Slope and run off 3. SNA area – initial transfer main length will have to cross this area. Though the existing transfer main is located in this same area, consents may be required which could	1. Land availability in regard to ability to purchase and cost 2. Ability to consent the activity 3. Stream buffer requirements 4. Archaeological site constraints and buffers 5. Cultural acceptability 6. Capital costs

Option	Technical Considerations	Environmental Risks	Financial Risks
	land, unwilling third party, etc.) then redesign (e.g. larger pumps) may be required. 4. Transfer main – if the existing transfer main is found to suffer from build-up within which restricts flow capacities, the client will either have to put in place a more onerous maintenance regime or this restriction will have to be factored into the design. 5. Potentially complex irrigation arrangement due to slope and streams 6. Further investigations are required into the long term sustainable hydraulic loading rate that the site soils are suitable for. This may increase or decrease land area given the actual recommended loading rate that is determined. 7. Impact of peak flows on the land area required. The option of discharging MBR effluent to water is limited by the capacity of the existing MBR system to a daily volume of 7.3ML.	cause delays and/or onerous construction conditions may have to be adhered to. 4. Application rate and the correlation to nutrient removal performance 5. Soil erosion at higher loading rates	(infrastructure works) could potentially be higher 7. Operational costs could potentially be higher
C	1. Transfer main – lack of space on road along route thus requiring deeper installation. 2. Watercourses – crossings may require the transfer main to be installed at a greater depth. Construction methodologies may also have to be modified to suit (trenchless construction, etc.). 3. Transfer main – if the existing transfer main is found to suffer from build-up within which restricts flow capacities, the client will either have to put in place a more onerous maintenance regime or this restriction will have to be factored into the design. 4. Further investigations are required into the long term sustainable hydraulic loading rate that the site soils are suitable for. This may increase or decrease land area given the actual recommended loading rate that is determined. 5. Impact of peak flows on the land area required. The option of discharging MBR effluent to water is limited by the capacity of the existing MBR system to a daily volume of 7.3ML.	1. Sandy soils: risk of leaching 2. Archaeological sites 3. Proximity to Lake Rotorua 4. Proximity to residential areas 5. SNA area – initial transfer main length will have to cross this area. Though the existing transfer main is located in this same area, consents may be required which could cause delays and/or onerous construction conditions may have to be adhered to. 6. Application rate and the correlation to nutrient removal performance 7. Soil erosion at higher loading rates 8.	1. Zoning implications on suitability of activity 2. Land availability in regard to ability to purchase and cost (likely to have relatively high land value) 3. Ability to consent the activity 4. Archaeological site constraints and buffers 5. Cultural acceptability 6. Capital costs (infrastructure works) could potentially be higher 7. Operational costs could potentially be higher

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7 Summary & Recommendations

7.1 Summary

A summary of findings is shown in Table 7.1.

Table 7.1: Summary of Findings

Area & Option	Loading Rate (mm/day)	Land Area Including Buffer Zones (ha)	CAPEX ($M)	OPEX ($M/Yr)	NPV ($M)	Key Risks
Area A (Option 4)	5	420	86.16	2.33	100.37	Geotechnically challenging and ability to consent the activity
	20	105	53.27	1.99	69.73	
Area A (Option 5)	5	600	106.90	3.11	127.38	
	20	150	59.91	2.62	83.62	
Area B (Option 4)	5	420	55.81	1.83	69.86	High number of streams, hilly, complex irrigation arrangement and ability to consent the activity
	20	105	33.16	1.51	47.10	
Area B (Option 5)	5	600	70.44	2.45	89.73	
	20	150	38.08	1.96	57.22	
Area C (Option 4)	5	420	60.06	1.13	63.08	Sandy soils, proximity to Lake Rotorua, likely to have relatively high land value and ability to consent the activity
	20	105	31.85	0.82	36.57	
Area C (Option 5)	5	600	77.83	1.42	80.96	
	20	150	37.52	0.97	43.10	

7.2 Recommendations

Providing further consideration of an LTS system is to be undertaken then further investigations and recommendations are as follows:

- Further nutrient removal assessment is undertaken for the for the preferred option which includes but is not limited to soil testing and nutrient leaching and removal modelling
- Groundwater assessment which includes but is not limited to aquifer tests, piezometer level testing for groundwater direction and sampling for water quality
- Geological, geotechnical, geothermal and seismic assessment
- Public and stakeholder consultation and communication plans
- Cultural consultation and cultural impact assessment
- Public health risk assessment and contaminated land assessment
- Assessment of risk to the receiving environment including water quality and ecological assessment
- Land value and purchase viability assessment
- Resource consent obtainability and policy analysis
- Consideration of further treatment at the WWTP to reduce contaminant load
- High rate infiltration is considered
- Other options which is not limited to wetlands and carbon walls is further investigated in order to increase wastewater quality
- Further investigations are required to determine the optimal hydraulic loading rate on the soils and the correlation between loading rate and the nutrient removal potential of the land treatment sites

Appendices

Appendix A. GIS Metadata

Appendix A. – GIS Metadata

Slope Class

Description: Polygon layer delineating physiographic areas of relatively homogeneous average slope class.

Origin: Derived from stereo aerial photograph interpretation, field verification and measurement as part of the 1:63 360/1:50 000 scale New Zealand Land Resource Inventory survey.

Item name(s): Slope

Item values:

Item code	***Class description***	***Class range***
A	Flat to gently undulating	0–3°
B	Undulating	4–7°
C	Rolling	8–15°
D	Strongly rolling	16–20°
E	Moderately steep	21–25°
F	Steep	26–35°
G	Very steep	>35° (36–42°)
H	Precipitous	(>42°)

Interpretation: Examples:

- C — denotes an area of dominantly rolling slopes between 8 and 15°
- E +F — denotes an area of compound slope, dominantly 21–25° but with some significant slopes of 26–35°
- D /E — denotes an area where average slope is intermediate between strongly rolling and moderately steep
- A' — denotes virtually flat land dissected by gullies or terrace edges

Flood return interval (Flood Class): The classes originate from and are described more fully in Webb and Wilson (1995). Flood return interval classes and their corresponding values, are as follows:

Item values:

FLOOD_ CLASS	***Description***	***Flood return interval (years)***
1	Nil	Nil
2	Slight	<1 in 60
3	Moderate	1 in 20–1 in 60
4	Moderately severe	1 in 10–1 in 20
5	Severe	1 in 5–1 in 10
6	Very severe	>1 in 5

Depth to a slowly permeable horizon (DSLO): Depth to a slowly permeable horizon describes the minimum and maximum depths (in metres) to a horizon in which the permeability is less than 4mm/hr as measured by techniques outlined in Griffiths (1985). If no slowly permeable horizon is observed, the taxon is allocated to Class 6 and a null value with numeric code -.99 is entered into the data fields. These classes, described more fully in Webb and Wilson (1995), are as follows:

Item values:

DSLO_ CLASS	***DSLO_ MIN (m)***	***DSLO_ MAX (m)***	***DSLO_ MOD (m)***
1	0	0.44	Refer comment under 'Item values & Interpretation'
2	0.45	0.59	
3	0.6	0.89	
4	0.9	1.19	
5	1.2	1.49	
6	-0.99	-0.99	

The ArcInfo 'world polygon' has a null value, otherwise all records contain values from the list above.

Soil drainage class: Soil drainage is described as a class. Drainage classes are assessed using criteria of soil depth and duration of water tables inferred from soil colours and mottles, as in the following table or from reference to diagnostic horizons, as described below this table. Drainage classes used here are the same as those used in the NZ Soil Classification (Hewitt 1993), and outlined by Milne *et al.* (1995). The drainage classes with their descriptions are as follows:

Item values:

DRAIN CLASS	Description	Depth below A horizon (cm)	Depth from surface (cm)	Low chroma on ped or cut surfaces (%)	High Chroma Redox mottles (%)
1	Very poor	1	≤10	≥50	
2	Poor	≤15	≤30	≥50	
3	Imperfect	≤15	≤30	≤50	and/or ≥2
		>15	30–90	≥50	
4	Moderately well		30–90		≥2
			60–90	≥50	
5	Well		<90		<2

P retention: P retention (phosphate retention) is estimated as weighted averages for the upper part of the soil profile from 0–0.2 m depth, and expressed as a percentage. The classes are described more fully in Blakemore *et al.* (1987) and Webb and Wilson (1995).

Item values:

PRET_ CLASS	***PRET_ MIN (%)***	***PRET_ MAX (%)***	***PRET_ MOD (%)***	***Description***
1	85	100	Refer comment under 'Item values & Interpretation'	Very high
2	60	84		High
3	30	59		Medium
4	10	29		Low
5	0	9		Very low

Appendix B. Preliminary Irrigable Areas

Appendix B. – Preliminary Irrigable Areas

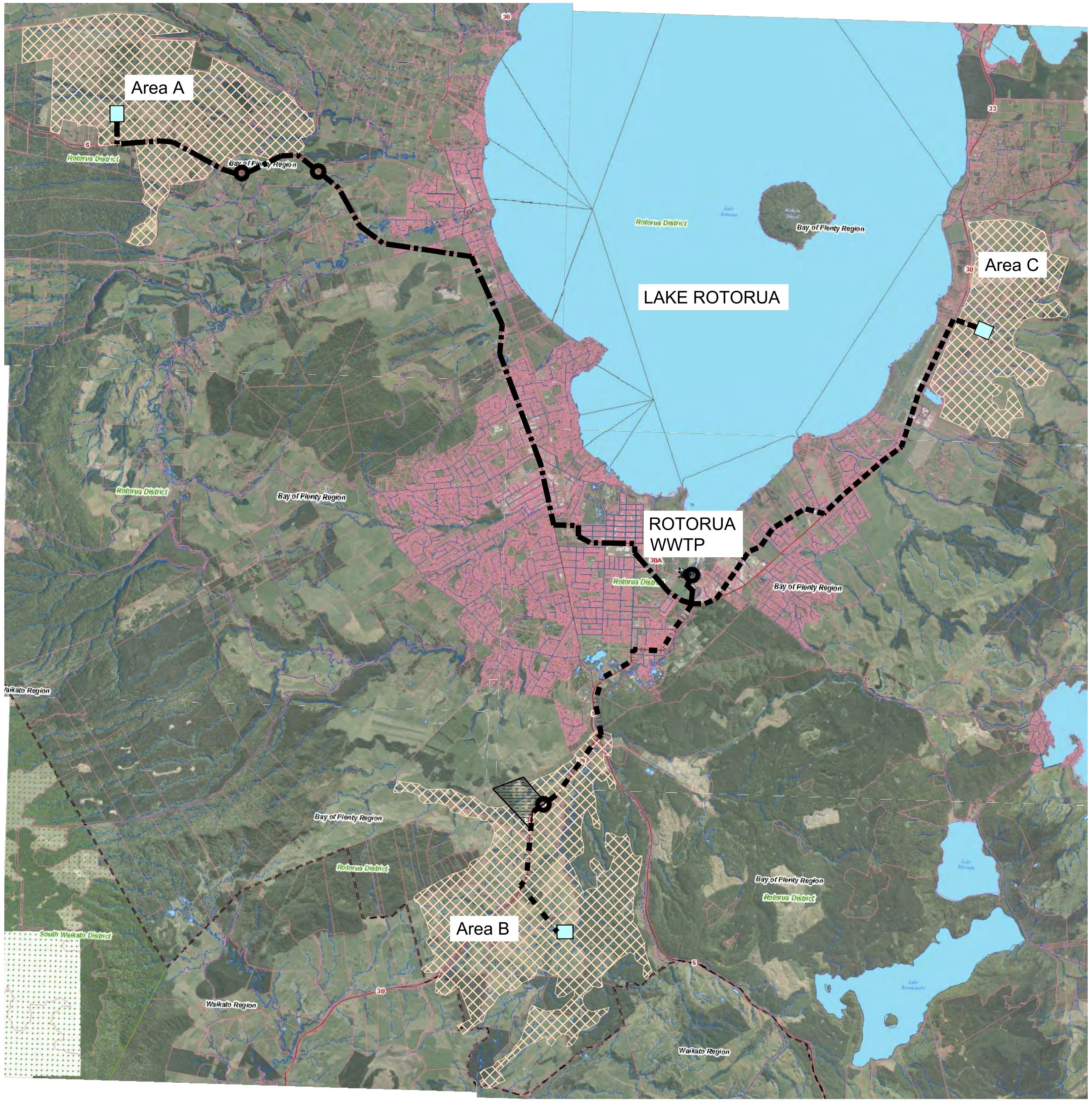
Preliminary Irrigable Areas

ID	Slope	Soil Series	Soil Type	Soil Code	P Retention Class	Depth Slowly Permeable Horizon	Drainage Class	Permeability	Flood Class	Area (Ha)
2528	A	Tikitere	sand	16b	4	3	4	M	1	370
8410	A +E	town	town	town			t	town		308.9
8430	A +F	town	town	town			t	town		167.1
8588	A /B	Rotomahana	sandy loam	3a	3	4	5	M	1	80.4
12052	B	Haparangi		18aH	2	5	5	M	1	138.5
12061	B	Haparangi		18aH	2	5	5	M	1	100.2
12080	B	Rotomahana	sandy loam	3a	3	4	5	M	1	44.63
12051	B	Pohaturoa	sandy loam	126	3	5	5	M	1	54.21
12073	B	Pohaturoa	sandy loam	126	3	5	5	M	1	122.6
12086	B	Ngongotaha	sandy loam	18jH	2	4	5	M	1	95.25
12087	B	Te Ngae	loamy sand	3	3	4	5	M	1	157.3
12094	B	Te Ngae	loamy sand	3	3	4	5	M	1	75.83
9064	B'	Haparangi		18a	2	5	5	M	1	90
9065	B'	Haparangi		18a	2	5	5	M	1	61.89
15051	B +C	Haparangi		18a	2	5	5	M	1	28.3
15058	B +C	Haparangi		18a	2	5	5	M	1	130.7
15060	B +C	Arahiwi	sand	126	2	4	5	M	1	113.2
15070	B +C	Ngakuru	loam	18a	1	5	5	M	1	61.66
15080	B +C	Rotomahana	sandy loam	3a	3	4	5	M	1	60.7
19477	C	Mamaku	loamy sand	20	4	4	5	M	1	214
19517	C	Mamaku	loamy sand	20	4	4	5	M	1	622
19452	C	Ngakuru	loam	18a	1	5	5	M	1	44.9
19488	C	Arahiwi	sand	126	2	4	5	M	1	30.41
19437	C	Haparangi		18aH	2	5	5	M	1	43.92
19444	C	Haparangi		18aH	2	5	5	M	1	35.98
19464	C	Haparangi		18a	2	5	5	M	1	105.5
19471	C	Rotomahana	fine sandy loam	3 H	3	4	5	M	1	63.09
19479	C	Haparangi		18a	2	5	5	M	1	69.79
19480	C	Haparangi		18a	2	5	5	M	1	49.62
19482	C	Haparangi		18aH	2	5	5	M	1	133.7
19487	C	Whakarewarewa	sandy loam	18dH	1	5	5	M	1	72.35
19503	C	Ngakuru	loam	18a	1	5	5	M	1	47.61
19516	C	Arahiwi	sand	126	2	4	5	M	1	70.08
19524	C	Rotomahana	sandy loam	3a	3	4	5	M	1	101.6
19541	C	Ngakuru	loam	18a	1	5	5	M	1	57.54
19548	C	Pohaturoa	sandy loam	126	3	5	5	M	1	40.19
19584	C	Ngakuru	loam	18a	1	5	5	M	1	181.1

ID	Slope	Soil Series	Soil Type	Soil Code	P Retention Class	Depth Slowly Permeable Horizon	Drainage Class	Permeability	Flood Class	Area (Ha)
19610	C	Oturoa	sand	16d	1	5	5	M	1	65.42
16686	C'	Mamaku	loamy sand	20	4	4	5	M	1	760
16684	C'	Ngongotaha	sandy loam	18jH	2	4	5	M	1	17.45
16688	C'	Mamaku	loamy sand	20	4	4	5	M	1	29.17
16678	C'	Haparangi		18a	2	5	5	M	1	62.39
16680	C'	Pohaturoa	sandy loam	126	3	5	5	M	1	121.1
16683	C'	Arahiwi	sand	126	2	4	5	M	1	148.3
16685	C'	Arahiwi	sand	126	2	4	5	M	1	71.38
20890	C +A	Ngongotaha	sandy loam	18jH	2	4	5	M	1	68.36
23970	C +D	Arahiwi	sand	126	2	4	5	M	1	338.2
23977	C +D	Te Ngae	loamy sand	3	3	4	5	M	1	63.56
23960	C +D	Arahiwi	sand	126	2	4	5	M	1	264.3
23974	C +D	Rotomahana	sandy loam	3a	3	4	5	M	1	16.66
23997	C +D	Rotoiti	loamy sand	16b	3	5	5	M	1	124.5
24000	C +D	Ngakuru	loam	18a	1	5	5	M	1	90.87
23998	C +D	Tikitere	sand	16b	4	3	4	M	1	26.43
24013	C +D	Rotoiti	loamy sand	16b	3	5	5	M	1	109.6
16728	C' +B	Haparangi		18a	2	5	5	M	1	8.9
28977	D	Haparangi		18a	2	5	5	M	1	26.51
25910	D'	Haparangi		18a	2	5	5	M	1	210.2
25911	D'	Haparangi		18a	2	5	5	M	1	215.2
35566	D +E	Haparangi		18aH	2	5	5	M	1	297.3
35541	D +E	Haparangi		18a	2	5	5	M	1	62.38
35542	D +E	Pohaturoa	sandy loam	126	3	5	5	M	1	145
35557	D +E	Haparangi		18aH	2	5	5	M	1	77.31
35564	D +E	Okareka	silt loam	126b	3	4	5	M	1	155.3
35571	D +E	Arahiwi	sand	126	2	4	5	M	1	86.6
35587	D +E	Ngakuru	fine sandy loam	18aH	1	5	5	M	1	128.3
35605	D +E	Mamaku	loamy sand	20	4	4	5	M	1	52.18
35609	D +E	Mamaku	loamy sand	20	4	4	5	M	1	59.53
Total										8148*

*Option A is not shown in as this area was added by RLC as the third option at the workshop. This total includes some areas to be excluded.

Appendix C. Layout Plans



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0 500m 1500m 3000m

Notes

1. This is a concept design stage drawing.
2. Areas A, B & C extents are indicative only & their exact sizes will be confirmed at the next stages of the project.
3. Location of transfer mains, pumping stations & holding ponds are indicative only.
4. 500mm ID & 600mm ID transfer mains for options 4 & 5 respectively.
5. This drawing should be read in conjunction with
   - MMD-353265-GA-002
   - MMD-353265-GA-003
   - MMD-353265-GA-004

Key to symbols

- Pumping Station
- New Transfer Main (WWTP to Te Ngae road)
- New Transfer Main (To area A)
- New Transfer Main (To area B)
- New Transfer Main (To area C)
- Final Effluent Holding Ponds
- Extent Of AREAS A, B, & C
- Existing Landfill Area

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
2	10.06.15	HH	Client Comments Integrated	KL	RB
1	24.04.15	HH	Concept Design	KL	RB

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Client

DESTINATION ROTORUA
ROTORUA DISTRICT COUNCIL

Title

Rotorua WWTP Effluent Alternate Disposal Site Pumping Stations & Transfer Main Overall Routes To Areas A, B & C Options 4 & 5

Designed	KL		Eng check	RW	
Drawn	HH		Coordination	RB	
Dwg check	KL		Approved	RB	
Scale at A1: 1:50000		Status: Concept		Rev: 2	

Drawing Number
MMD-353265-GA-001

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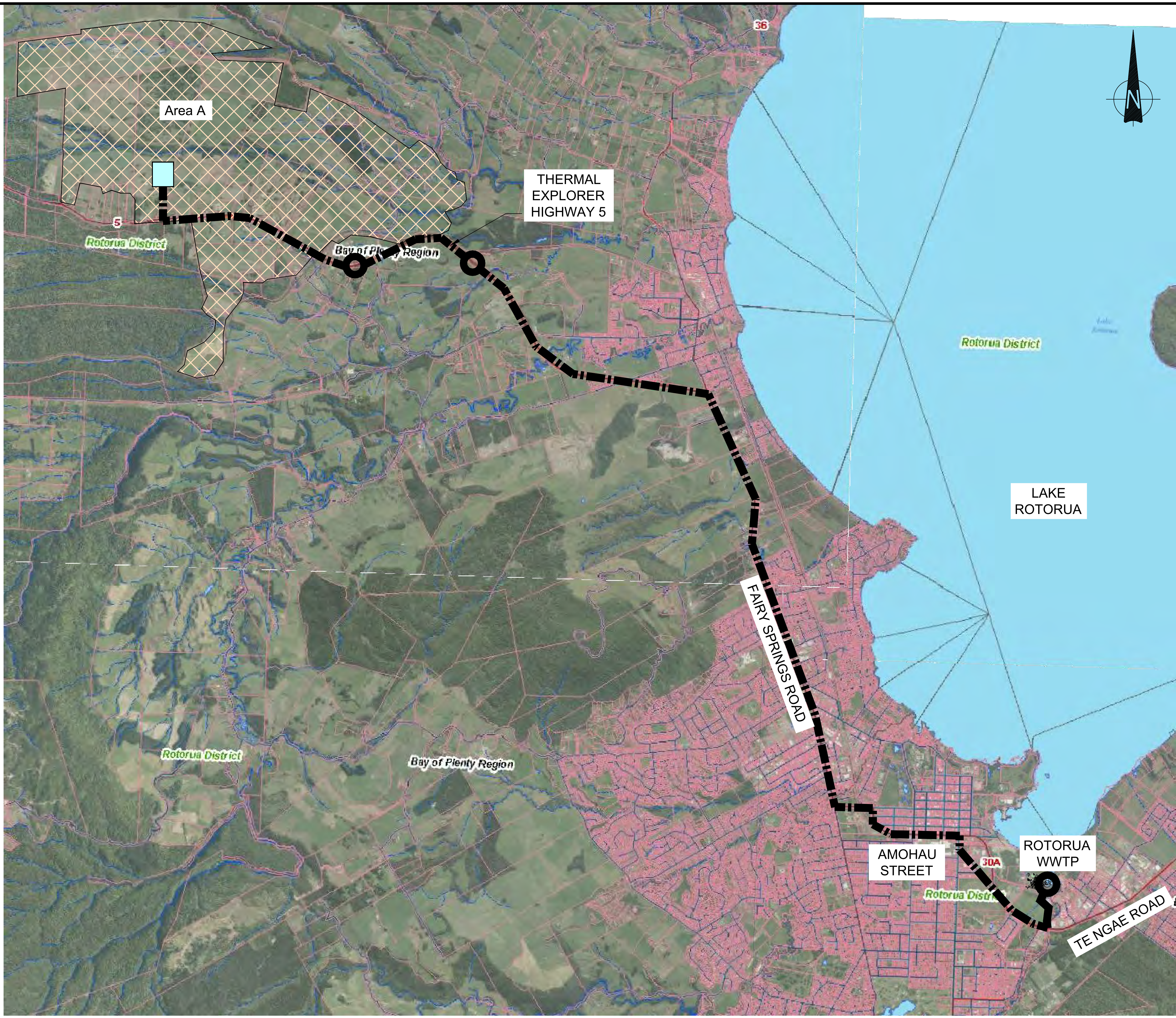

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Notes

1. This is a concept design stage drawing.
2. Areas A extent is indicative only & the exact size will be confirmed at the next stages of the project.
3. Location of transfer main, pumping stations & holding pond are indicative only.
4. 500mm ID & 600mm ID transfer mains for options 4 & 5 respectively.
5. This drawing should be read in conjunction with
   - MMD-353265-GA-001
   - MMD-353265-GA-003
   - MMD-353265-GA-004

Key to symbols

- Pumping Station
- New Transfer Main (WWTP to Te Ngae road)
- New Transfer Main (To area A)
- Final Effluent Holding Pond
- Extent Of AREA A.

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
1	24.04.15	HH	Concept Design	KL	RB

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Client

DESTINATION ROTORUA
ROTORUA DISTRICT COUNCIL

Title

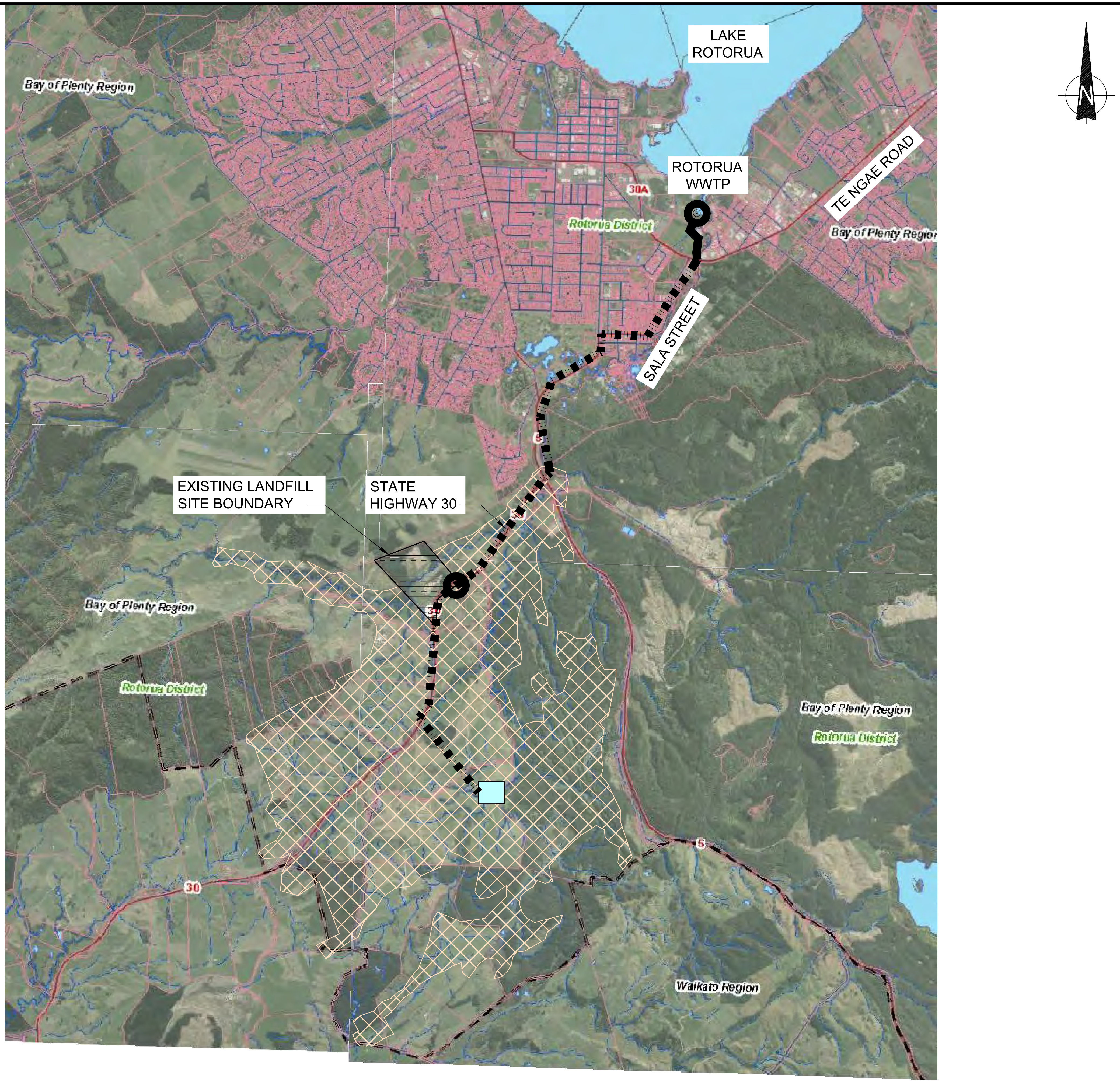
Rotorua WWTP Effluent
Alternate Disposal Site
Pumping Stations & Transfer Main
Route To Area A
Options 4 & 5

Designed	KL		Eng check	RW	
Drawn	HH		Coordination	RB	
Dwg check	KL		Approved	RB	

Scale at A1	Status	Rev
1:25000	Concept	1

Drawing Number

MMD-353265-GA-002



1:25000

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Notes

1. This is a concept design stage drawing.
2. Areas B extent is indicative only & the exact size will be confirmed at the next stages of the project.
3. Location of transfer main, pumping stations & holding pond are indicative only.
4. 500mm ID & 600mm ID transfer mains for options 4 & 5 respectively.
5. This drawing should be read in conjunction with
   - MMD-353265-GA-001
   - MMD-353265-GA-002
   - MMD-353265-GA-004

Key to symbols

- Pumping Station
- New Transfer Main (WWTP to Te Ngae road)
- New Transfer Main (To area B)
- Final Effluent Holding Pond
- Extent Of Area B
- Existing Landfill Area

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
2	10.06.15	HH	Client Comments Integrated	KL	RB
1	24.04.15	HH	Concept Design	KL	RB

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Client

DESTINATION ROTORUA
ROTORUA DISTRICT COUNCIL

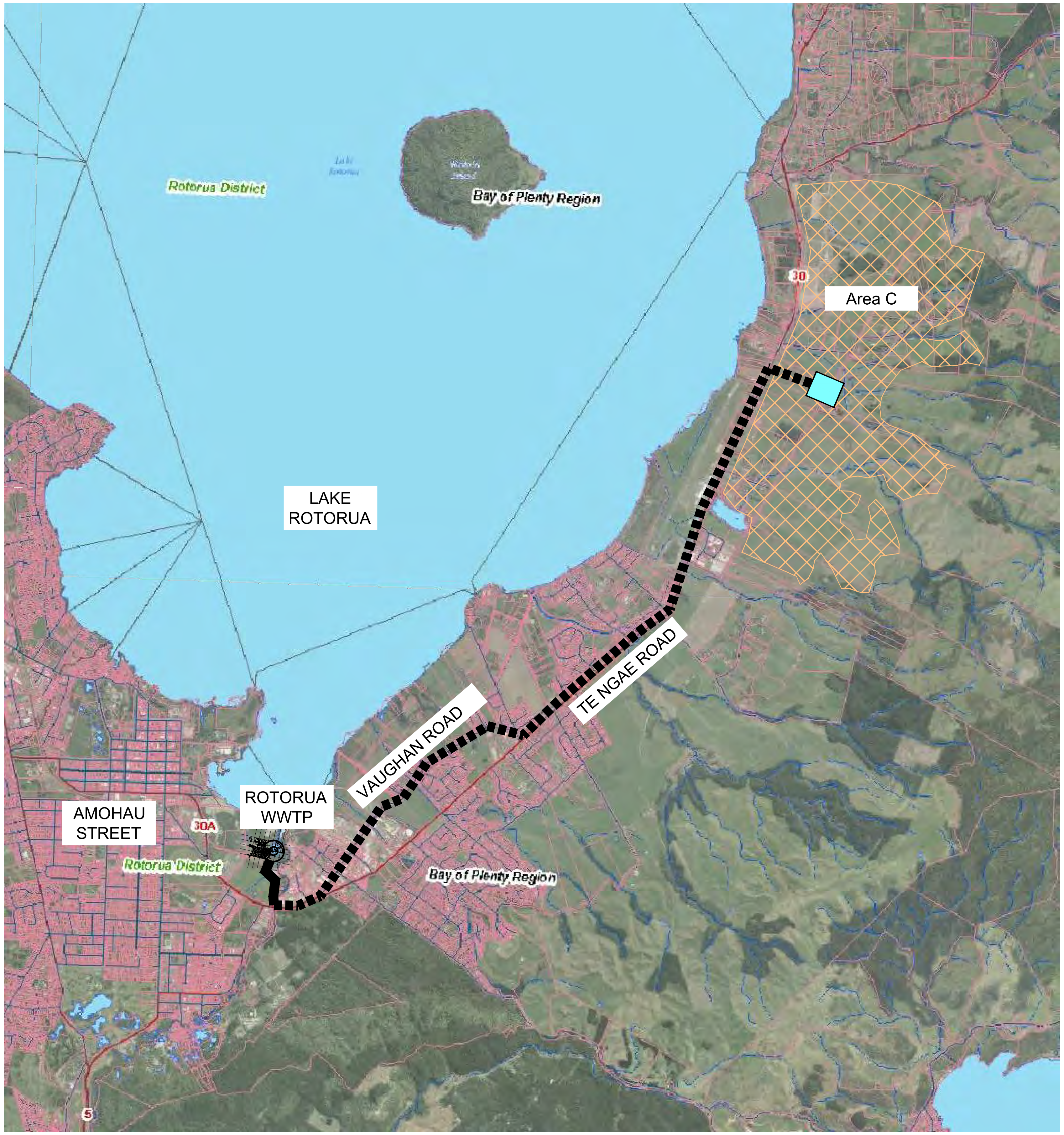
Title

Rotorua WWTP Effluent Alternate Disposal Site Pumping Stations & Transfer Main Route To Area B Options 4 & 5

Designed	KL		Eng check	RW	
Drawn	HH		Coordination	RB	
Dwg check	KL		Approved	RB	

Scale at A1	Status	Rev
1:25000	Concept	2

Drawing Number
MMD-353265-GA-003



Notes

1. This is a concept design stage drawing.
2. Areas C extent is indicative only & the exact size will be confirmed at the next stages of the project.
3. Location of transfer main, pumping stations & holding pond are indicative only.
4. 500mm ID & 600mm ID transfer mains for options 4 & 5 respectively.
5. This drawing should be read in conjunction with
   - MMD-353265-GA-001
   - MMD-353265-GA-002
   - MMD-353265-GA-003

Key to symbols

- Pumping Station
- New Transfer Main (WWTP to Te Ngae road)
- New Transfer Main (To area C)
- Final Effluent Holding Pond
- Extent Of Area C

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
2	10.06.15	HH	Client comments Integrated	KL	RB
1	24.04.15	HH	Concept Design	KL	RB

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Client

DESTINATION ROTORUA
ROTORUA DISTRICT COUNCIL

Title

Rotorua WWTP Effluent
Alternate Disposal Site
Pumping Stations & Transfer Main
Route To Area C
Options 4 & 5

Designed	KL	Eng check	RW
Drawn	HH	Coordination	RB
Dwg check	KL	Approved	RB

Scale at A1	Status	Rev
1:25000	Concept	2

Drawing Number
MMD-353265-GA-004

1:25000
0 250m 750m 1500m

Appendix D. CAPEX Cost Estimates

12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA A (OPTION 4)
5mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 5,660,000**
2.0	**New Transfer Main**				**$ 20,472,000**
2.1	500mm PE pipe	m	17060	$ 1,200	$ 20,472,000
3.0	**New Pumping Stations**	No.	3	$ 500,000	**$ 1,500,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 14,000,000**
5.1	Fixed Irrigation Type	Ha	350	$ 40,000	$ 14,000,000
6.0	**As Built Information by Contractor**				**$ 9,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 9,000	$ 9,000
7.0	**Land Purchase Cost**	Ha	420	$ 36,000	**$ 15,120,000**
	Sub Total - Works Costs				**$ 58,511,000**
	Contingency	%	25%		**$ 14,627,750**
	Professional Fees	%	15%		**$ 6,508,650**
	Other Non Works Costs	%	15%		**$ 6,508,650**
	Final Total				**$ 86,156,050**

NOTES

The above costs do not include GST and are a best estimate at the time of pricing. No allowance has been made for inflation, currency and commodity fluctuations and other factors unknown at the time. These costs have been prepared for the Project & Client listed above based on the project described to us and its extent is limited to the scope of work agreed. No responsibility is accepted by Mott MacDonald or its directors, servants, staff or employees for the accuracy of information provided by third parties and/or the use of any part of these costs in any other context or for any other purposes. These costs do not include the following services which cannot be quantified at this time; Geotechnical Investigations, Surveying, Feasibility Studies & Fast Tracking.

Live Path: P:\Auckland\NZL\01 Projects\353265 RDC WWTP Alternative Land Disposal Sites Study\04 Working\Final Report\Khems Info\[Disposal Options - Capex Variation Costs 20150612.xlsx]Area A (Op4) 20mm Loading
Original Revision P:\Auckland\NZL\01 Projects\353265 RDC WWTP Alternative Land Disposal Sites Study\04 Working\Final Report\Khems Info\[Disposal Options - Capex Variation Costs 20150612.xlsx]Area A (Op4) 20mm Loading

12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA A (OPTION 4)
20mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 4,085,000**
2.0	**New Transfer Main**				**$ 20,472,000**
2.1	500mm PE pipe	m	17060	$ 1,200	$ 20,472,000
3.0	**New Pumping Stations**	No.	3	$ 500,000	**$ 1,500,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 3,500,000**
5.1	Fixed Irrigation Type	Ha	87.5	$ 40,000	$ 3,500,000
6.0	**As Built Information by Contractor**				**$ 9,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 9,000	$ 9,000
7.0	**Land Purchase Cost**	Ha	105	$ 36,000	**$ 3,780,000**
	Sub Total - Works Costs				**$ 35,096,000**
	Contingency	%	25%		**$ 8,774,000**
	Professional Fees	%	15%		**$ 4,697,400**
	Other Non Works Costs	%	15%		**$ 4,697,400**
	Final Total				**$ 53,264,800**

NOTES

The above costs do not include GST and are a best estimate at the time of pricing. No allowance has been made for inflation, currency and commodity fluctuations and other factors unknown at the time. These costs have been prepared for the Project & Client listed above based on the project described to us and its extent is limited to the scope of work agreed. No responsibility is accepted by Mott MacDonald or its directors, servants, staff or employees for the accuracy of information provided by third parties and/or the use of any part of these costs in any other context or for any other purposes. These costs do not include the following services which cannot be quantified at this time; Geotechnical Investigations, Surveying, Feasibility Studies & Fast Tracking.

12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA A (OPTION 5)
5mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 6,723,000**
2.0	**New Transfer Main**				**$ 20,813,200**
2.1	600mm PE pipe	m	17060	$ 1,220	$ 20,813,200
3.0	**New Pumping Stations**	No.	3	$ 500,000	**$ 1,500,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 20,000,000**
5.1	Fixed Irrigation Type	Ha	500	$ 40,000	$ 20,000,000
6.0	**As Built Information by Contractor**				**$ 10,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 10,000	$ 10,000
7.0	**Land Purchase Cost**	Ha	600	$ 36,000	**$ 21,600,000**
	Sub Total - Works Costs				**$ 73,146,200**
	Contingency	%	25%		**$ 18,286,550**
	Professional Fees	%	15%		**$ 7,731,930**
	Other Non Works Costs	%	15%		**$ 7,731,930**
	Final Total				**$ 106,896,610**

NOTES

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12 June 2015

AWT H2knOw-how

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA A (OPTION 5) 20mm/day Loading					
Level of Accuracy: ± 25%					
Item	**Description**	**Unit**	**QTY**	**Rate**	**Estimate**
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 4,473,000**
2.0	**New Transfer Main**				**$ 20,813,200**
2.1	600mm PE pipe	m	17060	$ 1,220	$ 20,813,200
3.0	**New Pumping Stations**	No.	3	$ 500,000	**$ 1,500,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 5,000,000**
5.1	Fixed Irrigation Type	Ha	125	$ 40,000	$ 5,000,000
6.0	**As Built Information by Contractor**				**$ 10,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 10,000	$ 10,000
7.0	**Land Purchase Cost**	Ha	150	$ 36,000	**$ 5,400,000**
	Sub Total - Works Costs				**$ 39,696,200**
	Contingency	%	25%		**$ 9,924,050**
	Professional Fees	%	15%		**$ 5,144,430**
	Other Non Works Costs	%	15%		**$ 5,144,430**
	Final Total				**$ 59,909,110**

NOTES

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Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA B (OPTION 4)
5mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 4,254,000**
2.0	**New Transfer Main**				**$ 11,604,000**
2.1	500mm PE pipe	m	9670	$ 1,200	$ 11,604,000
3.0	**New Pumping Stations**	No.	2	$ 500,000	**$ 1,000,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 14,000,000**
5.1	Fixed Irrigation Type	Ha	350	$ 40,000	$ 14,000,000
6.0	**As Built Information by Contractor**				**$ 8,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 8,000	$ 8,000
7.0	**Land Purchase Cost**	Ha	420	$ 10,000	**$ 4,200,000**
	Sub Total - Works Costs				**$ 36,816,000**
	Contingency	%	25%		**$ 9,204,000**
	Professional Fees	%	15%		**$ 4,892,400**
	Other Non Works Costs	%	15%		**$ 4,892,400**
	Final Total				**$ 55,804,800**

NOTES

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12 June 2015

AWT H2knOw-how

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA B (OPTION 4)
20mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 2,679,000**
2.0	**New Transfer Main**				**$ 11,604,000**
2.1	500mm PE pipe	m	9670	$ 1,200	$ 11,604,000
3.0	**New Pumping Stations**	No.	2	$ 500,000	**$ 1,000,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 3,500,000**
5.1	Fixed Irrigation Type	Ha	87.5	$ 40,000	$ 3,500,000
6.0	**As Built Information by Contractor**				**$ 8,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 8,000	$ 8,000
7.0	**Land Purchase Cost**	Ha	105	$ 10,000	**$ 1,050,000**
	Sub Total - Works Costs				**$ 21,591,000**
	Contingency	%	25%		**$ 5,397,750**
	Professional Fees	%	15%		**$ 3,081,150**
	Other Non Works Costs	%	15%		**$ 3,081,150**
	Final Total				**$ 33,151,050**

NOTES

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12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA B (OPTION 5)
5mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 5,296,000**
2.0	**New Transfer Main**				**$ 11,797,400**
2.1	600mm PE pipe	m	9670	$ 1,220	$ 11,797,400
3.0	**New Pumping Stations**	No.	2	$ 500,000	**$ 1,000,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 20,000,000**
5.1	Fixed Irrigation Type	Ha	500	$ 40,000	$ 20,000,000
6.0	**As Built Information by Contractor**				**$ 9,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 9,000	$ 9,000
7.0	**Land Purchase Cost**	Ha	600	$ 10,000	**$ 6,000,000**
	Sub Total - Works Costs				**$ 46,602,400**
	Contingency	%	25%		**$ 11,650,600**
	Professional Fees	%	15%		**$ 6,090,360**
	Other Non Works Costs	%	15%		**$ 6,090,360**
	Final Total				**$ 70,433,720**

NOTES

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12 June 2015

Job Name:	ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES		
Job No.	353265		
Client:	RDC		
Currency:	NZD	*Revision:*	
Prepared by:	KL	*Date:*	8-Jun
Checked by:		*Date:*	

AREA B (OPTION 5)
20mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 3,046,000**
2.0	**New Transfer Main**				**$ 11,797,400**
2.1	600mm PE pipe	m	9670	$ 1,220	$ 11,797,400
3.0	**New Pumping Stations**	No.	2	$ 500,000	**$ 1,000,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 5,000,000**
5.1	Fixed Irrigation Type	Ha	125	$ 40,000	$ 5,000,000
6.0	**As Built Information by Contractor**				**$ 9,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 9,000	$ 9,000
7.0	**Land Purchase Cost**	Ha	150	$ 10,000	**$ 1,500,000**
	Sub Total - Works Costs				**$ 24,852,400**
	Contingency	%	25%		**$ 6,213,100**
	Professional Fees	%	15%		**$ 3,502,860**
	Other Non Works Costs	%	15%		**$ 3,502,860**
	Final Total				**$ 38,071,220**

NOTES

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12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA C (OPTION 4)
5mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 3,463,000**
2.0	**New Transfer Main**				**$ 10,332,000**
2.1	500mm PE pipe	m	8610	$ 1,200	$ 10,332,000
3.0	**New Pumping Stations**	No.	1	$ 500,000	**$ 500,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 10,500,000**
5.1	Pivot Irrigation Type	Ha	350	$ 30,000	$ 10,500,000
6.0	**As Built Information by Contractor**				**$ 7,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 7,000	$ 7,000
7.0	**Land Purchase Cost**	Ha	420	$ 36,000	**$ 15,120,000**
	Sub Total - Works Costs				**$ 41,672,000**
	Contingency	%	25%		**$ 10,418,000**
	Professional Fees	%	15%		**$ 3,982,800**
	Other Non Works Costs	%	15%		**$ 3,982,800**
	Final Total				**$ 60,055,600**

NOTES

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12 June 2015

AWT H2knOw-how

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA C (OPTION 4) 20mm/day Loading					
Level of Accuracy: ± 25%					
Item	**Description**	**Unit**	**QTY**	**Rate**	**Estimate**
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 2,282,000**
2.0	**New Transfer Main**				**$ 10,332,000**
2.1	500mm PE pipe	m	8610	$ 1,200	$ 10,332,000
3.0	**New Pumping Stations**	No.	1	$ 500,000	**$ 500,000**
4.0	**New Holding Ponds (28,000m^3)**				**$ 1,750,000**
4.1	Ponds pipework	LS	1	$ 140,000	$ 140,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 175,000	$ 175,000
4.3	Bulk Earthworks	LS	1	$ 977,200	$ 977,200
4.4	Storage chamber for filters backwash water	LS	1	$ 175,000	$ 175,000
4.5	PE lining installation	LS	1	$ 210,000	$ 210,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 4,200	$ 4,200
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 68,600	$ 68,600
5.0	**New Irrigation System**				**$ 2,625,000**
5.1	Pivot Irrigation Type	Ha	87.5	$ 30,000	$ 2,625,000
6.0	**As Built Information by Contractor**				**$ 7,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 7,000	$ 7,000
7.0	**Land Purchase Cost**	Ha	105	$ 36,000	**$ 3,780,000**
	Sub Total - Works Costs				**$ 21,276,000**
	Contingency	%	25%		**$ 5,319,000**
	Professional Fees	%	15%		**$ 2,624,400**
	Other Non Works Costs	%	15%		**$ 2,624,400**
	Final Total				**$ 31,843,800**

NOTES

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Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA C (OPTION 5) 5mm/day Loading					
Level of Accuracy: ± 25%					
Item	**Description**	**Unit**	**QTY**	**Rate**	**Estimate**
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 4,277,000**
2.0	**New Transfer Main**				**$ 10,504,200**
2.1	600mm PE pipe	m	8610	$ 1,220	$ 10,504,200
3.0	**New Pumping Stations**	No.	1	$ 500,000	**$ 500,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 15,000,000**
5.1	Fixed Irrigation Type	Ha	500	$ 30,000	$ 15,000,000
6.0	**As Built Information by Contractor**				**$ 8,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 8,000	$ 8,000
7.0	**Land Purchase Cost**	Ha	600	$ 36,000	**$ 21,600,000**
	Sub Total - Works Costs				**$ 54,389,200**
	Contingency	%	25%		**$ 13,597,300**
	Professional Fees	%	15%		**$ 4,918,380**
	Other Non Works Costs	%	15%		**$ 4,918,380**
	Final Total				**$ 77,823,260**

NOTES

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Live Path: P:\Auckland\NZL\01 Projects\353265 RDC WWTP Alternative Land Disposal Sites Study\04 Working\Final Report\Khems Info\[Disposal Options - Capex Variation Costs 20150612.xlsx]Area C (Op5) 20mm Loading
Original P:\Auckland\NZL\01 Projects\353265 RDC WWTP Alternative Land Disposal Sites Study\04 Working\Final Report\Khems Info\[Disposal Options - Capex Variation Costs 20150612.xlsx]Area C (Op5) 20mm Loading
Revision

12 June 2015

Job Name: ROTORUA WWTP - ALTERNATIVE LAND DISPOSAL SITES
Job No. 353265
Client: RDC
Currency: NZD *Revision:*
Prepared by: KL *Date:* 8-Jun
Checked by: *Date:*

AREA C (OPTION 5)
20mm/day Loading

Level of Accuracy: ± 25%

Item	Description	Unit	QTY	Rate	Estimate
1.0	**Preliminary and General** (15% of works costs)	%	15%		**$ 2,589,000**
2.0	**New Transfer Main**				**$ 10,504,200**
2.1	600mm PE pipe	m	8610	$ 1,220	$ 10,504,200
3.0	**New Pumping Stations**	No.	1	$ 500,000	**$ 500,000**
4.0	**New Holding Ponds (40,000m^3)**				**$ 2,500,000**
4.1	Ponds pipework	LS	1	$ 200,000	$ 200,000
4.2	Inlet/outlet Structures / valve chambers / flowmeter chamber	LS	1	$ 250,000	$ 250,000
4.3	Bulk Earthworks	LS	1	$ 1,396,000	$ 1,396,000
4.4	Storage chamber for filters backwash water	LS	1	$ 250,000	$ 250,000
4.5	PE lining installation	LS	1	$ 300,000	$ 300,000
4.6	Storage ponds testing / commissioning / reinstatement	LS	1	$ 6,000	$ 6,000
4.7	Security fence and gate (5m wide, 2 winged)	LS	1	$ 98,000	$ 98,000
5.0	**New Irrigation System**				**$ 3,750,000**
5.1	Fixed Irrigation Type	Ha	125	$ 30,000	$ 3,750,000
6.0	**As Built Information by Contractor**				**$ 8,000**
6.1	Provision of As Built drawings to meet Council Standards	LS	1	$ 8,000	$ 8,000
7.0	**Land Purchase Cost**	Ha	150	$ 36,000	**$ 5,400,000**
	Sub Total - Works Costs				**$ 25,251,200**
	Contingency	%	25%		**$ 6,312,800**
	Professional Fees	%	15%		**$ 2,977,680**
	Other Non Works Costs	%	15%		**$ 2,977,680**
	Final Total				**$ 37,519,360**

NOTES

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