Wairoa Wastewater Consenting Project

Land Treatment Opportunities

(LEI, 2017:A5I1)

Prepared for

Wairoa District Council

Prepared by

L W E
Environmental
I m p a c t

October 2017

Wairoa Wastewater Consenting Project

Land Treatment Opportunities

Wairoa District Council

This report has been prepared for **Wairoa District Council** by Lowe Environmental Impact (LEI). No liability is accepted by this company or any employee or sub-consultant of this company with respect to its use by any other parties.

Quality Assurance Statement		
Task	Responsibility	Signature
Project Manager:	Hamish Lowe	
Prepared by:	Angela Lane, Katie Beecroft	
Reviewed by:	Hamish Lowe	
Approved for Issue by:	Hamish Lowe	HJ Lowe
Status:	Final	

Prepared by:

Lowe Environmental Impact
P O Box 4467
Palmerston North 4442

| T | [+64] 6 359 3099
| E | office@lei.co.nz
| W| www.lei.co.nz

Ref: RE-10292-WDC-A5I1-Land_Tmt_Opps-171009-FINAL

Job No.: 10292

Date: October 2017

Revision Status			
Version	Date	Author	What Changed and Why
1	08/12/16	AL	Original Draft
2	09/10/2017	AL	Finalised through review process

TABLE OF CONTENTS

Appendix A: Figures

1. Investigation Area
2. Property Parcel
3. Current Land Use
4. Nutrient Uptake Potential
5. Drainage Class
6. Depth to Restrictive Layer
7. Slope
8. Flood Return
9. Riparian Areas
10. Suitability for Irrigation

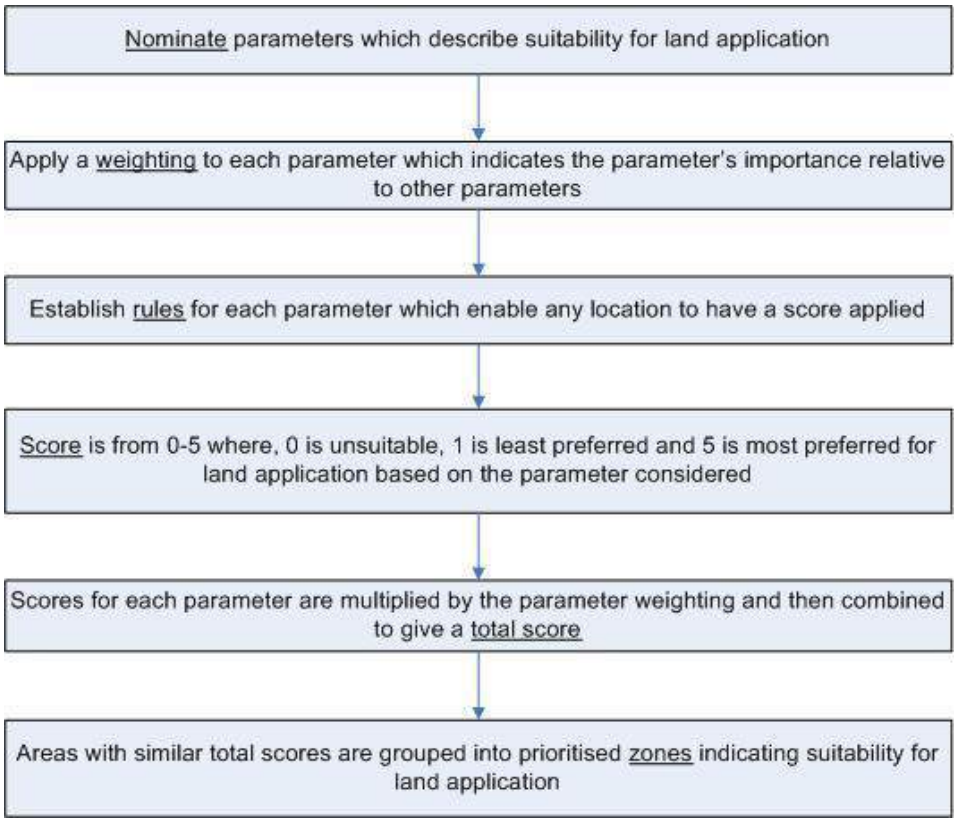
1 EXECUTIVE SUMMARY

The Wairoa wastewater treatment plant (WWTP) is located on Whakamahi Road, Wairoa, Hawke's Bay. Currently, wastewater from the WWTP is disposed of at night on a falling tide into the Wairoa River mouth estuary.

The Wairoa municipal wastewater discharge resource consent expires in May 2019. The performance of the existing system, and an assessment of alternative discharge options, will be needed to inform what method of discharge is used when new resource consents are sought. A decision will need to be made by Wairoa District Council (WDC) as to whether the existing discharges are to be continued, or whether alternatives are more feasible.

One alternative being considered is the application of treated wastewater to land. Nearby land may be suited to receiving irrigated wastewater; therefore, an evaluation of the suitability of land near the WWTP to receive wastewater application is needed.

Lowe Environmental Impact Limited (LEI) have been engaged by WDC to consider the potential for land based discharges of the WWTP wastewater. This report assesses the suitability of land within a 10 km radius (Investigation Area) of the Wairoa WWTP for land application of wastewater. A 10 km radius was used to ensure that a sufficient area to apply wastewater was evaluated. Additionally, areas outside of the 10 km boundary pose limitations due to increased slope of hill country and distance from the WWTP, resulting in increased costs to pump wastewater further afield. The process undertaken to determine the suitability of areas around the WWTP to receive treated wastewater is summarised as follows:



The parameters used to assess how suitable a location is for receiving wastewater application include:

- Land use (current capability);
  - Nutrient uptake potential.
- Soil attributes;
  - Slope and stability.
  - Soil drainage and permeability.
  - Depth to restrictive layer for plant root growth or water percolation.
- Hydrological and hydrogeological attributes;
  - Flood return interval.
  - Riparian buffer.

Maps developed using information from GIS databases show the suitability and limitations for each parameter with respect to land application are given in Appendix A.

When the wastewater application suitability parameters are considered and grouped together, Zones are created in order of preference. The Zones are labelled A to E, where Zone A has no significant limitations for land application of wastewater and Zone E indicates severe limitations for land application of wastewater. A summary of the Zones within 10 km of the WWTP are given in the following table.

Zone	Description and Design Considerations	Area (ha)	% Investigation Area
A	**Well Suited** Requires smaller land area, as more water can be applied to a given area High value and/or short rotation crops Non-deficit irrigation – nil or limited storage required Greater number of irrigable days High rate of nutrient removal Routine cultivation and harvest, with short withholding periods.	893	5
B	**Moderately Well Suited** High value and/or short rotation crops Non-deficit irrigation or partial deficit irrigation Can irrigate in shoulder seasons (April, May, September, October) for drier than average years – some storage likely to be required Moderately high rate of nutrient removal Short withholding period for grazing or cultivation and harvest	1,238	7
C	**Minor Limitations** Pasture or restricted range of annual crops Predominantly deficit irrigation, requiring large storage or combined water discharge Larger land area requirement Withholding period prior to grazing or cultivation and harvest is extended	8,665	50
D	**Significant Limitations** Plantation forestry, pasture, shallow rooting crops Deficit irrigation over summer months, requiring larger storage/combined water discharge Low nutrient loading Limitation to cultivation and harvest Extended withholding period for stock trafficking	5,714	33

Zone	Description and Design Considerations	Area (ha)	% Investigation Area
E	**Severe Limitations** Requires largest land area Conservation plantings Low deficit irrigation for short season, requiring larger storage/combined water discharge No cultivation, infrequent harvest.	163	1
N/A	**Town, River and Lakes**	771	4
Total	**Total land within a 10 km radius of the Wairoa WWTP**	17,444	100

Of the identified Zones, a total of around 256 ha would be excluded as riparian buffers next to waterways, of which around 24 ha is within Zone A. There will be additional exclusions of areas, particularly adjacent to property boundaries and roadways. It should also be noted, that given the location of the WWTP near to the coast, only around 50 % of the 10 km radius investigation area is land, with the remainder being water including Hawke Bay.

The areas categorised as Zones A and B should be the priorities for further consideration for land application of wastewater. An area of 2,131 ha, representing 12% of the Investigation Area, is suitable or moderately suitable to receive irrigation, of that, 38 ha would have to be regarded as riparian zone (no land treatment to occur). However, because Zones A and B occupy a comparatively small part of the investigation area and comprise of smaller land parcels, the use of Zone C land should be considered in further evaluations. A larger land area would be needed for discharge of Wairoa wastewater to Zone C land compared to Zone A or B land.

To accommodate for an average discharge volume of 2,700 m^3/day of municipal waste, this investigation has determined that the approximate land areas which are required are:

Zone	Land Treatment Area Required (ha)	Land Disposal Area Required (ha)
A	54	0.5 – 1.4
B	270	-
C	338	-
D	540	-
E	-	-

These areas are the theoretical allowance and do not include buffer areas, which may be needed for land in proximity to riparian zones, residential housing and property boundaries.

These areas have been identified on 'paper' only and the acceptance and feasibility of acquiring or using the land needs to be determined. Also, care is needed to ensure the land areas identified do not have management and current use limitations that would render land application inappropriate or unsuitable on these areas (public access, high value crops, industry limitations, etc).

Should land application be considered further, the first step would be to assess (consider and/or investigate) the following areas in further detail, specifically:

- Zone A areas, being the flat land (0 - 3°) adjacent to the Wairoa River and north of the Wairoa township totalling 893 ha. Zone A land is well suited to land treatment, however, accessibility (third party owned land) and continuity of land parcels in these

areas is the greatest limitation. Zone A land tends to be smaller lifestyle/ cropping land that would be unsuitable for land treatment. Zone A land is located adjacent to the Wairoa River, north of Wairoa and between the Wairoa Airport and Awamate Rd.

- Zone B land between North Clyde township and Silver Fern Farms, west of Frasertown Road, this includes the Wairoa Airport; Land west and south of the Wairoa township totalling 1,238 ha. Areas west of the township and areas adjacent to the WWTP may warrant consideration for land treatment due to their proximity to the WWTP. However, land parcel size may limit this.

- Zone C land that is <3° slope totalling 3,889 ha is located NW and NE of the WWTP along SH2. These land parcel sizes tend to be larger and could be suitable for low rate irrigation of wastewater. Zone C land >3° slope totalling 4,776 ha located to the west of the WWTP could be investigated further as an option for pine plantation irrigation.

The use of a continuous (or at least adjacent) block of land would be more efficient than several smaller blocks; although finding a block of land that can cater for the WWTP discharge rate and associated cost of infrastructure will likely be the biggest limitation to land application of the WWTP wastewater. The flat land within the 10 km radius of the WWTP including Zones A, B and C tends to be smaller property parcels occupied by lifestyle blocks and small-holdings.

As mentioned previously, this assessment is to consider the 'potential' for land application. This doesn't imply the land is available, and in fact there has been no approach to property owners to ascertain their interest in receiving wastewater for irrigation.

2 INTRODUCTION

2.1 Purpose

The purpose of this report is to assess the suitability of land in the vicinity of Wairoa WWTP and Wairoa township to receive wastewater for long term irrigation (or disposal).

2.2 Background

The current Wairoa wastewater treatment system has discharge resource consents which are about to expire and new consents for the same or alternative options require consideration. The continuation of the current discharge into the Wairoa River estuary is one of the options to be considered, but this will **only** warrant consent if it is shown to be the best practicable option (BPO). In order for WDC to agree on a BPO, other credible options for the wastewater discharge will also need to be evaluated, and land discharge is one credible alternative to a river discharge.

2.3 Scope

This assessment is Task A5I1 of the "Wairoa Wastewater Consenting Task Scopes". It is intended to be a preliminary desktop assessment considering the suitability of land that could potentially be used for the discharge of wastewater from the WWTP. Matters to be addressed are as follows:

- Broad assessment of priorities of land suitability for land treatment;
- Broad assessment of land assimilative capacity in the Wairoa locality;
- Consideration of environmental constraints;
- Consideration of regulatory constraints.

The report is **not** intended to provide any recommendation of a favoured option, but to provide a factual basis upon which WDC may select favoured options for further consideration.

This investigation is to identify if land is potentially suitable for land treatment, prior to further investigation. Prior to final selection, areas identified as suitable in this report should be considered in terms of their current and future management suitability, and subject to a site investigation to verify if their characteristics are suitable for a land application system[1].

[1] No consideration has been given to land availability, and no field investigations to verify the accuracy of the mapped information have been undertaken.

3 LAND SUITABILITY FOR LAND TREATMENT OF WASTEWATER

3.1 General

The use of land for the application of wastewater can be an alternative to the current discharge into the Wairoa River mouth estuary. Land can be used as a form of treatment, thereby meaning that additional wastewater treatment is not needed prior to its application. Wastewater discharge to land can be managed as **irrigation**, where the properties of the wastewater are **beneficially re-used** to assist the production of a crop. Alternatively, a high rate discharge to a smaller area of land can be used where the focus is wastewater **disposal**, rather than beneficial re-use. It is considered appropriate to base the land treatment assessment on current wastewater characteristics. Characteristics considered in the design include of a land treatment system include:

- Wastewater characteristics (flow, population growth and wastewater quality);
- Climate and receiving environment;
- Land management and operational considerations.

This report focusses on the land resource and land management. Other characteristics are considered following the identification of suitable land.

3.2 Investigation Area

Land within a 10 km radius of the WWTP has been assessed and is referred to as the Investigation Area. The characteristics of land in this **Investigation Area** are variable, and can be broadly described as having the following landforms:

- Hills – being land with a slope >16° that are located west of the WWTP and areas throughout the NE and NW quadrants of the Investigation Area. These hills consist of early Pliocene undifferentiated fossiliferous mudstone, bedded sandstone and limestone. Being predominantly a mudstone, argillite base, these hills are prone to erosion which is a major limitation within this area. Soils are generally moderately-well to well drained. Predominant land use is sheep and beef farming.

- Alluvial Flats – are the flat areas surrounding the Wairoa River from the WWTP, north to Frasertown, approximately 8 km NW of the WWTP along SH2 at Ohinepaka and 6 km NE of the WWTP at Tuhara. The soil consists of alluvial deposits of Holocene to Pleistocene age, deeply weathered, poorly to moderately sorted, with some areas overlain with tephra. These soils are generally imperfectly drained despite having high permeability, and consist of shallow sand and silt over gravel. These areas are predominantly used for cropping.

3.3 Resource Assessment

This section of the report provides an initial desktop investigation into the characteristics of rainfall, groundwater, geology and soil within the 10 km radius Investigation Area of the WWTP. The review is to inform this land suitability assessment, and a more detailed account will be prepared if needed to support a land treatment option.

3.3.1 Rainfall

One climate station was assessed for rainfall data; the Wairoa – North Clyde Ews station, 4.8 km north of the Wairoa WWTP. This site was chosen to give the best representation of rainfall characteristics within the investigation area, and its data was collected between 1996 and 2016. Rainfall averaged 1,347 mm/year. Table 3.1 gives a summary of these rainfall amounts.

Table 3.1 Rainfall Data for the Wairoa Investigation Area

Month	Rainfall (mm/month)
Jan	105
Feb	83
Mar	109
April	121
May	90
June	120
July	141
Aug	114
Sep	84
Oct	91
Nov	76
Dec	82
Annual (mm/year)	**1347**
Site	Wairoa - North Clyde
Period	1996 - 2016
Site No.	3126

3.3.2 Groundwater

A brief review of hydrogeology information indicates that the WWTP and the surrounding area is located within the vicinity of the Wairoa aquifer system, covering an area of 5,200 ha (Gordon, 2016; Dodson, 2010). There are two aquifers within this system, a shallow aquifer (12 – 22 m deep) and a deeper aquifer (26 – 54 m deep). An analysis of water age within these aquifers has shown the following: >30 years old in the shallow aquifer and >44 years old in the deeper aquifer (Gordon, 2016).

The Wairoa aquifer system is considered to be confined, based on the presence of flowing artesian wells and bore logs. Based on the groundwater quality report 2008 (Dodson, 2010), nitrate nitrogen concentrations are generally low (<1.5 mg/l) in the Wairoa District. Ammoniacal nitrogen concentrations are also low (<0.3 mg/L), except two wells (1923 and 3498) which had ammoniacal nitrogen concentration of >3.6 mg/L (Dodson, 2010). However, recent data suggests an increase in ammoniacal nitrogen values, as shown in Table 3.3. The low nitrate nitrogen and high ammoniacal nitrogen suggest that this confined aquifer is a closed system in respect to oxygen (Dodson, 2010).

Table 3.2: Wells located in the Wairoa Valley aquifer and their values on 21 Feb 2017 (Source: HBRC)

Well Location	Number	Depth	Ammoniacal Nitrogen (NH4)	Nitrate Nitrogen (NO3)	E. Coli
Aranui Rd	3498	20.1 m	3.4 mg/L	0.005 mg/L	<1 cfu/100 mL
Railway Rd	1560	19.5	0.29 mg/L	<0.02 mg/L	<1 cfu/100 mL
Waihirere Rd	1637	40.3	7.9 mg/L	< 0.02 mg/L	<1 cfu/100 ml

The quality of the Wairoa aquifer is of poor quality, with high concentrations of iron, manganese, hardness and chloride that exceed the Drinking Water Standards New Zealand (DWSNZ). The age of water within this aquifer could be a reason why it has naturally poor water quality in regard to the DWSNZ for iron, manganese, hardness and chloride (Gordon, 2016).

The hydraulic characteristics of the Wairoa aquifer are poorly understood, and further work is needed to assess the mounding[2] risk of irrigation within the investigation area. In the absence of aquifer hydraulic information, the depth to a restrictive layer, as provided by resource conformation, provides a proxy for the risk from mounding on flat land and low-lying areas.

3.3.3 Geology and Soils

The surrounding geology consists of Holocene and late Pleistocene deeply weathered alluvial deposits along the river flats. These are generally poorly to moderately sorted gravel with minor sand and mud, overlain with tephra. The hill country surrounding the Wairoa township is made up of early Pliocene undifferentiated fossiliferous mudstone, bedded sandstone and limestone (Mazengarb & Speden, 2000). This soft tertiary rock is prone to erosion and exposed hill sides within the Wairoa Catchment have worn the brunt of this. The most common soil type within the Investigation Area is a sandy loam (38% of the area) located mainly along the alluvial flats and hill country north and east of Wairoa. Silt loam makes up 29% of the Investigation Area and are located along the flats north of Wairoa township, and the hill country and coastal areas east of Wairoa. The remaining soil types include sandy loam and peaty silt loam.

3.4 Land Application Area for Assessment Purposes

The land area required for wastewater application from the WWTP is dependent on the design of the land discharge system and the amount of storage available. Land area required for full time land treatment varies from 0.4 ha to 540 ha, excluding buffer areas (Table 3.2). The wide range of variation is due to the consideration of different discharge regimes under different soil and land use scenarios. The regimes represent a range of hydraulic loading for each scenario i.e. varying depth (mm) of irrigation per year. Areas of 0.5 to 1.4 ha were needed for rapid infiltration (land disposal) options. Appendix A, Figure 2 shows the land parcels in the Investigation Area. Further work would be needed to determine which parcels are in the same ownership so that the size of contiguous land areas can be identified.

To accommodate for the average discharge of ~2,700 m³/day of municipal waste, the approximate land areas which are required are given in Table 3.2

[2] Mounding refers to the raising of the groundwater table under the irrigation area, and occurs if irrigation is applied at a rate which is higher than the rate of groundwater movement away from the site. It results in reduced drainage depth and may cause groundwater flow direction to be altered near to the irrigation zone.

Table 3.3: Approximate Land Area Requirements

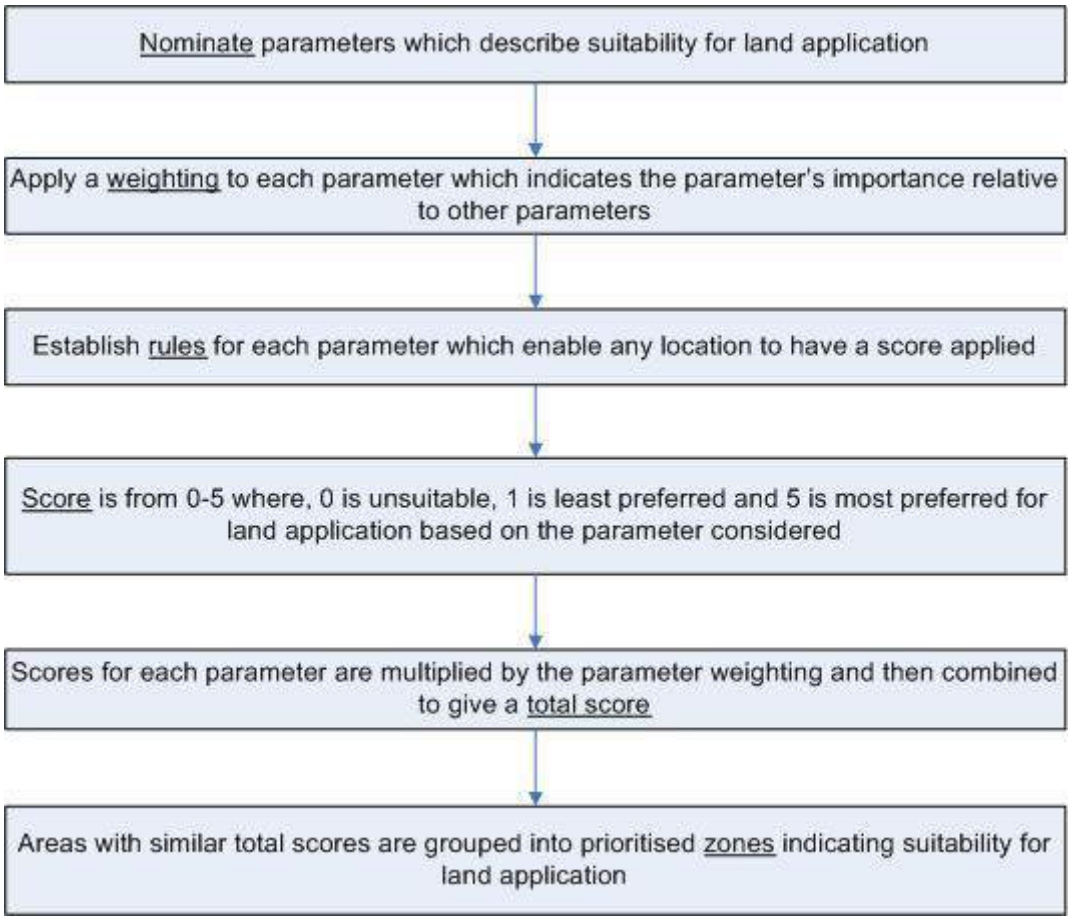
Zone	Land Treatment Area Required (ha)	Land Disposal Area Required (ha)
A	54	0.5 - 1.4
B	270	-
C	338	-
D	540	-
E	-	-

In the absence of ownership details Appendix A, Figure 3 shows the area on the basis of land use (LUCAS, 2012).

4 LAND APPLICATION ASSESSMENT METHODOLOGY

4.1 Process Overview

The process undertaken to determine the ability of areas near Wairoa WWTP to receive wastewater is outlined as follows:



4.2 Parameters

There is a wide range of parameters which influence the ability of a land application system to receive wastewater. The selection and interpretation of assessment parameters that reflect a system's suitability may vary due to location specific challenges or advantages.

The relative importance of the parameters varies and in many cases, is subjective. However, there is a need to consider the collective suitability of a particular site or area based on the merits of each parameter. This can be achieved using a weighted scoring system whereby each parameter is given a percentage (the weighting), which indicates its importance relative to other parameters. What this means is that each location within the Investigation Area is given a score for each parameter from 1 to 5 based on suitability, with 1 being least preferred for land application and 5 being most preferred. This then enables sites (and individual points on a map) to be compared. The generation of maps that demonstrate the scores for each parameter are discussed in Section 5.

A range of parameters can be considered within the Investigation Area as listed below.

- Land use;
    - Nutrient uptake potential.
- Soil attributes;
    - Slope and stability.
    - Soil drainage and permeability.
    - Depth to restrictive layer.
- Hydrological and hydrogeological attributes;
    - Mounding risk.
    - Flood return interval.
    - Riparian buffers.

Explanation of the parameters, their relevance to the investigation, and their scoring are given in Section 5. For this exercise, all parameters have been given equal weighting based on a technical assessment of parameters likely to affect the feasibility of a wastewater land treatment system. At this stage, in depth investigations of non-technical aspects such as social and cultural consideration have not been incorporated into the assessment.

As part of a more detailed examination, which should include some field investigation, the following parameters should also be considered:

- Property ownership and residential housing;
- Land management (crop sensitivity, industry limitations);
- Reticulation requirements (distance and elevation);
- Land area available; and
- Special use locations and values (cultural sites, archaeological, historic, water take, native forest, recreational etc.).

Following the addition of these parameters, it is considered appropriate for the Stakeholder Group to score and weight the necessary range of assessment criteria. However, the analysis required to complete these layers is substantial and it is considered that these parameters should be examined following initial identification of preferred areas.

4.3 Development of Land Application Suitability Zones

When the scores from individual parameters for an individual point on a map are combined, they provide a total that can be compared with totals of parameters from different locations. This allows the summation of the parameters to be compared across the Investigation Area. To make the comparison easier, the combined totals can be grouped. These groupings are referred to as Land Application Suitability Zones. Five Zone groupings have been used and are given in Table 4.1, which summarises the implications of the Zones for land application system design.

Table 4.1: Land Application Suitability Zones

Zone	Suitable for
A	**Well Suited** Requires smaller land area High value and/or short rotation crops Non-deficit irrigation – nil or limited storage required Greater number of irrigable days High rate of nutrient removal Routine cultivation and harvest, with short withholding periods.
B	**Moderately Well Suited** High value and/or short rotation crops Non-deficit irrigation or partial deficit irrigation Can irrigate in shoulder seasons (April, May, September, October) for drier than average years – some storage likely to be required Moderately high rate of nutrient removal Short withholding period for grazing or cultivation and harvest
C	**Minor Limitations** Pasture or restricted range of annual crops Predominantly deficit irrigation, requiring large storage or combined water discharge Larger land area requirement Withholding period prior to grazing or cultivation and harvest is extended
D	**Significant Limitations** Plantation forestry, pasture, shallow rooting crops Deficit irrigation over summer months, requiring larger storage/combined water discharge Low nutrient loading Limitation to cultivation and harvest Extended withholding period for stock trafficking
E	**Severe Limitations** Requires largest land area Conservation plantings Low deficit irrigation for short season, requiring larger storage/combined water discharge No cultivation, infrequent harvest.

4.4 Using GIS and Aggregation of Parameter Rating Results

A GIS based approach has been used to develop the land application suitability zones, effectively resulting from an aggregation of the induvial parameter scores. In GIS terms this is known as combining layers.

As mentioned above, a score has been developed for each parameter for every point on a map in the Investigation Area. This allows a graduated map to be produced which shows how the individual parameter score varies over an area, and essentially creates the data for a single parameter layer (as represented by an individual GIS layer). The maps for each parameter are presented in Appendix A, Figures 4 to 8.

This GIS approach to generate layers for each parameter allows an assessment of individual points on a map to be compared on separate maps. It also allows the individual parameter maps to be aggregated to produce a map which shows the summation of the combined parameters.

Rather than a graduated scale of totals from the sum of the parameters being shown on a map, the totals can be grouped into Zones, as discussed above. The combined Zone map, indicating greatest to least preference for land application, is shown in Appendix A, Figure 10.
This process means that a transition between any one individual parameter score (layer) will not be shown, and instead boundaries will be the Zones; being as mentioned above an aggregation and grouping of the sum of scores of all parameters being considered.

5 ASSIMILATIVE CAPACITY ASSESSMENT

5.1 General

The parameters listed in Section 4 are described below and the method for rating them in the Investigation Areas surrounding the WWTP are given.

Information for each parameter is available from a number of accessible national resource databases. The data is made available as GIS information. The map scale of the data is given for each parameter and should be regarded to be accurate to this scale. A higher degree of variation can be expected at field scale, however it is the purpose of this report to determine whether land application is broadly feasible within the Investigation Area.

5.2 Land Use Attributes

The land use capability (LUC) of each site along with the current land use, indicates the potential for nutrient removal from the site. For the purpose of this report, nutrient uptake was based on LUC class as described in Section 5.2.1. This is an assessment of the land's capability for use, with consideration of its physical limitations and versatility for sustained production. LUC was determined from the national database of physical land resource information compiled by Landcare Research.

The existing land use within the Investigation Area was determined from the MfE Land Use and Carbon Analysis System (LUCAS) database. The most recent data for land use held by the MfE data service is dated June 2012. Data from LUCAS was used since it is well defined, published, consistently recorded and regularly updated. Land use parameters considered are as follows:

5.2.1 Nutrient Uptake

The versatility of land for productive use (cropping, horticulture, pastoral, forestry) is an indicator of a site's ability to remove nutrients applied in wastewater. Sites in the Investigation Area are scored as given in Table 5.1 and based on the land use capability (LUC) at the time.

Table 5.1: Land use capability nutrient removal rating

LUC Class	Rating	Nutrient uptake score
1	high nutrient removal	6
2	high nutrient removal	6
3	moderately high nutrient removal	5
4	moderate nutrient removal	4
5	moderately low nutrient removal	3
6	low nutrient removal	2
7	very low nutrient removal	1
8	N/A	0
Town	N/A	0

The LUC is chosen to represent nutrient uptake potential since the LUC class identifies the land's general versatility for productive use.

5.2.2 Current Land Use

The land cover type and land management practices adopted on any site are another indicator of the site's ability to remove nutrients applied in wastewater. Sites in the Investigation Area have been identified but not scored as LUC class was the most appropriate way to determine nutrient uptake. The approximate areas in each land use are given in Table 5.2.

Table 5.2: Land Use Near Wairoa WWTP

Land use class	Description	Land Area (ha)	Land Area (% of Total)
71	Natural Forest	74	0.4
72	Planted Forest - Pre-1990	145	1
73	Post 1989 Forest	1,757	10
74	Grassland - With woody biomass	498	3
75	Grassland - High producing	8,992	52
76	Grassland - Low producing	3,231	19
77	Cropland - Perennial	10	0.1
78	Cropland - Annual	1,591	9
79	Wetland - Open water	519	3
80	Wetland - Vegetated non forest	92	1
81	Settlements	434	2
82	Other	89	1
	Total Area Considered	**17,432**	**100%**

5.3 Soil Attributes

The soil is the primary receiving environment for applied wastewater and is the final treatment process for renovating the wastewater. The capability of the soil to avoid transmittance of wastewater derived contaminants to the wider environment, and effectively recover the nutrient resource within the wastewater for plant and biota use is key to the successful development of a low rate (irrigation) land application scheme. For the purpose of rating the land in the Investigation Area, soil parameters assessed are given below.

It should be noted that a number of the data sets were created in the 1970s and 1980s and so some details may have changed due to drains and other large scale works. Following the prioritisation of land areas, it may be necessary to confirm or review data on-site.

5.3.1 Soil Drainage and Permeability

The soil's ability to drain is a function of soil texture and soil structure. Data for the Investigation Area comes from the Fundamental Soil Layer (FSL, LRIS portal) and has a scale of 1:50,000. Areas are scored as follows:

- 5 – Well drained;
- 4 – Moderately well drained;
- 3 – Imperfectly drained or excessively drained;
- 2 – Poorly drained; and
- 1 – Very poorly drained.

5.3.2 Depth to Restrictive Layer

Restriction to water passage may be due to soil pans, rocks or groundwater. Data is from the FSL and has a scale of 1:50,000. Areas are scored as follows:

- 5 – >1.50 m;
- 4 – 1.20 – 1.49 m;
- 3 – 0.90 – 1.19 m
- 2 – 0.60 – 0.89 m;
- 1 – 0.45 – 0.59 m; and
- 0 – <0.44 m.

5.3.3 Soil Slope and Stability

In the absence of suitable flat land, steeper land may be used for wastewater irrigation, but it requires specific design to manage the risk of runoff and soil movement under moist soil conditions. Data for the Investigation Area comes from the Land Resource Inventory (LRI, LRIS portal) and has a scale of 1:50,000. Areas are scored as follows:

- 5 – Slope class A (flat, 0 - 3°);
- 4 – Slope class B (gentle slopes, 4 - 7°);
- 3 – Slope class C (rolling, 8 - 15°);
- 2 – Slope class D (hill slopes, 16 - 20°) and E (hill slopes,21 - 25°); and
- 1 – Slope class F (steepland, 26 - 35°) and G (steepland, >35°).

5.4 Hydrological and Hydrogeological Attributes

The prevention of wastewater derived contaminants entering water (surface or ground) is a key environmental objective of a low rate (irrigation) land treatment system design. It is generally of lesser concern in a high rate land disposal system. The main mechanisms for transport to water are drainage to groundwater and direct surface water discharge i.e. by overland flow or flooding. The system should be designed to avoid overland flow and ideally excessive drainage volumes if land disposal is to be avoided. The likelihood of insufficiently treated wastewater entering water is reduced by:

a) Avoidance of sites with a high groundwater table;
b) Avoidance of sites with steep slopes and low permeability soil; and
c) Avoidance of sites with a high risk of flooding.

In addition, the hydraulic properties of the shallow groundwater can influence the impact that the increased drainage volume can have and so must be considered. Land areas have been assessed as follows.

5.4.1 Depth to Groundwater

The ability to treat and disperse applied wastewater is limited by the available unsaturated soil volume, i.e. depth to groundwater. The depth to groundwater is considered to be important in considering the suitability of land for wastewater discharge.

Section 5.3.2 describes the depth to restrictive layer mapping. This is considered to adequately describe the depth to a saturated layer since it includes saturation due to a perched water table where that occurs. As a result, a separate layer for depth to groundwater is considered to be redundant, and inclusion here would be effectively double counting this parameter.

5.4.2 Flood Return Interval

Flooding along the areas adjacent to the Wairoa River poses a risk to land application of wastewater. Flooding of a land application site causes:

- Loss of soluble applied nutrients;
- Potential loss of nutrient laden sediment;
- Damage to crops and soil quality;
- Damage to irrigation infrastructure; and
- Reduction in number of irrigable days.

The areas are scored based on the FSL Flood Return Interval as follows:

- 6 – Nil risk;
- 5 – Slight risk = <1 in 60 y;
- 4 – Moderate risk = 1 in 20 y to 1 in 60 y;
- 3 – Moderately severe risk = 1 in 10 y to 1 in 20 y;
- 2 – Severe risk = 1 in 5 y 1 in 10 y;
- 1 – Very severe risk = >1 in 5 y.

5.4.3 Riparian Buffers

Riparian buffer zones have been identified but are not ranked. These areas are effectively setbacks from waterways where irrigation is not recommended. This reduces the risk of over land flow to surface water. A riparian buffer of 20 m either side of any mapped waterway has been used for this report. For further investigations, this distance will vary depending on width of the channel, channel shape, capacity of the waterway, topography and soils and natural vegetation already growing alongside the waterway. The Hawke's Bay Regional Resource Management Plan, Chapter 6, states when discharging to land, air, or water with agricultural products or discharging wastewater from a new sewage system, a buffer of 20 m is used as stated in rule 16 f and 37 e respectively (HBRC, 2015).

5.5 Summary

The described parameters when combined are considered to give a semi-quantitative assessment of the suitability of an area suitable for land application of wastewater at any point within the Investigation Area.

6 RESULTS OF PARAMETER ASSESSMENT

6.1 General

Assessment of each parameter has been undertaken as described in Section 5. Maps for each parameter and for the aggregated map are provided in Appendix A and the results and trends shown are detailed below.

Figure 1, Appendix A defines the Investigation Area. Orientation to the locations can be made by the location of the Wairoa WWTP that is central to the delineated 10 km radius area.

6.2 Nutrient Uptake Potential

Appendix A, Figure 4, gives a map of nutrient uptake potential based on LUC. Land that has a high nutrient removal (green area – score 5) comprises 31% of the total area and is found generally along the flats adjacent to the Wairoa River, south of Awamato Rd and an area between Silver Fern Farms Frasertown and Aranui Rd.

Land with a moderately high nutrient removal (yellow area – score 4) comprises 15% of the investigation area and is found along the flat area adjacent to Ngamotu lagoon, a small area SW of the Wairoa township and a larger area (714 ha) north of Clyde, encompassing the golf course on Frasertown Rd, the A & P Showgrounds, the Wairoa Airport and as far as Kiwi Rd in the east.

Land with minor limitations (50%) are classed as either steeper land where nutrient loss occurs due to erosion and surface runoff but has sufficient drainage, a deep restrictive layer (if any) and minimal flooding risk or land that has a high flood risk, poor drainage and a shallower restrictive layer but is flat land. This land is found along the flat areas that follow SH2 south of Ohinepaka and Tuhara and an area of flat land between Ruataniwha Rd and Waihirere Rd. Steeper land with minor limitations are located throughout the Investigation Area with a large area NW of the WWTP to SH2.

Low nutrient removal areas (red – score 1) cover 1% of the total investigation area and are confined to areas of extreme physical limitations or hazards that make it unsuitable for arable, pastoral, or commercial forestry use. Within the investigation area these cover slopes >16° with poor drainage and a shallow restrictive layer. These areas are located approx. 5 km north of the WWTP along Awatere Rd and on the corner of Mill and Frasertown Rd, another section is located 3 km NE of the WWTP on a bend of the Wairoa River.

6.3 Soil Drainage and Permeability

Figure 5, Appendix A, gives a map of soil drainage for the Investigation Area. Moderately well to well drained (scoring 4 and 5) land comprises 64% of the Investigation Area. Drainage in areas scoring 5 and 4 (green and yellow) is unlikely to be a limiting factor for the application of wastewater. These areas occur predominantly within the hill country of the Investigation Area and throughout some flat land bordering the Wairoa River and the area between Awamate Rd and the Wairoa Airport and the flat land north of Silver Fern Farms.

Areas with imperfectly drained soil covers 24% of the investigation area. This includes the remainder of the flat land not already covered as well to moderately-well drained. These areas correspond to the lower lying areas of the Wairoa River flood plain, and other water ways (Tahaenui River, Awatere Stream) and may have been drained for productive use.

Low scores (1 and 2 – very poorly to poorly drained) for drainage only cover 7% of the investigation area and are mostly poorly drained sandy loams or low lying peaty soils that were former estuarine environments located south of Tuhara and some flat land between SH2 and Ohuia Lagoon.

6.4 Soil Depth to Restrictive Layer

Figure 6, Appendix A gives a map of soil depth to a restrictive layer. The soil depth to a restrictive layer may be related to the soil drainage and to the depth available for root exploration or aerobic treatment of applied wastewater. Only 4% of the Investigation Area has no observed restriction. this area is located along the hills between the Wairoa River and the Ohuia Lagoon. Much of the Investigation Area (64%) has a 0.9 – 1.19 m restriction. These areas are located within the hill country west of the WWTP and the flat land between Wairoa township and Frasertown in the north and along SH2 to the east.

Areas with low scores for depth to restrictive layer mirror those with low nutrient removal and poor drainage. These areas correspond to the presence of clay pans in some hill country sections which restrict soil drainage.

6.5 Soil Slope and Stability

Figure 7, Appendix A, gives a map of slope. A large portion of the investigation area (37%) has a low slope (green). These are the areas surrounding the Wairoa River and flat land approx. 4 km NE of the WWTP along SH2 and areas NW of the WWTP close to Ohinepaka.

Gentle slopes, highlighted in yellow (4 – 7°), cover only 2% of the total Investigation Area. These areas are limited to the coastal area and a small section on the NNW section of the Investigation Area.

The areas rated as 1 and 2 (16 - >35° slope) are located predominantly towards the west, NNW and east to NE of the WWTP and cover 55% of the investigation area.

6.6 Flood Return Interval

Figure 8, Appendix A, gives a map of the flooding risk in the Investigation Area as indicated by the flood return interval. The hill country to the west and east of the WWTP provides a nil flooding risk covering 61% of the investigation area. A slight risk of flooding (<1 in 60 years) is seen along land adjacent to the Wairoa River, NW of the township and the area of land between the Wairoa Airport and Awamate Rd and north of Silver Fern Farms (10% of the investigation area). A moderate flooding risk (1 in 20 to 1 in 60 years) is present in 24% of the investigation area. This covers much of the flat land north of the Wairoa township and to the east and west of the Investigation Area along SH2. Three areas between Clyde and Frasertown have a severe risk of flooding (1 in 5 year to 1 in 10 year risk).

6.7 Riparian Buffers

Within the 10 km radius investigation area there is an extensive network of streams and gullies which transport surface water to the coast. The main surface water feature is the Wairoa River. A minimum of a 20 m buffer distance on either side of a waterway is recommended. The result of this is the loss of land area for irrigation within land blocks.

The more dissected an area is, the more disruption to irrigation infrastructure and the greater the total area needed. No ranking has been applied to this parameter but Figure 9, Appendix A shows the extent of riparian buffer zones within the investigation area. In total, approximately **257 ha of land is excluded** within the Investigation Area due to riparian buffers. Table 6.1 outlines the extent of these riparian buffers within each zone. Refer to Section 7 for a discussion of the Zones. Zone A land is located adjacent to sections of the Wairoa River, the riparian areas within this zone reflect this. The largest portion of riparian zones are within Zone E, due to the steep topography, many areas are dissected with streams, increasing the riparian area.

Table 6.1: Area of riparian zones within each zone of the Wairoa Investigation Area

Zone	Riparian Area (ha)	Zone Area (ha)	% of Zone as Riparian
A	24	893	3%
B	14	1,238	1%
C	115	8,665	1%
D	66	5,714	1%
E	19	163	11%
#N/A	19	771	2%
Total	**257**	**17,444**	**1%**

6.8 Rating Summary

The parameters examined indicate that there are areas likely to be suitable for land treatment of wastewater. Different areas are constrained by different parameters. The relative suitability of areas for wastewater land application can be determined by aggregating the scores for each parameter as discussed in the next Section.

7 SUMMARY OF CAPACITY AND PRIORITY

As described in Section 4.3 above, the scores for the parameters can be combined to create zones representing the suitability of the land in the Investigation Area for land application of wastewater. Figure 10 shows the aggregated zones. Table 7.1 summarises the land area for each zone within the Investigation Area.

Table 7.1: Irrigation Suitability – Wairoa Locality

Zone	Suitability	Land Area (ha)	Land Area (% of total)
Zone A	Suitable – negligible limitations	893	5
Zone B	Moderately Suitable – minor limitations	1,238	7
Zone C	Marginally Suitable – moderate limitations	8,665	50
Zone D	Not Suitable – significant limitations	5,714	33
Zone E	Not Suitable – severe limitations	163	1
Lake, River, Town	Not assessed	771	4
Total		**17,444**	**100%**

Of the identified zones a total of approximately 257 ha would need to be excluded as riparian buffers.

In Figure 10, Appendix A, areas of Zone A (green) land occur on flat or gentle slopes with well-drained soils, and are the best prospects in the Investigation Area for beneficial irrigation (where value is gained from the water and nutrients applied). Areas of Zone A land have the fewest limitations for design of a land application system, and can be expected to support higher rates of irrigation for a greater number of days annually than in other zones. Restrictions to plant growth are typically absent in Zone A land and so the choice of crops to grow, and correspondingly the ability to sequester or remove applied nutrients is high. As a result, smaller land areas are typically needed to discharge a given volume of wastewater as compared to other land zones.

- The closest area of Zone A land, surrounds Wairoa township and are small (lifestyle block) parcel sizes which are not likely to be suitable for irrigation of wastewater. The nearest area of Zone A land with land parcels which may be of suitable size are 8 km N of the WWTP, between the Wairoa River and Awamate Rd, south of Frasertown.

Areas of Zone B (yellow) land occur on flat and gentle slopes with well-drained soils. These areas require more consideration of irrigation management than Zone A soils. Only 7% of the Investigation Area is Zone B land and is generally adjacent to Zone A land.

Half of the Investigation Area includes Zone C (light brown) land which is marginally suitable. This land could still potentially be workable to enhance the summer productivity of north facing hill slopes which are more prone to drying out. Other benefits include the irrigation of pine plantations which are located within this Zone north of SH2 at Tuhara and 1 km north of the WWTP along Fraser St. A higher cost and management requirement are associated with irrigation of Zone C soils compared to Zone A and B soils.

Areas of Zones D (orange) tend to occur in those areas described in Section 6 as having limitations due to shallow depth to a restrictive layer or very steep slopes.

For a high rate disposal system (rapid infiltration), the requirements are for high capacity land to receive wastewater without ponding or run-off, and without risk of contaminating surface water bodies. The areas identified as most suitable for this purpose are within Zone A and potentially the free draining coastal sand country. These locations however, provide some obstacles in relation to the size of land parcels and proximity to residential housing whereby buffer zones will need to be established.

8 REGULATORY CONSTRAINTS

8.1 General

The Planning and resource consenting implications of the various potential components of the Wairoa municipal wastewater management system are described in Report A7I1 of the "Wairoa Wastewater Consenting Task Scopes". This section of this report re-caps the Planning issues to be addressed in any land discharge option.

8.2 Rapid Infiltration Scenarios

Rapid Infiltration (RI) involves setting aside a modest sized area of land for effectively the permanent discharge of high rates of wastewater. The intensity of the activity and its effects are likely to be high enough to rule out any use of the land involved for productive use, or any prospect of public access. The designation of an RI facility for wastewater discharge purposes would be appropriate. The qualities of the soils of the site will not be preserved or protected, and so should be designated in the same manner as must apply to any WWTP.

RI is for wastewater disposal, rather than for any beneficial re-use, but is a potential candidate for Best Practicable Option ("BPO") consideration because of its small footprint and low cost compared to other potential options. Its environmental constraints will include the following;

- Odours and air discharge will need to be considered in a neighbourhood context, including appropriate designation and/or zoning in the district plan to protect the investment in, and community dependence on, the RI facility from reverse sensitivities (i.e. a new neighbour building a house next to the RI facility then complaining about the smell). There would need to be contingency plans to respond to odour events, and an enforceable consent requirement for there to be no offensive or objectionable odours beyond the property boundary.
- Effects on Groundwater should be expected because of the rapid rate of discharge involved, resulting in a high contaminant loading entering shallow groundwater beneath the discharge area. RI is used internationally in areas where adverse effects on local groundwater quality are considered acceptable. In HBRC's relevant plans, groundwater quality is to be maintained or enhanced **where it is used for human consumption or irrigation,** but the option is implicitly left open for RI in locations where the groundwater is not used for these purposes.
- Effects on the coastal marine environment will need to be considered, although this is likely to be more from a cultural perspective than from one of measurable effects. Any RI site should be selected to utilise the high permeability and capacity of the sandy deposits near the shore, while also being sited sufficiently far inland to ensure an adequate distance of land passage before any discharge plume reaches the sea. This will be the most important aspect of any RI scenario to be discussed with tangata whenua.

8.3 Irrigation Scenarios

Irrigation involves applying low rates of wastewater to a comparatively large area of land, to enable the beneficial re-use of the water and nutrients involved. The effects of the activity are able to be managed to be compatible with a range of productive land uses on a sustainable basis. The qualities of the soils of the site will be protected and even enhanced, in the same manner as applies to the use of clean irrigation water and the use of commercial fertilisers.

Irrigation is for beneficial re-use of wastewater, rather than for disposal, and is a potential candidate for BPO consideration. Its environmental constraints will include the following;

- Odours and aerosol discharges arising from sprinkler irrigation will need to be considered in a neighbourhood context. There would need to be contingency plans to respond to odour events, and an enforceable consent requirement for there to be no offensive or objectionable odours or aerosols beyond the property boundary.
- Surface water quality will need to be protected from any surface ponding or run off, but this is standard for all effluent discharges to land, and is capable of being met with good design and management.
- Groundwater quality will need to be protected from any over-application of wastewater, but this is capable of being met with good design and management.
- There will be expectations, and maybe even requirements, for the protection of the quality of the receiving soil from the potential adverse effects of the irrigation discharge. Again, this is standard practice with effluent discharges, this is capable of being met with good design and management.
- While all the above environmental considerations relate to measurable performance standards that are capable of being met, the concern will be how the wastewater is to be managed when irrigation is not possible. The two options for this are a wastewater storage facility, and a contingent discharge facility. Storage facilities have been addressed in terms of land area requirement and likely land purchase cost in Section 8 above. The alternative of a contingent discharge facility could remove the need for storage, but at the cost of an occasional and recurring discharge to the estuary. Such a continued estuary discharge would need to be discussed with tangata whenua.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 Assessment Conclusions

In general, there is suitable land available for the establishment of a land application system within the Investigation Area. Zone A land could be restricted for land treatment due to buffering restrictions for riparian zones, residential housing, and property boundaries. Zone B has similar restrictions with land south of the Wairoa township and opposite the WWTP on the true left of the Wairoa River. Although there are further flats that are grouped into Zone C, this flat land along with Zone A and B areas should be the priority for any further investigations of land treatment.

9.2 Recommendations

This report presents the outcomes of a preliminary, desktop based, assessment designed to inform an overall assessment of options for WDC as part of its consent renewal for wastewater discharge and consultation process. Should a land-based application option be considered further, then additional stages would be required to confirm desktop identified characteristics. This includes focusing on specific zones for a more detailed assessment. Within these areas, the following should also be considered:

- Land parcel sizes and ownership;
- Special use considerations i.e. known heritage sites;
- Feasibility of establishing irrigation or high rate infrastructure as appropriate; and
- Approximate reticulation routes.

This report considers only the technical feasibility of land application in the area. If land application is further pursued, then non-technical considerations such as cultural preference and cost to the community can be included and may alter the relative weighting of the technical attributes.

If a land application option is to be pursued then, based on the outcomes of this report, it is recommended that the following areas are assessed in further detail:

- The flat land (0 - 3°) adjacent to the Wairoa River, north of the Wairoa township and south of Frasertown. Accessibility (third party owned land) and continuity of land parcels in these areas is the greatest limitation. Areas adjacent to the WWTP and along the coast margin may warrant consideration for high rate application systems, noting there may be coastal erosion and planning issues which also need consideration.
- Pine plantations in Zone C land located along Fraser St and SH2 at Tuhara could also warrant further investigation for land treatment of wastewater.

The availability of a continuous block of land of 0.5 ha to 540 ha (inclusive of rapid infiltration but exclusive of storage) is needed for land application, and associated cost of infrastructure, remains the biggest limitation to land application of Wairoa's municipal wastewater. Flat land within Zones A, B and C tend to be smaller property parcels occupied by cropping enterprises and small-holdings (as shown in Figure 9.1 in the green, yellow and light brown areas). Larger land parcels in Zone C (light brown) are located within close proximity to the WWTP and should be investigated further. Although these areas are >3° slope, these should still be considered as options for land treatment.

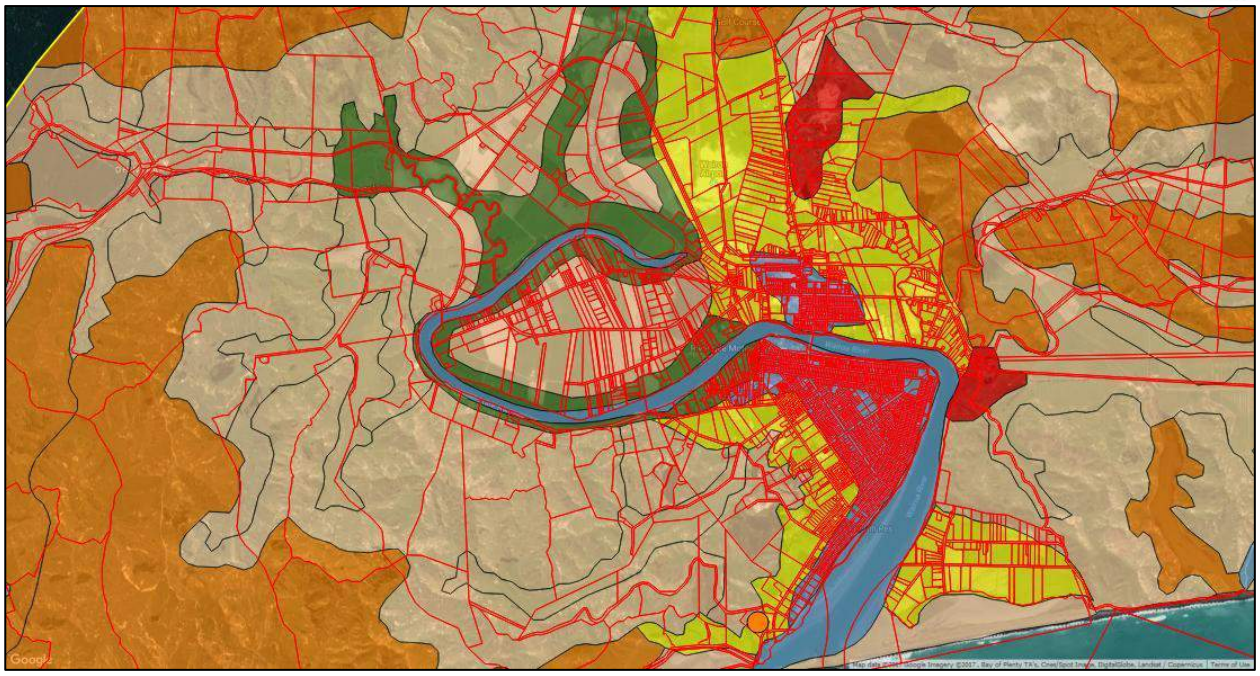


Figure 9.1: Cadastral Parcel Overlay with Zones

If land application is investigated further the following should be considered:

- Property ownership, including how many owners occur within a continuous block of land large enough for the wastewater flow from the WWTP (0.5 ha to 540 ha; dependent on irrigation method and zone to be applied);
- Land management (crop sensitivity, erosion risk, flat land hydrogeology);
- Costs for reticulation requirements (distance and elevation); and
- Special use locations (archaeological, historic, water take, native forest, recreational etc.).

It is recommended that any further investigation is limited to areas identified as Zone A, B and C.

10 REFERENCES

Dodson, M. (2010). *Assessment of nitrogen and E. coli groundwater quality in the Hawkes Bay Region, 2008.* Napier: Hawkes Bay Regional Council.

Gordon, D. (2016). *Groundwater quality state of environment: state and trends.* Napier: Hawke's Bay Regional Council.

HBRC. (2015). *Hawke's Bay Regional Resource Management Plan.* HBRC.

Lee, J. M., Bland, K., Townsend, D. B., & Kamp, P. J. (2011). Geology of the Hawke's Bay area: scale 1:250,000. 93. Lower Hutt: Institute of Geological & Nuclear Sciences Limited.

Mazengarb, C., & Speden, I. G. (2000). Geology of the Raukumara area: scale 1:250,000. Lower Hutt: Institute of Geological & Nuclear Sciences Limited.

Zemansky, G., Lovett, A., & Tschritter, C. (2012). *The extent and depth of known East Coast aquifers, North Island, New Zealand.* GNS Science.

11 APPENDICES

Appendix A: Figures

1. Investigation Area
2. Property Parcel
3. Current Land Use
4. Nutrient Uptake Potential
5. Drainage Class
6. Depth to Restrictive Layer
7. Slope
8. Flood Return
9. Riparian Areas
10. Suitability for Irrigation

APPENDIX A

Figures

NOTES

L W E
Environmental
I m p a c t
www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

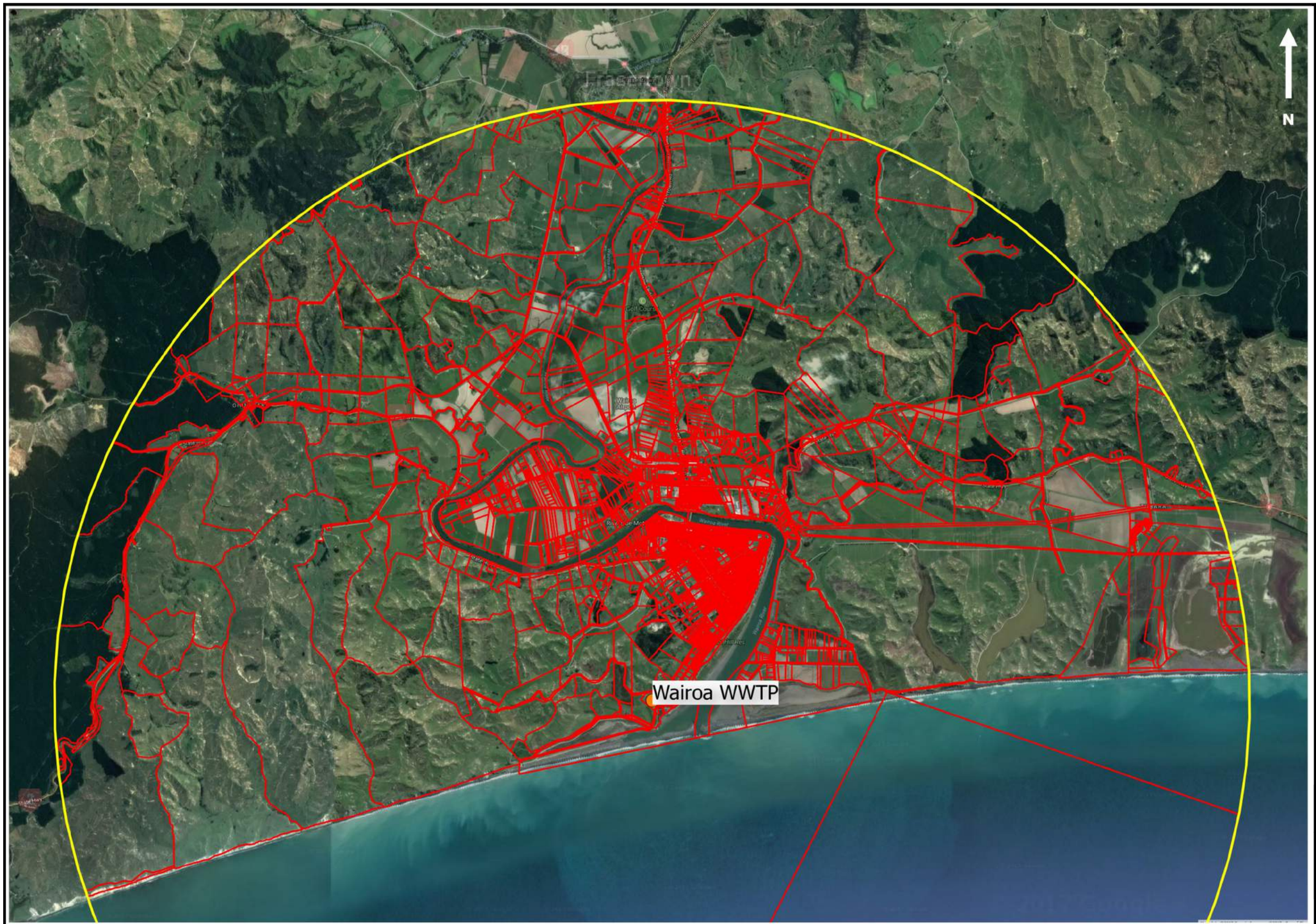
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 1: Investigation Area

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F1_Investigation_Area



NOTES

L W E
Environmental
I m p a c t
www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

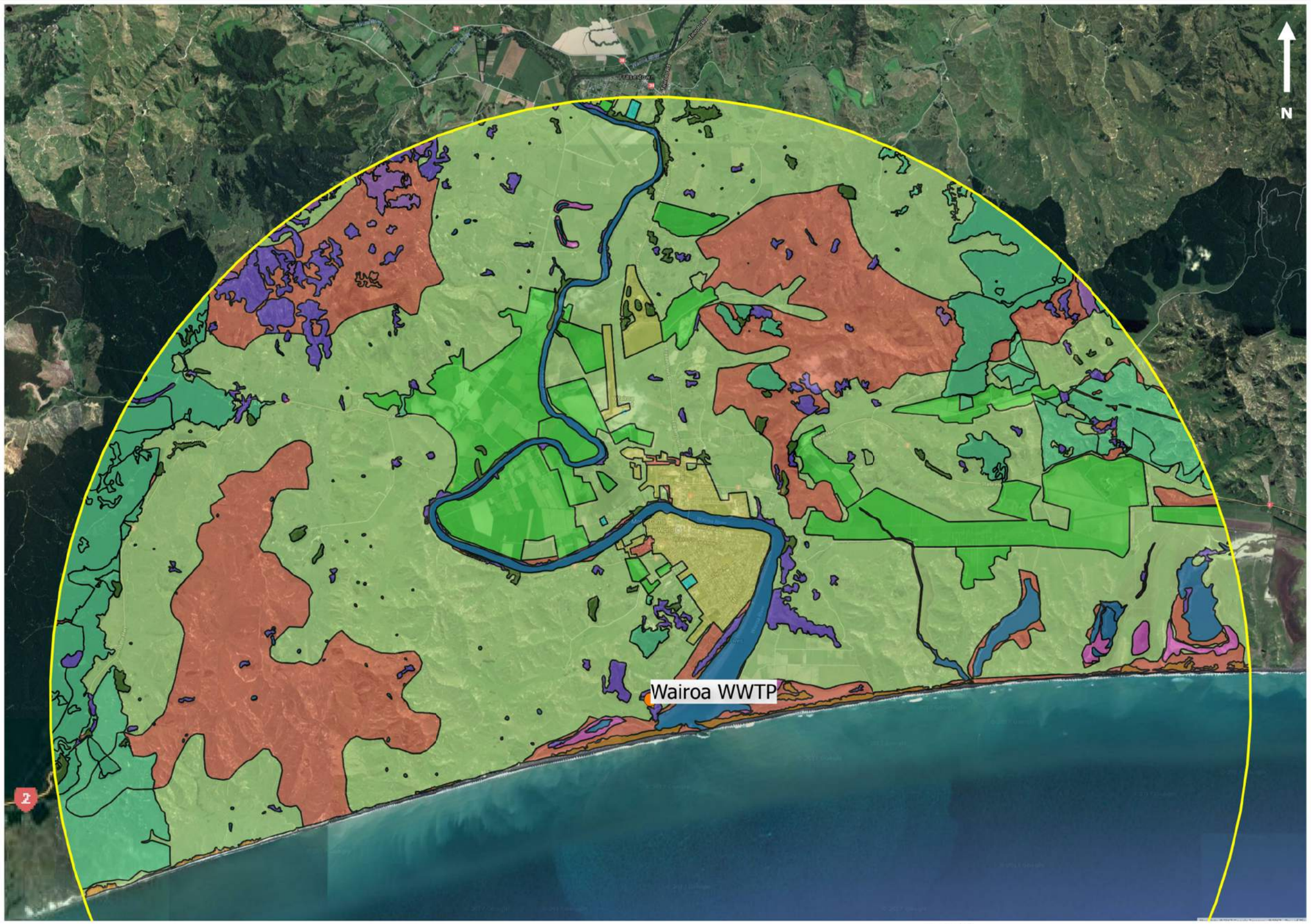
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 2: Property Parcels

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F2_Property_Parcels



Legend

10 km Investigation Area

Current Land Use

- Cropland - Annual
- Cropland - Perennial
- Grassland - High producing
- Grassland - Low producing
- Grassland - With woody biomass
- Natural Forest
- Other
- Planted Forest - Pre-1990
- Post 1989 Forest
- Settlements
- Wetland - Open water
- Wetland - Vegetated non forest

NOTES

L W E Environmental Impact
www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

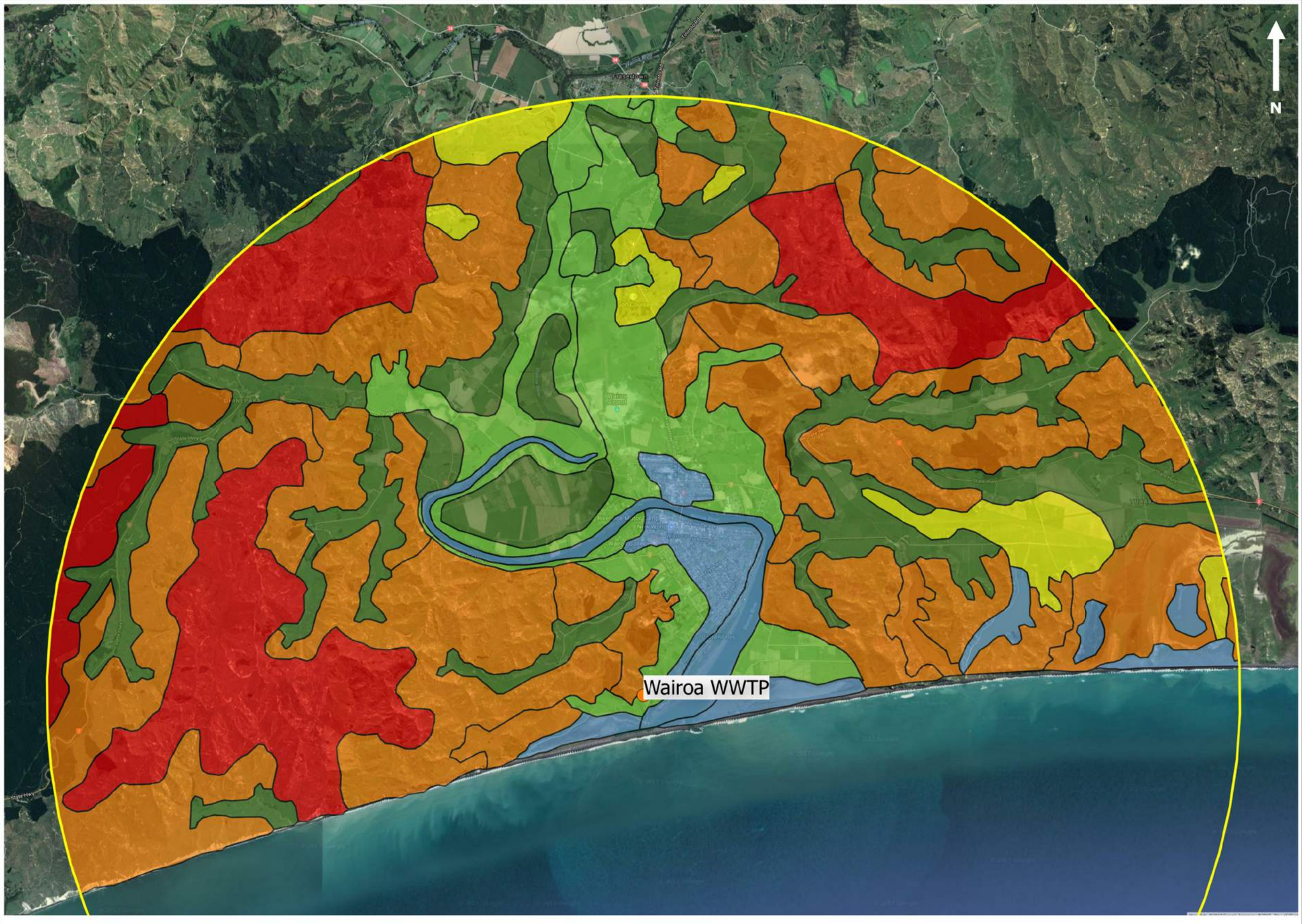
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 3 : Current Land Use

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F3_Current_Land_Use



NOTES

LWE Environmental Impact

www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

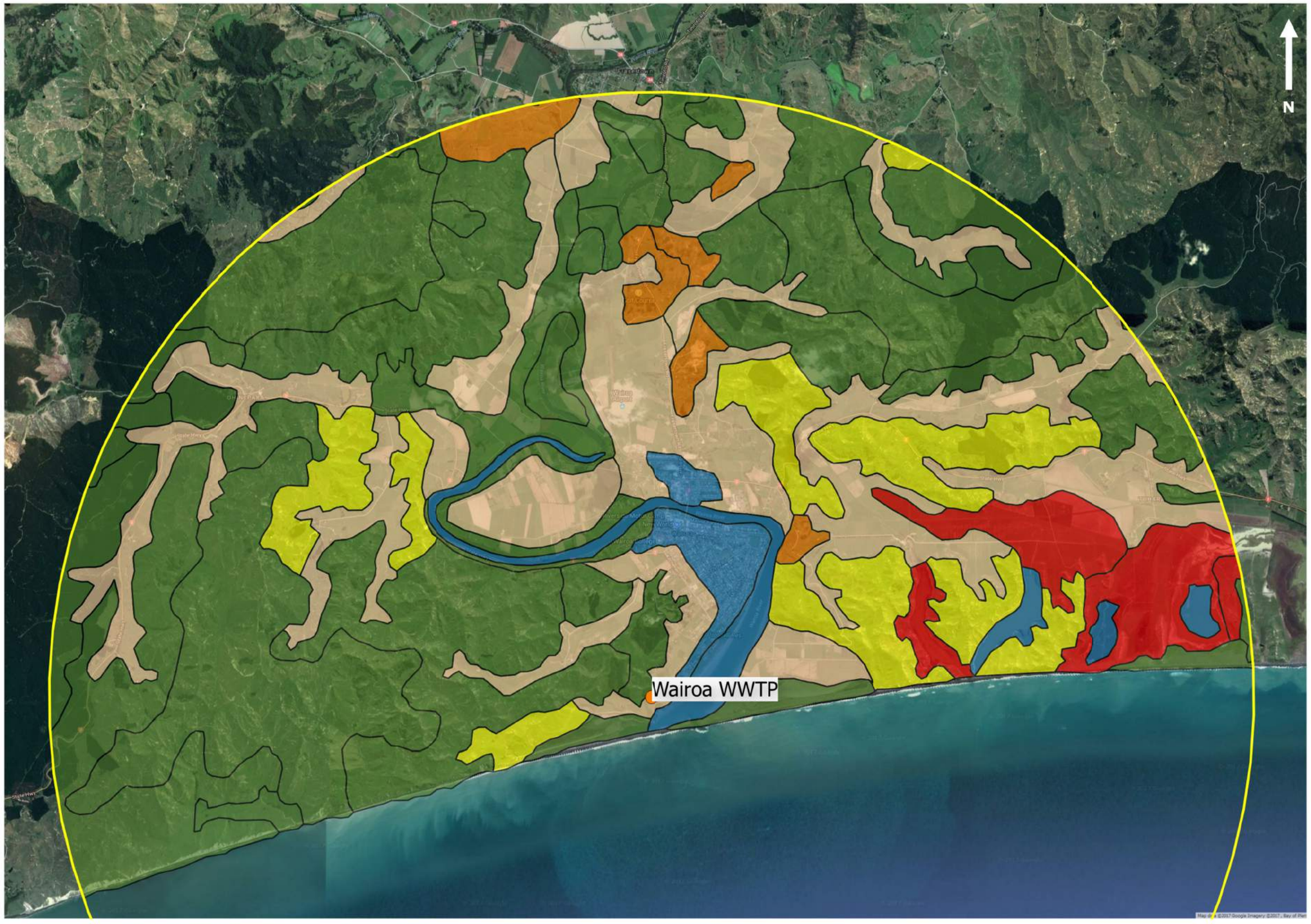
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 4: Nutrient Uptake Potential

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F4_Nutrient_Uptake_Potential



Legend

10 km Investigation Area

Drainage Class

1 - Very poorly drained
2 - Poorly drained
3 - Imperfectly drained or excessively drained
4 - Moderately well drained
5 - Well drained
N/A

NOTES

L W E
Environmental
I m p a c t

www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

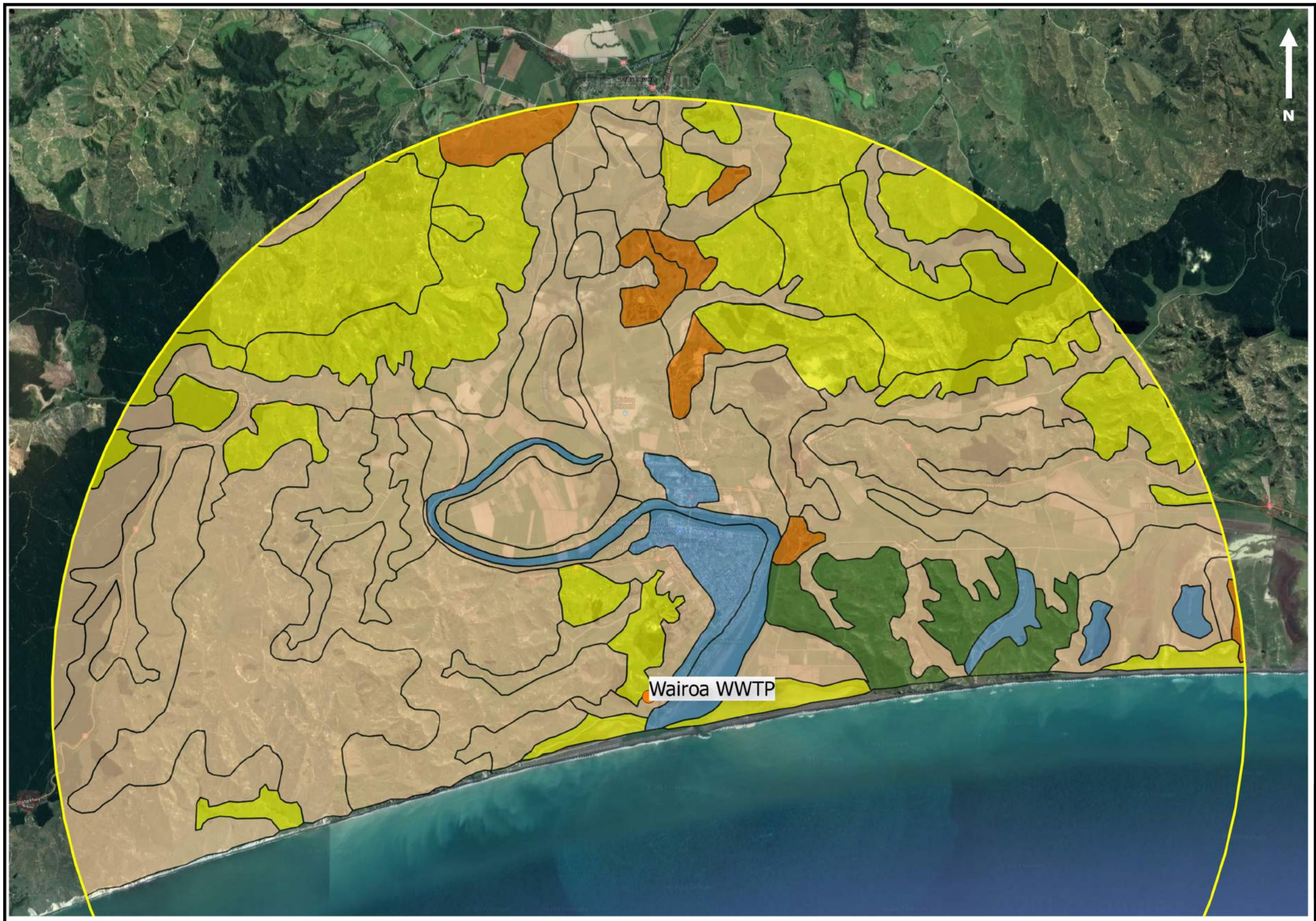
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 5: Drainage Class

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F5_Drainage_Class



NOTES

L O W E
Environmental
I m p a c t

www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

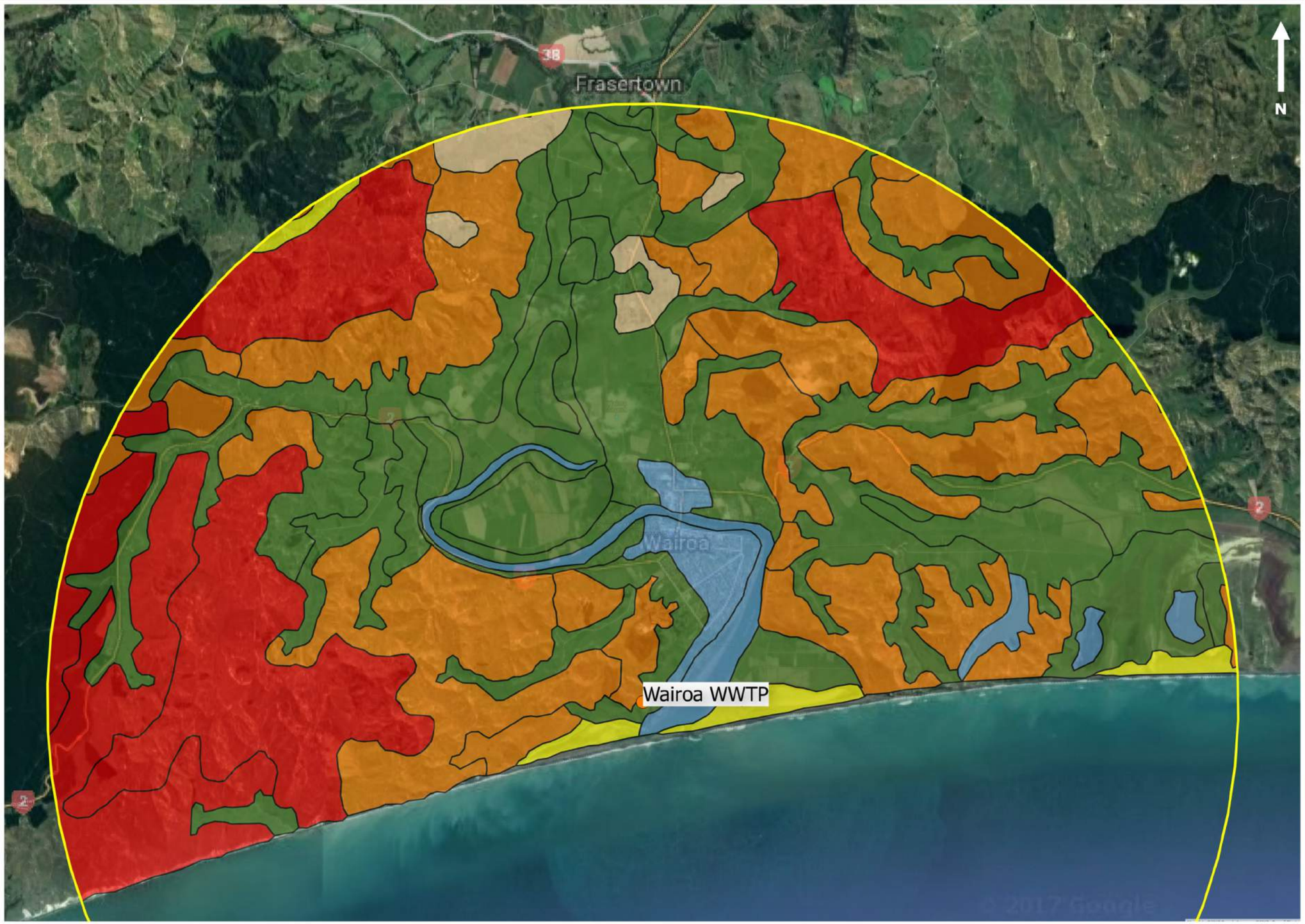
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 6: Depth to Restrictive Layer

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F6_Depth_to_Restrictive_Layer



NOTES

L O W E
Environmental
I m p a c t
www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

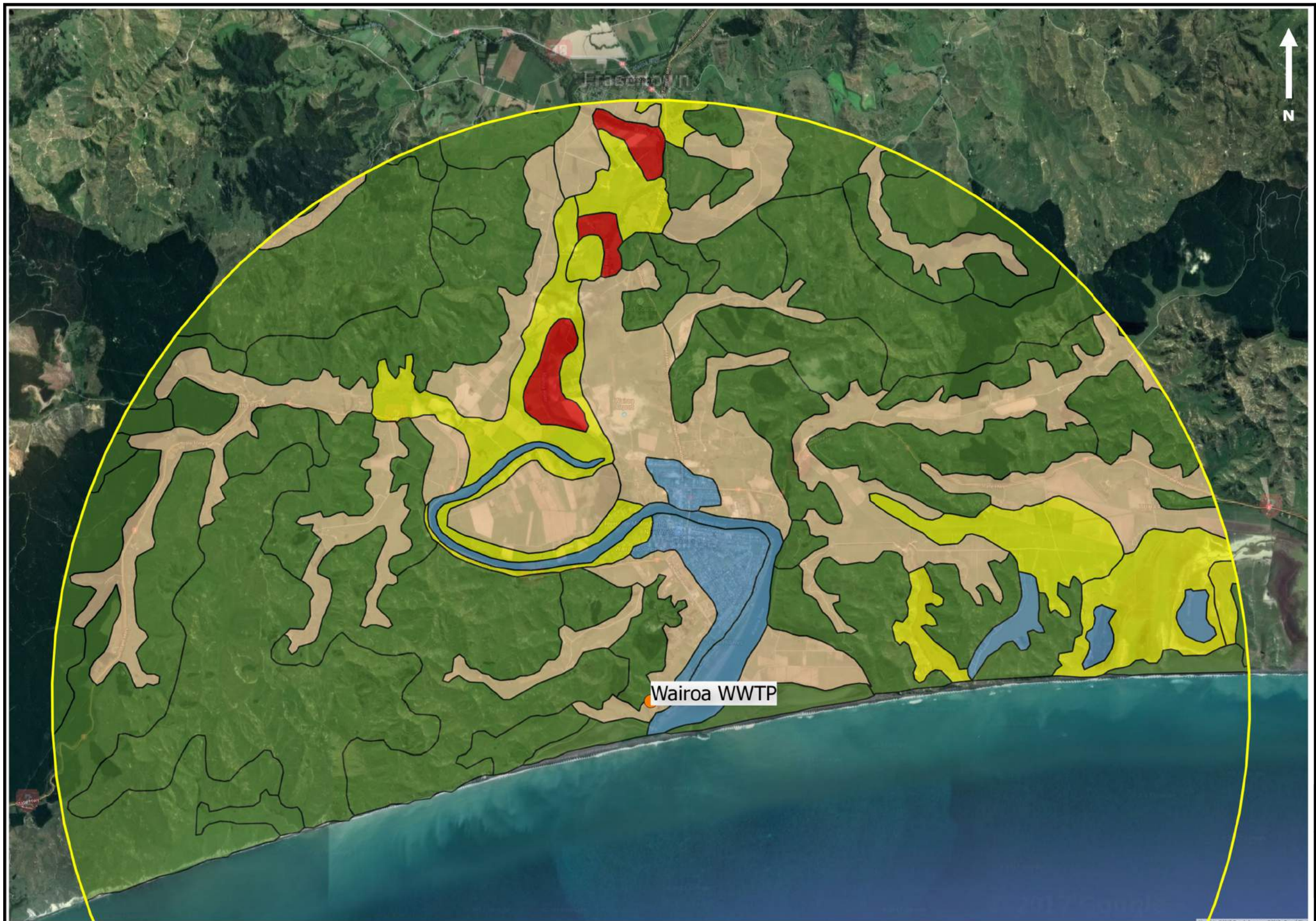
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 7: Slope

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F7_Slope



NOTES

L O W E
Environmental
I m p a c t

www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 8: Flood Return

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F8_Flood_Return

NOTES

L W E
Environmental
Impact
www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

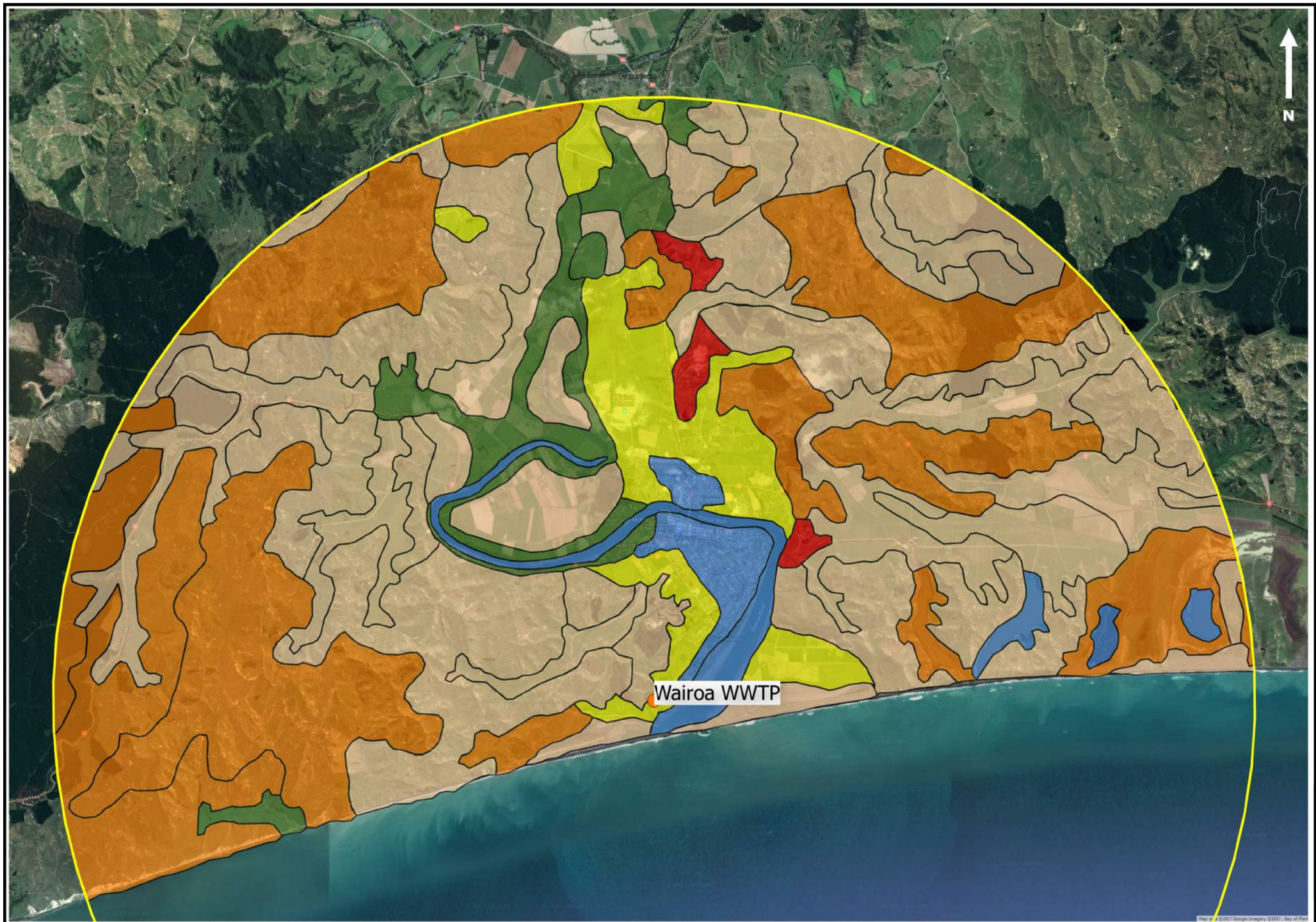
PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 9: Riparian Areas

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F9_Riparian_Areas



NOTES

L O W E
Environmental
I m p a c t

www.lei.co.nz | office@lei.co.nz

APPROVED	HL	
DESIGNED	AL	
DRAWN	AL	

CLIENT
Wairoa District Council

PROJECT
Wairoa Wastewater Consenting Project

DRAWING TITLE
Figure 10: Suitability for Irrigation

DRAWING STATUS
Final

DATE	SCALE
11/8/2017	NTS

FILE NAME
FI-10292-WDC-A5I1-F10_Suitability_for_Irrigation