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Ratana Wastewater Treatment Plant

Preliminary Water Balance

17 August 2021

CONFIDENTIAL

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150 YEARS IN AOTEAROA

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Contents

1 Introduction

WSP have been engaged by Rangitikei District Council to investigate the area of land necessary to dispose of treated effluent from the Ratana Wastewater Treatment Plant (WWTP) by irrigation. Assuming effluent disposal will be by deficit irrigation, a preliminary monthly water balance has been derived using local soil properties and climatic parameters and indices.

2 Climate Data

A monthly soil moisture balance was used to estimate the availability of water and therefore the potential for deficit irrigation of the soils near the Ratana WWTP.

The climatic data used in this assessment was obtained from the National Climate Database. Sites were chosen based on their proximity and similarity in elevation and topography to the Ratana WWTP, and the length of the data records.

A summary of the data used and the locations of the climate stations are presented in Table 2.1 and Figure 2.1, respectively.

Table 2.1: Data used in the water balance and assessment of the disposal area.

Type	Authority	Station Number	Site Name	Record Start	Record End	Length
Rainfall	NIWA	3719	Wanganui Aws	2-Aug-1987	-	34-years
Evaporation (Penman)	NIWA	3715	Wanganui, Spriggens Park Ews	2-Jan-1972	-	49-years

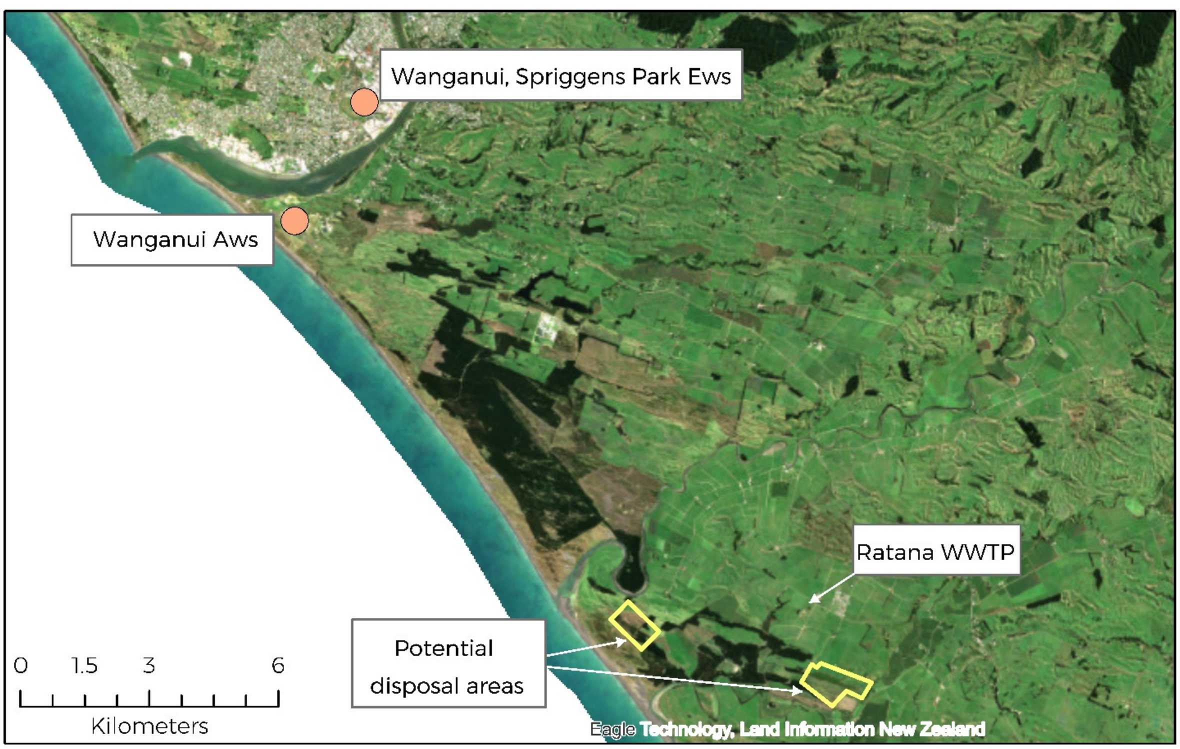

Figure 2.1: Ratana study area with the locations of the Wanganui AWS rain gauge and Wanganui, Spriggens Park EWS evaporation data station.

2.1 Rainfall

The two nearest rain gauges to the Ratana WWTP are 'Marton, Ross Street' and 'Wanganui, AWS'; which are located in Marton and Wanganui respectively. Both gauges are a similar distance from the WWTP (~15km) and have similar record lengths. To determine which data would be most applicable to the Ratana WWTP, comparison of the site elevations and mean annual rainfall (developed for the wider region) was undertaken. Following this analysis, it is considered that the rain gauge at 'Wanganui, AWS' is likely to be more representative of rainfall experienced at the Ratana WWTP.

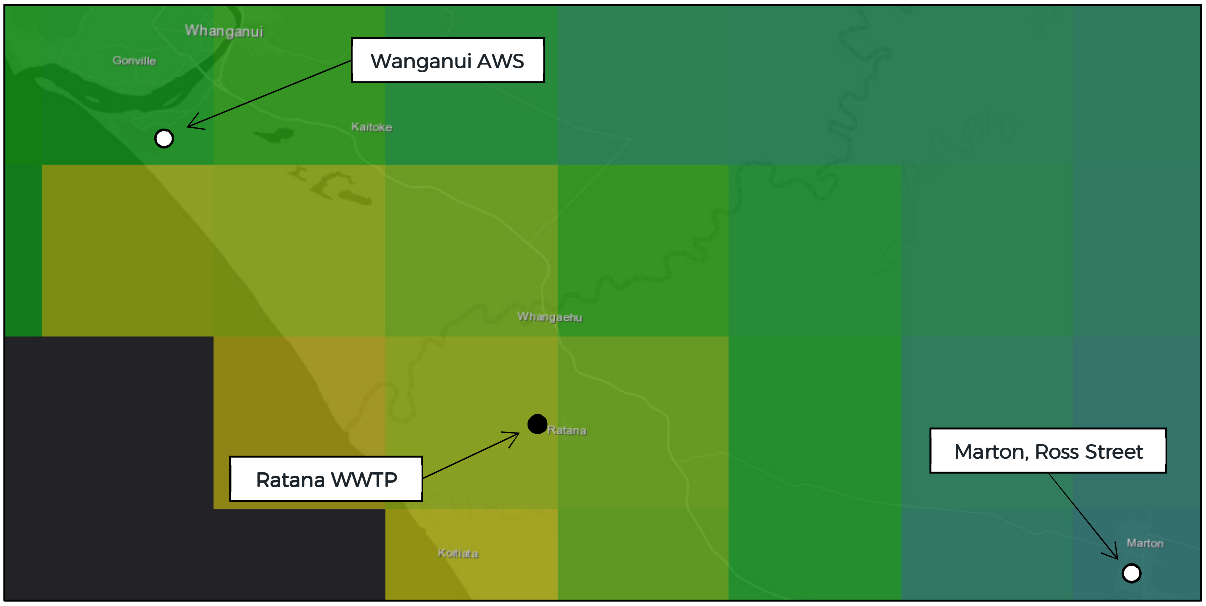

Figure 2.2: Mean Annual Rainfall across the wider area of the Ratana WWTP. Rainfall increases from yellow to dark blue.

2.2 Evaporation

Wanganui, Spriggens Park is the most appropriate evapotranspiration data to use for the analysis. The record is approximately 49-years long, extending back to 1972. Although this site is some distance from the Ratana WWTP, potential evapotranspiration has been shown to be relatively uniform across large areas, particularly across areas with little topographic or aspect variability. The assumption of consistent evapotranspiration across the study area, given the nature of the terrain and the controls on evapotranspiration, is not considered a major constraint on the reliability of the analysis presented in this report.

3 Water Balance

A simple soil moisture balance was used to estimate the availability of water, and therefore the potential for irrigation or soakage, within the soils near the WWTP for each month of the year.

Water enters the system as Precipitation (P) and is lost through evapotranspiration and runoff. Potential evapotranspiration (PE) is the maximum amount of water lost to the system (assuming an unlimited supply) as a result of solar radiation, wind speed and vapour pressure deficit (McConchie, 2000). However, because of limitations to water availability, this maximum is often not achieved. Actual evapotranspiration (AE) therefore is a function of both the PE and water availability and quantifies the actual amount of water lost to the system.

In the water balance, precipitation is initially used to meet the PE requirements. If precipitation is sufficient, then AE will equal PE. Any excess water will recharge the soil water storage (ST), or when that reaches capacity, become a surplus (S) and run off. Water which is stored in the pores of the soil is released to the plants and atmosphere when water supply from precipitation is less than the PE. However, moisture within the soil may not be sufficient to fully meet PE. This results in a water deficit (D).

3.1 Available moisture

Data from the long-term rain gauge at Wanganui Aws shows a slight seasonal pattern of median monthly rainfall (Figure 3.1). June receives an average of only 32mm more rainfall than March. October has approximately 8mm less rain than June. The months with the least rainfall are January, February and March i.e. during summer. It is slightly wetter during winter months.

Obviously, there is considerable annual variation about the median, with some months in 'dry summers' having no rain. Any resource consent, or calculation of the requirement for storage or the area of land for effluent irrigation, must consider months and years when rainfall is distinctly different to the median (Table 3.1).

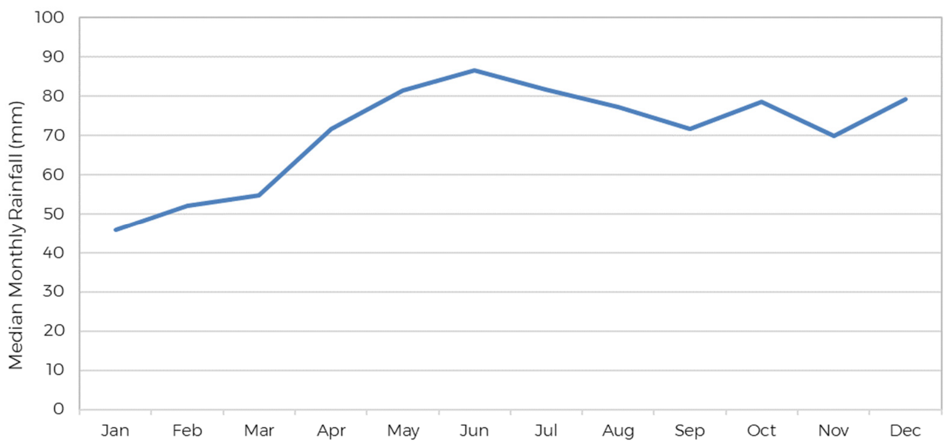

Figure 3.1: Median monthly rainfall at Wanganui AWS.

Table 3.1: Median rainfall and evapotranspiration data used for the Ratana WWTP water balance.

Month	Median Rainfall (mm)	Median Evapotranspiration (mm)
January	46	154
February	52	121
March	55	98
April	72	58
May	81	36
June	87	24
July	82	28
August	77	43
September	72	68
October	79	99
November	70	123
December	79	145
Total	**852**	**997**

3.2 Soil moisture storage

Pores within the soil can store moisture and therefore act as a buffer against the natural inputs and losses of moisture which would occur solely as a result of the climate.

The soil's Profile Readily Available Water content (PRAW) describes the water that can be readily absorbed by plant roots without resulting in water deficit stress. This is generally assumed to be the water content difference between field capacity and permanent wilting point. Field capacity describes the maximum amount of water a soil can hold against gravitational force. Wilting point is the moisture content below which plants can no longer extract water because of capillary tension. At this point plants will suffer extreme water stress and possibly die.

For a high-level desktop study such as this, the PRAW can be considered a conservative measure of the soil's water storage capacity. This is because the calculation of PRAW considers the soil depth, potential rooting depth, and soil moisture properties of the soil.

It should be noted that monthly rainfall and PE can vary significantly from the median. Consequently, there may be considerable residual risk if this water balance is applied without more detailed analysis. The water balance is based on monthly data and does not explicitly account for either the variability or timing of rainfall. As such, it is possible that a large amount of rainfall could fall in one event. Much of this rainfall may run off and not be absorbed by the soil. Consequently, the overall deficit may be larger than anticipated. Also, the soil moisture storage capacity of the soils in this area has been based on the PRAW referenced in national databases. No site-specific analysis of the soil moisture storage potential has been undertaken.

Site 1

The PRAW of the Site 1 where treated wastewater may be irrigated is classed as 'Very Low', i.e. between 0 and 25mm (Figure 3.2). This reflects the classification being a function of the potential rooting depth (Newsome *et al.*, 2006). Very low PRAW soils have a highly limited capacity to store moisture.

It is noted that part of the potential area for irrigation is classed as bedrock, with a PRAW value of zero (Figure 3.2). However, a mid-PRAW value of 12mm has been used in this water balance to provide a representative value of the other soils present.

A water balance was therefore calculated using the median monthly rainfall and evapotranspiration data and a PRAW of 12mm (Table 3.2 & Figure 3.3).

The average annual soil moisture surplus and deficit, assuming a PRAW of 12mm, would be 202 and 347mm, respectively (Table 3.2 and Figure 3.3). In the current climate, deficit irrigation could start in October with relatively low applications of water, before ceasing in March.

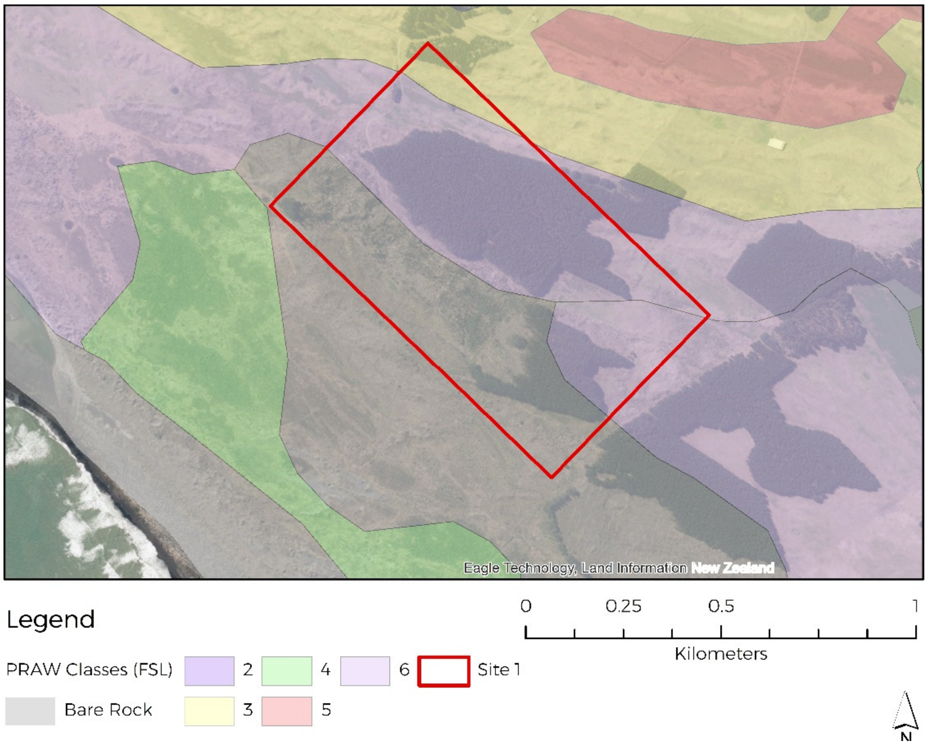

Figure 3.2: Soil profile readily available water (PRAW) for Site 1.

Table 3.2: Water balance based on median rainfall (P) and evapotranspiration (PET) and a PRAW of 12mm.

Water balance for soils with 12mm storage capacity													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
P	46	52	55	72	81	87	82	77	72	79	70	79	852
PE	154	121	98	58	36	24	28	43	68	99	123	145	997
P - PE	-108	-69	-43	14	45	63	54	34	4	-20	-53	-66	
ΔST	0	0	0	12	0	0	0	0	0	-12	0	0	
ST	0	0	0	12	12	12	12	12	12	0	0	0	
AE	46	52	55	58	36	24	28	43	68	91	70	79	
D	108	69	43	0	0	0	0	0	0	8	53	66	347
S	0	0	0	2	45	63	54	34	4	0	0	0	202

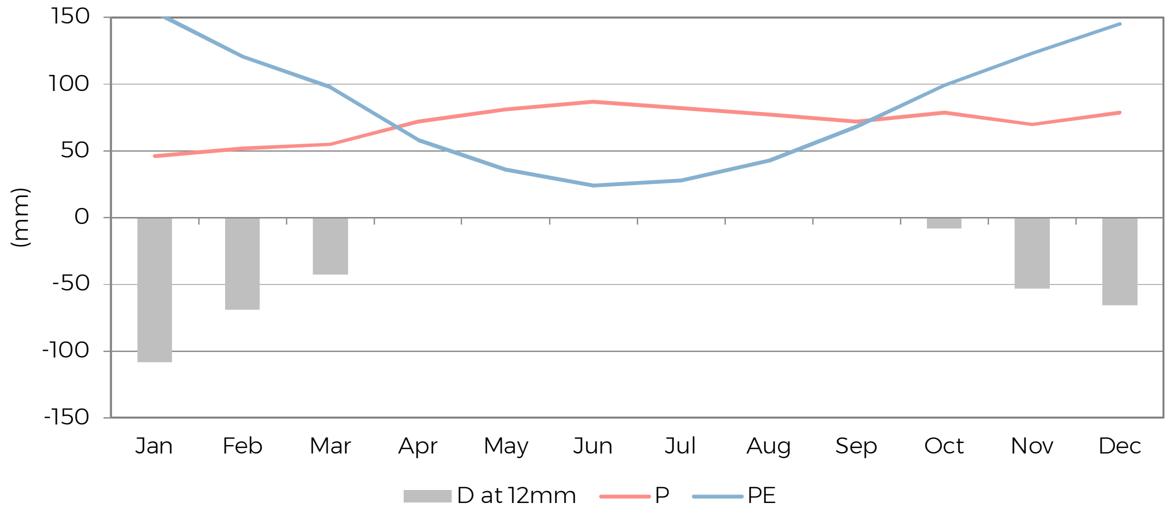

Figure 3.3: P, PE and deficit curves for Ratana WWTP assuming a PRAW of 12mm during a median climate scenario.

Site 2 (Plan B)

For Site 2, the majority of site is classed as having 'Moderate' PRAW, i.e. between 50 and 74mm (Figure 3.4), although it ranges between very low to moderately high. A mid-PRAW value of 62mm is therefore used.

Similar to Site 1, a water balance was calculated using the median monthly rainfall and evapotranspiration data. However, a PRAW of 62mm was applied in line with the PRAW class which covered most of the site (Table 3.3 and Figure 3.5).

The average annual soil moisture surplus and deficit, assuming a PRAW of 62mm, would be 152 and 297mm, respectively (Table 3.3 and Figure 3.5). In the current climate, deficit irrigation could start in November with relatively low applications of water, before ceasing in March.

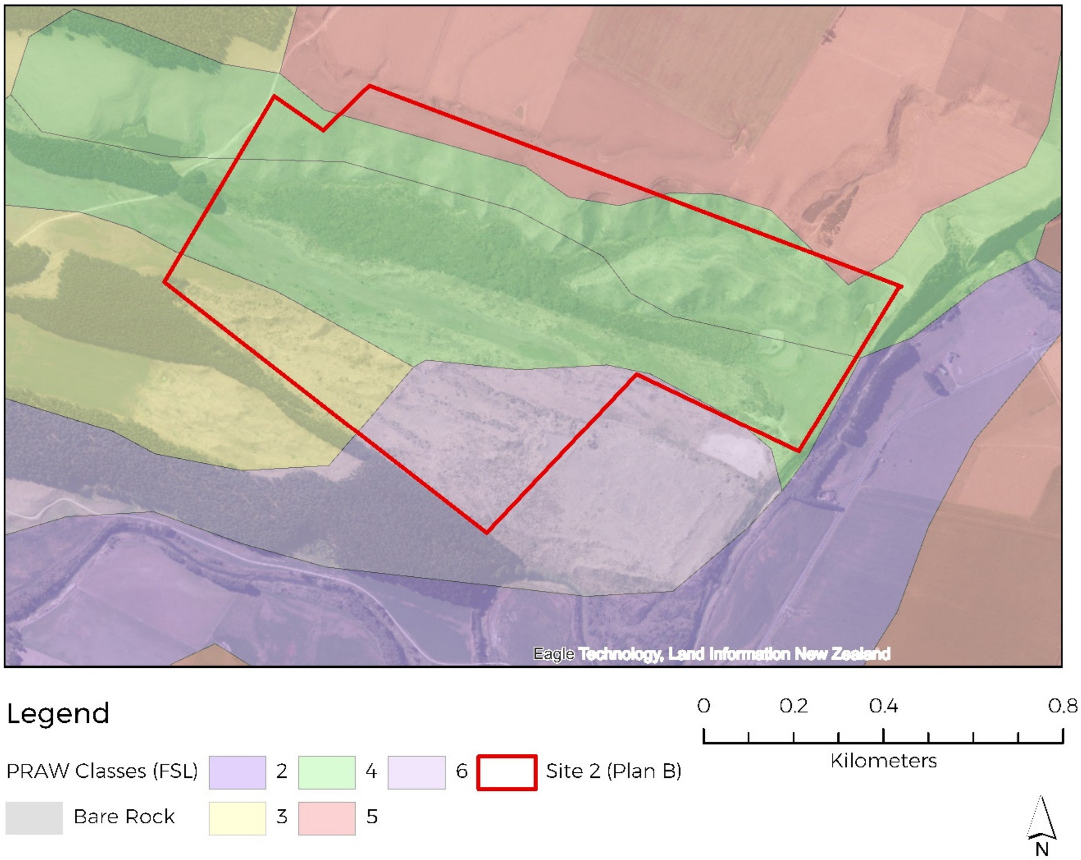

Figure 3.4: Soil profile readily available water (PRAW) for Site 2 (Plan B).

Table 3.3: Water balance based on median rainfall (P) and evapotranspiration (PET) and a PRAW of 62mm.

Water balance for soils with 62mm storage capacity													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
P	46	52	55	72	81	87	82	77	72	79	70	79	852
PE	154	121	98	58	36	24	28	43	68	99	123	145	997
P - PE	-108	-69	-43	14	45	63	54	34	4	-20	-53	-66	
ΔST	0	0	0	14	45	3	0	0	0	-20	-42	0	
ST	0	0	0	14	59	62	62	62	62	42	0	0	
AE	46	52	55	58	36	24	28	43	68	99	112	79	
D	108	69	43	0	0	0	0	0	0	0	11	66	297
S	0	0	0	0	0	60	54	34	4	0	0	0	152

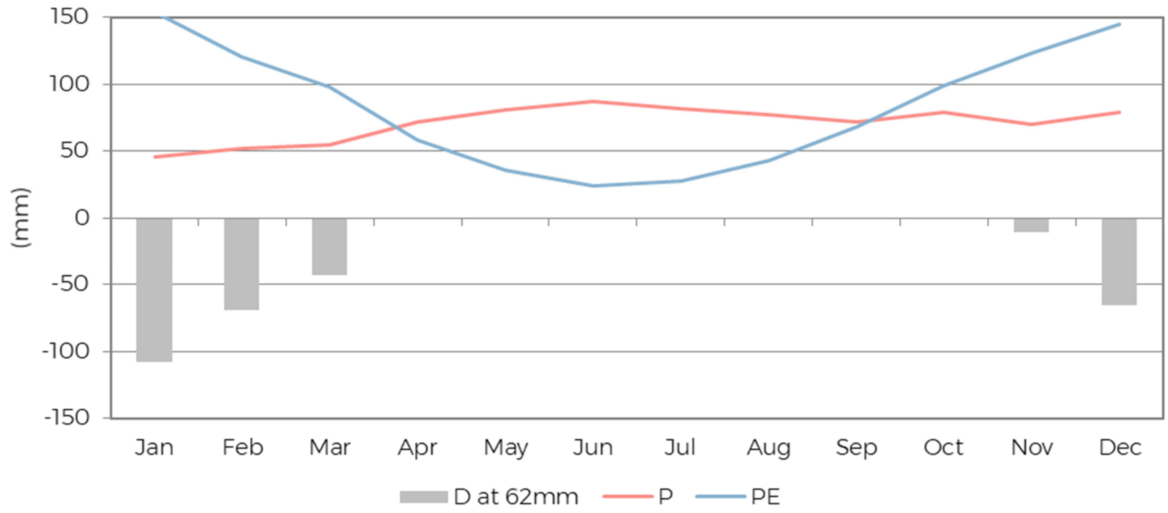

Figure 3.5: P, PE and deficit curves for Ratana WWTP assuming a PRAW of 62mm during a median climate scenario.

4 Land Requirements

4.1 Outflows from WWTP

The daily volume of effluent from the Ratana WWTP has been provided by Rangitikei District Council for 2017, part of 2018, and early 2021. Although this is limited data, experience at other WWTP sites in the Manawatu-Wanganui region suggests that 2018 was a wet year in the lower North Island. Consequently, these values are likely to be at the upper range of expected flows.

Average daily flows have been derived for both the current population and with the addition of 60 more households contributing to the WWTP inflows. These estimates are outlined in Table 4.1.

Table 4.1: Average flows for Ratana WWTP.

	Current flows	Future flows
Average daily outflow (m^3/day)	142 – 168 [1]	217

[1] *This range is based on differences between the measured and theoretical calculations. The higher value of 168m^3/day has been used in this assessment to be conservative.*

Further information on the derivation of these flows is provided in Appendix A.

4.2 Annual irrigation and storage potential

The assessed water balances for both property options provide the total deficit and surplus over an average year at the Ratana WWTP. As expected, there is a deficit of soil moisture over the summer months (October to March for Site 1 and November to March for Site 2) which allows for irrigation of treated wastewater to occur. Wastewater from the treatment plant would need to be stored between April and September (Site 1) or October (Site 2), when the soils are at capacity or when there is a surplus of soil moisture. However, the minimal soil moisture deficit over these latter shoulder months also means wastewater may need to be stored at these times too.

By assessing the water budget, the land required to irrigate the accumulated annual surplus of wastewater and the volume of storage required over the winter months have been derived (Table 4.2). It is noted that the area of land provided is the effective area for irrigation. In the winter months when there is a surplus of soil moisture, all wastewater will be required to be stored within the WWTP. The shoulder months of October for Site 1 and November for Site 2 have been included due to the limited capacity of the soils at these times.

However, in the highest deficit summer months the volume of wastewater able to be applied will enable discharge of the stored wastewater, increasing the capacity of storage for the following winter.

Table 4.2: Area of land required to discharge annual accumulated surplus of wastewater and volume of storage required.

	Current flows	Future flows
Area of land required (ha):		
Site 1	~10.5	~13.5
Site 2 (Plan B)	~13.9	~17.9
Volume of storage required (m^3)		
Site 1	~36,000	~46,500
Site 2 (Plan B)	~41,200	~53,200

5 References

McConchie, J. A. (2000). From floods to forecasts: The hydrology of Wellington, (in) Dynamic Wellington: A contemporary synthesis and explanation of Wellington (eds. McConchie, J., Winchester, D., and Willis, R.). Institute of Geography, Victoria University of Wellington, New Zealand, 344p.

Appendix A
Ratana Wastewater Treatment Plant Flows

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Memorandum

To	Tabitha Manderson
Copy	
From	Andrew Springer
Office	Auckland
Date	3 June 2021
Subject	Ratana WWTP Flows

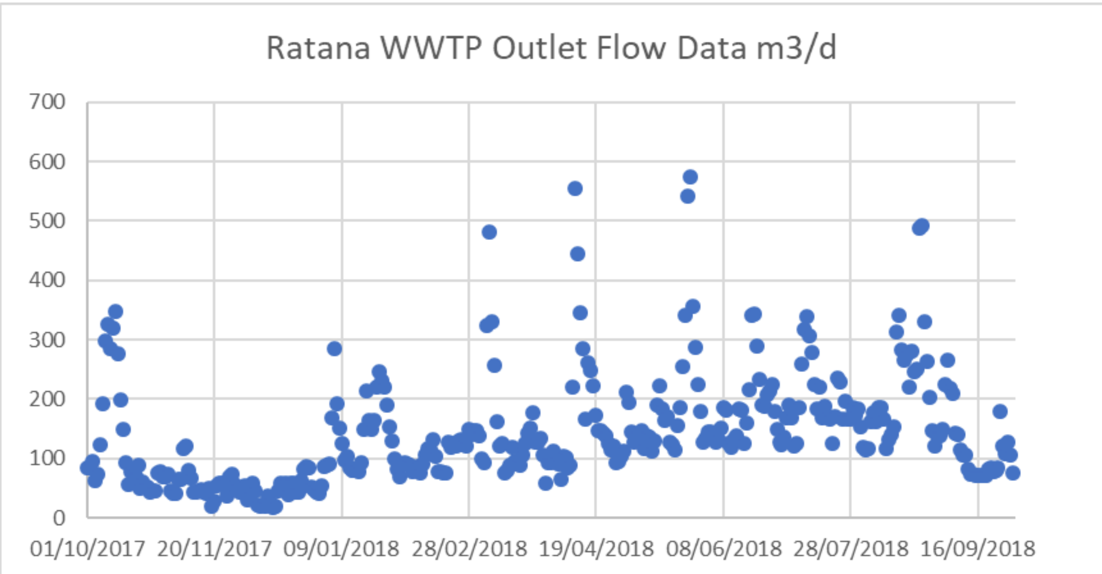
Introduction

Ratana WWTP serves approximately 370 people in Rangitikei District. The treatment system comprises of 2 oxidation ponds before discharge to a local stream. It is intended that the discharge will in future be discharged to land. WSP have been engaged to assess the high level requirements of disposal fields in the area.

This memorandum presents a review of flow data available (provided May 2021) to aid in sizing of the land requirement. For calculations the 2018 current population is assumed to be as given by Wikipedia reference https://en.wikipedia.org/wiki/R%C4%81tana_P%C4%81 which quotes 2018 census data as a population of 345. The current estimate for 2021 population is 370 people, with an additional 60 properties to be assumed for future estimates.

Flow data has been provided as totalised daily volume for 2017, and part of 2018, and early 2021. Although data is not provided for other periods, it is considered from our experience at other sites in the Region, that 2018 was a wet year in the lower North Island, so the values reported will be at the upper range of expected flows. If data were focused on 2019-21, the flow estimates used could lead to under sizing as these years have both had prolonged warm dry conditions.

Current Flow Data



The statistics for flow data over the 2017-18 this period is given below.

	Daily Flow m^3/d	Avg Flow /person l/ d
Avg	142.37	413
Min	18.40	53
Max	574.8	1660
20%ile	72.37	210
95%ile	323.85	938
Annual Total	51967 m^3/yr.	150m^3/yr.

These figures are significantly higher than Nationally applied typical flow figures, where average flow is 200-250 l/person/d. It is known that Ratana community has a metered water supply and many properties have roof tanks so it is expected that daily flow with some infiltration should be < 200 l/person/d including infiltration. Many users will prefer to continue with their tank as a cheaper alternative source.

To define future flows, it is necessary to identify the components of the flow. These components are population contribution and infiltration. No trade effluent is expected at Ratana.

Infiltration levels have been assessed using 2021 February Inlet Data, a recognised dry period. February flow data is presented below. Over this period the mean nighttime flow between 1st and 10th February between midnight and 06:00 was 1.18 l/s. That is equivalent to 102 m3/d. Over this same period the average flow into the plant was 1.49 l/s equivalent to 129 m3/d. Therefore, the domestic contribution over this period was only 27 m3/d. That is equivalent to 78 l/hd. This value per head of water contribution is consistent with other roof tank served communities in New Zealand.

Of note, should the network be improved, and infiltration rates are reduced, this will make a significant impact on the volumes of wastewater to be treated.

The maximum flow recorded into the plant in all data assessed has been an hourly an hourly average flow of 14.4 l/s. The maximum recorded discharge rate is 8.8 l/s due to attenuation in the pond system.

The following approach is used for calculation of flows.

Per Capita contribution 80 l/hd/d

Infiltration 102 m^3/d

DWF = Population x per capita + Infiltration =0.08x345 +102 = 129.6 m^3/d

ADWF = 1.3 x DWF = 1.3 x 129.6 = 168 m^3/d

Peak Flow =

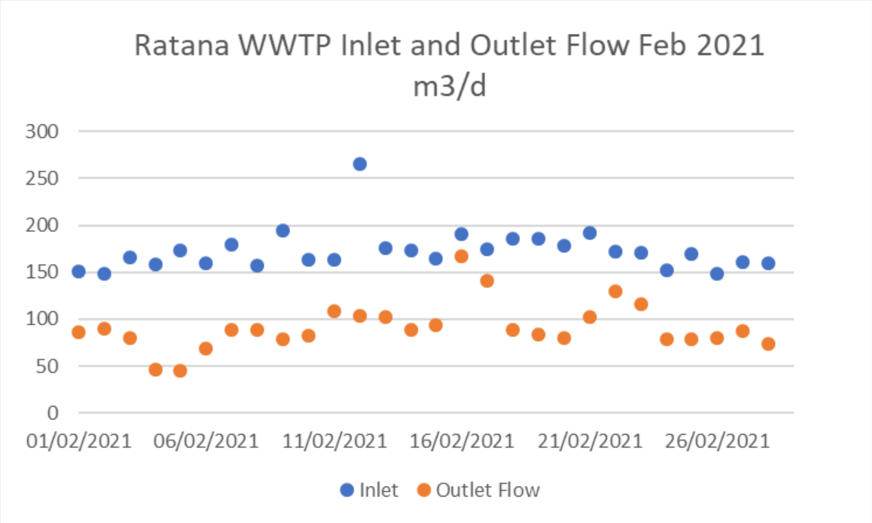
Formula A = 1.36 x Pop + DWF = 1.36x 345 + 129.6 = 598.8 m^3/d.

These figures show a good correlation with flow data gathered between October 2017 to Sep 18

	2017-18 Outlet	2021 Inlet	2021 Outlet	Theoretical inflow
DWF (20%ile) m^3/d	73	131	84	129
Average Flow m^3/d	142	150	116	168
Max Daily Flow m^3/d	574	420	374	598

Data for 2021 is from 6/1/21 to 20/5/21

Looking specifically at February 2021 data as an indicator of the difference between the two sets of flow data, this period of warm dry weather shows a reduction in average flow in to out by 49 m3/d, 34 % of inflow.



Future Flows

- The following forecast of flows makes the following assumptions.
- Water consumption will be similar to currently measured.
- No significant change in infiltration will occur.
- It is assumed that all new properties have less leaky infrastructure, so a lower infiltration value of 100 l/person is applied.
- Growth is based on an additional 60 properties since the 2018 census, some of this growth may have occurred.
- It is assumed that there are 3 residents in each property.
- No allowance Is made for fluctuation in population due to festivals.

Theoretical Future Flows

The following approach is used for calculation of flows.

Per Capita contribution	80 l/hd/d for 345 people
Current Infiltration	102 m^3/d
Additional population	to 2021, 25 people
Future Population	60 properties, 180 people
Future infiltration	100 l/person per day

DWF = Population x per capita + Infiltration=current DWF + 80x205 + 205x100 = 166.5 m^3/d

ADWF = 1.3 x DWF = 1.3 x 166.5 = 217 m^3/d

Annual Flow =79,205 m^3/yr.

Peak Flow = Formula A – 1.36 x Pop + DWF

= current FA + 1.36 x 205 +new DWF (36.9) = 915 m^3/d.

Note that if all new properties are built to a reasonable standard with low infiltration and separate storm water, this Peak figure will be reduced to 710 m3/d but not substantially change the average flow.

Basis of Design

For the purpose of sizing land, it is recommended to use figures that will over estimate the land required so the inflow values are assumed as these can be 30% greater than outflow values.

Therefore, the new disposal system will be required to;

Peak Flow	915 m^3/d.
Max Pumped Flow	15l/s.
Average Daily Flow	217 m^3/d
Annual Average Flow	79,205 m^3/yr.

If you have any queries regarding this summary, please contact me.

Regards,

Andrew Springer

Technical Principal Wastewater Engineer

wsp.com/nz