Memorandum

To	Tabitha Manderson
Copy	
From	Nick Adams, Jessica Hall and Kyle Wills
Office	Nelson, Timaru, Christchurch
Date	13 December 2023
File/Ref	5-P1472.00
Subject	Rātana WWTP - Technical assessments for irrigation design & Overseer

1 Introduction

This memo addresses the s92 further information request received from Horizons Regional Council in relation to resource consent application APP-1997003515.01 for the Ratana WWTP.

The specific information request questions addressed are:

- Please explain:
    - how the hydraulic loading rates have been estimated using the soil water balance approach, including:
        - proportion of land that is poorly draining and free-draining,
        - confirmation that this has been calculated at a daily time-step,
        - volume (or depth in mm) of surplus water (i.e., drainage) in non-deficit scenarios.
- During the site visit we discussed the possibility of standing water forming in the low-lying areas, and potentially that irrigation would continue regardless of standing water/ponding. Please:
    - elaborate further on these comments and, should this be the intended approach,
        - provide greater specificity regarding when this would occur and what the 'triggers' may be.
- Please provide evidence to support the assumptions made regarding Nitrogen leaching and Phosphorus run-off (Overseer files).
    - Please ensure that the Overseer modelling is based on the soil types present at Rātana and
    - consider the specific wastewater characteristics (current) and crop/pasture types (proposed), as well as:
        - the hydraulic loading for the site (current and future).

This memo provides updated irrigation design parameters based on proposed changes to the originally proposed management of treated wastewater irrigation.

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Additional ecological assessments have been undertaken at the site and as a result, some consequential changes to the irrigation management are now proposed have been modelled.

In addition, as per the further information request, an Overseer model was generated for the site. It is noted that Overseer was not used in the lodged consent application as the RDC advisors did not consider it was fit for purpose due to limitations of the model. This is discussed in Section 4 of this memo.

2 Updated analysis

As a result of the purchase of the additional 4ha and ecological assessments, new irrigation management areas have been identified. The management of wastewater irrigation in these areas will vary depending on the management objectives for each area.

Table 1 shows the size of the different management zones in hectares and Figure 1 shows the locations of these management zones within the property boundary.

Table 1. Irrigation Management zone areas

Irrigation Management Zones	Land Area (ha)	
Gross Area	**25.3**	
Dune Management Zone	8.0	
General Management Zone	10.4	
Edge Management Zone	3.8	
Areas excluded	**3.1**	
Wetland Enhancement and Offset Area	0.4	
Southern Ecological Enhancement Area	0.8	
Pond Area	1.9	
Net Area including	**22.2**	

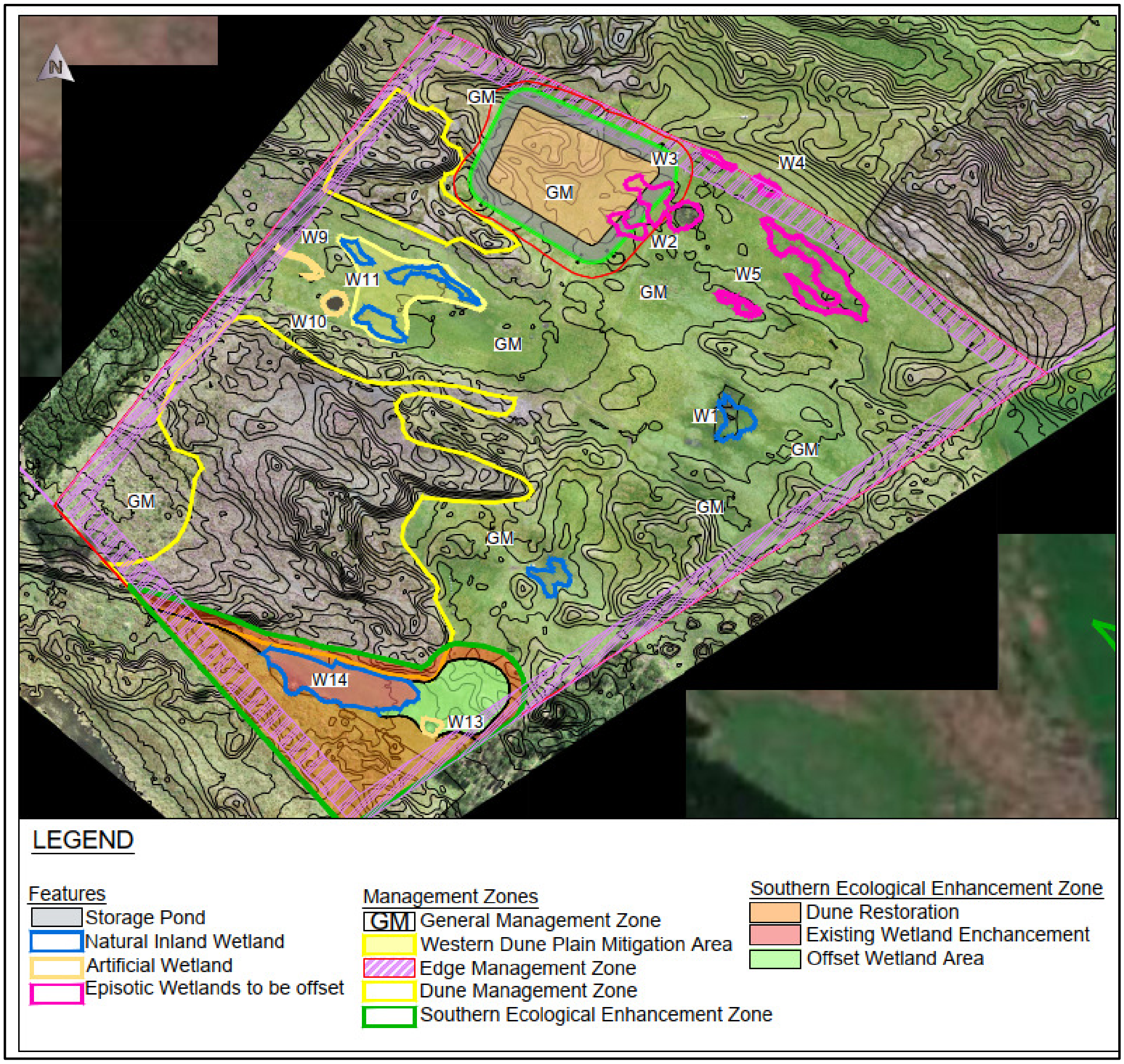


Figure 1. Irrigation Management zone map

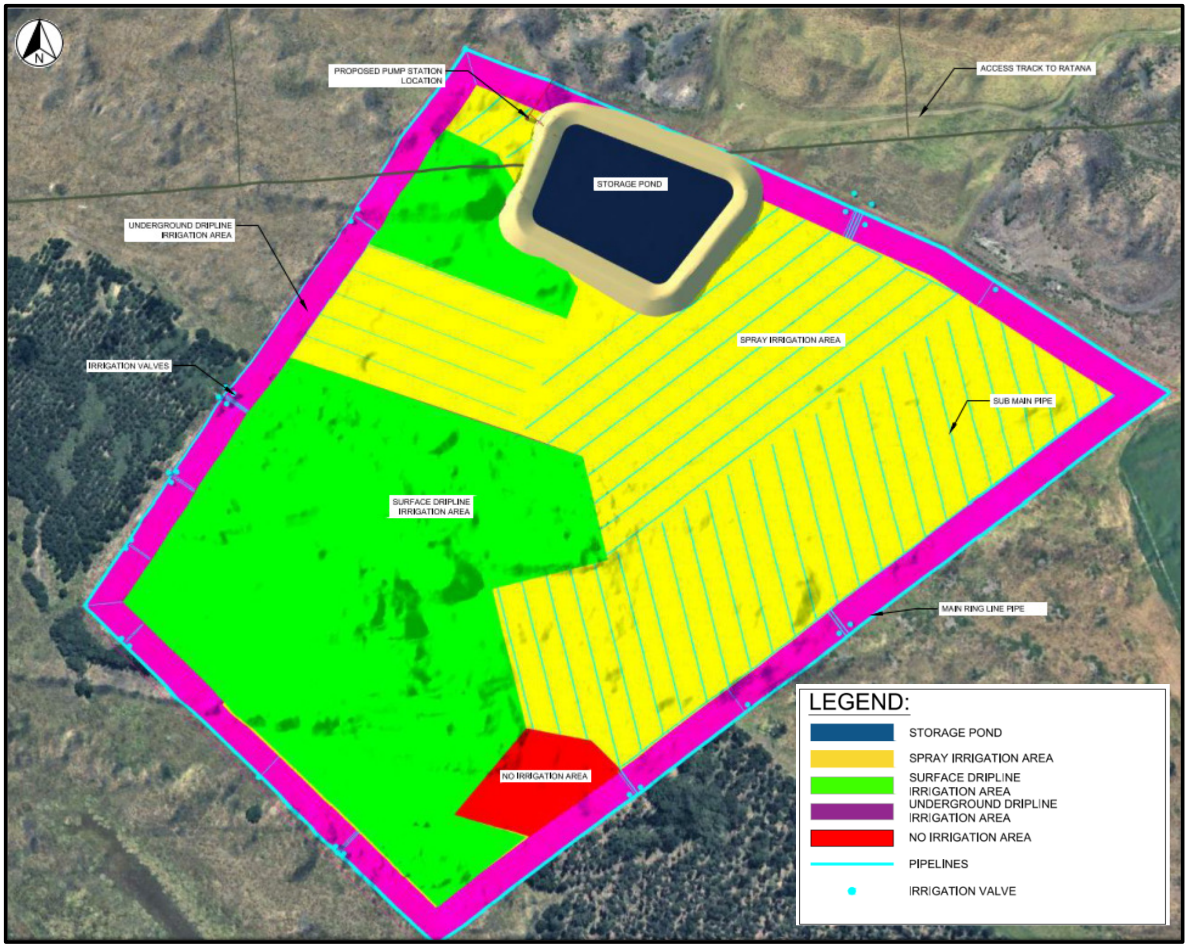


Figure 2: Irrigation Specimen Design map

All areas, excluding the pond and the 'no irrigation area' as shown in Figure 2 are to be irrigated. Irrigation management of sensitive areas such as wetlands, perimeter buffer and the dune area will be managed in accordance the proposed management objectives and generally more conservatively than the net area. In general deficit irrigation is preferred, but where required non-deficit irrigation would need to be undertaken in the general management zone or dune management zone. This would occur in years wetter than median.

Only deficit irrigation will occur over the wetland enhancement area and southern ecological enhancement area. The Western dune plain mitigation area will be kept wet to a certain height to mimic and encourage wetland ecosystems. Remaining natural wetlands will either be covered by storage dam or treated the same as the 'general management area'.

Storage capacity is 28,500 m^3. A median wet year has been the basis of design. A 1: 5 wet year will mean deficit irrigation becomes much harder to achieve. A 1:5 dry year will likely mean irrigation will need to be rationed.

There are two scenarios, current wastewater flow and future wastewater flow.

- Scenario 1: Current wastewater flows

  Volume is 136.5 m^3/day or 48,800 m^3/year. Total Nitrogen load is 839 kg N/yr

- Scenario 2: Future wastewater flows

  Volume is 187 m^3/day or 68,500 m^3/year. Total Nitrogen load is 1,549 kg N/yr

3 Irrigation Overview

3.1 Scenario 1 – Current wastewater flows – Median Wet year.

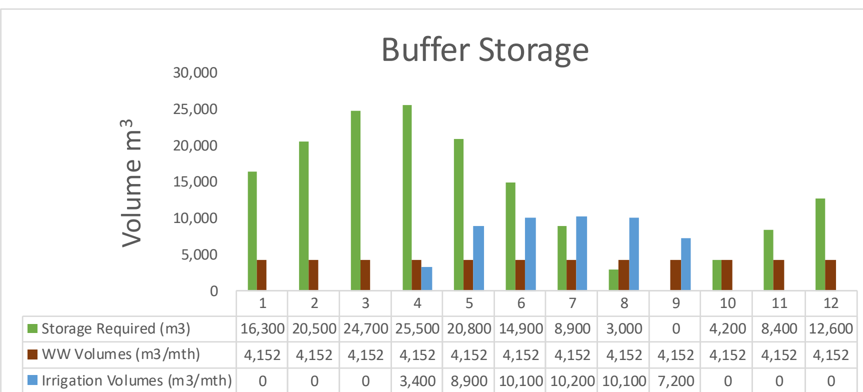
Tables 2 and 3 show the irrigation scheduling under current wastewater volumes. It summarises that 16.7ha and 25,500 m^3 will allow deficit irrigation to be achieved within the current land area and design storage.

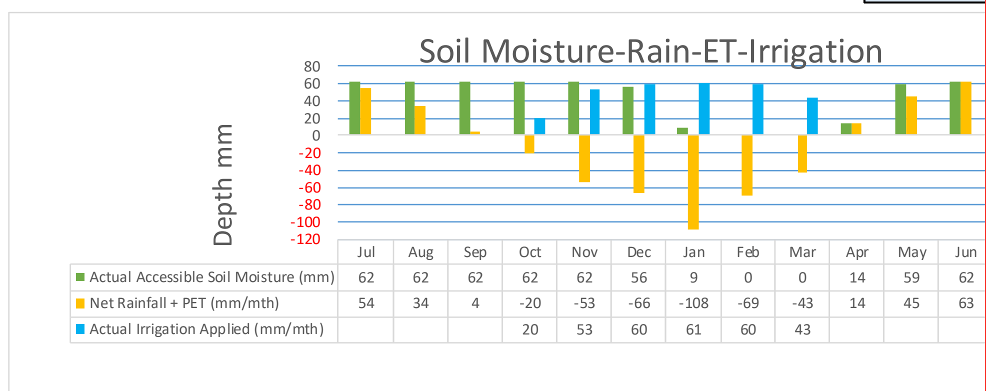
Table 2.

Scenario 1: Existing Flows with median rainfall and evapotranspiration.		
Irrigation Philosophy	Deficit	
Rainfall-Evapotranspiration Data Period	Median year	
WW water flow scenario	Based on Average flows over last 5 years	
Operational times per day	12	hrs
Field Capacity of Soil	62	mm
Target Soil Moisture	42	mm
Distribution uniformity (DUlq)	80	%
Net Area Available	22.9	ha
Net Area Needed	16.7	ha
Months of deficit Irrigation	6	Oct - Mar
Months of non deficit irrigation.	0	
Months of no irrigation	6	Apr - Sep
Buffer Storage Required	25,500	m3
Boundary Buffer Zones	20	m

Table 3.

Option	Land Area	16.7	ha										
Median	Soil WHC	62	mm										
Month	WW Flows (m^3/d)	WW Volumes (m^3/mth)	WW Volumes (mm/mth)	Rainfall (mm/mth)	PET (mm/mth)	Net Rainfall + PET (mm/mth)	Actual Irrigation Applied (mm/mth)	Theoretical Accessible Soil Moisture (mm)	Actual Accessible Soil Moisture (mm)	Irrigation Volumes (m^3/mth)	Deficit Irrigation (Yes/ No)	Net Volume (WW_Flows - Irrigation) (m^3/mth)	Storage Required (m^3
									62				**12,100**
Jul	136.5	4,152	25	82	-28	54		116	62	0		4,152	16,300
Aug	136.5	4,152	25	77	-43	34		96	62	0		4,152	20,500
Sep	136.5	4,152	25	72	-68	4		66	62	0		4,152	24,700
Oct	136.5	4,152	25	79	-99	-20	20	62	62	3,400	Yes	752	25,500
Nov	136.5	4,152	25	70	-123	-53	53	62	62	8,900	Yes	-4,748	20,800
Dec	136.5	4,152	25	79	-145	-66	60	56	56	10,100	Yes	-5,948	14,900
Jan	136.5	4,152	25	46	-154	-108	61	9	9	10,200	Yes	-6,048	8,900
Feb	136.5	4,152	25	52	-121	-69	60	0	0	10,100	Yes	-5,948	3,000
Mar	136.5	4,152	25	55	-98	-43	43	0	0	7,200	Yes	-3,048	0
Apr	136.5	4,152	25	72	-58	14		14	14	0		4,152	4,200
May	136.5	4,152	25	81	-36	45		59	59	0		4,152	8,400
Jun	136.5	4,152	25	87	-24	63		122	62	0		4,152	12,600
Totals		**49,823**		**852**	**-997**	**-145**	**297**			**49,900**			**25,500**
		0		**Residual Storage**		**0%**							**0**





3.2 Scenario 2 – Future wastewater flow – Median Wet Year

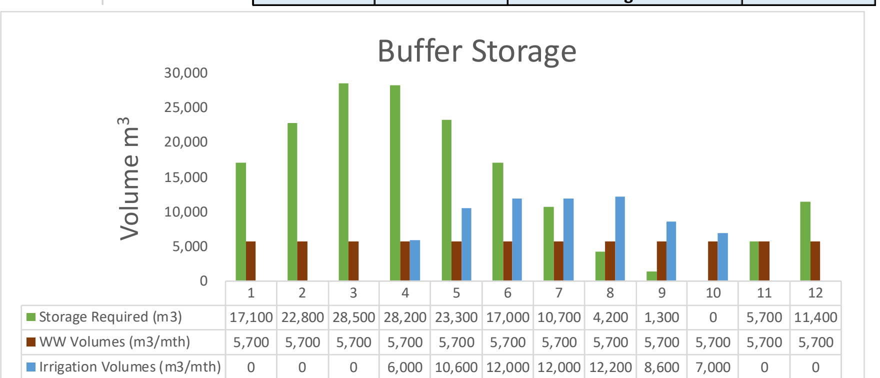
Tables 4 and 5 show the irrigation scheduling under the potential future wastewater flows (based on potential population increase). It summarises that with 20 Ha of land application and 28,500 m^3 of storage will allow deficit irrigation to be achieved within the current land area and design storage.

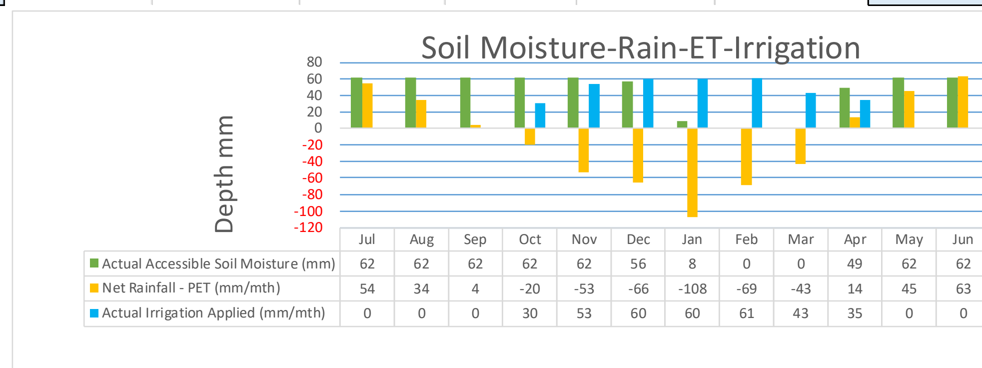
Table 4:

Scenario 2: Future Flows with median rainfall and evapotranspiration.		
Irrigation Philosophy	Deficit	
Rainfall-Evapotranspiration Data Period	Median year	
WW water flow scenario	Based on future maximum average flows	
Operational time per day	12	hrs
Field Capacity of Soil	62	mm
Target Soil Moisture	42	mm
Distribution uniformity (DU_{lq})	80	%
Net Area Available	22.9	ha
Net Area Needed	20.0	ha
Months of deficit Irrigation	7	Oct - Apr
Months of non deficit irrigation.	0	
Months of no irrigation	5	May - Sep
Buffer Storage Required	28,500	m^3
Boundary Buffer Zones	20	m

Table 5:

Option	Land Area	20.0	ha										
Medium	Soil WHC	62	mm										
Month	WW Flows (m3/d)	WW Volumes (m^3/mth)	WW Volumes (mm/mth)	Rainfall (mm/mth)	PET (mm/mth)	Net Rainfall - PET (mm/mth)	Actual Irrigation Applied (mm/mth)	Theoretical Accessible Soil Moisture (mm)	Actual Accessible Soil Moisture (mm)	Irrigation Volumes (m^3/mth)	Deficit Irrigation (Yes/ No)	Net Volume (WW_Flows - Irrigation) (m^3/mth)	Storage Required (m^3)
									62				**11,400**
Jul	187	5,700	29	82	-28	54	0	116	62	0		5,700	17,100
Aug	187	5,700	29	77	-43	34	0	96	62	0		5,700	22,800
Sep	187	5,700	29	72	-68	4	0	66	62	0		5,700	28,500
Oct	187	5,700	29	79	-99	-20	30	72	62	6,000	Yes	-300	28,200
Nov	187	5,700	29	70	-123	-53	53	62	62	10,600	Yes	-4,900	23,300
Dec	187	5,700	29	79	-145	-66	60	56	56	12,000	Yes	-6,300	17,000
Jan	187	5,700	29	46	-154	-108	60	8	8	12,000	Yes	-6,300	10,700
Feb	187	5,700	29	52	-121	-69	61	0	0	12,200	Yes	-6,500	4,200
Mar	187	5,700	29	55	-98	-43	43	0	0	8,600	Yes	-2,900	1,300
Apr	187	5,700	29	72	-58	14	35	49	49	7,000	Yes	-1,300	0
May	187	5,700	29	81	-36	45	0	94	62	0		5,700	5,700
Jun	187	5,700	29	87	-24	63	0	125	62	0		5,700	11,400
Totals		**68,400**		**852**	**-997**	**-145**	**342**			**68,400**			**28,500**
		0		**Residual Storage**		**0%**							**0**





3.3 Scenario 3 – Current wastewater flow – 1 in 5 Wet Year

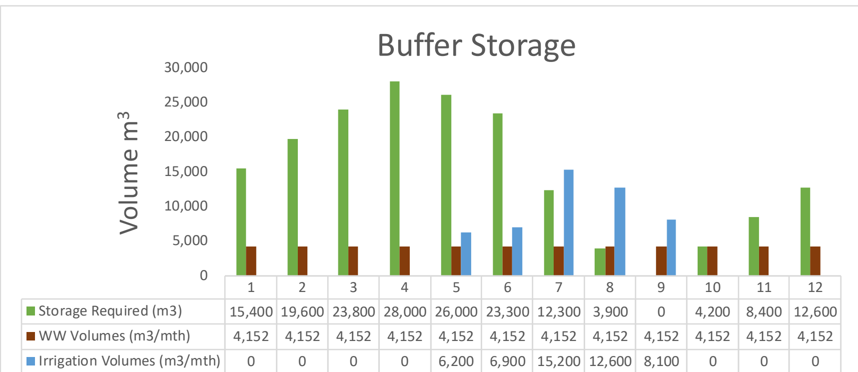
Tables 6 and 7 show the irrigation scheduling under the potential future wastewater flows (based on potential population increase) for a 1 in 5 wet year. It summarises that with 22.9 ha of land application and 28,500 m^3 of storage irrigation is required from November to March. Deficit irrigation can only be achieved during January. Otherwise the irrigation is non deficit.

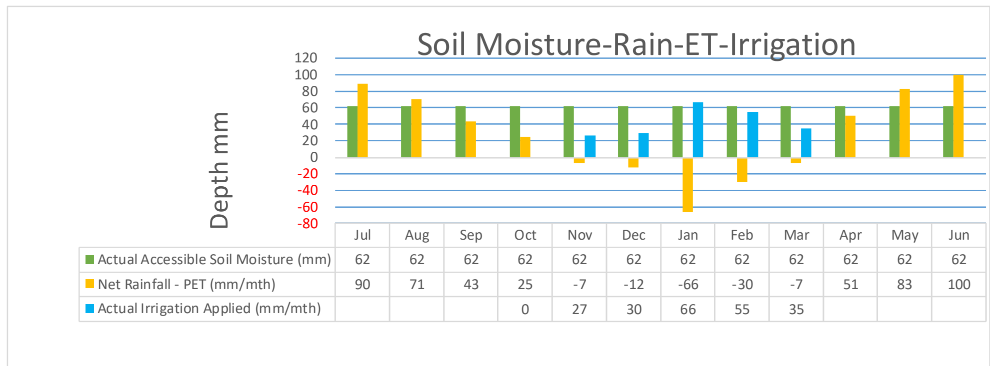
Table 6

Scenario 3: Future Flows with 1:5 year maximum rainfall and minimum evapotranspiration with needed area.		
Irrigation Philosophy	Deficit	
Rainfall-Evapotranspiration Data Period	1 in 5 wet year	
WW water flow scenario	Based on future maximum average flows	
Operational times per day	12	hrs
Field Capacity of Soil	62	mm
Target Soil Moisture	42	mm
Distribution uniformity (DUlq)	80	%
Net Area Available	22.9	ha
Net Area Needed	22.9	ha
Months of deficit Irrigation	1	January
Months of non deficit irrigation.	6	Nov - Dec, Feb-Mar
Months of no irrigation	6	Apr - Oct
Buffer Storage Required	28,000	m3
Boundary Buffer Zones	20	m

Table 7

Option	Land Area	22.9	ha										
1-5 Wet	Soil WHC	62	mm										
Month	WW Flows (m3/d)	WW Volumes (m^3/mth)	WW Volumes (mm/mth)	Rainfall (mm/mth)	PET (mm/mth)	Net Rainfall - PET (mm/mth)	Actual Irrigation Applied (mm/mth)	Theoretical Accessible Soil Moisture (mm)	Actual Accessible Soil Moisture (mm)	Irrigation Volumes (m^3/mth)	Deficit Irrigation (Yes/ No)	Net Volume (WW_Flows - Irrigation) (m^3/mth)	Storage Required (m^3)
									62				11,200
Jul	137	4,152	18	113	-23	90		152	62	0		4,152	15,400
Aug	137	4,152	18	107	-36	71		133	62	0		4,152	19,600
Sep	137	4,152	18	100	-57	43		105	62	0		4,152	23,800
Oct	137	4,152	18	109	-84	25	0	87	62	0		4,152	28,000
Nov	137	4,152	18	97	-104	-7	27	82	62	6,200	No	-2,048	26,000
Dec	137	4,152	18	110	-122	-12	30	80	62	6,900	No	-2,748	23,300
Jan	137	4,152	18	64	-130	-66	66	62	62	15,200	Yes	-11,048	12,300
Feb	137	4,152	18	72	-102	-30	55	87	62	12,600	No	-8,448	3,900
Mar	137	4,152	18	76	-83	-7	35	90	62	8,100	No	-3,948	0
Apr	137	4,152	18	100	-49	51		113	62	0		4,152	4,200
May	137	4,152	18	113	-30	83		145	62	0		4,152	8,400
Jun	137	4,152	18	120	-20	100		162	62	0		4,152	12,600
Totals		**49,823**		**1181**	**-840**	**341**	**213**			**49,000**			**28,000**
		0		**Residual Storage**		**0%**							**0**





3.4 Scenario 4 – Future wastewater flow – 1 in 5 Wet Year

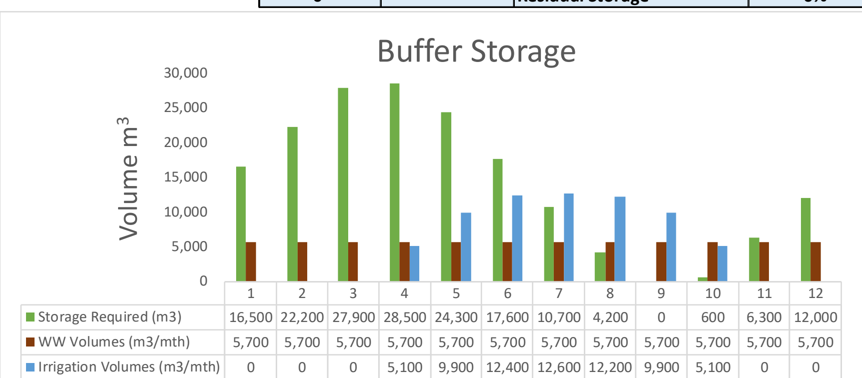
Table 8 and 9 show the irrigation scheduling under the potential future wastewater flows (based on potential population increase). It summarises that with 22.9 ha of land application and 28,500 m^3 of storage irrigation is required from October to April. Deficit irrigation can only be achieved during January. Otherwise the irrigation is non deficit.

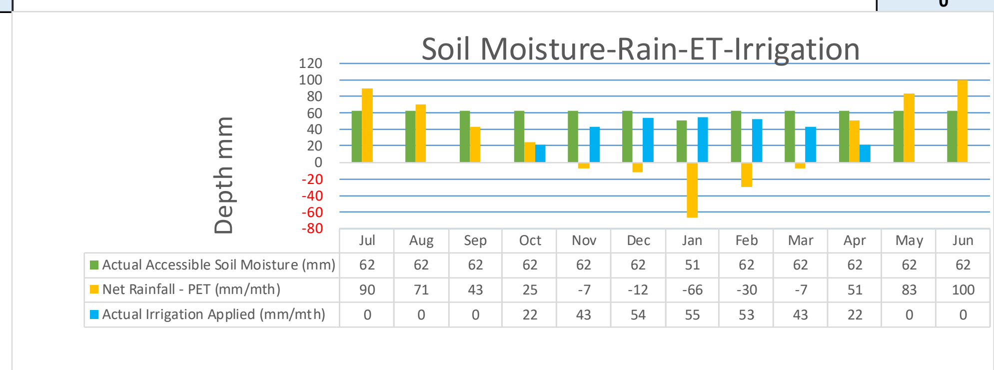
Table 8

Scenario 4: Future Flows with 1:5 year maximum rainfall and minimum evapotranspiration with available area.		
Irrigation Philosophy	Non-Deficit	
Rainfall-Evapotranspiration Data Period	1 in 5 wet year	
WW water flow scenario	Based on future maximum average flows	
Operational times per day	12	hrs
Field Capacity of Soil	62	mm
Target Soil Moisture	42	mm
Distribution uniformity (DUlq)	80	%
Net Area Available	22.9	ha
Net Area Needed	22.9	ha
Months of deficit Irrigation	1	January
Months of non deficit irrigation.	6	Oct - Dec, Feb-Apr
Months of no irrigation	5	May - Sept
Buffer Storage Required	28,500	m3
Boundary Buffer Zones	20	m

Table 9

Option	Land Area	22.9	ha										
1-5 Wet	**Soil WHC**	**62**	**mm**										
Month	**WW Flows (m3/d)**	**WW Volumes (m^3/mth)**	**WW Volumes (mm/mth)**	**Rainfall (mm/mth)**	**PET (mm/mth)**	**Net Rainfall - PET (mm/mth)**	**Actual Irrigation Applied (mm/mth)**	**Theoretical Accessible Soil Moisture (mm)**	**Actual Accessible Soil Moisture (mm)**	**Irrigation Volumes (m^3/mth)**	**Deficit Irrigation (Yes/ No)**	**Net Volume (WW_Flows - Irrigation) (m^3/mth)**	**Storage Required (m^3)**
									62				**10,800**
Jul	187	5,700	25	113	-23	90	0	152	62	0		5,700	16,500
Aug	187	5,700	25	107	-36	71	0	133	62	0		5,700	22,200
Sep	187	5,700	25	100	-57	43	0	105	62	0		5,700	27,900
Oct	187	5,700	25	109	-84	25	22	109	62	5,100	No	600	28,500
Nov	187	5,700	25	97	-104	-7	43	98	62	9,900	No	-4,200	24,300
Dec	187	5,700	25	110	-122	-12	54	104	62	12,400	No	-6,700	17,600
Jan	187	5,700	25	64	-130	-66	55	51	51	12,600	Yes	-6,900	10,700
Feb	187	5,700	25	72	-102	-30	53	74	62	12,200	No	-6,500	4,200
Mar	187	5,700	25	76	-83	-7	43	98	62	9,900	No	-4,200	0
Apr	187	5,700	25	100	-49	51	22	135	62	5,100	No	600	600
May	187	5,700	25	113	-30	83	0	145	62	0		5,700	6,300
Jun	187	5,700	25	120	-20	100	0	162	62	0		5,700	12,000
Totals		**68,400**		**1181**	**-840**	**341**	**292**			**67,200**			**28,500**
		0		**Residual Storage**		**0%**							**0**





3.5 Answers to Specific Questions:

3.5.1 Question 1:

Please explain how the hydraulic loading rates have been estimated using the soil water balance approach, including proportion of land that is poorly draining and free-draining, confirmation that this has been calculated at a daily time-step, volume (or depth in mm) of surplus water (i.e., drainage) in non-deficit scenarios.

1 The hydraulic loading scenarios were based on Rainfall-Evapotranspiration Data for a median year and 1 in 5 wet years.

2 Based on field data we have assumed an overall soil field capacity of 62mm. This will vary but the actual field capacity of the soil does not significantly affect the annual buffer volume required to minimise the risk and effects of not achieving deficit irrigation at any time. Particularly during winter months.

In terms of determining the volume required for annual buffer storage, field capacity has only a small influence in extending the periods where irrigation can occur (particularly the spring and Autumn seasons).

Soils with smaller field capacities will provide less buffer. But this primarily affects the design and operation of an irrigation system. In particular; the period between irrigation operations.

(a) A very deep soil may allow for large applications (50mm) every 10 days. This would allow for systems such as travelling irrigators and moveable sprinkler pods.

(b) Very shallow soils might only allow for very small applications (5mm) every day. Variable soils might require the ability to operate different area at different times. This would mean fixed systems either sprinklers, drippers or small centre pivots.

3 The data is based on monthly rainfall and evapotranspiration data. We think this is a conservative approach compared with using daily data. Daily data may produce a scenario where more irrigation can be applied than what the monthly data shows. This is because it is possible that deficit irrigation could occur during a month where the average rainfall/ evapotranspiration would not allow irrigation.

4 The approach to date was to ensure that the overall land area, buffer storage and irrigation approach was reasonable for median year.

5 Going forward into the detailed design of the irrigation system the following things still need doing:

- A more detailed understanding of the soils to enable an irrigation system layout that reflects the complexity of the site.
- A choice of what to plant and how to manage those plantings needs to defined. This will influence the type of irrigation system. RDC have purposefully not specified a crop or tree type yet, additional consultation (including with iwi) is likely to be undertaken before this is specified.
- How the irrigation system needs to operate in terms of instantaneous application rates, daily application rates and period.
- How the irrigation system is monitored and controlled.

- An irrigation layout plan in terms of planting area and zone layout (in line with soils, boundaries, wetland and other constraints).
- The current specimen design is based on a ring main around the property from which irrigation zones are supplied. This allows for the irrigation system to be refined and changed as better understanding of the site is gained over time.

3.5.2 Question 2:

During the site visit we discussed the possibility of standing water forming in the low-lying areas, and potentially that irrigation would continue regardless of standing water/ponding. Please elaborate further on these comments and, should this be the intended approach, provide greater specificity regarding when this would occur and what the 'triggers' may be.

We have identified that for years wetter than a median year the ability to achieve deficit irrigation reduces. For 1 in 5 wet years irrigation is a mixture of deficit and non-deficit irrigation. This risk is further magnified if the wastewater inflows increase over time.

To minimise the occurrence that non deficit irrigation does not occur (particularly if there is standing water in places);

(a) There will be no irrigation in Winter when the risk of standing water and saturated soils is at its highest, unless required for emergency scenarios or soil conditions are suitable.

(b) The whole area will be divided into discrete irrigation areas that will ensure high risk areas can be irrigated separately from other areas and if necessary switched off completely. There will be the ability to adjust these areas over time to reflect operational observations and soil moisture sensors outputs.

(c) Soil moisture sensors will be employed to ensure that the field capacity of the soils is not exceeded. Standing water would indicate that the soils are well above field capacity and soil moisture sensors would pick this up. And therefore no irrigation would be allowed.

The only way to ensure deficit irrigation is to:

- Increase the land area irrigated to.
- Increase the storage volume.
- Minimise Wastewater flows.

4 Overseer

Overseer is a tool commonly used to inform our understanding of nutrient loss across agricultural landscapes and the effect of farm practices on those nutrient losses, at both farm and catchment scales[1]. Using Overseer to model wastewater applications requires many compromises due to limitations in the software. It is noted that Overseer was designed for long term modelling of farms with crops and or pasture being grazed or harvested and was not designed for modelling wastewater application to land. Therefore, to meet the requirements for the wastewater application to land, we have had to manipulate Overseer to best reflect what is likely to occur onsite.

The primary limitation of Overseer, as proposed in this case, is that you cannot have irrigation and trees in the same spatial area. This means that we cannot model a wastewater application to land where the primary crop is trees. We have used supplement removal (pasture silage) in Overseer as one way to simulate nitrogen uptake from trees to give a reasonable, but 'semi realistic' result of what nitrogen leaching could be expected under the proposed system.

The scenarios in Section 4.2 and Section 4.3 have used pasture silage cuts to remove around 50% of the applied nitrogen from wastewater. Nitrogen removal of 50% is a reasonable figure derived from [2]Hanel et al. 2022. Referenced literature on wastewater applications to trees stated nitrogen removal achieved by this method varies from 12 to 99%. Six trials reported a total nitrogen (TN) removal higher than 90%, 22 trials reached a TN removal efficiency of 50%–90%, and in 15 trials, the removal was below 50%. Some tree species such as willow were very effective at removing nitrogen from wastewater at 200kg N/ha/yr, which is significantly higher than what we are modelling here for the current and future scenarios.

4.1 Model inputs and assumptions

1. Five blocks were created in Overseer based on the different management zones. The blocks area as follows;
    a. Dune Management Zone: 8 ha, 100% surface dripline irrigation, unimproved tussock grassland
    b. Edge Management Zone: 3.8 ha, 100% underground dripline irrigation, browntop pasture
    c. General Management Zone: 12.3 ha, 92.5% spray irrigation, 5.3% surface dripline irrigation, browntop pasture
    d. Western Dune Plain: 0.4ha, Assumes no irrigation, fenced wetland
    e. Southern Ecological Enhancement Zone: 0.8ha Assumes no irrigation, riparian area
    f. Pond area excluded. The pond is not a productive block but is included in the total farm area.
2. The area of the storage pond (1.87 ha) is excluded.
3. Default climate data was used- including average temperature, average rainfall and annual potential evapotranspiration (PET).
4. Proportions of soils in productive blocks have been altered to reflect a higher degree of accuracy in accordance with the soil drainage mapping completed by Alan Palmer. Overseer limits the user to three soil types per block, so the area allocated to imperfectly drained soil (0.99 ha or 4% of productive area) has been shared between poorly drained

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[1] Ministry for the Environment. 2023. Responding to the Overseer model redevelopment review: A guide for councils. Wellington: Ministry for the Environment, overseer-model-redevelopment-review-guide.pdf (environment.govt.nz)

[2.] Mirko, Hanel., Darja, Istenic., Hans, Brix., Carlos, A, Aris. 2022. Wastewater-Fertigated Short-Rotation Coppice, a Combined Scheme of Wastewater Treatment and Biomass Production: A State-of-the-Art Review, Forest Hydrology, Volume 13, Issue 5, Page 810, Forests | Free Full-Text | Wastewater-Fertigated Short-Rotation Coppice, a Combined Scheme of Wastewater Treatment and Biomass Production: A State-of-the-Art Review (mdpi.com) and moderately well drained area at 2% productive area each. This brings the proportions of soils over the block to 60 % well drained (Fere_4e.4), 26% moderately well drained (Fere_28a.1) and 14% poorly drained (Aran_10a.2).

5. Irrigation areas are split into underground driplines, surface driplines and solid set spray irrigation. Areas are 3.8ha, 8.5ha and 11.3ha respectively. In efficiencies/limitations in Overseers mapping capability means there are 21.7ha irrigated of the 22.3ha in effective blocks
6. There are three main irrigation systems across the block, including underground dripline irrigation, surface dripline irrigation and solid set spray irrigation.
7. Silage has been cut off the blocks to imitate the nutrient removal from the trees. The supplements removed have been prorated across the general, dune and edge management zones.

Current wastewater flows

8. All irrigation blocks nutrient source is 'Block specific', Nitrogen is 16 mg/l. This adds up to 34kg N/ha applied through irrigation in Overseer summary tables. Note Overseer assumes 9kg N/ha from clover fixation. Phosphorus is 3 mg/l. This adds up to 6kg P/ha applied through irrigation Overseer summary tables. All other nutrients are 0.
9. Irrigation for all blocks is based on 'Application depth' per month to achieve monthly irrigation volumes as required. The irrigation for the current system is as follows: October (15mm), November (38mm), December (45mm), January (45mm), February (36mm), March (31mm).
10. Irrigation is applied from October through to, and including, March.
11. 27t DM total of silage is cut in January and exported off farm to reflect 50% removal of Nitrogen available in the system. This removes 22kg N/ha.

Future wastewater flows

12. All irrigation blocks Nutrient source is 'Block specific', Nitrogen is 22 mg/l. This adds up to 63kg N/ha applied through irrigation in Overseer summary tables. Note Overseer assumes 8kg N/ha from clover fixation. Phosphorus is 4.1 mg/l. This adds up to 12kg P/ha applied through irrigation Overseer summary tables. All other nutrients are 0.
13. Irrigation for all blocks is based on 'Application depth' per month to achieve monthly irrigation volumes as required. The irrigation for the current system is as follows: October (16mm), November (44mm), December (51mm), January (51mm), February (51mm), March (38mm) and April (35mm)
14. Irrigation is applied from October through to ,and including, April.
15. 45t DM total of silage is cut in January and exported off farm to reflect 50% removal of Nitrogen available in the system. This removes 36kg N/ha.

4.2 Scenario – Current wastewater flows

Under the current scenario overall Nitrogen loss is predicted to be 18 kg/ha (TableTable 10). Overall Phosphorus loss is predicted to be 0.4kg/ha.

Table 10. Current wastewater flows scenario overall Nitrogen & Phosphorus loss

		RATANA WWA CURRENT - NOVEMBER 2023
Nitrogen	Total loss (kg)	462
	Loss/ha (kg/ha)	18
	NCE (%)	51
	N Surplus (kg/ha)	21
Phosphorus	Total loss (kg)	10
	Loss/ha (kg/ha)	0.4
	P Surplus (kg/ha)	4

The primary source of Nitrogen input is from irrigation (Figure 3), with a small amount from clover fixation. The primary source of Nitrogen loss is from supplement removal, closely followed by nitrogen leaching.

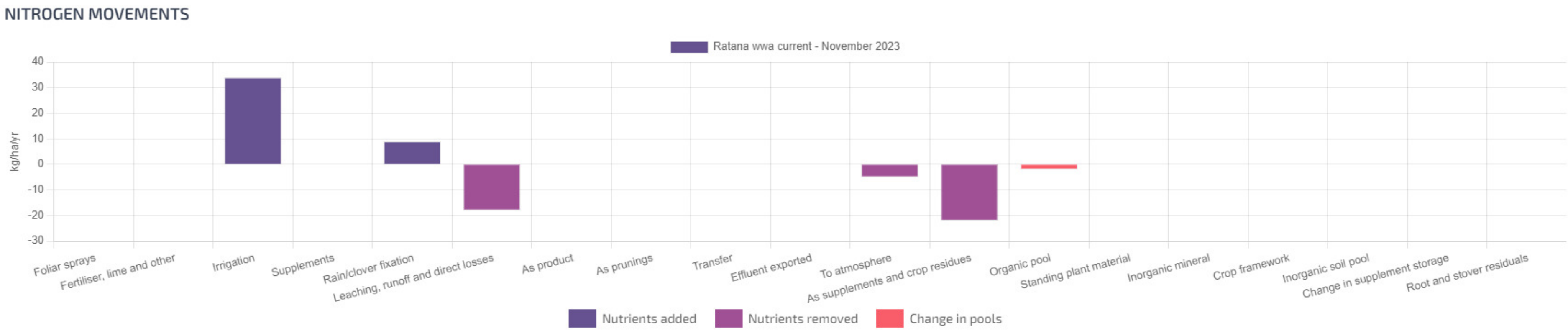


Figure 3. Current wastewater flows scenario Nitrogen movements

The primary source of Phosphorus (P) input is from the organic pool (Figure 3) with much less added from irrigation. The primary source of P loss is from the inorganic pool with much less P being removed in the supplements. The amount of P removed in supplements is based on a default calculation within Overseer. Further research needs to be conducted into P requirements for tree crops as there is potential that under current wastewater flows, P may need to be supplemented to avoid a P deficiency.

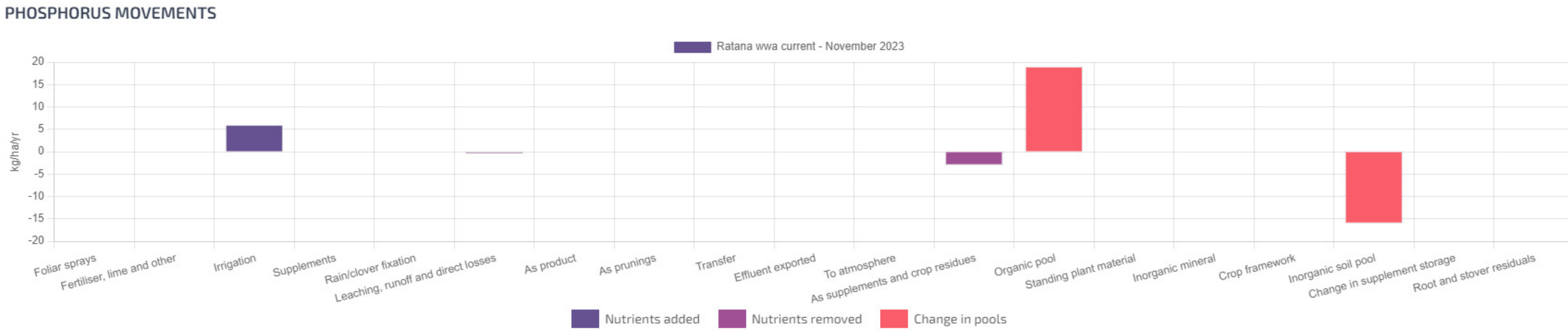


Figure 4. Current wastewater flows scenario Phosphorus movements

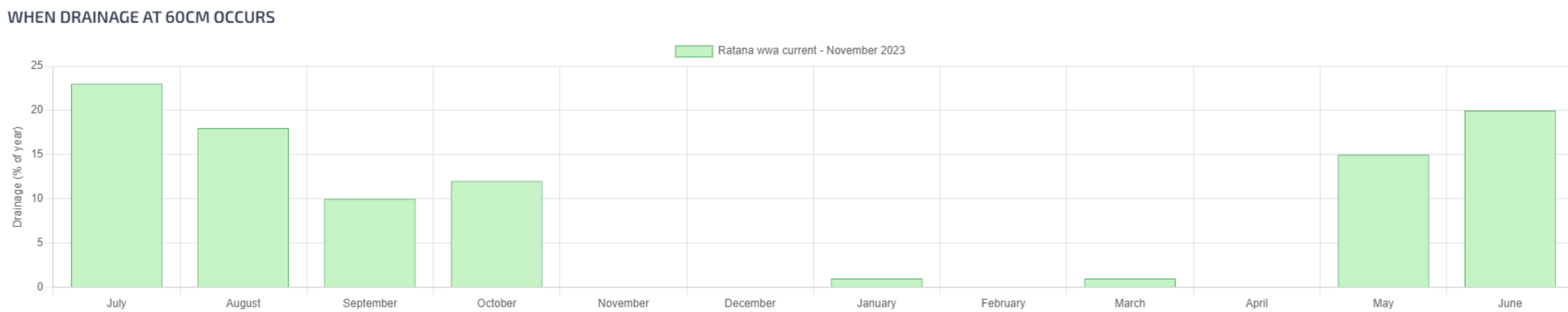


Figure 5. Current wastewater flows scenario drainage

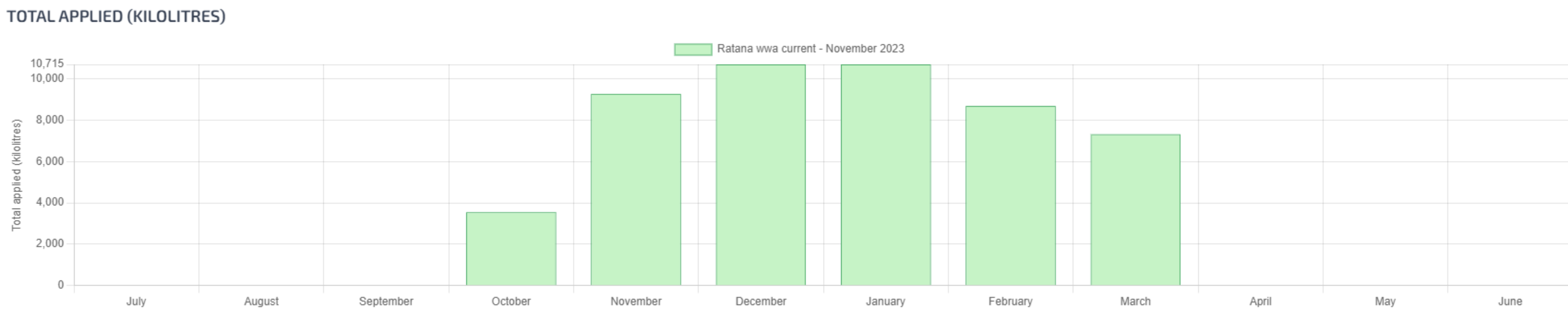
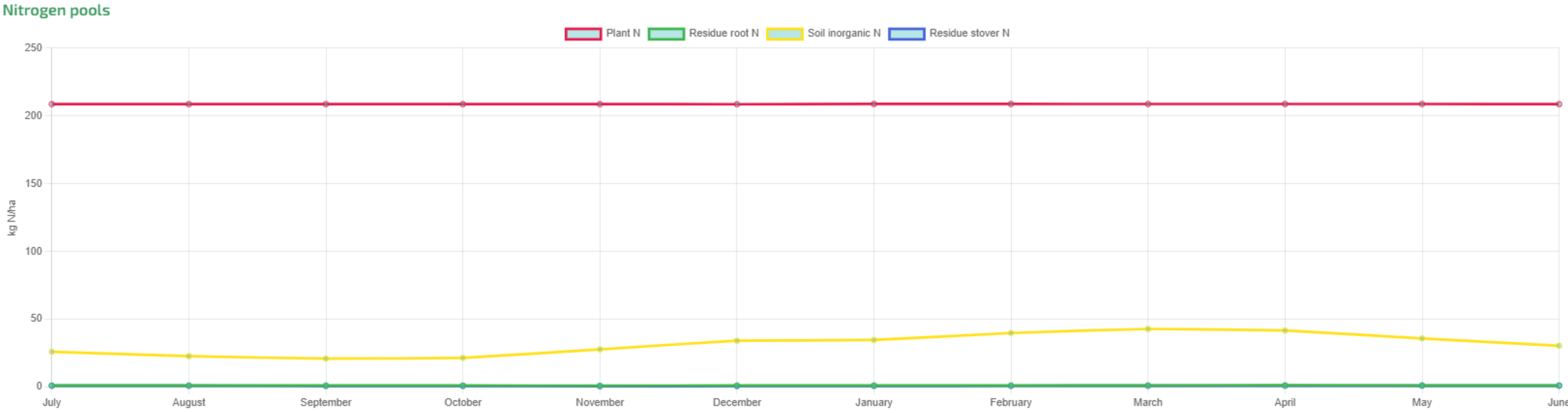


Figure 6. Current wastewater flows scenario Irrigation applied

Monthly irrigation totals are displayed in Figure 6. These differ slightly from the irrigation requirements set out in the Irrigation section 3.1. However, overall annual irrigation volume is very similar. Figure 5 shows monthly drainage volume which is influenced by soil type and irrigation.



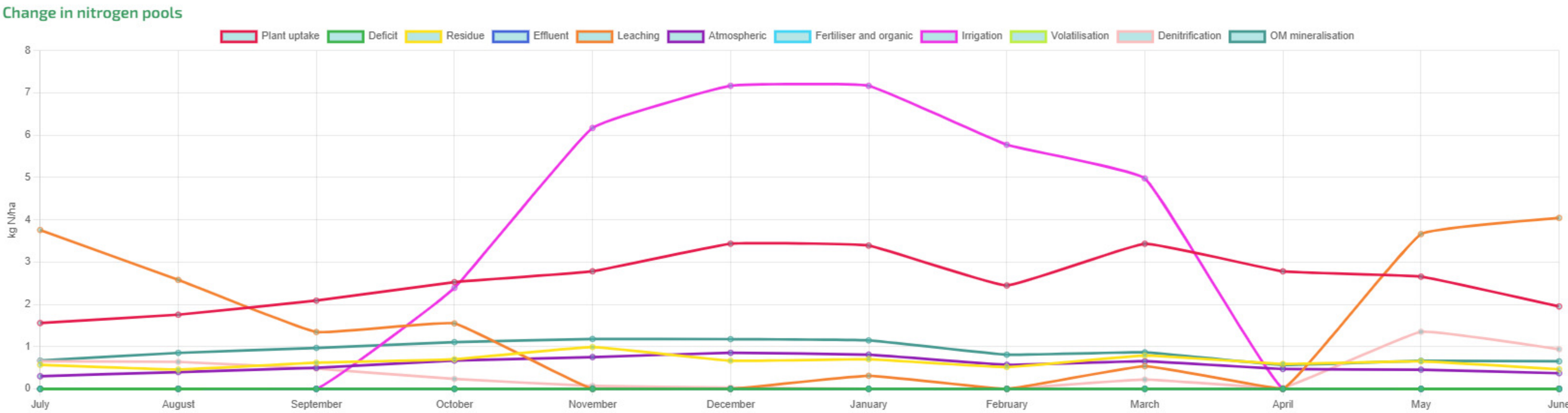
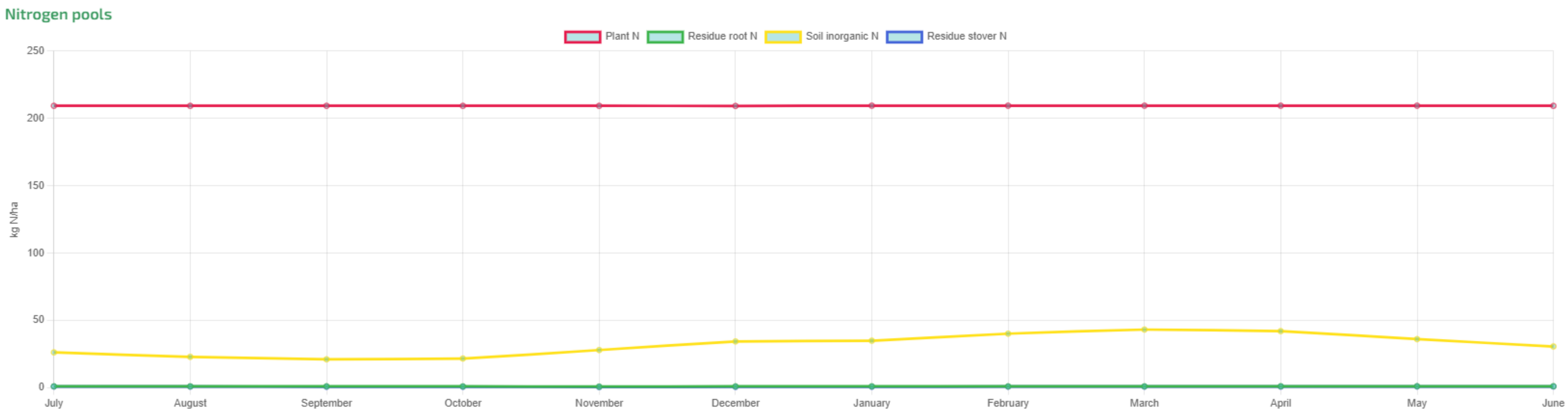


Figure 7. Current wastewater flows scenario General Management Zone nitrogen pools.

Figure 7 shows the change in nitrogen pools for the General Management Zone. It shows that leaching primarily occurs from May through to October. It also shows a 5.5kg/ha net increase in the soil inorganic pool which points to a small amount of nitrogen accumulation.



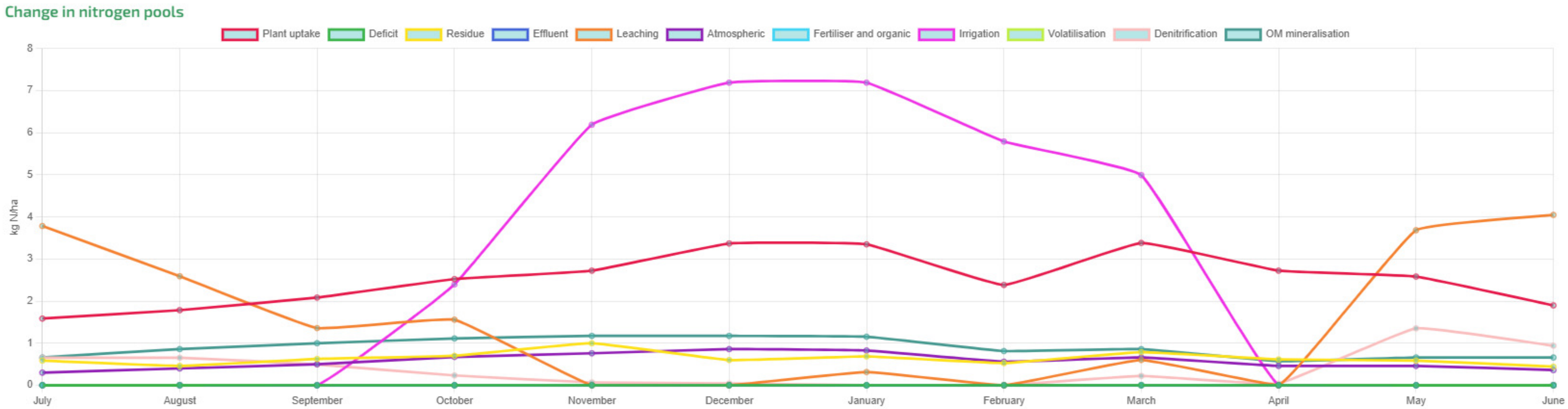


Figure 8. Current wastewater flows scenario for the Dune Management Zone Nitrogen pools.

Figure 8 shows the change in nitrogen pools for the tussock block. It shows that leaching primarily occurs in winter and spring. It also shows a 4.4 kg/ha net increase in the soil inorganic pool which points to a small amount of accumulation.

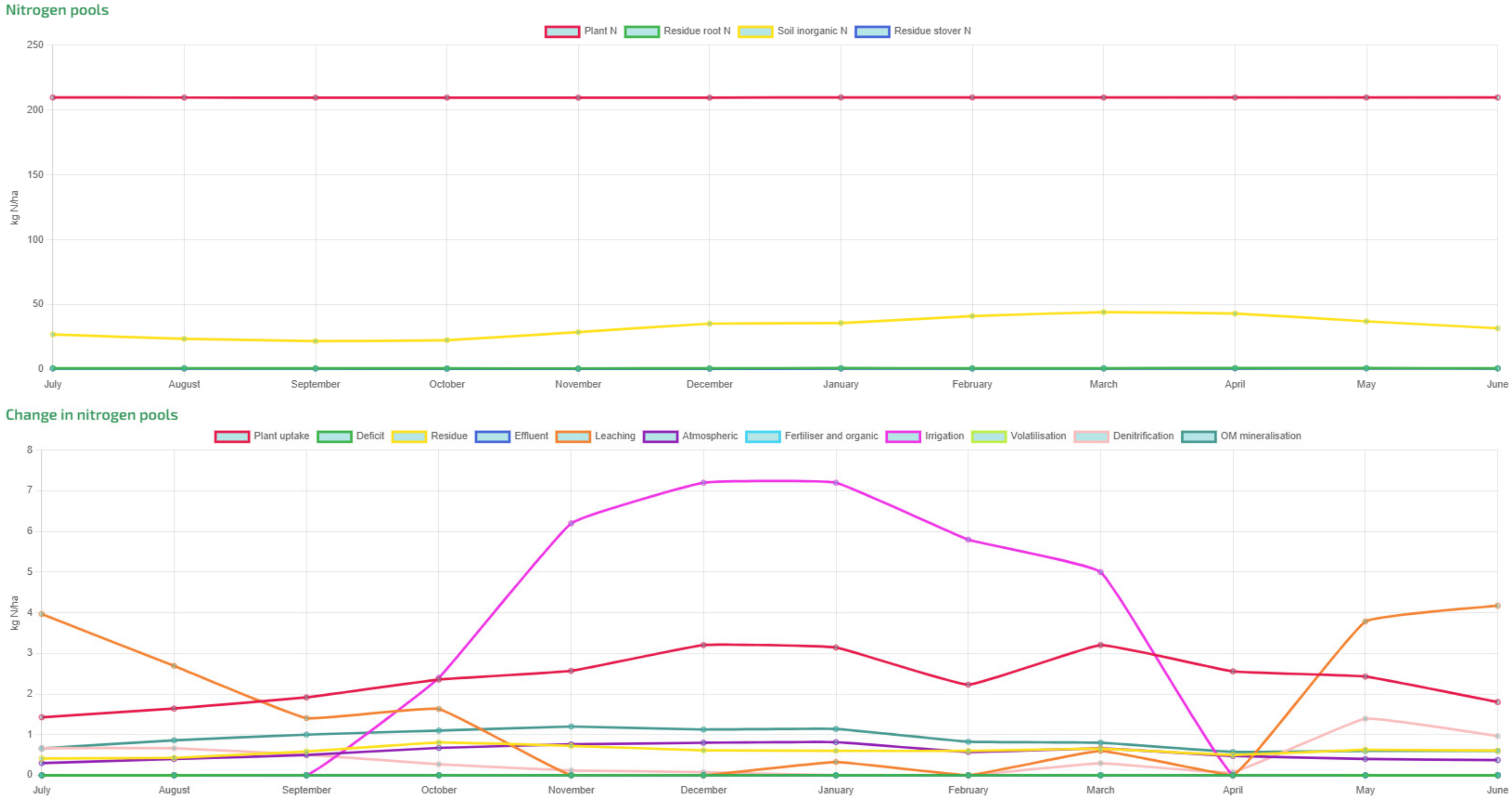


Figure 9. Current wastewater flows scenario for the Edge Management Zone Nitrogen pools.

Figure 9 shows the change in nitrogen pools for the tussock block. It shows that leaching primarily occurs in winter and spring. It also shows a 4.7kg/ha net increase in the soil inorganic pool which points to a small amount of nitrogen accumulation.

4.3 Scenario – Future wastewater flows

Under the future wastewater flows scenario overall nitrogen loss is predicted to be 28 kg/ha (Table 11). Overall Phosphorus loss is predicted to be 0.6kg/ha.

Table 11. Future wastewater flows scenario overall Nitrogen & Phosphorus loss

NUTRIENTS

		RATANA WWA FUTURE- NOVEMBER 2023
Nitrogen	Total loss (kg)	715
	Loss/ha (kg/ha)	28
	NCE (%)	52
	N Surplus (kg/ha)	34
Phosphorus	Total loss (kg)	15
	Loss/ha (kg/ha)	0.6
	P Surplus (kg/ha)	7

The primary source of Nitrogen input is from irrigation (Figure 10), with a small amount from clover fixation. The primary source of Nitrogen loss is removed as supplements, closely followed by nitrate leaching.

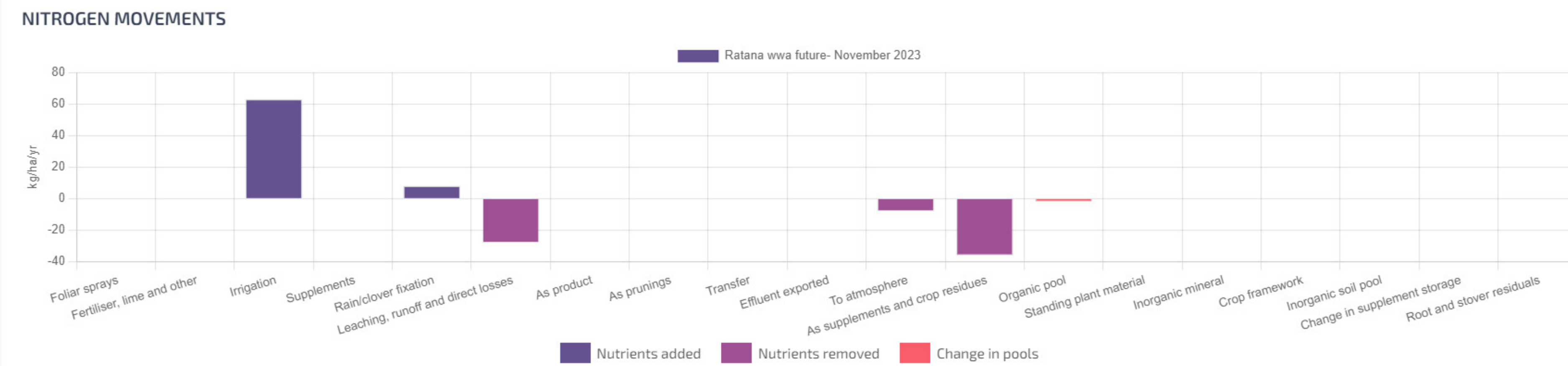


Figure 10. Future wastewater flows scenario Nitrogen movements

The primary source of Phosphorus (P) input is from the organic pool (Figure 11) and secondly, nutrients through added irrigation. The primary source of P loss is from to the inorganic pool with less being removed in supplements. Phosphorus removal in supplements is based on a calculation within Overseer. Further research needs to be conducted into tree P requirements as there is potential that under current wastewater flows. Additional P may need to be supplemented to avoid a P deficiency.

PHOSPHORUS MOVEMENTS

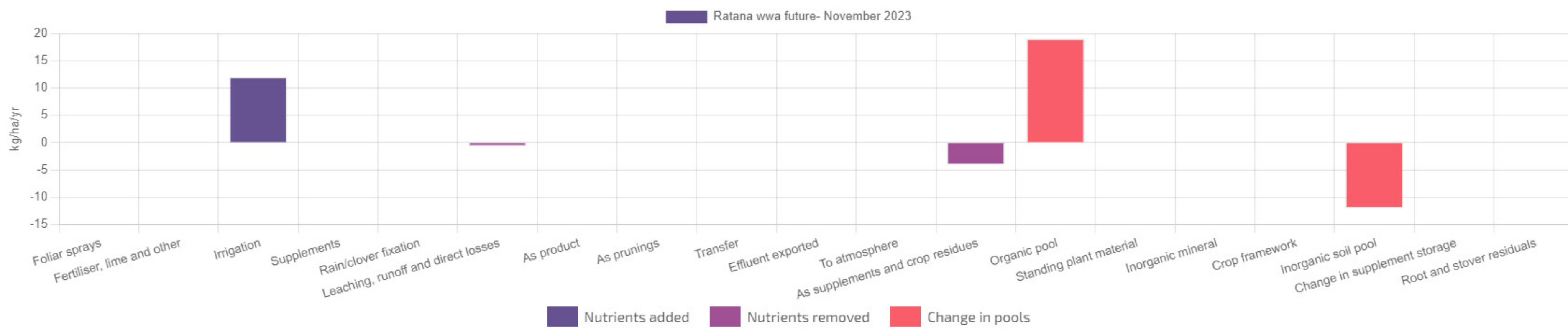


Figure 11. Future wastewater flows scenario Phosphorus movements.

WHEN DRAINAGE AT 60CM OCCURS

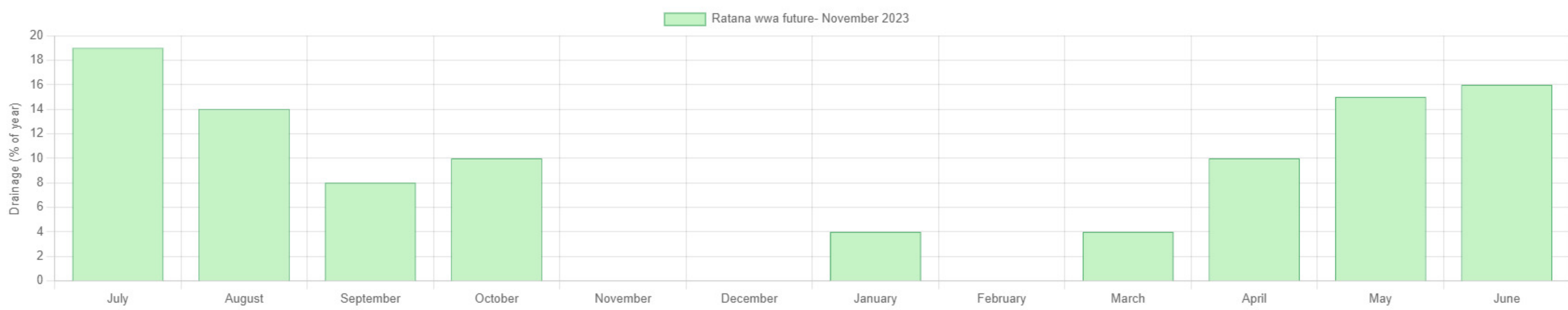


Figure 12. Future wastewater flows scenario drainage

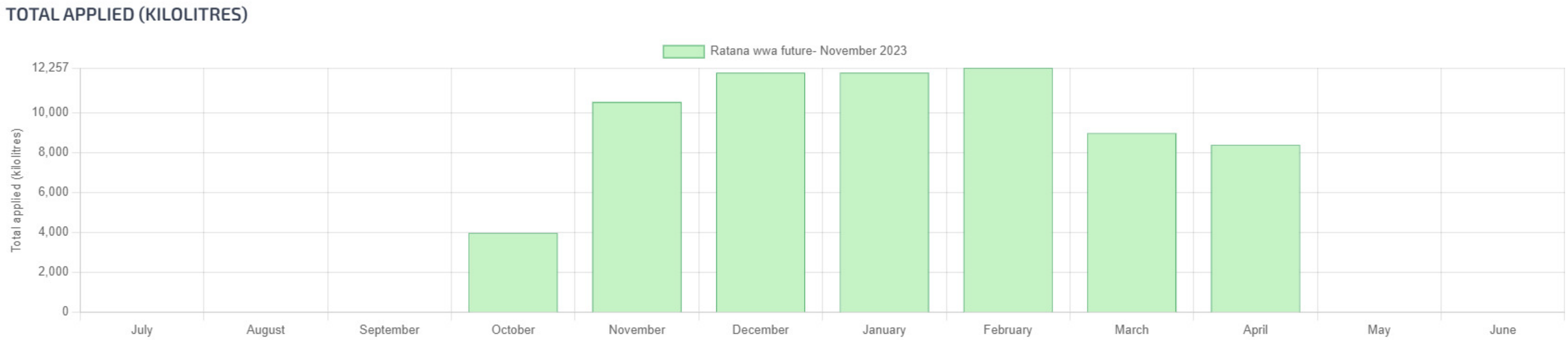


Figure 13. Future wastewater flows scenario Irrigation applied.

Monthly irrigation totals are displayed in Figure 13. These differ slightly from the irrigation requirements set out in the Irrigation section 3.2. However, overall annual irrigation volume is very similar. Non deficit irrigation was only applied to the pasture area to continue GMP on the dunes, perimeter buffer and wetland areas. Figure 12 shows monthly drainage volume which is influenced by irrigation inputs.

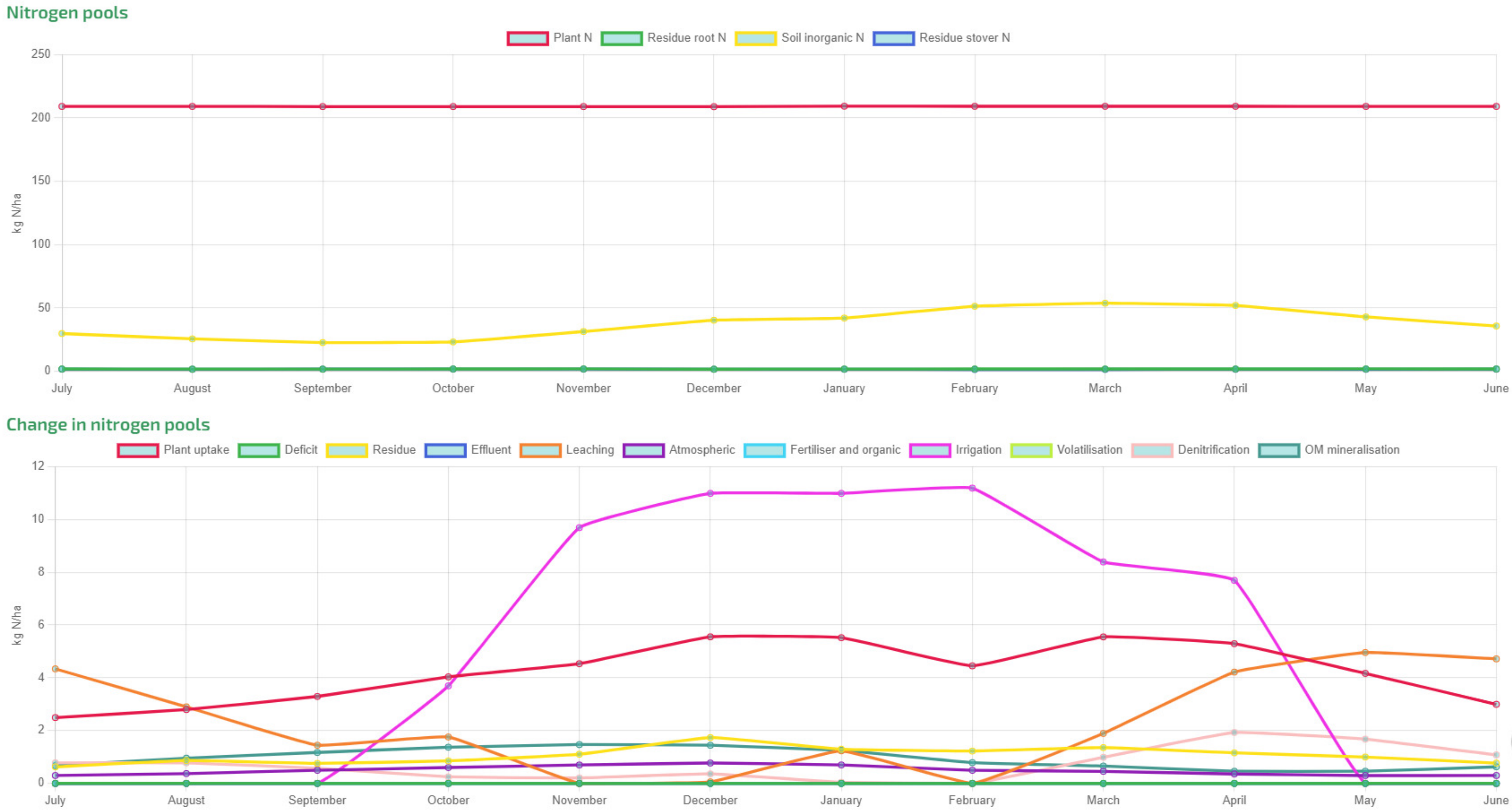
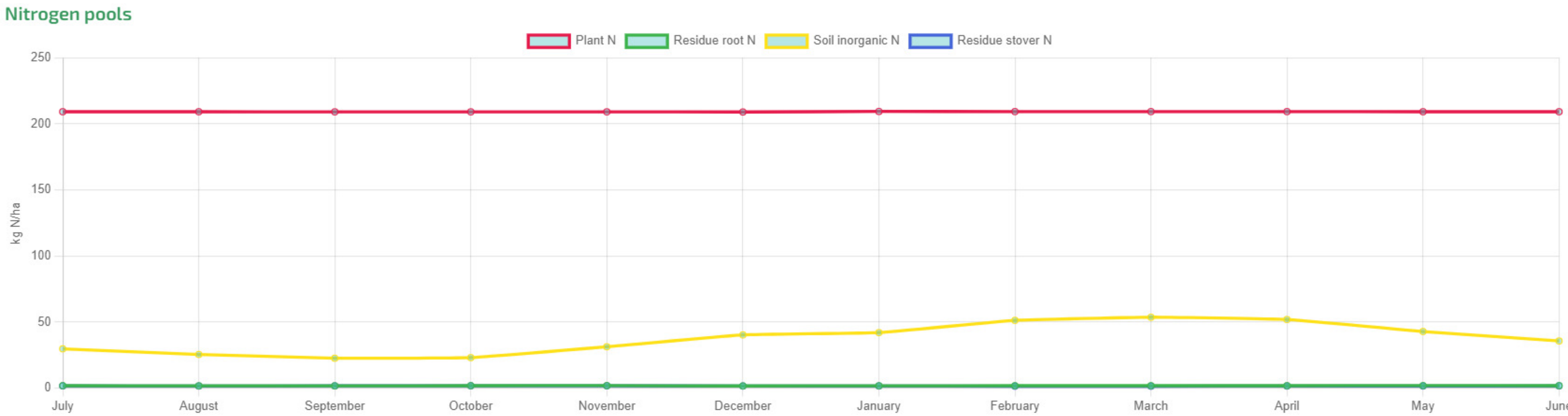


Figure 2. Future wastewater flows scenario General Management Zone nitrogen pools.

Figure 12 shows the change in nitrogen pools for the pasture block. It shows that leaching occurs all year, peaking in March. It also shows a 7.4kg/ha net increase in the soil inorganic pool which points to a some accumulation.



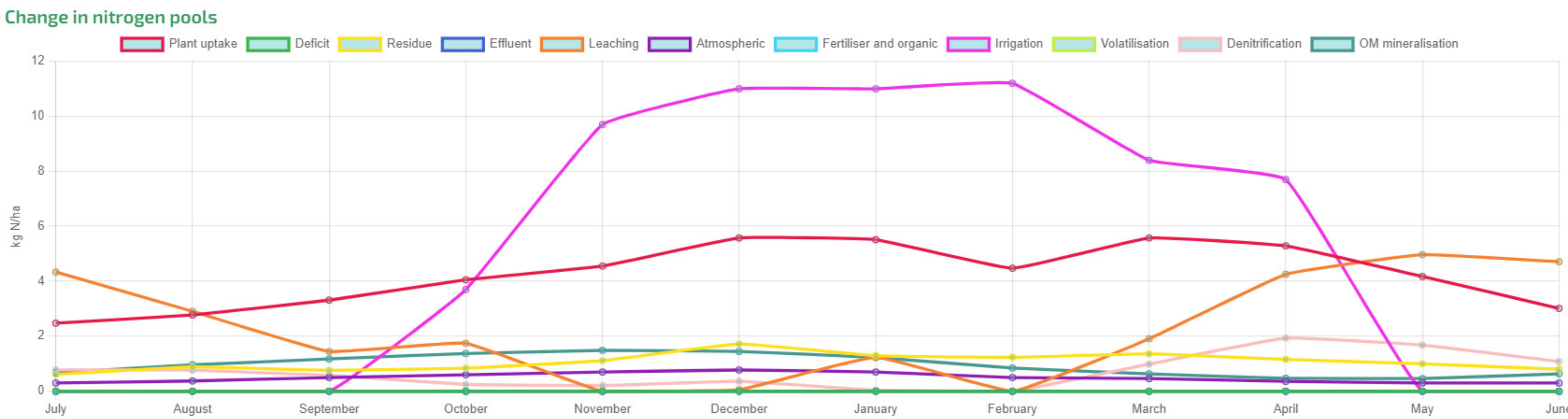


Figure 3. Future wastewater flows scenario for the Edge Management Zone Nitrogen pools.

Figure 13 shows the change in nitrogen pools for the tussock block. It shows that leaching primarily occurs in winter and spring. It also shows a 5.9 kg/ha net increase in the soil inorganic pool which points to a small amount of accumulation.

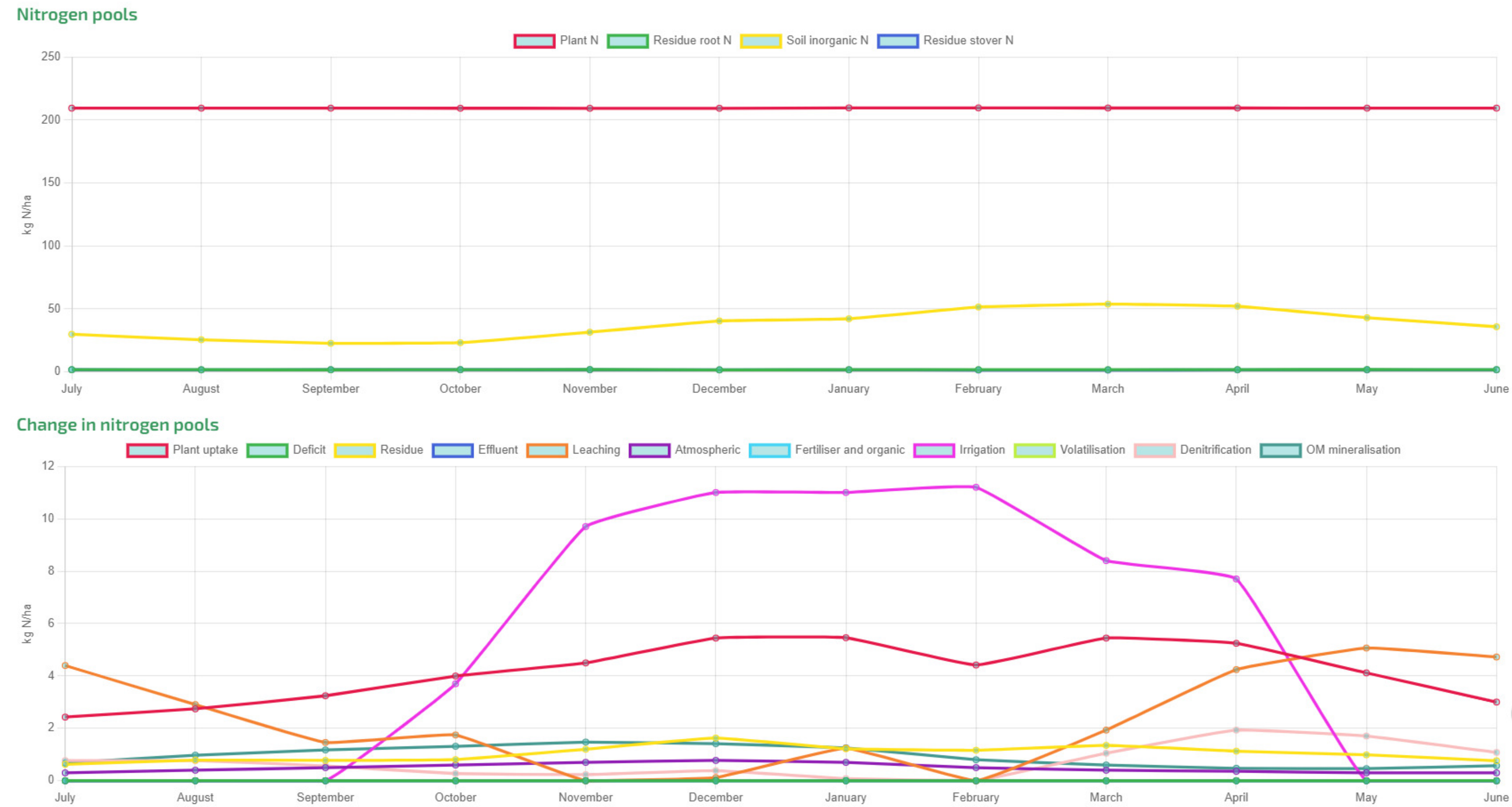


Figure 14. Future wastewater flows scenario for the Dune Management Zone Nitrogen pools.

Figure 14 shows the change in nitrogen pools for the tussock block. It shows that leaching primarily occurs in winter and spring. It also shows a 5.99 kg/ha net increase in the soil inorganic pool which points to a small amount of accumulation.

5 Discussion

As outlined above, due to the limitations of Overseer in modelling wastewater, it is considered that the Overseer modelling is quite conservative and that actual leaching values are likely to be less.

Due to the large variation in nitrogen uptake figure by trees in the literature, the figure of 50% nitrogen uptake is likely to be much higher in the field. By increasing the nitrogen percentage removed by trees, the nitrogen leaching numbers will be directly reduced. Overseer also fails to model the increased transpiration that would occur from trees when compared to a pastoral system, especially from deeper within the soil profile. In reality, increased transpiration will result in less runoff and therefore decreased nitrogen leaching below the root zone.

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