Soil Investigation, soil sampling, runoff determination and pond/land sizing using MEDLI for the proposed Springfield Feedlot expansion

Prepared for: RDC Engineers Pty Ltd
Attention: Rod Davis

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JG Environmental Pty Ltd
+61 429 472 029
justin@jgenvironmental.com.au
www.jgenvironmental.com.au

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Table of Contents

List of Tables

List of Figures

1 Introduction

Doolin Farming Pty Ltd own and operate a 10,000 ha mixed farming operation across several properties at North Star including “Glenhoma”, “Glenmodel”, “Springfield”, “Myall Downs” and “Yetman West” some 27 km east of Yetman and 45 km south-southeast of Goondiwindi (QLD) in NSW.

“Springfield” comprises some 1,713 ha (~4,231 acres) and there has been a beef cattle feedlot on “Springfield” for over three years after approval was granted for a 999 head feedlot by the Gwydir Shire Council in 2021 (DA31/2020). In addition to the feedlot, a dryland and irrigated cropping business is undertaken on a large proportion of the property with grazing of beef cattle on the remaining land which is unsuitable for cropping.

Doolin Farming Pty Ltd wish to expand Springfield Feedlot from the current approved capacity of 999 head by gaining development approval for intensive livestock agriculture to operate as a 3,000 head beef cattle feedlot on the site. The proposed development is to be developed in two stages with the first stage having a capacity of 1,251 head. The second stage will provide an additional 750 head, bringing the capacity of Springfield Feedlot to 3,000 head.

JG Environmental was engaged to undertake an assessment of the soils in the current/proposed effluent and manure utilisation areas through on-site assessment including taking soil cores and samples for analyses.

Furthermore, JG Environmental was engaged to undertake an assessment of the runoff generated, pond sizing and sustainability of the proposed feedlot effluent utilisation system.

2 Description of the Existing Environment

2.1 Location of Subject Land

The subject land is located approximately 15 km by road east of the small village of North Star in the Gwydir Shire of northern New South Wales. The subject land has primary frontage to Getta Getta Road (sealed to property entrance) of approximately 5.1 km in length.

Figure 1 is a locality plan showing the proximity of the subject land to nearby towns and roads.

2.2 Climate

Climate data for the locality was obtained from the SILO database with data provided by the Bureau of Meteorology (BOM). Daily climate data for the site for 100 years is summarised in Table 1. The mean annual rainfall is ~617 mm/year, whilst the mean annual pan evaporation is 1,889 mm/year.

Table 1: Climatic Data for Springfield Feedlot (-28.95 deg S 150.55 deg E)

Month	Mean Rainfall (mm)	Pan Evaporation (mm)	Net Evaporation (mm)	Max Temp (°C)	Min Temp (°C)	Rad (MJ/m²/d)
Jan	79.8	252.1	172.3	33.2	18.8	25.2
Feb	73.4	204.2	130.8	32.3	18.4	23
Mar	59.6	186.5	126.9	30.4	16.1	20.4
Apr	31.7	131.2	99.5	26.5	11.6	17.2
May	38.5	87.9	49.4	22	7.4	13.5
Jun	36.8	62.9	26.1	18.5	4.7	11.6
Jul	39.1	68.6	29.5	17.8	3.3	12.7
Aug	32.8	98.7	65.9	19.7	4.5	16.2
Sep	34.7	139.6	104.9	23.4	7.5	20.1
Oct	55.4	187.4	132	27	11.8	22.8
Nov	65.6	220.7	155.1	30	14.9	25.1
Dec	69.7	249.2	179.4	32.2	17.4	25.9
Year	617.3	1889.1	1271.8	26.1	11.3	19.4

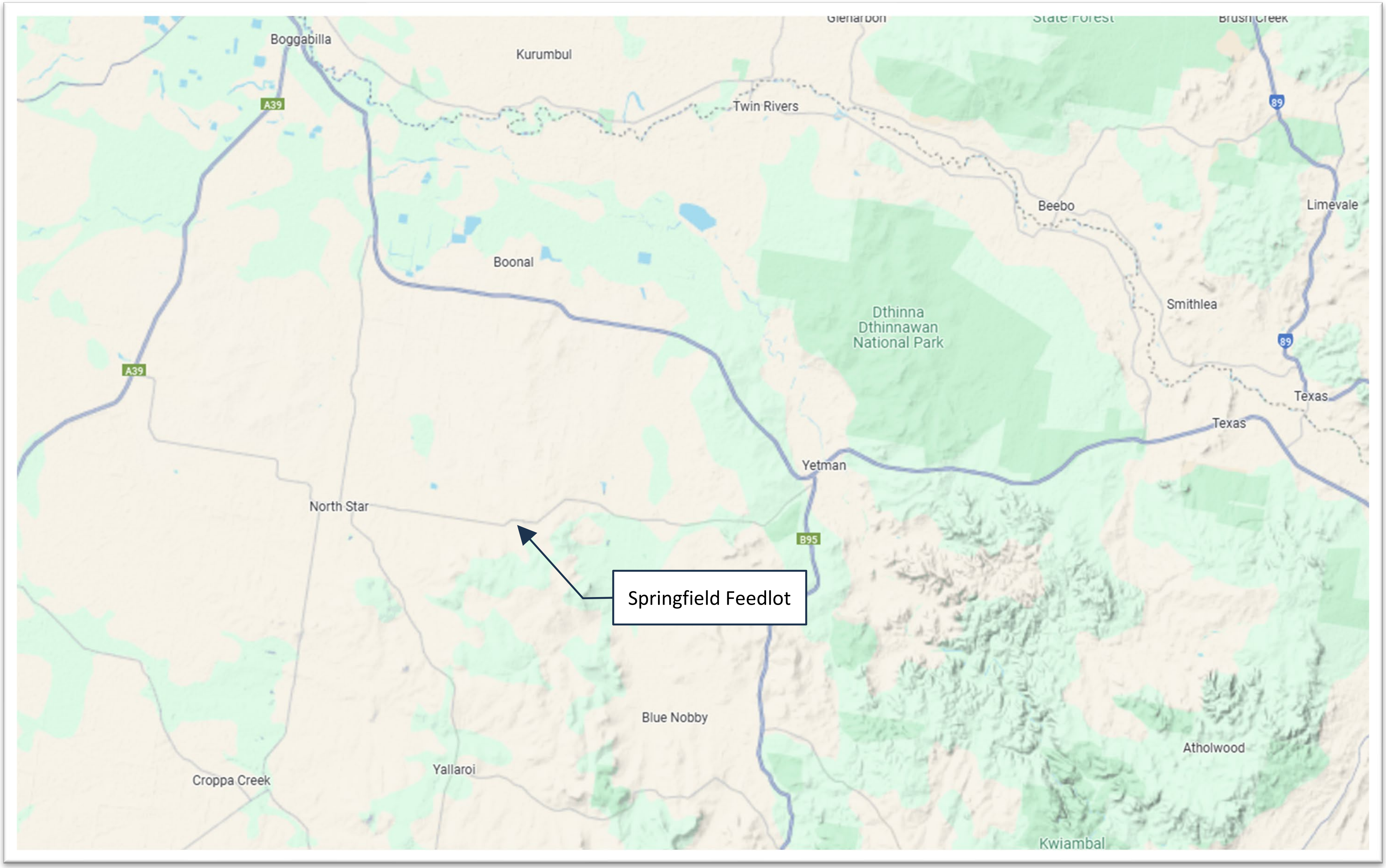


Figure 1: Locality Plan

2.3 Land Resource Information

The subject land has previously been mapped to a landscape level as part of the natural resource mapping for the Moree Plains (OEH 2015). This digital only soil landscape product covers the alluvial plains and fans of the Namoi, Gwydir, Barwon and Macintyre Rivers in the north and Pilliga Outwash fans in the South. The scale of the information and mapping in this publication is not provided.

Forty-four soil landscape map units have been described for the Moree Plains. Each unit is an inventory of soil and landscape information with relatively uniform land management requirements, allowing major soil and landscape qualities and constraints to be identified. The report and online map identify two soil landscape mapping units within the existing effluent reuse and manure spreading areas on the property.

These soil landscapes are summarised in Table 2, which describes the landform, vegetation, major soils and encountered in the three identified landscape mapping units.

Table 2: Landscape Units Occurring in the Liquid/Solid Reuse Areas (OEH 2015)

Landscape Unit	Landform	Major Soils
mgh Mungle	Gently undulating rises to hills mainly on sandstones. Slopes 3 - 10%, local relief 10 - 50 m, elevation 200 - 320 m. Extensively cleared grasslands to woodlands.	Deep to very deep (>150 cm), moderately well-drained Red Ferrosols, Red and Brown Dermosols (Red-brown Earths), Red Chromosols (Red Podzolic Soils), and Brown Chromosols (Yellow Podzolic Soils) on hillcrests to upper slopes. Deep to very deep (>150 cm), moderately well-drained Red Ferrosols, Red and Brown Dermosols (Red-brown Earths), Red Chromosols (Red Podzolic Soils), and Brown Chromosols (Yellow Podzolic Soils) on slopes.
mkt Mobbindry Creek	Narrow drainage lines and alluvial flats usually draining basalt-influenced catchments. Slopes 0 - 2%, local relief 0 - 5 m, elevation 160 - 340 m. Extensively cleared tall open-forest, woodland and grassland.	Very deep (>150 cm), imperfectly drained to poorly-drained Black Vertosols (Black Earths), Grey Vertosols (Grey Clays) and Brown Dermosols (Alluvial Soils) on alluvial flats.

2.4 Site Specific Soil Information

The available land resource mapping should provide sufficient information to be used for property scale planning and management. However, a site-specific soil assessment was undertaken by Mr Justin Galloway (Certified professional soil scientist) in the current effluent and manure utilisation areas to validate the soil mapping information and provided physical and chemical data for input to the hydraulic and nutrient balance modelling.

A total of 18 sites were described to a depth of up to 120 cm using a 5 cm diameter soil push tube that removed intact soil cores. The soil assessment confirmed the alluvial and flat plains are dominated by deep dark clay soils (Dermosols or Vertosols). These soils have been utilised for successfully growing irrigated/dryland cotton and various fodder and grain crops.

The dominant soils observed in the mid and lower slope positions were deep brown Dermosols (some Chromosols). Once again, these soils are currently being utilised for growing irrigated/dryland cotton and various fodder and grain crops. The mid to upper slope positions also contain deep reddish soils similar to the red and brown Ferrosols and Dermosols described in OEH (2015).

In the high crests and upper landscape positions, also observed were shallow to moderately deep soils (Tenosols and Rudosols). These soils are used for grazing only and have not been developed. These unsuitable soils have been excluded from the current manure spreading areas.

Photographs of the various typical soil profiles observed within the current effluent and manure utilisation areas are shown below in Figure 2. Typical profile descriptions of the dominant soil types are provided in Tables 3, 4 and 5.

The existing landscape around soil observation and sampling sites are shown in Figures 3 to 7.

Figure 2: Typical Soil Profiles Observed

Table 3: Dominant soil in alluvial areas - Typical Description

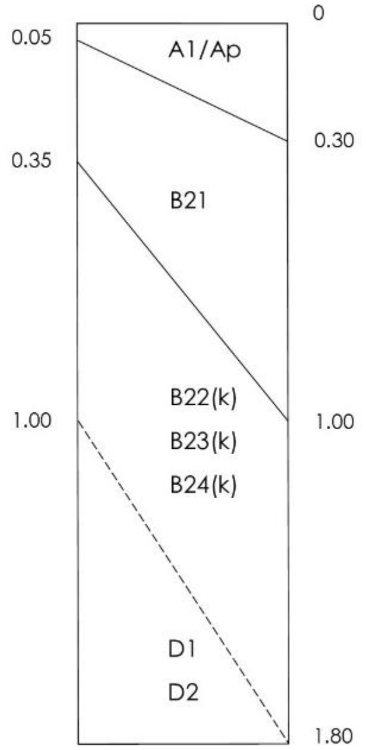
Profile Diagram	Description
	**A1/Ap:** Black (10YR 2-3/1-2) light to medium clay; moderate to strong angular/subangular blocky structure; field pH 8.0-5.5; clear change to
	B21: Black (7.5-10YR 2-3/1-2) light to heavy clay; weak lenticular structure parting to moderate to strong angular/subangular blocky, frequent slickensides; rarely few gravels; few medium calcareous segregations; field pH 8.0-9.0; gradual/diffuse change to
	B22(k)/23(k): black or brown (7.5-10YR 2-4/1-4, 2.5Y 4/3) light medium to medium heavy clay; moderate to strong prismatic and lenticular structure with slickensides; few to common fine to coarse calcareous segregations; occasional manganiferous nodules; field pH 8.5-9.0.
	D1/D2: Where present, black or brown (10YR 2/1, 2-3/2-3) medium clay; weak to moderate prismatic structure, frequently few medium calcareous nodules; field pH 9.0.

Table 4: Dominant soil (Dermosol) in mid and lower slopes - Typical Description

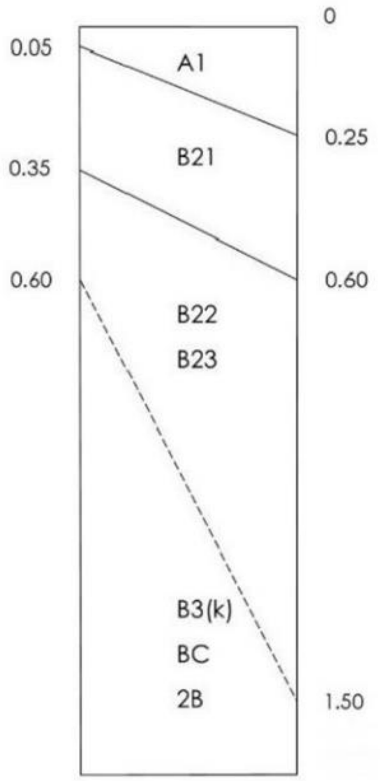
Profile Diagram	Description
	**A1:** Black to dark brown (10YR 2-3/1-2; light to medium clay; moderate polyhedral, granular or angular/subangular blocky structure; rarely few gravels; field pH 7.5-8.0; gradual to -
	B21: Grey or brown (10YR 3-4/2-4, 7.5YR 3-4/3); medium to medium heavy clay; moderate to strong subangular blocky structure; very few calcareous or manganiferous segregations; field pH 8.5-9.0; clear to gradual change to -
	B22/23: Black, brown or grey (7.5-2.5Y 3-5/1-4) medium to heavy clay; weak to moderate lenticular structure, parting to subangular blocky structure; few to common calcareous or manganiferous nodules; field pH 8.5-9.0; gradual to diffuse to –
	B3/BC: Where present, grey (10YR 5-7/1-2) silty/sandy light to medium heavy clay; strong subangular blocky structure, or weak to moderate lenticular structure with slickensides; few distinct mottles; few calcareous and manganiferous segregations; field pH 8.5-9.0.

Table 5: Dominant soil (Tenosol) in upper slopes - Typical Description

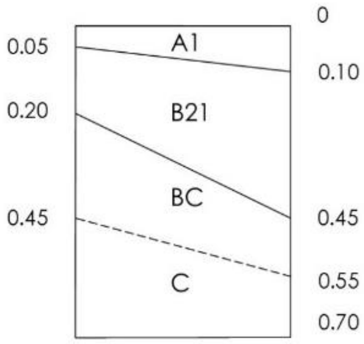
Profile Diagram	Description
	**A1:** Brown to dull reddish brown (5-10YR 3-4/4-6; clay loam to light clay; moderate subangular blocky structure; few to common fine gravels; field pH 7.5-8.0; clear change to
	B21: Dull yellowish brown (5-7.5YR 5/3-4) light to medium clay; week to moderate subangular blocky structure; common fine and medium gravels; field pH 7.5-8.5; gradual change to
	BC: Where present, dull yellowish brown (10YR 5/3-4) light to medium clay; weak angular/subangular blocky structure; many fine and medium gravels; field pH 7.5-8.5.
	C/R: Weak to moderate, massive saprolite.

Figure 3: Typical landscape (mid/lower slopes) showing contour banks (near TP6)

Figure 4: Typical landscape on alluvial flats (near TP1)

Figure 5: Typical landscape on lower slopes and flats (near TP9)

Figure 6: Typical landscape (red soils) in mid/upper slopes (near TP11)

Figure 7: Typical landscape in Effluent Reuse Area (near TP13)

2.5 Soil Sampling and Analysis

Representative soil profiles (refer Figure 8) were sampled at 0-20, 20-40, 40-70 and 70-100cm depths. The samples were submitted to the Environmental Analysis Laboratory (EAL), a NATA and ASPAC accredited laboratory located at the Southern Cross University in Lismore (NSW), for analysis.

The analysis results are given in the following series of tables (Table 6 through Table 12). The full laboratory results are also presented in Appendix A.

Table 6: Soil Analysis Results (TP1)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		8.58	8.70	9.03	9.37
Electrical Conductivity	dS/m	0.169	0.283	0.295	0.573
Organic Matter	%	2.7	2.4	1.7	1.6
Nitrogen (Total)	%	0.11	0.10	0.07	0.06
Nitrogen (Nitrate)	mg/kg	15	49	30	18
Nitrogen (Ammonium)	mg/kg	2.9	2.2	2.0	1.8
Phosphorus (Colwell)	mg/kg	29	9.8	2.6	2.0
Phosphorus (Bray)	mg/kg	20	2.2	1.5	1.5
Phosphorus Sorption	mg P/kg	164	194	128	189
Exch. Calcium	cmol+/kg	30	28	22	25
Exch. Magnesium	cmol+/kg	13	15	20	22
Exch. Potassium	cmol+/kg	0.70	0.37	0.31	0.37
Exch. Sodium	cmol+/kg	1.4	2.5	5.6	8.7
Exch. Aluminium	cmol+/kg	0.02	0.02	<0.01	<0.01
Cation Exch. Capacity	cmol+/kg	45	45	48	56
Exchangeable Sodium	%	3.1	5.5	12	15

Figure 8: Soil Observation and Sampling Locations (sites in yellow)

Table 7: Soil Analysis Results (TP6)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		8.10	8.49	8.69	8.87
Electrical Conductivity	dS/m	0.207	0.145	0.184	0.212
Organic Matter	%	4.2	3.1	2.8	2.5
Nitrogen (Total)	%	0.17	0.10	0.09	0.07
Nitrogen (Nitrate)	mg/kg	53	7.6	12	5.6
Nitrogen (Ammonium)	mg/kg	16	2.6	2.3	2.7
Phosphorus (Colwell)	mg/kg	13	3.0	2.3	1.3
Phosphorus (Bray)	mg/kg	3.6	2.5	1.1	<1
Phosphorus Sorption	mg P/kg	381	521	506	487
Exch. Calcium	cmol+/kg	36	39	39	31
Exch. Magnesium	cmol+/kg	7.9	14	19	19
Exch. Potassium	cmol+/kg	1.1	0.57	0.62	0.61
Exch. Sodium	cmol+/kg	0.38	0.48	1.4	2.4
Exch. Aluminium	cmol+/kg	0.02	0.02	0.01	0.02
Cation Exch. Capacity	cmol+/kg	46	54	59	53
Exchangeable Sodium	%	0.82	0.89	2.4	4.6

Table 8: Soil Analysis Results (TP9)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		7.83	8.46	8.79	9.14
Electrical Conductivity	dS/m	0.083	0.111	0.119	0.206
Organic Matter	%	2.2	2.3	1.8	1.7
Nitrogen (Total)	%	0.09	0.07	0.06	0.04
Nitrogen (Nitrate)	mg/kg	5.5	1.4	0.66	0.62
Nitrogen (Ammonium)	mg/kg	4.0	2.1	1.6	2.3
Phosphorus (Colwell)	mg/kg	7.9	4.3	2.3	3.0
Phosphorus (Bray)	mg/kg	5.0	1.6	1.7	2.7
Phosphorus Sorption	mg P/kg	131	208	220	214
Exch. Calcium	cmol+/kg	30	35	30	37
Exch. Magnesium	cmol+/kg	7.8	9.9	12	16
Exch. Potassium	cmol+/kg	0.43	0.35	0.31	0.37
Exch. Sodium	cmol+/kg	0.48	0.89	1.7	3.5
Exch. Aluminium	cmol+/kg	0.01	0.02	0.02	0.01
Cation Exch. Capacity	cmol+/kg	39	46	45	58
Exchangeable Sodium	%	1.2	1.9	3.7	6.1

Table 9: Soil Analysis Results (TP11)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		8.20	8.30	8.53	8.83
Electrical Conductivity	dS/m	0.108	0.096	0.136	0.119
Organic Matter	%	2.3	1.2	2.2	1.8
Nitrogen (Total)	%	0.08	0.17	0.05	0.03
Nitrogen (Nitrate)	mg/kg	12	10	14	8.2
Nitrogen (Ammonium)	mg/kg	1.7	1.3	1.3	1.5
Phosphorus (Colwell)	mg/kg	33	4.9	5.9	3.3
Phosphorus (Bray)	mg/kg	22	3.7	<1	<1
Phosphorus Sorption	mg P/kg	146	274	236	90
Exch. Calcium	cmol+/kg	19	20	28	27
Exch. Magnesium	cmol+/kg	2.1	2.9	3.0	4.3
Exch. Potassium	cmol+/kg	0.91	0.47	0.38	0.30
Exch. Sodium	cmol+/kg	0.18	0.14	0.13	0.14
Exch. Aluminium	cmol+/kg	0.01	0.01	<0.01	0.01
Cation Exch. Capacity	cmol+/kg	22	24	31	31
Exchangeable Sodium	%	0.83	0.58	0.42	0.43

Table 10: Soil Analysis Results (TP13)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		8.58	9.03	9.13	9.28
Electrical Conductivity	dS/m	0.265	0.268	0.398	0.518
Organic Matter	%	2.4	1.7	1.7	0.96
Nitrogen (Total)	%	0.10	0.07	0.06	<0.02
Nitrogen (Nitrate)	mg/kg	18	8.1	13	1.8
Nitrogen (Ammonium)	mg/kg	2.1	1.8	3.1	2.5
Phosphorus (Colwell)	mg/kg	24	3.0	2.0	1.3
Phosphorus (Bray)	mg/kg	13	1.5	1.3	1.6
Phosphorus Sorption	mg P/kg	262	280	288	210
Exch. Calcium	cmol+/kg	31	32	28	27
Exch. Magnesium	cmol+/kg	10	12	13	15
Exch. Potassium	cmol+/kg	1.0	0.39	0.30	0.31
Exch. Sodium	cmol+/kg	1.6	3.3	5.2	8.5
Exch. Aluminium	cmol+/kg	0.02	0.01	0.01	0.02
Cation Exch. Capacity	cmol+/kg	44	48	47	50
Exchangeable Sodium	%	3.6	7.0	11	17

Table 11: Soil Analysis Results (TP15)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		8.71	8.97	9.20	9.34
Electrical Conductivity	dS/m	0.196	0.277	0.432	0.540
Organic Matter	%	2.6	2.3	1.7	1.6
Nitrogen (Total)	%	0.11	0.07	0.05	0.03
Nitrogen (Nitrate)	mg/kg	7.2	7.5	11	5.8
Nitrogen (Ammonium)	mg/kg	2.6	1.6	1.7	2.4
Phosphorus (Colwell)	mg/kg	8.9	2.0	<1	2.3
Phosphorus (Bray)	mg/kg	3.9	1.3	1.8	1.1
Phosphorus Sorption	mg P/kg	290	349	324	272
Exch. Calcium	cmol+/kg	31	29	25	25
Exch. Magnesium	cmol+/kg	13	15	17	18
Exch. Potassium	cmol+/kg	0.89	0.53	0.49	0.51
Exch. Sodium	cmol+/kg	2.1	3.5	5.9	8.0
Exch. Aluminium	cmol+/kg	<0.01	0.01	<0.01	<0.01
Cation Exch. Capacity	cmol+/kg	47	48	49	52
Exchangeable Sodium	%	4.5	7.4	12	16

Table 12: Soil Analysis Results (TP17)

Parameter	Unit	0-20cm	20-40cm	40-70cm	70-100cm
pH		6.87	8.78	9.14	9.32
Electrical Conductivity	dS/m	0.046	0.175	0.274	0.336
Organic Matter	%	2.7	2.0	1.9	2.3
Nitrogen (Total)	%	0.13	0.07	0.04	0.06
Nitrogen (Nitrate)	mg/kg	5.7	2.8	3.2	3.2
Nitrogen (Ammonium)	mg/kg	3.1	1.4	1.3	1.6
Phosphorus (Colwell)	mg/kg	35	2.0	2.3	3.0
Phosphorus (Bray)	mg/kg	19	5.4	2.8	1.1
Phosphorus Sorption	mg P/kg	216	433	475	446
Exch. Calcium	cmol+/kg	17	32	28	26
Exch. Magnesium	cmol+/kg	8.0	13	18	19
Exch. Potassium	cmol+/kg	0.74	0.49	0.48	0.45
Exch. Sodium	cmol+/kg	0.49	1.5	3.6	4.9
Exch. Aluminium	cmol+/kg	0.01	0.02	0.02	0.01
Cation Exch. Capacity	cmol+/kg	26	48	49	51
Exchangeable Sodium	%	1.9	3.2	7.3	9.7

2.6 Brief Soil Analyses Interpretation and Discussion

The following provides a brief interpretation and discussion of the soil analysis results.

2.6.1 pH

The surface (0-20 cm) pH for samples collected and analysed range from 6.9 (neutral) at TP17 to 8.7 (strongly alkaline) at TP15. The subsoil (70-100 cm) pH ranges from 8.8 (strongly alkaline) at TP11 to 9.4 (very strongly alkaline) at site TP1. Surface soil pH measured at the representative sites is considered acceptable for pasture and crop growth and is typical for these soil types under natural conditions.

2.6.2 Nitrogen

Results for soil samples collected and analysed in July 2024 show that total nitrogen in the surface (0-20 cm) ranges from 826 mg/kg to 1,690 mg/kg. The total nitrogen concentrations are considered low to moderate (Hazelton and Murphy 2016). Whilst the majority of the total nitrogen is not immediately available to plants, adequate concentrations will ensure soil microbes can mineralise the reserves to plant-available forms such as ammonium and nitrate.

Nitrate nitrogen in the surface (0-20 cm) ranges from 6 mg/kg to 53 mg/kg. Results from the recent sampling shows that all but one of the surface nitrate concentrations are considered deficient to marginal and a plant response to nitrogen additions is highly likely (Hazelton and Murphy 2016). Adequate available nitrogen will maximise crop growth and maximise nutrient uptake, especially of phosphorus. The subsoil (70-100 cm) nitrate nitrogen concentrations measured in samples collected in 2024 range from <1 mg/kg to 18 mg/kg at site TP1 (mean of 6 mg/kg).

2.6.3 Phosphorus

The available (Colwell) phosphorus concentrations measured for the surface soil (0-20 cm) ranges from 8 mg/kg at site TP9 to 35 mg/kg at monitoring site TP17. These are considered low concentrations. The subsoil (70-100 cm) available (Colwell) phosphorus concentrations measured in samples collected in 2024 are considered very low and range from 1 mg/kg to 3 mg/kg.

2.6.4 Phosphorus Sorption Capacity

The behaviour of labile inorganic phosphorus in soils is dominated by sorption and desorption processes (Hazelton and Murphy 2016). The amount of phosphorus (P) that a soil will remove from solution (be absorbed) is critical for effluent disposal, to ensure long term sustainability. The phosphorus adsorption capacity is the ability of a soil material to sorb P compounds onto soil particles thereby rendering the P unavailable to plants and immobilising it within the soil itself.

The surface soil (0-20 cm) phosphorus sorption results range from 131 up to 381 mg/kg. As for the subsoil (70-100 cm), phosphorus sorption results range from 90 up to 487 mg/kg. The phosphorus sorption levels are good to excellent and suggest a good capacity to safely store excess phosphorus.

2.6.5 Salinity

Salinity refers to the dissolved salts in a liquid or in soil solution and is usually measured by electrical conductivity. Salt is mostly added to the soil through soil formation, hydrologic processes and rainfall (Shaw et al. 1994). However, effluent irrigation can add significant quantities of salt to the soil.

The electrical conductivity measured in the surface soil ranges from 0.05 dS/m (very low) at site TP17 to 0.27 dS/m (medium) at site TP13. The subsoil electrical conductivity results range from 0.12 dS/m (low) to 0.57 dS/m (medium to high).

If soil conductivity for these soil types becomes very high (>0.96 dS/m in surface or >1.18 dS/m in subsoil), it may restrict potential rooting depth, decrease plant available water and reduce crop performance in species, which are not classed as 'very tolerant' (DNR 1997).

2.6.6 Sodicity

Soil sodicity occurs when the ratio of exchangeable sodium ions to other exchangeable cations is sufficient to influence the swelling and dispersion behaviour of soils (Rengasamy and Churchman 1999). Sodicity can cause a range of land management issues and the soils exchangeable sodium percentage (ESP) is the easiest and best indicator of soil sodicity. A soil is considered non-sodic if ESP is less than 6 %, marginally sodic to sodic if ESP is between 6 and 14 % and strongly sodic if ESP is greater than 14 % (Northcote and Skene 1972).

The surface soil (0-20 cm) ESP results range from <1 % at site TP11 to 4.5 % at sites TP15. The subsoil ESP results range from <1 % at site TP11 to 17 % at site TP13. All surface sites are considered non-sodic. The majority of the deep subsoil (70-100cm) sites are considered sodic or strongly sodic.

3 Land/Soil Capability and Suitability

3.1 Land Capability Assessment

Land capability is the inherent physical capacity of the land to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water resources.

An updated land and soil capability (LSC) assessment scheme titled "The Land and Soil Capability Scheme—a general rural land evaluation scheme for NSW" (OEH 2012) was implemented after building on previous assessment methodologies.

The following summarises the concepts and methodology of the LSC scheme.

> *The LSC assessment scheme uses the biophysical features of the land and soil including landform position, slope gradient, drainage, climate, soil type and soil characteristics to derive detailed rating tables for a range of land and soil hazards. These hazards include water erosion, wind erosion, soil structure decline, soil acidification, salinity, waterlogging, shallow soils and mass movement. Each hazard is given a rating between 1 (best, highest capability land) and 8 (worst, lowest capability land). The final LSC class of the land is based on the most limiting hazard.*
>
> *The LSC class gives an indication of the land management practices that can be applied to a parcel of land without causing degradation to the land and soil at the site and to the off-site environment. High impact practices require good quality, high capability land, such as LSC classes 1 to 3, while low impact practices can be sustainable on poorer quality, lower capability land, such as LSC classes 5 to 8. As land capability decreases, the management of hazards requires an increase in knowledge, expertise and investment. In lands with lower capability, the hazards cannot be managed effectively for some land uses.*

The definitions and descriptions for each LSC class are outlined in Table 13.

Table 13: Land and soil capability classes – general definitions (OEH 2012)

LSC Class	General Definition
	Land capable of a wide variety of land uses (cropping, grazing, horticulture, forestry, nature conservation)
1	Extremely high capability land: Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices.
2	Very high capability land: Land has slight limitations. These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.
3	High capability land: Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.
	Land capable of a variety of land uses (cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation)
4	Moderate capability land: Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.
5	Moderate–low capability land: Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.
	Land capable for a limited set of land uses (grazing, forestry and nature conservation, some horticulture)
6	Low capability land: Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation
	Land generally incapable of agricultural land use (selective forestry and nature conservation)
7	Very low capability land: Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.
8	Extremely low capability land: Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.

3.1.1 Summary of Land Capability

A summary of the assessment of hazards and land capability classes are shown below in Table 14. The results show that the alluvial and mid/lower slope soils are considered high capable land capable of a wide variety of land uses. The land has slight to moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.

The upper slope soils are considered moderate capability land, which has moderate to high limitations for high-impact land uses. This will generally restrict land management options for high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology.

Table 14: Summary of hazards and LSC classes

Main Hazard	Alluvial soils	Mid and lower slope soils	Upper slope soils
water erosion, including sheet, rill and gully erosion	1-2	2-3	3-4
wind erosion	1-2	1-2	1-2
soil structure decline	1-3	1-3	2-3
soil acidification	1-2	2-3	3-4
salinity	1	2	1-3
waterlogging	2-3	2-3	1
shallow soils and rockiness	1	1	2-4
mass movement	1	1	1
Overall LSC Capability	**2-3**	**2-3**	**3-4**

3.2 Effluent Reuse Suitability

Selecting a suitable site is important for successfully establishing an effluent irrigation system that complies with the principles and guidelines set out in the Environmental Guidelines – Use of effluent by irrigation (DEC 2004). The suitability of a particular site depends on both landform and soil factors.

Detailed soil investigations were undertaken and confined to potentially suitable sites identified from the preliminary investigations. The aim of the detailed survey is to (a) confirm the suitability of the proposed irrigation site and (b) identify 'moderate' and/or 'severe' soil limitations.

Landform and soil properties that describe sites likely to be suitable for effluent irrigation are shown below in Table 15 and Table 16. Surface and subsoil properties both need to be considered. Where a soil property limitation is considered 'slight', no soil amelioration is generally required. If the property limitation is considered 'moderate', some soil amelioration or a management response is required, for example, application of gypsum to a sodic (dispersive) soil, lime to an acidic soil, or careful irrigation of poorly drained or excessively well drained soil. Where a limitation is considered 'severe', the site may be unsuited to irrigation of some or all potential effluent products (DEC 2004).

Table 15: Landform requirements for effluent irrigation systems (DEC 2004)

Property	Nil or Slight	Moderate	Severe	Restrictive Feature
Slope (%) (for following irrigation methods) – flood/surface – sprinkler/spray – trickle/microspray	 < 1 < 6 < 10	 1–3 6–12 10–20	 > 3 > 12 > 20	excess runoff and erosion risk
Flooding	none or rare	Occasional	frequent	limited irrigation opportunities
Landform	crests, convex slopes and plains	concave slopes and foot-slopes	drainage lines and incised channels	erosion and seasonal water-logging risk
Surface rock outcrop (%)	Nil	0–5	> 5	interferes with irrigation and/or cultivation

Table 16: Typical soil characteristics for effluent irrigation systems (DEC 2004)

Property	Nil or Slight	Moderate	Severe	
Exchangeable sodium percentage (0–40 cm)	0–5	5–10	> 10	structural degradation and waterlogging
Exchangeable sodium percentage (40–100 cm)	< 10	>10	-	structural degradation and waterlogging
Salinity as electrical conductivity (ECe) (dS/m at 0–70 cm)	< 2	2–4	> 4	excess salt may restrict plant growth
Salinity measured as electrical conductivity (ECe) (dS/m at 70–100 cm)	< 4	4–8	> 8	excess salt may restrict plant growth; potential seasonal groundwater rise
Depth to top of seasonal high water table (metres)	> 3	0.5–3	< 0.5	poor aeration, restricts plant growth, risk to groundwater
Depth to bedrock or hardpan	> 1	0.5–1	< 0.5	restricts plant growth, excess runoff, waterlogging
Available water capacity (AWC, mm/m)	> 100	< 100	-	little plant-available water in reserve, risk to groundwater
Soil pHCaCl2 (surface layer)	> 6–7.5	3.5–6.0 > 7.5	< 3.5	reduces optimum plant growth
Cation capacity (CEC, cmol (+)/kg, exchange average 0–40 cm)	> 15	3–15	< 3	unable to hold plant nutrients
Emerson aggregate test (0–100cm)	4, 5, 6, 7, 8	2, 3	1	Poor structure
Phosphorus (P) sorption (kg/ha at total 0–100 cm	high	moderate	Low	unable to immobilise any excess phosphorus

3.2.1 Summary of Suitability

Table 17 below summarises the assessment of landform hazards for effluent utilisation. The results show that for a sprinkler/spray irrigation system the mid and lower slope soils have nil to slight ratings and are suitable. The alluvial soils are also suitable with the only moderate hazard identified as occasional flooding risk. Management needs to acknowledge the risk and plan infrastructure accordingly. The timing and frequency of irrigation also needs to factor the risk of flooding in low lying areas. The soils occurring in the upper slopes have moderate hazard ratings for irrigation method and rock outcrop. However, they are also suitable with appropriate management actions.

Table 17: Assessment of landform requirements outlined in DEC (2004)

Property	Alluvial soils	Mid and lower slope soils	Upper slope soils
Slope (%) (for following irrigation methods)			
– flood/surface	Nil/slight	Severe	Severe
– sprinkler/spray	Nil/slight	Nil/slight	Moderate
– trickle/microspray	Nil/slight	Nil/slight	Nil/slight
Flooding	Nil/slight to Moderate	Nil/slight	Nil/slight
Landform	Nil/slight	Nil/slight	Nil/slight
Surface rock outcrop (%)	Nil/slight	Nil/slight	Moderate

In addition to the landform hazards, Table 18 below summarises the assessment of soil characteristic hazards for effluent reuse.

The alluvial soils are assessed as being suitable, having nil/slight limitations for all identified soil hazards except for subsoil sodicity. Likewise, the mid and lower slope soils have nil/slight limitations for all hazards except a nil/slight to moderate hazard for sodicity. It must be noted that the topsoil (0-20cm) is non sodic at all sites.

The upper slope soils are also mostly nil/slight limitations for all hazards except a nil/slight to moderate hazard for soil depth and possibly water availability. Some minor occurrences of soils within the crests and upper slope position were identified as having weathered bedrock at <100cm depth. These minor occurrences should not cause any issues for manure reuse considering the majority of these areas have already been excluded from the dryland cropping area. However, management should prioritise the use of the deeper soils where possible.

Table 18: Assessment of soil characteristic requirements outlined in DEC (2004)

Property	Alluvial soils	Mid and lower slope soils	Upper slope soils
Exchangeable sodium percentage (0–40 cm)	Nil/slight	Nil/slight to Moderate	Nil/slight
Exchangeable sodium percentage (40–100 cm)	Nil/slight to Moderate	Nil/slight to Moderate	Nil/slight
Salinity as electrical conductivity (ECe) (dS/m at 0–70 cm)	Nil/slight	Nil/slight	Nil/slight
Salinity measured as electrical conductivity (ECe) (dS/m at 70–100 cm)	Nil/slight	Nil/slight	Nil/slight
Depth to top of seasonal high water table (metres)	Nil/slight	Nil/slight	Nil/slight
Depth to bedrock or hardpan	Nil/slight	Nil/slight	Nil/slight to Moderate
Available water capacity (AWC, mm/m)	Nil/slight	Nil/slight	Nil/slight to Moderate
Soil pHCaCl2 (surface layer)	Nil/slight	Nil/slight	Nil/slight
Cation capacity (CEC, cmol (+)/kg, exchange average 0–40 cm)	Nil/slight	Nil/slight	Nil/slight
Emerson aggregate test (0–100cm)	Nil/slight	Nil/slight	Nil/slight
Phosphorus (P) sorption (kg/ha at total 0–100 cm	Nil/slight	Nil/slight	Nil/slight

4 Runoff Estimation

4.1 Introduction

Runoff generated from the proposed development complex controlled drainage area has the potential to pollute surface and ground water if it is not effectively controlled and managed. The correct sizing of ponds to accommodate runoff and the responsible application of the organic and nutrient rich runoff to land are both important considerations.

4.2 MEDLI Feedlot Hydrological Model

MEDLI® is a Windows® based computer model for designing and analysing effluent reuse systems for intensive rural industries, agri-industrial processors (e.g. abattoirs) and sewage treatment plants.

Confined intensive cattle feeding systems are described in MEDLI V2.5 using the waste estimation/feedlot module. The feedlot module contained in MEDLI, models the daily water and nutrient balance of the pen/feeding area and its surrounding catchment (hard and soft) and then predicts the quantity and quality of the runoff entering the holding pond following rainfall.

The description of a feedlot enterprise in MEDLI is very flexible with provision for modifying the market composition of the herd, manure excretion rates, stocking density, catchment configurations, manure pad maintenance rules and harvesting rates. To obtain accurate manure production values (total solids, volatile solids, nitrogen, phosphorus, potassium and salt) for beef cattle to be entered in MEDLI, we used BeefBal v10.01 (DAF 2019). In BeefBal, the percentages of individual feed ingredients and the amount fed were input. Annual manure production in kilograms per head per year were then entered into the MEDLI model.

The model assumes all runoff from the catchment area is directed into a holding pond via a sedimentation basin. The sedimentation basin surface area was included in the “hard area”. Runoff from the hard and soft areas, and from any other non-production areas defined by the user i.e. “other areas”, is assumed to be free of solids, nutrients and salts. The assumption is reasonable unless these “other areas” involve manure stockpiling/composting areas.

The feedlot summary report includes information on annual runoff, nutrients contained in the runoff, manure harvesting rates and average pad nutrient and dry matter composition.

In summary, the feedlot waste estimation module predicts the quantity and quality of runoff entering the holding pond. The module is a deterministic, daily time-step program which generates the runoff details (date, volume, concentrations) for the run period.

4.3 Catchment Runoff Modelling (Expanded CDA)

The expanded controlled drainage area (CDA) of the proposed development consists of the following component areas for MEDLI modelling purposes:

Pen Area - area occupied by production pens, irrespective of their occupancy rate. The total pen area is a derived value based on the inputted stocking density (m^2/SCU), licensed capacity (SCU) and number of pens.

Hard Area - area occupied by concrete, roads, drains, cattle lanes, surface area of sedimentation basin(s), building roofs etc.

Soft Area - permanently grassed and vegetated areas within the catchment.

Other area(s) - any non-production area which possess different hydraulic properties to those of the soft and hard areas.

The various catchment area components for the expanded catchment (CDA) are summarised below in Table 19.

Table 19: Expanded Catchment Area Details

Catchment component	Area (ha)
Pens – production, holding, hospital	5.64
Hard – feed roads, cattle lanes / drains, cattle handling facility, manure stockpile	4.96
Hard – Sedimentation Basin	0.56
Soft - grassed areas	2.61
Other –	-
Total	13.77

The predicted runoff from the expanded controlled drainage area (CDA) is summarised on a monthly basis for the 100 modelling years in Table 20 and presented graphically in Figure 9.

There is high variability in the annual runoff (range 2.69 ML/yr to 53.57 ML/yr). The mean and median annual runoff for the 100-year modelling period is 21.16 and 19.70 ML/yr respectively.

Table 20: Monthly Runoff (ML) Predicted for Expanded CDA

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1924	1.8	5.0	0.3	2.8	0.0	0.9	1.8	2.0	0.4	0.5	8.1	0.2	23.79
1925	1.9	0.6	0.2	0.0	1.1	0.0	0.9	1.1	0.0	0.1	5.2	2.4	13.61
1926	0.2	1.5	0.1	0.6	2.3	1.0	2.0	0.0	1.4	0.1	0.0	6.0	15.19
1927	1.9	0.1	1.1	1.1	0.0	0.5	0.0	0.6	0.0	2.7	2.7	0.7	11.49
1928	4.0	5.6	3.7	1.0	0.1	2.5	0.4	0.0	0.0	0.4	0.1	0.0	17.80
1929	0.2	5.3	0.8	6.2	0.0	0.4	0.2	1.1	0.1	2.5	0.2	1.8	18.89
1930	6.6	0.1	1.9	0.3	1.2	3.2	5.3	3.7	0.3	3.4	0.6	1.2	27.86
1931	1.0	0.4	1.4	0.2	0.7	3.2	2.3	0.3	0.8	1.3	2.0	4.6	18.13
1932	0.3	0.6	1.0	1.4	0.5	1.0	1.0	0.1	2.3	0.8	2.0	1.1	12.10
1933	2.6	0.2	0.0	0.2	1.4	3.5	2.5	2.1	0.3	6.3	2.8	0.2	21.98
1934	0.8	5.4	0.2	0.6	1.3	1.1	1.0	0.6	0.7	3.3	0.2	11.7	27.08
1935	9.8	0.7	0.0	0.0	0.0	0.8	0.7	0.1	1.8	1.2	0.1	1.2	16.31
1936	1.0	3.4	2.0	0.1	1.9	0.2	1.7	1.8	1.0	0.0	0.0	2.4	15.54
1937	9.1	0.3	15.1	0.2	0.0	0.7	1.2	0.0	0.0	0.1	4.3	0.7	31.62
1938	1.5	0.6	0.0	0.0	11.4	0.5	0.0	1.7	0.9	1.9	4.0	0.1	22.58
1939	0.5	0.0	2.6	0.8	0.0	1.3	0.3	2.8	0.0	0.1	0.2	0.3	8.85
1940	0.5	4.6	7.2	0.2	0.0	0.0	0.0	0.0	0.3	0.2	0.6	1.4	14.93
1941	7.3	5.1	1.5	0.0	0.0	0.4	0.1	0.0	0.0	0.5	0.7	0.0	15.48
1942	0.4	4.2	0.0	0.0	1.1	0.5	5.1	0.0	0.0	2.2	1.0	6.1	20.64
1943	1.8	0.0	0.5	3.9	0.1	1.4	0.4	0.4	0.2	0.8	4.9	2.2	16.75
1944	1.2	0.3	0.0	0.0	0.2	0.1	0.4	4.4	0.3	0.4	0.3	0.1	7.57
1945	0.9	9.6	0.0	0.2	0.4	6.0	1.4	0.7	0.0	0.0	1.1	2.4	22.79
1946	6.5	1.9	0.4	3.2	0.1	0.0	0.0	0.0	7.5	0.0	1.0	2.1	22.59
1947	0.4	2.7	8.2	0.3	0.6	0.5	0.1	0.6	1.6	2.1	2.3	2.6	21.98
1948	4.0	0.3	0.9	0.5	1.5	5.6	1.0	0.0	1.3	0.3	0.0	0.9	16.37
1949	11.1	3.4	0.0	0.1	0.0	0.4	0.1	0.0	1.0	3.1	1.0	0.0	20.31

1950	0.8	8.8	1.5	0.6	1.9	10.2	11.0	0.0	0.0	2.3	15.1	1.4	53.57
1951	7.9	0.0	0.3	0.0	0.3	4.2	0.0	0.5	1.2	0.3	0.3	0.0	14.87
1952	0.0	2.6	2.5	0.7	1.8	0.5	0.5	2.8	0.3	7.6	0.0	0.1	19.47
1953	0.1	23.2	0.7	0.2	2.0	0.0	0.1	2.6	0.0	0.7	0.7	0.0	30.37
1954	0.2	9.7	0.0	0.0	0.1	0.3	0.4	0.7	0.0	12.2	3.1	0.6	27.39
1955	0.4	11.0	0.0	2.3	1.1	0.0	0.6	0.3	0.3	1.4	0.1	2.4	19.93
1956	12.3	7.7	1.5	1.2	3.7	4.6	1.2	0.0	0.4	0.3	0.2	0.4	33.40
1957	1.6	2.6	2.4	0.1	0.0	1.2	0.0	0.1	0.0	1.0	0.0	0.1	9.30
1958	0.5	0.9	9.7	1.6	0.1	2.7	0.0	0.1	1.0	0.7	0.6	1.6	19.46
1959	4.1	6.6	0.4	0.0	1.3	0.0	1.6	0.0	0.0	1.0	7.5	1.3	23.94
1960	1.0	0.9	0.4	0.3	1.8	0.3	0.5	2.1	0.6	0.1	0.5	1.6	10.03
1961	1.0	3.7	1.5	0.1	3.2	3.4	1.1	1.1	0.0	0.5	9.0	1.1	25.65
1962	11.6	0.4	5.0	0.6	0.4	0.0	0.2	0.6	0.3	0.8	0.0	3.9	23.97
1963	0.7	0.8	1.9	0.0	1.4	0.2	0.0	0.5	0.0	0.0	6.7	4.9	17.16
1964	2.7	0.5	1.1	7.6	0.9	0.0	0.8	1.1	2.4	2.8	0.4	0.7	21.05
1965	0.2	0.0	0.1	0.0	0.0	0.0	0.5	0.1	0.8	0.4	0.0	1.7	3.74
1966	0.0	0.0	0.2	1.0	0.1	1.3	0.0	7.7	0.7	0.3	4.3	0.2	15.70
1967	0.6	0.0	6.1	0.0	0.6	1.1	0.2	0.2	0.0	2.7	0.0	1.3	12.80
1968	2.7	2.8	0.3	0.4	2.3	0.1	0.4	0.4	0.3	0.3	0.0	1.4	11.21
1969	1.7	0.3	0.7	1.2	3.7	1.8	0.4	0.4	1.6	5.8	5.6	0.1	23.35
1970	1.4	4.6	0.0	1.8	0.1	0.0	0.0	0.3	6.2	0.9	1.2	15.6	32.13
1971	8.4	5.8	0.0	0.4	0.0	0.0	5.5	2.4	0.2	0.3	1.3	3.5	27.86
1972	0.7	0.2	0.1	2.5	0.1	0.0	0.0	1.2	4.2	3.9	2.9	1.0	16.90
1973	1.1	5.0	0.7	0.0	0.2	0.2	1.6	0.3	0.5	4.1	2.0	4.4	20.04
1974	3.9	0.7	0.3	0.5	0.2	0.4	0.0	0.6	0.2	0.5	8.4	0.1	15.87
1975	0.6	9.2	6.6	0.3	0.0	0.5	2.1	0.7	0.4	2.8	1.3	4.7	29.27
1976	1.7	31.4	1.1	0.0	0.4	0.7	0.7	0.4	3.2	0.3	2.4	1.4	43.67
1977	5.7	5.7	6.8	1.2	4.5	0.6	0.0	0.2	0.1	0.5	0.8	0.5	26.58
1978	6.4	0.1	0.6	0.8	6.9	0.6	1.8	0.7	3.6	2.2	3.3	1.0	28.03

1979	0.0	0.0	2.9	0.3	3.0	0.5	0.1	0.1	1.0	8.1	1.6	0.0	17.69
1980	0.0	0.4	0.5	0.0	3.8	0.1	0.2	0.0	0.0	3.2	0.3	6.4	14.91
1981	0.0	2.4	0.3	0.7	3.5	6.0	5.3	0.1	0.1	0.7	2.3	1.2	22.65
1982	1.6	0.8	14.3	0.4	0.7	0.0	0.1	0.0	0.4	2.3	0.0	2.2	22.79
1983	4.8	0.0	2.8	8.0	14.7	1.9	0.9	1.0	2.2	1.5	2.5	0.9	41.23
1984	6.7	3.3	0.3	5.2	0.1	0.9	9.0	0.1	0.4	0.7	2.7	2.8	32.21
1985	0.0	1.5	1.2	1.0	0.2	0.1	4.1	2.3	0.2	0.8	2.6	1.5	15.63
1986	1.2	0.2	0.0	0.0	2.4	0.0	2.7	2.3	3.5	2.9	4.9	0.8	20.94
1987	5.9	0.3	1.6	0.0	2.7	1.2	2.2	1.0	0.1	1.5	0.2	1.7	18.38
1988	8.7	5.8	0.0	16.5	0.6	0.1	5.5	1.6	0.9	0.4	2.2	0.2	42.39
1989	1.0	0.0	8.1	3.1	1.2	1.4	0.6	0.0	0.0	0.4	2.2	1.3	19.37
1990	3.5	6.2	0.2	4.5	2.5	0.8	0.2	0.0	0.1	0.5	0.2	0.1	18.84
1991	7.8	7.7	1.0	0.0	1.2	0.1	2.7	0.0	0.0	0.4	0.5	5.2	26.52
1992	0.2	7.2	0.2	1.6	0.5	0.1	0.2	2.0	0.0	0.2	0.7	2.5	15.30
1993	0.5	1.1	0.2	0.0	0.2	1.1	3.1	0.8	2.4	1.0	0.0	2.6	12.98
1994	0.4	9.0	3.2	0.0	0.0	0.3	0.0	0.6	0.0	0.3	1.1	2.2	17.15
1995	7.9	1.1	1.8	0.0	0.4	1.8	0.0	0.0	1.1	0.8	11.1	1.2	27.27
1996	25.2	0.5	0.3	0.3	5.4	0.3	1.9	0.4	2.3	1.6	0.7	8.2	47.19
1997	5.5	6.6	0.0	0.0	6.7	0.1	0.1	0.0	0.1	2.0	0.9	2.0	23.92
1998	0.3	2.7	0.3	1.6	3.5	1.5	8.8	11.9	0.5	1.8	1.0	0.1	33.98
1999	0.8	5.3	8.8	0.0	0.4	0.9	1.4	1.8	0.1	2.5	3.1	3.1	28.23
2000	0.5	1.7	7.8	0.3	1.1	0.0	1.6	0.3	0.0	3.1	6.5	1.9	24.92
2001	3.3	12.4	1.0	0.0	0.6	1.2	4.1	0.2	0.1	1.4	2.0	0.3	26.50
2002	0.3	0.8	8.9	0.0	0.0	0.1	0.0	2.3	0.1	0.5	1.2	0.9	15.26
2003	0.1	4.9	2.5	1.6	0.0	0.5	0.6	0.2	0.0	4.0	0.9	4.9	20.20
2004	5.9	0.6	6.2	1.1	0.7	0.0	0.5	0.3	5.3	0.3	2.9	3.7	27.64
2005	0.5	0.0	0.4	0.0	0.7	8.0	0.0	0.2	0.3	1.0	3.3	1.9	16.40
2006	4.2	2.9	0.4	0.2	0.0	1.1	1.6	0.0	0.6	0.0	1.0	0.2	12.05
2007	0.1	1.5	0.3	1.7	0.4	1.7	0.0	1.9	0.0	1.0	0.9	3.4	12.93

2008	0.8	2.2	0.0	0.0	0.0	0.9	0.6	0.0	2.9	0.1	3.8	1.0	12.27
2009	1.7	8.2	0.0	0.1	1.4	0.3	0.1	0.0	1.9	0.1	0.3	4.7	18.91
2010	0.6	1.4	4.1	0.0	0.7	0.1	3.4	1.4	4.1	4.5	3.9	0.9	25.06
2011	2.1	1.5	4.9	0.7	0.4	0.4	0.1	1.2	3.8	1.2	5.0	8.4	29.68
2012	11.1	0.9	0.2	0.5	1.8	0.3	0.7	0.0	0.1	0.3	0.4	2.9	19.21
2013	14.3	0.5	6.8	0.4	0.1	1.3	0.3	0.1	0.5	0.3	1.2	0.0	25.93
2014	1.3	1.0	8.4	0.1	0.3	0.5	0.1	1.3	0.2	0.0	0.3	3.0	16.51
2015	5.5	0.8	1.9	4.4	2.5	2.2	2.5	0.1	0.0	0.6	0.2	3.0	23.67
2016	5.2	0.2	0.1	0.2	0.8	3.0	2.1	2.3	2.9	0.9	0.1	0.7	18.43
2017	1.1	0.6	6.5	1.0	0.5	0.8	0.0	0.3	0.0	7.1	0.5	1.3	19.45
2018	0.2	0.7	2.8	0.5	0.0	0.0	0.2	0.5	0.1	1.5	2.5	0.0	9.20
2019	0.0	0.0	1.9	0.0	0.2	0.2	0.0	0.0	0.0	0.4	0.0	0.1	2.69
2020	1.3	1.7	2.3	0.2	1.5	1.0	0.2	0.6	0.0	1.5	0.0	2.7	13.06
2021	1.2	1.0	9.7	0.2	0.1	1.9	0.6	0.7	2.6	0.5	5.1	3.1	26.58
2022	2.4	2.3	3.5	0.3	2.3	1.2	0.1	0.3	3.7	8.8	1.5	0.9	27.32
2023	0.4	0.2	6.3	0.4	2.5	0.3	0.1	0.0	0.0	0.1	2.5	1.1	13.88
Mean	**3.03**	**3.17**	**2.36**	**1.07**	**1.37**	**1.17**	**1.30**	**0.93**	**0.96**	**1.64**	**2.10**	**2.06**	**21.16**
Median	**1.21**	**1.42**	**0.96**	**0.30**	**0.57**	**0.53**	**0.48**	**0.38**	**0.29**	**0.81**	**1.07**	**1.31**	**19.70**
Min	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.69**
10^{th} %ile	**0.15**	**0.03**	**0.00**	**0.00**	**0.00**	**0.02**	**0.00**	**0.00**	**0.00**	**0.10**	**0.04**	**0.07**	**12.09**
90^{th} %ile	**7.97**	**7.74**	**7.22**	**2.85**	**3.47**	**3.17**	**3.45**	**2.27**	**2.97**	**3.95**	**5.15**	**4.76**	**30.49**
Max	**25.23**	**31.36**	**15.10**	**16.52**	**14.73**	**10.18**	**10.96**	**11.93**	**7.49**	**12.24**	**15.11**	**15.60**	**53.57**
Std Dev.	**4.01**	**4.61**	**3.23**	**2.20**	**2.21**	**1.73**	**2.01**	**1.59**	**1.45**	**2.13**	**2.63**	**2.47**	**8.66**

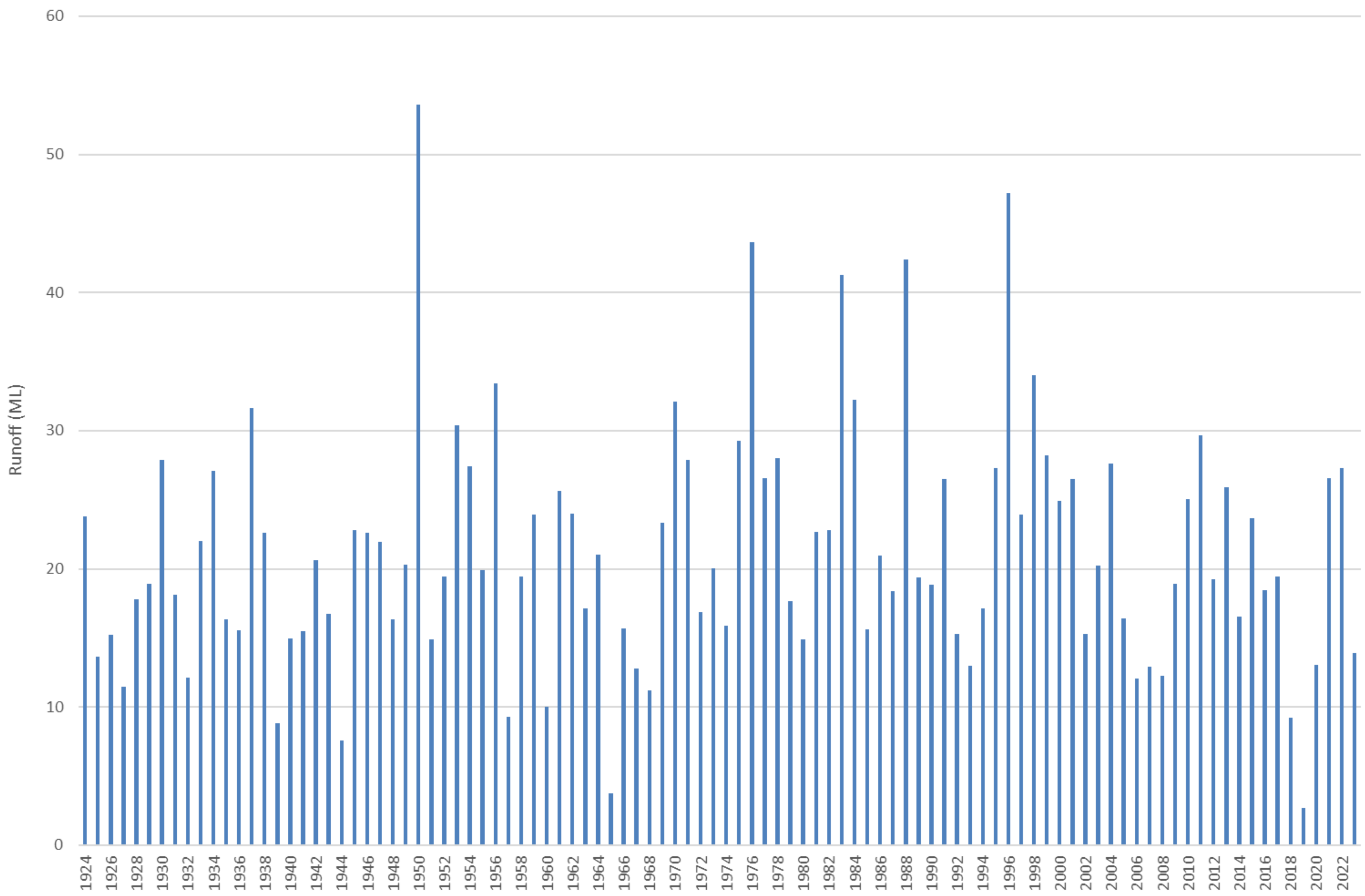


Figure 9: Summary of Annual Runoff Volume (ML) for Expanded CDA

5 Sizing of Holding Pond and Effluent Utilisation Area

Land application of feedlot effluent onto areas growing crops or pastures is regarded as the most efficient and beneficial means of utilising the valuable water, nutrient and organic components of this feedlot by-product. This practice is consistent with the principles of the internationally accepted waste management hierarchy (i.e. avoidance, recycling, waste to energy, treatment and disposal) that lists recycling as the second most desirable management option.

The reuse of effluent through irrigation is aimed at:

- Using crops, pastures and soils to efficiently utilise or sustainably assimilate the nutrients, salts, organic matter and water contained in the effluent (ARMCANZ, 1997).
- Maximise the utilisation of the fertiliser, water and soil amendment values of feedlot effluent while avoiding adverse environmental impacts.

Effluent irrigation must be managed carefully to ensure that:

- Nutrients are not excessively leached below the active root zone.
- Dissolved and suspended contaminants are not exported from utilisation areas to watercourses.
- Excessive application of effluent does not adversely affect the chemical and physical properties of the soils in the reuse areas.
- The productivity of pasture or cropping land is maintained or enhanced.
- Nearby neighbours do not experience odour or dust nuisance due to poorly timed and managed applications of effluent.

To maximise the benefits of the valuable water, nutrient and soil amendment values of the effluent, while minimising any adverse impacts upon the environment, land areas used for effluent irrigation must be carefully selected and managed.

JG Environmental used MEDLI modelling to determine the hydraulic and nutrient loading rate of the proposed expanded effluent utilisation system to assess its sustainability under proposed operating conditions.

5.1 MEDLI Model

MEDLI stands for "Model for Effluent Disposal using Land Irrigation". MEDLI is a Windows™ based daily time step computer model for designing and assessing effluent reuse systems. MEDLI V2.5 is a mathematical model developed to simulate the operation of an effluent irrigation scheme over a 'long' period, typically many decades. The model's basis is a 'physical system' comprising a field of crop or pasture which has been irrigated with effluent supplied from a tank or pond. This in turn provides a buffer storage to hold incoming effluent at times when water is not being applied to the soil.

Although MEDLI is based on a group of previously available models covering soil-water balance and crop growth, its primary focus is on liquid waste management. It simulates day to day natural processes which take place, by performing material balance calculations to account for the incoming water and constituents such as nitrogen, phosphorus and dissolved salts, to estimate irrigation demand. It also uses data about the physical system itself plus historical climatic data for the particular site.

MEDLI uses a material balance between storage systems, soil systems and crop growth. This provides information on the fate of the irrigated wastewater, nutrients, salts and pathogens and their potential impact in the receiving environment. The model can be used to design the effluent irrigation scheme and provides details of the required land area and wet weather storage, in addition to guide strategies for irrigation.

5.2 Analysis of Nutrient Application Sustainability

The objective of the MEDLI modelling is to develop a system, which will provide the sustainable utilisation of effluent generated from the proposed expansion at the Springfield Feedlot. The performance criteria for such as system include:

- Holding pond overflows are less frequent than 1 in 10 years.
- Nitrogen loading rate (after losses) from effluent less than crop removal.
- Nitrate leaching below the root zone such that NO_{3-} concentration in leachate is < 10 mg/L.
- Phosphorus loading rate from effluent is lower than crop removal and safe soil sorption.
- Salinity levels in soil do not reduce crop yields.

Given that the runoff volume is fixed (for a particular feedlot configuration), the options available include:

- Adjust holding pond volume to limit overflows.
- Adjust irrigation area to limit loading rate.
- Adjust crop type to change nutrient removal.
- Adjust irrigation scheduling to maximise water usage.

5.3 Input Data for MEDLI Modelling

The following scenarios were modelled:

Scenario 1 – Expanded CDA

- Catchment details = See Section 4
- Effluent Inflow = See Section 4
- Irrigation Area = 120 ha (existing pivot)
- Demand-Based Irrigation Scheduling = 30mm SWD
- Feedlot Holding Pond = 20 ML (expanded pond)
- Vegetation = Summer/winter cropping (current practice)
- Shandy Water = Yes

The average annual effluent inflow to the ponds was estimated by the MEDLI feedlot module (Refer Section 4) to be 21.16 ML/yr for the expanded CDA. This equates to 154mm/yr of runoff from the 13.77 ha catchment. This represents ~25% of the annual rainfall for the site.

A 100-year (1924-2023) climate file for the North Star area was obtained from the SILO database operated by the Bureau of Meteorology (BOM) that gives daily meteorological data (refer Table 1). The mean annual rainfall is just 617 mm/year, whilst pan evaporation is 1889 mm/yr. This provides a large net evaporation and large scope for irrigation.

The soil parameters were calculated from data collected during the site inspection and physical/chemical tests undertaken. The results were compared with published data for similar soil types. The dominant soil type is best correlated with the default "dermosol" contained within MEDLI. This default soil type was modified to include site specific soil depths, nitrogen, phosphorus and absorption isotherms (all recently analysed).

The irrigation input data includes the irrigator type, irrigation area size and irrigation scheduling rules. The irrigator modelled was a centre pivot (spray) with scheduling based on a soil water deficit i.e irrigation does not occur when soil conditions do not allow for the volume to be applied without runoff or reaching the soil's field capacity.

5.4 Modelling Results

Table 21 summarises the pond water balance and diagnostics, whilst Table 22 summarises the predicted hydraulic and nutrient balances for the effluent irrigation system. The full MEDLI output files are presented in Appendix B.

Table 21: Pond Water Balance and Diagnostics

Parameter	Springfield Feedlot (Expanded CDA)
Water Balance (ML/yr)	
Effluent Inflow (runoff)	21.16
Rainfall added	4.86
Evaporation	7.16
Irrigation	18.02
Overflow	0.48
Sludge	0.17
Pond Diagnostics	
Effluent Reuse Efficiency (%)	97
Overflow events (per 10 yrs)	0.8
Overflow days (per 10 yrs)	3.3

The modelling results for the Springfield Feedlot expanded catchment (CDA) show that under the proposed effluent reuse system, overtopping of the holding pond only occurs during extreme storm and prolonged wet events. Pond overflows occur less than once every 10 years (design criteria).

The predicted overflows are shown in Figure 10. The effluent reuse efficiency is 97%, which exceeds the 90% suggested in the NSW Environmental Guidelines: Use of Effluent by Irrigation (DEC 2004).

Table 22: Effluent Irrigation Area Water and Nutrient Balance

Parameter	Springfield Feedlot (Expanded CDA)
Water Balance (mm/yr)	
Rainfall	617
Irrigation (effluent)	15
Irrigation (clean water)	640
Runoff (rain)	71
Runoff (irrigation)	0
Drainage	16
Nutrient Application and Losses (kg/ha/yr)	
N applied via effluent	103
N removed by crop harvest	108
N Denitrified	<1
N Leached	<0.1
P applied via effluent	10
P removed by crop harvest	10
P Sorbed (safely stored)	0
P Leached	0

NB: All data are means over 100-year simulation period.

The annual effluent irrigation volume applied is just 15 mm/yr, which is very low. This is because of the large pivot that is currently utilised for irrigated cropping. The predicted deep drainage rate is 16 mm and predicted runoff is estimated to be 71 mm/yr. There is no runoff due to effluent application. The predicted runoff and deep drainage are low due to deficit irrigation and are similar to background values (no irrigation).

The annual average nitrogen loading rate is estimated at just 103 kg/ha/yr and leached nitrogen is predicted to be <0.1 kg/ha/yr. The nitrogen predicted to be removed through crop production is higher than that applied. Almost certainly, the crop will be nitrogen stressed and additional applications of inorganic nitrogen will be required (as is typically agronomic practice).

The average annual phosphorus loading rate is just 10 kg/ha/yr, with approximately 10 kg/ha/yr utilised by the crop. It is predicted that no phosphorus leaching should occur. This is due to good phosphorus adsorption capacities measured at the site, and the low applications through effluent.

The modelling predicts that a minimum 20 ML holding pond is required for acceptable holding pond overflows. The full MEDLI output files are located in Appendix B.

In summary, the hydraulic and nutrient balance modelling of the proposed feedlot effluent reuse system at the Springfield Feedlot site is considered sustainable, because predicted overtopping of the holding pond occurs very infrequently, the reuse efficiency target is exceeded, the nutrient applications through effluent are exceeded by the predicted removal rates; there is no runoff caused by irrigation applications and the predicted deep drainage does not result in excessive leaching losses of nutrients.

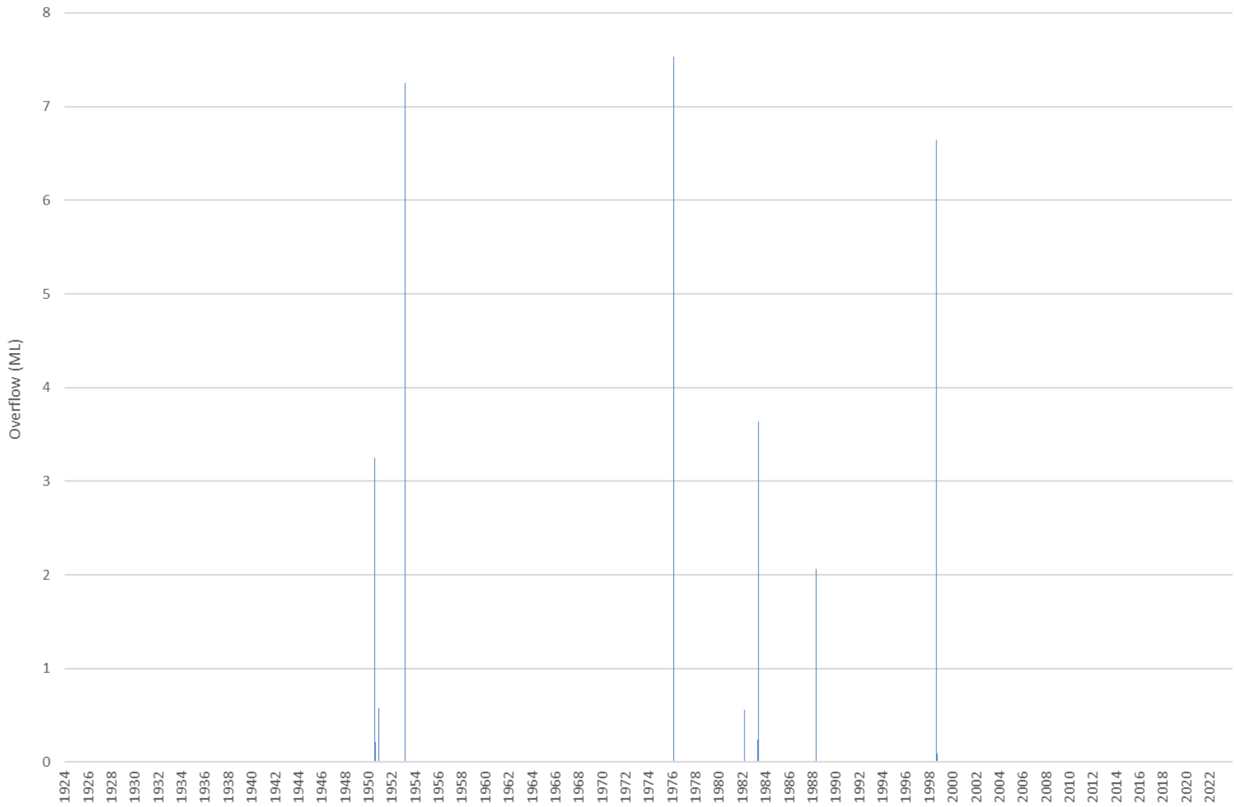


Figure 10: Expanded Catchment (CDA) Pond Overflows

6 Summary

The sustainable utilisation of effluent can be accommodated on the existing effluent utilisation area on the subject land with allowance for additional holding pond capacity and utilisation of the current irrigation infrastructure. Our main conclusions are listed below.

1. The subject land is appropriate and soil types along with historic cropping regime is suitable for the reuse of effluent and manure generated at the site.

2. MEDLI modelling of the effluent reuse system shows overtopping of the proposed 20 ML holding pond only occurs during extreme events. The target effluent reuse efficiency of 90% is far exceeded and the overflow frequency (<1 in 10 years) is achieved.

3. The hydraulic and nutrient balance modelling of the proposed feedlot effluent utilisation system is considered sustainable, because the nutrient applications through effluent are exceeded by the predicted removal rates (including safe storage); there is no runoff cause by irrigation and the predicted deep drainage does not result in excessive leaching losses of nutrients. The hydraulic and nutrient loads are considered very low.

4. The environmental impacts from the reuse of effluent and manure applied to land on the subject land is considered entirely manageable with good management practices and ongoing monitoring.

7 References

DEC 2004, *Use of Effluent by Irrigation; Environmental Guidelines*, Department of Environment and Conservation (DEC), New South Wales Government, Sydney.

Hazelton PA and Murphy BW 2016, *Interpreting Soil Test Results - What Do All The Numbers Mean? f*. CSIRO Publishing, Collingwood VIC. ISBN: 9781486303984

Northcote, K. H., and Skene, J. K. M. (1972). Australian soils with saline and sodic properties. CSIRO Australia, Soil Publication No. 27, Canberra.

OEH 2012 The Land and Soil Capability Scheme—a general rural land evaluation scheme for NSW. Technical Report. Office of Environment and Heritage NSW, Sydney.

Office of Environment and Heritage, 2015, *Soil and Land Resources of the Moree Plains*, NSW Office of Environment and Heritage, Sydney.

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Appendix A: Soil Analysis Results

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974
Analysis requested by Justin Galloway. Your Job: 20229
PO Box 237 NAMBOUR QLD 4560

			Sample 1	Sample 2	Sample 3	Sample 4
		Sample ID:	20229/ TP1/ 0-20cm	20229/ TP1/ 20-40cm	20229/ TP1/ 40-70cm	20229/ TP1/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
Parameter		**Method reference**	**R6974/1**	**R6974/2**	**R6974/3**	**R6974/4**
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	2,921	4,090	1,859	5,969
Soluble Magnesium (mg/kg)			640	762	742	1,037
Soluble Potassium (mg/kg)			56	38	<25	<25
Soluble Phosphorus (mg/kg)			3.5	2.3	2.2	2.1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	20	2.2	1.5	1.5
		**Rayment & Lyons 2011 - 9B2 (Colwell)	29	9.8	2.6	2.0
		**Inhouse S3A (Bray 2)	36	8.4	6.8	8.8
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	15	49	30	18
Ammonium Nitrogen (mg/kg N)			2.9	2.2	2.0	1.8
Sulfur (mg/kg S)			10	12	12	51
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.58	8.70	9.03	9.37
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.169	0.283	0.295	0.573
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.7	2.4	1.7	1.6
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	30	28	22	25
	(kg/ha)		13,282	12,396	9,970	11,186
	(mg/kg)		5,930	5,534	4,451	4,994
Exchangeable Magnesium	(cmol+/kg)		13	15	20	22
	(kg/ha)		3,670	4,044	5,311	6,111
	(mg/kg)		1,638	1,805	2,371	2,728
Exchangeable Potassium	(cmol+/kg)		0.70	0.37	0.31	0.37
	(kg/ha)		615	321	272	325
	(mg/kg)		275	143	121	145
Exchangeable Sodium	(cmol+/kg)		1.4	2.5	5.6	8.7
	(kg/ha)		726	1,289	2,885	4,493
	(mg/kg)		324	576	1,288	2,006
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.02	0.02	<0.01	<0.01
	(kg/ha)		5.0	4.8	1.5	1.8
	(mg/kg)		2.2	2.1	<1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	45	45	48	56
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	65	61	47	44
Magnesium (%)			30	33	41	40
Potassium (%)			1.6	0.81	0.65	0.66
Sodium - ESP (%)			3.1	5.5	12	15
Aluminium (%)			0.05	0.05	0.02	0.02
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	2.2	1.9	1.1	1.1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Parameter	Method reference	Sample 1	Sample 2	Sample 3	Sample 4
	Sample ID:	20229/ TP1/ 0-20cm	20229/ TP1/ 20-40cm	20229/ TP1/ 40-70cm	20229/ TP1/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
		R6974/1	R6974/2	R6974/3	R6974/4
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.60	<0.5	<0.5	<0.5
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	3.4	3.2	1.5	1.7
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	14	10	11	12
Copper (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.79	0.48	0.67	0.60
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.43	0.27	0.35	0.79
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	37	22	22	5.2
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.5	1.4	0.99	0.90
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.11	0.10	0.07	0.06
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	13	14	14	16
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour	**Inhouse S65	Black	Black	Black	Black
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	108	181	189	367
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	164	194	128	189

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer SCU.edu.au/eal).
17. This report was issued on 5/08/2024.

Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

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Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal

ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229

PO Box 237 NAMBOUR QLD 4560

			Sample 5	Sample 6	Sample 7	Sample 8
		Sample ID:	20229/ TP6/ 0-20cm	20229/ TP6/ 20-40cm	20229/ TP6/ 40-70cm	20229/ TP6/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
Parameter		**Method reference**	**R6974/5**	**R6974/6**	**R6974/7**	**R6974/8**
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	5,464	6,519	8,844	6,289
Soluble Magnesium (mg/kg)		**Inhouse S10 - Morgan 1	446	674	1,219	1,180
Soluble Potassium (mg/kg)		**Inhouse S10 - Morgan 1	84	25	30	37
Soluble Phosphorus (mg/kg)		**Inhouse S10 - Morgan 1	1.9	1.8	<1	<1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	3.6	2.5	1.1	<1
		**Rayment & Lyons 2011 - 9B2 (Colwell)	13	3.0	2.3	1.3
		**Inhouse S3A (Bray 2)	19	9.1	5.8	8.0
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	53	7.6	12	5.6
Ammonium Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	16	2.6	2.3	2.7
Sulfur (mg/kg S)		**Inhouse S37 (KCl)	4.2	8.1	4.7	3.5
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.10	8.49	8.69	8.87
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.207	0.145	0.184	0.212
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	4.2	3.1	2.8	2.5
Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	36	39	39	31
	(kg/ha)		16,338	17,707	17,360	13,856
	(mg/kg)		7,294	7,905	7,750	6,186
Exchangeable Magnesium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	7.9	14	19	19
	(kg/ha)		2,159	3,690	5,074	5,148
	(mg/kg)		964	1,647	2,265	2,298
Exchangeable Potassium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	1.1	0.57	0.62	0.61
	(kg/ha)		980	501	542	533
	(mg/kg)		438	224	242	238
Exchangeable Sodium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	0.38	0.48	1.4	2.4
	(kg/ha)		194	248	739	1,256
	(mg/kg)		87	111	330	561
Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	0.02	0.02	0.01	0.02
	(kg/ha)		3.9	3.8	2.6	3.4
	(mg/kg)		1.7	1.7	1.2	1.5
Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	46	54	59	53
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	79	73	65	58
Magnesium (%)			17	25	31	36
Potassium (%)			2.4	1.1	1.0	1.2
Sodium - ESP (%)			0.82	0.89	2.4	4.6
Aluminium (%)			0.04	0.03	0.02	0.03
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	4.6	2.9	2.1	1.6

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974

Analysis requested by Justin Galloway. Your Job: 20229

PO Box 237 NAMBOUR QLD 4560

		Sample 5	Sample 6	Sample 7	Sample 8
	Sample ID:	20229/ TP6/ 0-20cm	20229/ TP6/ 20-40cm	20229/ TP6/ 40-70cm	20229/ TP6/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
Parameter	**Method reference**	**R6974/5**	**R6974/6**	**R6974/7**	**R6974/8**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	<0.5	<0.5	<0.5
Manganese (mg/kg)		7.5	4.1	3.4	3.3
Iron (mg/kg)		10	14	16	18
Copper (mg/kg)		0.80	0.99	0.91	0.95
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.26	0.11	0.22	0.47
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	21	1.5	1.5	2.4
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.4	1.8	1.6	1.4
Total Nitrogen (%)		0.17	0.10	0.09	0.07
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14	17	18	19
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour		Brownish	Brownish	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	132	93	118	136
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	381	521	506	487

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_c/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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17. This report was issued on 5/08/2024.

Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

Southern Cross University

CRICOS Provider: 01241G

Environmental Analysis Laboratory

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229

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Parameter	Unit	Method reference	Sample 9	Sample 10	Sample 11	Sample 12
		Sample ID:	20229/ TP9/ 0-20cm	20229/ TP9/ 20-40cm	20229/ TP9/ 40-70cm	20229/ TP9/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
			R6974/9	R6974/10	R6974/11	R6974/12
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1,843	2,931	2,553	7,019
Soluble Magnesium (mg/kg)		**Inhouse S10 - Morgan 1	365	464	591	825
Soluble Potassium (mg/kg)		**Inhouse S10 - Morgan 1	<25	<25	<25	40
Soluble Phosphorus (mg/kg)		**Inhouse S10 - Morgan 1	1.4	<1	<1	1.6
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	5.0	1.6	1.7	2.7
		**Rayment & Lyons 2011 - 9B2 (Colwell)	7.9	4.3	2.3	3.0
		**Inhouse S3A (Bray 2)	21	3.7	3.3	7.8
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	5.5	1.4	0.66	0.62
Ammonium Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	4.0	2.1	1.6	2.3
Sulfur (mg/kg S)		**Inhouse S37 (KCl)	1.5	<1	4.2	6.2
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	7.83	8.46	8.79	9.14
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.083	0.111	0.119	0.206
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.2	2.3	1.8	1.7
Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	30	35	30	37
	(kg/ha)		13,558	15,734	13,641	16,795
	(mg/kg)		6,053	7,024	6,090	7,498
Exchangeable Magnesium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	7.8	9.9	12	16
	(kg/ha)		2,111	2,684	3,358	4,436
	(mg/kg)		942	1,198	1,499	1,980
Exchangeable Potassium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	0.43	0.35	0.31	0.37
	(kg/ha)		374	303	270	324
	(mg/kg)		167	135	121	145
Exchangeable Sodium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	0.48	0.89	1.7	3.5
	(kg/ha)		246	457	856	1,796
	(mg/kg)		110	204	382	802
Exchangeable Aluminium	(cmol$_+$/kg)	**Inhouse S37 (KCl)	0.01	0.02	0.02	0.01
	(kg/ha)		2.2	4.3	4.4	2.5
	(mg/kg)		<1	1.9	2.0	1.1
Exchangeable Hydrogen	(cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	39	46	45	58
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	78	76	68	65
Magnesium (%)			20	21	28	28
Potassium (%)			1.1	0.75	0.69	0.64
Sodium - ESP (%)			1.2	1.9	3.7	6.1
Aluminium (%)			0.03	0.05	0.05	0.02
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	3.9	3.6	2.5	2.3

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by Justin Galloway. Your Job: 20229

PO Box 237 NAMBOUR QLD 4560

		Sample 9	Sample 10	Sample 11	Sample 12
	Sample ID:	20229/ TP9/ 0-20cm	20229/ TP9/ 20-40cm	20229/ TP9/ 40-70cm	20229/ TP9/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
Parameter	**Method reference**	**R6974/9**	**R6974/10**	**R6974/11**	**R6974/12**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	<0.5	<0.5	<0.5
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	7.5	2.2	2.3	2.4
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	8.5	6.4	9.8	14
Copper (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.40	0.35	0.43	0.49
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.30	0.14	0.13	<0.1
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	57	54	21	5.3
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.3	1.3	1.1	0.98
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.09	0.07	0.06	0.04
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	13	18	17	26
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour	**Inhouse S65	Black	Black	Black	Black
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	53	71	76	132
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	131	208	220	214

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_c/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
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Quality Checked: Kris Saville
Agricultural Co-Ordinator
KS

CRICOS Provider: 01241G

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Parameter		Method reference	Sample 13	Sample 14	Sample 15	Sample 16
		Sample ID:	20229/ TP11/ 0-20cm	20229/ TP11/ 20-40cm	20229/ TP11/ 40-70cm	20229/ TP11/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
Parameter		Method reference	R6974/13	R6974/14	R6974/15	R6974/16
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	2,756	2,217	11,594	9,344
Soluble Magnesium (mg/kg)			142	197	364	449
Soluble Potassium (mg/kg)			94	28	41	32
Soluble Phosphorus (mg/kg)			11	<1	<1	<1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	22	3.7	<1	<1
		**Rayment & Lyons 2011 - 9B2 (Colwell)	33	4.9	5.9	3.3
		**Inhouse S3A (Bray 2)	74	4.7	9.8	4.1
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	12	10	14	8.2
Ammonium Nitrogen (mg/kg N)			1.7	1.3	1.3	1.5
Sulfur (mg/kg S)			7.7	5.3	<1	7.4
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.20	8.30	8.53	8.83
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.108	0.096	0.136	0.119
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.3	1.2	2.2	1.8
Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	19	20	28	27
	(kg/ha)		8,458	9,184	12,389	11,917
	(mg/kg)		3,776	4,100	5,531	5,320
Exchangeable Magnesium	(cmol$_+$/kg)		2.1	2.9	3.0	4.3
	(kg/ha)		582	788	828	1,178
	(mg/kg)		260	352	369	526
Exchangeable Potassium	(cmol$_+$/kg)		0.91	0.47	0.38	0.30
	(kg/ha)		796	413	334	263
	(mg/kg)		356	184	149	117
Exchangeable Sodium	(cmol$_+$/kg)		0.18	0.14	0.13	0.14
	(kg/ha)		95	71	67	70
	(mg/kg)		42	32	30	31
Exchangeable Aluminium	(cmol$_+$/kg)	**Inhouse S37 (KCl)	0.01	0.01	<0.01	0.01
	(kg/ha)		2.7	2.1	1.1	2.3
	(mg/kg)		1.2	<1	<1	1.0
Exchangeable Hydrogen	(cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	22	24	31	31
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	85	85	89	85
Magnesium (%)			9.7	12	9.8	14
Potassium (%)			4.1	2.0	1.2	0.96
Sodium - ESP (%)			0.83	0.58	0.42	0.43
Aluminium (%)			0.06	0.04	0.02	0.04
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	8.8	7.1	9.1	6.1

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229

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		Sample 13	Sample 14	Sample 15	Sample 16
	Sample ID:	20229/ TP11/ 0-20cm	20229/ TP11/ 20-40cm	20229/ TP11/ 40-70cm	20229/ TP11/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
Parameter	**Method reference**	**R6974/13**	**R6974/14**	**R6974/15**	**R6974/16**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	1.1	<0.5	<0.5	<0.5
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	7.7	2.9	2.9	0.94
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	6.1	6.3	4.9	3.5
Copper (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.52	0.31	0.27	<0.1
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.43	0.55	0.26	0.37
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	56	33	19	60
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.3	0.71	1.3	1.0
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.08	0.17	0.05	0.03
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	16	4.2	24	35
Basic Texture	**Inhouse S65	Clay Loam	Clay	Clay	Clay
Basic Colour	**Inhouse S65	Brownish	Red	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	69	61	87	76
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	146	274	236	90

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
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Quality Checked: Kris Saville
Agricultural Co-Ordinator KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Parameter		Method reference	Sample 17	Sample 18	Sample 19	Sample 20
		Sample ID:	20229/ TP13/ 0-20cm	20229/ TP13/ 20-40cm	20229/ TP13/ 40-70cm	20229/ TP13/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
			R6974/17	R6974/18	R6974/19	R6974/20
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	5,214	7,879	8,784	6,304
Soluble Magnesium (mg/kg)			651	850	1,106	990
Soluble Potassium (mg/kg)			126	<25	<25	<25
Soluble Phosphorus (mg/kg)			3.4	<1	<1	<1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	13	1.5	1.3	1.6
		**Rayment & Lyons 2011 - 9B2 (Colwell)	24	3.0	2.0	1.3
		**Inhouse S3A (Bray 2)	90	7.0	5.0	9.3
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	18	8.1	13	1.8
Ammonium Nitrogen (mg/kg N)			2.1	1.8	3.1	2.5
Sulfur (mg/kg S)			31	16	25	43
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.58	9.03	9.13	9.28
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.265	0.268	0.398	0.518
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.4	1.7	1.7	0.96
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	31	32	28	27
	(kg/ha)		13,968	14,381	12,629	12,038
	(mg/kg)		6,236	6,420	5,638	5,374
Exchangeable Magnesium	(cmol+/kg)		10	12	13	15
	(kg/ha)		2,782	3,298	3,560	4,005
	(mg/kg)		1,242	1,472	1,589	1,788
Exchangeable Potassium	(cmol+/kg)		1.0	0.39	0.30	0.31
	(kg/ha)		914	338	265	270
	(mg/kg)		408	151	118	120
Exchangeable Sodium	(cmol+/kg)		1.6	3.3	5.2	8.5
	(kg/ha)		804	1,719	2,670	4,352
	(mg/kg)		359	767	1,192	1,943
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.02	0.01	0.01	0.02
	(kg/ha)		3.1	2.5	3.0	4.0
	(mg/kg)		1.4	1.1	1.3	1.8
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	44	48	47	50
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	71	67	60	53
Magnesium (%)			23	25	28	29
Potassium (%)			2.4	0.81	0.65	0.61
Sodium - ESP (%)			3.6	7.0	11	17
Aluminium (%)			0.04	0.03	0.03	0.04
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	3.0	2.6	2.2	1.8

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974

Analysis requested by Justin Galloway. Your Job: 20229

PO Box 237 NAMBOUR QLD 4560

Parameter	Method reference	Sample 17	Sample 18	Sample 19	Sample 20
	Sample ID:	20229/ TP13/ 0-20cm	20229/ TP13/ 20-40cm	20229/ TP13/ 40-70cm	20229/ TP13/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
		R6974/17	R6974/18	R6974/19	R6974/20
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	3.1	<0.5	<0.5	<0.5
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	6.2	2.9	3.2	3.8
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	11	15	15	11
Copper (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.58	0.47	0.62	0.55
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.53	0.30	0.81	1.7
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	25	4.2	3.5	8.1
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.4	0.97	0.97	0.55
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.10	0.07	0.06	<0.02
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14	14	15	37
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour	**Inhouse S65	Brownish	Brownish	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	170	172	255	332
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	262	280	288	210

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_c/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229

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Parameter		Method reference	Sample 21	Sample 22	Sample 23	Sample 24
		Sample ID:	20229/ TP15/ 0-20cm	20229/ TP15/ 20-40cm	20229/ TP15/ 40-70cm	20229/ TP15/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
			R6974/21	R6974/22	R6974/23	R6974/24
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	3,249	7,919	7,939	7,814
Soluble Magnesium (mg/kg)			803	1,093	1,266	1,337
Soluble Potassium (mg/kg)			58	28	<25	26
Soluble Phosphorus (mg/kg)			<1	<1	<1	<1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	3.9	1.3	1.8	1.1
		**Rayment & Lyons 2011 - 9B2 (Colwell)	8.9	2.0	<1	2.3
		**Inhouse S3A (Bray 2)	16	11	7.9	9.3
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	7.2	7.5	11	5.8
Ammonium Nitrogen (mg/kg N)			2.6	1.6	1.7	2.4
Sulfur (mg/kg S)			10	21	47	49
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	8.71	8.97	9.20	9.34
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.196	0.277	0.432	0.540
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.6	2.3	1.7	1.6
Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	31	29	25	25
	(kg/ha)		13,724	12,960	11,200	11,097
	(mg/kg)		6,127	5,786	5,000	4,954
Exchangeable Magnesium	(cmol+/kg)		13	15	17	18
	(kg/ha)		3,560	4,147	4,727	4,989
	(mg/kg)		1,589	1,851	2,110	2,227
Exchangeable Potassium	(cmol+/kg)		0.89	0.53	0.49	0.51
	(kg/ha)		783	464	428	445
	(mg/kg)		349	207	191	198
Exchangeable Sodium	(cmol+/kg)		2.1	3.5	5.9	8.0
	(kg/ha)		1,079	1,826	3,053	4,119
	(mg/kg)		482	815	1,363	1,839
Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	<0.01	0.01	<0.01	<0.01
	(kg/ha)		1.8	2.3	<1	1.8
	(mg/kg)		<1	1.0	<1	<1
Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	47	48	49	52
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	66	60	51	48
Magnesium (%)			28	32	36	36
Potassium (%)			1.9	1.1	1.0	0.98
Sodium - ESP (%)			4.5	7.4	12	16
Aluminium (%)			0.02	0.02	0.00	0.02
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	2.3	1.9	1.4	1.3

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974

Analysis requested by Justin Galloway. Your Job: 20229

PO Box 237 NAMBOUR QLD 4560

		Sample 21	Sample 22	Sample 23	Sample 24
	Sample ID:	20229/ TP15/ 0-20cm	20229/ TP15/ 20-40cm	20229/ TP15/ 40-70cm	20229/ TP15/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
Parameter	**Method reference**	**R6974/21**	**R6974/22**	**R6974/23**	**R6974/24**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	<0.5	<0.5	<0.5
Manganese (mg/kg)		5.4	3.4	3.1	3.8
Iron (mg/kg)		19	20	18	15
Copper (mg/kg)		0.80	0.68	0.72	0.65
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.36	0.63	1.4	1.3
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	18	6.6	6.8	5.2
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.5	1.3	0.98	0.91
Total Nitrogen (%)		0.11	0.07	0.05	0.03
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14	19	18	26
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour		Brownish	Brownish	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	125	177	276	346
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	290	349	324	272

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_c/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
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Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229

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			Sample 25	Sample 26	Sample 27	Sample 28
		Sample ID:	20229/ TP17/ 0-20cm	20229/ TP17/ 20-40cm	20229/ TP17/ 40-70cm	20229/ TP17/ 70-100cm
		Crop:	Soil	Soil	Soil	Soil
		Client:	20229	20229	20229	20229
Parameter		**Method reference**	**R6974/25**	**R6974/26**	**R6974/27**	**R6974/28**
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1,359	7,389	8,954	8,264
Soluble Magnesium (mg/kg)			415	999	1,318	1,372
Soluble Potassium (mg/kg)			50	<25	<25	<25
Soluble Phosphorus (mg/kg)			<1	<1	<1	<1
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	19	5.4	2.8	1.1
		**Rayment & Lyons 2011 - 9B2 (Colwell)	35	2.0	2.3	3.0
		**Inhouse S3A (Bray 2)	26	4.3	6.6	5.4
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	5.7	2.8	3.2	3.2
Ammonium Nitrogen (mg/kg N)			3.1	1.4	1.3	1.6
Sulfur (mg/kg S)			3.8	8.0	4.4	7.8
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.87	8.78	9.14	9.32
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.046	0.175	0.274	0.336
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.7	2.0	1.9	2.3
Exchangeable Calcium	(cmol$_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	17	32	28	26
	(kg/ha)		7,721	14,459	12,380	11,825
	(mg/kg)		3,447	6,455	5,527	5,279
Exchangeable Magnesium	(cmol$_+$/kg)		8.0	13	18	19
	(kg/ha)		2,166	3,643	4,825	5,148
	(mg/kg)		967	1,626	2,154	2,298
Exchangeable Potassium	(cmol$_+$/kg)		0.74	0.49	0.48	0.45
	(kg/ha)		648	430	421	397
	(mg/kg)		289	192	188	177
Exchangeable Sodium	(cmol$_+$/kg)		0.49	1.5	3.6	4.9
	(kg/ha)		252	778	1,847	2,522
	(mg/kg)		112	347	825	1,126
Exchangeable Aluminium	(cmol$_+$/kg)	**Inhouse S37 (KCl)	0.01	0.02	0.02	0.01
	(kg/ha)		2.3	4.4	3.2	2.5
	(mg/kg)		1.0	2.0	1.4	1.1
Exchangeable Hydrogen	(cmol$_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01	<0.01	<0.01
	(kg/ha)		<1	<1	<1	<1
	(mg/kg)		<1	<1	<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	26	48	49	51
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	65	68	56	52
Magnesium (%)			30	28	36	37
Potassium (%)			2.8	1.0	0.97	0.89
Sodium - ESP (%)			1.9	3.2	7.3	9.7
Aluminium (%)			0.04	0.05	0.03	0.02
Hydrogen (%)			0.00	0.00	0.00	0.00
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol$_+$/kg)	2.2	2.4	1.6	1.4

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Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

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Analysis requested by Justin Galloway. Your Job: 20229

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		Sample 25	Sample 26	Sample 27	Sample 28
	Sample ID:	20229/ TP17/ 0-20cm	20229/ TP17/ 20-40cm	20229/ TP17/ 40-70cm	20229/ TP17/ 70-100cm
	Crop:	Soil	Soil	Soil	Soil
	Client:	20229	20229	20229	20229
Parameter	**Method reference**	**R6974/25**	**R6974/26**	**R6974/27**	**R6974/28**
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.83	<0.5	<0.5	<0.5
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	35	4.1	2.5	1.6
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	30	16	17	13
Copper (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	1.0	0.62	0.83	0.73
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.62	0.46	0.84	1.9
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	102	5.8	<1	2.3
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.5	1.1	1.1	1.3
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.13	0.07	0.04	0.06
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	12	16	31	21
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay
Basic Colour	**Inhouse S65	Brownish	Brownish	Brownish	Brownish
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	29	112	175	215
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)	216	433	475	446

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_c/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
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Agricultural Co-Ordinator

KS

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

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Analysis requested by Justin Galloway. Your Job: 20229
PO Box 237 NAMBOUR QLD 4560

Sample ID:
Crop:
Client:

Parameter		Method reference
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1
Soluble Magnesium (mg/kg)		
Soluble Potassium (mg/kg)		
Soluble Phosphorus (mg/kg)		
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1) **Rayment & Lyons 2011 - 9B2 (Colwell) **Inhouse S3A (Bray 2)
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)
Ammonium Nitrogen (mg/kg N)		
Sulfur (mg/kg S)		
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75
Exchangeable Calcium	(cmol+/kg) (kg/ha) (mg/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)
Exchangeable Magnesium	(cmol+/kg) (kg/ha) (mg/kg)	
Exchangeable Potassium	(cmol+/kg) (kg/ha) (mg/kg)	
Exchangeable Sodium	(cmol+/kg) (kg/ha) (mg/kg)	
Exchangeable Aluminium	(cmol+/kg) (kg/ha) (mg/kg)	**Inhouse S37 (KCl)
Exchangeable Hydrogen	(cmol+/kg) (kg/ha) (mg/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100
Magnesium (%)		
Potassium (%)		
Sodium - ESP (%)		
Aluminium (%)		
Hydrogen (%)		
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)

Southern Cross University
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P: +61 2 6620 3678
E: eal@scu.edu.au
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Analysis requested by Justin Galloway. Your Job: 20229

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Sample ID:

Crop:

Client:

Parameter	Method reference
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)
Manganese (mg/kg)	
Iron (mg/kg)	
Copper (mg/kg)	
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)
Total Nitrogen (%)	
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen
Basic Texture	**Inhouse S65
Basic Colour	
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
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10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions
17. This report was issued on 5/08/2024.

Quality Checked: Kris Saville
Agricultural Co-Ordinator

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
E: eal@scu.edu.au
www.scu.edu.au/eal
ABN: 41 995 651 524

AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974
Analysis requested by Justin Galloway. Your Job: 20229
PO Box 237 NAMBOUR QLD 4560

			Heavy Soil	Medium Soil	Light Soil	Sandy Soil
		Sample ID:				
		Crop:				
		Client:	Clay	Clay Loam	Loam	Loamy Sand
Parameter		**Method reference**	**Indicative guidelines - refer to Notes 6 and 8**			
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	1150	750	375	175
Soluble Magnesium (mg/kg)			160	105	60	25
Soluble Potassium (mg/kg)			113	75	60	50
Soluble Phosphorus (mg/kg)			15	12	10	5.0
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	45 note 5	30 note 5	24 note 5	20 note 5
		**Rayment & Lyons 2011 - 9B2 (Colwell)	80	50	45	35
		**Inhouse S3A (Bray 2)	90 note 5	60 note 5	48 note 5	40 note 5
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	15	13	10	10
Ammonium Nitrogen (mg/kg N)			20	18	15	12
Sulfur (mg/kg S)			10.0	8.0	8.0	7.0
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.5	6.5	6.3	6.3
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.200	0.150	0.120	0.100
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	> 5.5	>4 .5	> 3.5	> 2.5
Exchangeable Calcium	**(cmol+/kg)**	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	15.6	10.8	5.0	1.9
	(kg/ha)		7000	4816	2240	840
	(mg/kg)		3125	2150	1000	375
Exchangeable Magnesium	**(cmol+/kg)**		2.4	1.7	1.2	0.60
	(kg/ha)		650	448	325	168
	(mg/kg)		290	200	145	75
Exchangeable Potassium	**(cmol+/kg)**		0.60	0.50	0.40	0.30
	(kg/ha)		526	426	336	224
	(mg/kg)		235	190	150	100
Exchangeable Sodium	**(cmol+/kg)**		0.3	0.26	0.22	0.11
	(kg/ha)		155	134	113	57
	(mg/kg)		69	60	51	25
Exchangeable Aluminium	**(cmol+/kg)**	**Inhouse S37 (KCl)	0.6	0.5	0.4	0.2
	(kg/ha)		121	101	73	30
	(mg/kg)		54	45	32	14
Exchangeable Hydrogen	**(cmol+/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.6	0.5	0.4	0.2
	(kg/ha)		13	11	8	3
	(mg/kg)		6	5	4	2
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	20.1	14.3	7.8	3.3
Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	77.6	75.7	65.6	57.4
Magnesium (%)			11.9	11.9	15.7	18.1
Potassium (%)			3.0	3.5	5.2	9.1
Sodium - ESP (%)			1.5	1.8	2.9	3.3
Aluminium (%) **Hydrogen (%)**			6.0	7.1	10.5	12.1
Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	6.5	6.4	4.2	3.2

Southern Cross University

CRICOS Provider: 01241G

Southern Cross University
PO Box 157 Lismore NSW 2480
P: +61 2 6620 3678
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AGRICULTURAL SOIL ANALYSIS REPORT

32 samples supplied by JG Environmental Pty Ltd on 26/07/2024. Lab Job No.R6974
Analysis requested by Justin Galloway. Your Job: 20229
PO Box 237 NAMBOUR QLD 4560

		Heavy Soil	Medium Soil	Light Soil	Sandy Soil
Sample ID:					
Crop:					
Client:		Clay	Clay Loam	Loam	Loamy Sand
Parameter	**Method reference**	**Indicative guidelines - refer to Notes 6 and 8**			
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	6.0	5.0	4.0	3.0
Manganese (mg/kg)		25	22	18	15
Iron (mg/kg)		25	22	18	15
Copper (mg/kg)		2.4	2.0	1.6	1.2
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	2.0	1.7	1.4	1.0
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	50	45	40	35
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	> 3.1	> 2.6	> 2.0	> 1.4
Total Nitrogen (%)		> 0.30	> 0.25	> 0.20	> 0.15
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	10–12	10–12	10–12	10–12
Basic Texture	**Inhouse S65	..	..	..	..
Basic Colour		..	..	..	..
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	..	..	..	..
Phosphorus Sorption (mg P/kg)	**Inhouse S18b (Based on Abbott 1985)				

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.* CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013, Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium, 122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
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Quality Checked: Kris Saville
Agricultural Co-Ordinator

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

Algorithms from HSPF (Johnson et al., 1984) and described fully in the MEDLI Version 2.0 Manual

Excel version by Alison Vieritz, NRS, NR&M [09/2002]

1 Colwell P

Analyse the sample for sodium bicarbonate extractable P (Colwell-P) in a solution to soil mixture. Enter the Colwell P in mg/kg solution and the solution to soil ratio used.

2 Isotherm Data

P sorption curve is performed on dried (40oC) soil samples ground to <2mm. The soil is then equilibrated with a solution containing 0.01 M CaCl2 and phosphorus (added as KH2PO4) ranging in concentration from 20 to 1600 mgP/kg (six data points on the curve). A soil to solution ratio of 1:10 is used and each sample is shaken end-over-end at 30 rpm for 18 hr at 25oC, before centrifuging at 2000 g for 30 minutes. The supernatant solution P concentration is then read by Auto Analyser using the procedure of Warrell and Moody (1984). This measure is then used to calculate the amount of extra phosphorus (mg/kg) that can be adsorbed by the soil at each equilibrium solution P concentration (Padded ads). For each equilibrium solution P concentration (mg/L):

Total sorbed P (mg/kg) = $P_{added\ ads}$ + Colwell-P

3 Linear regression of Ln(X) and Ln(Y)

The X (P Equilibrium concentration in mg/L) and Y (P sorbed in mg/kg) data is then fitted to the equation:

$Y = AX^B$ by linear regression of Ln(Y) = aLn(X) + b

where b = Ln(A) and a=B.

A = MEDLI adsorption coefficient

B = MEDLI adsorption exponent

Check the fit shown by the graph.

4 MEDLI Parameters

The MEDLI adsorption coefficient, adsorption exponent, desorption exponent are then estimated. In the absence of a desorption isotherm the desorption exponent is assumed to be 95% of the adsorption exponent to allow conservatively a very minor hysteresis effect.

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

Input data in white cells only

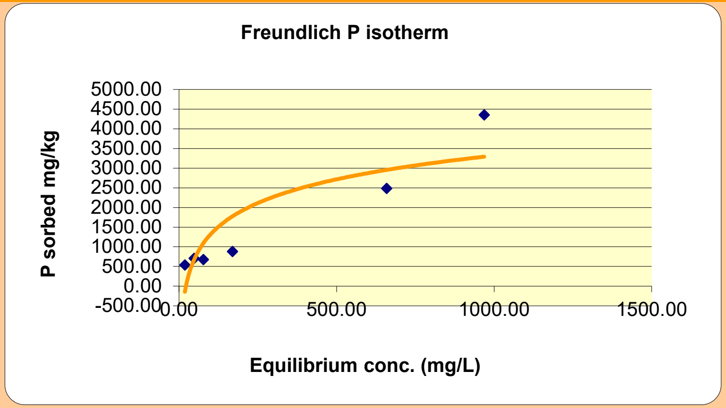
1 Colwell P

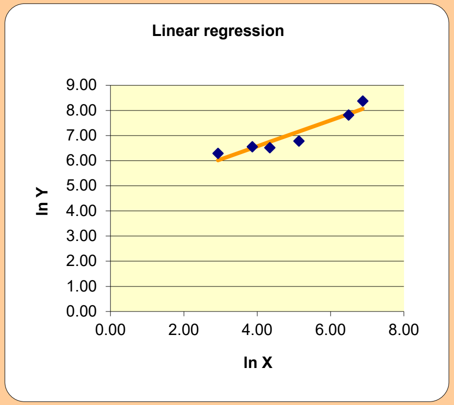
Colwell P mg/kg solution	Solution:soil ratio
20.99	10

R6974/29
20229/ MEDLI/ 0-20cm

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
51.68	18.74	539.32
97.49	47.84	706.42
123.70	77.20	674.92
237.20	169.90	882.92
886.60	659.20	2483.92
1383.00	968.40	4355.92





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.5184	4.4960	Equation is y = 0.5184x + 4.4960	0.8929

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	89.66
Adsorption Exponent (B)	0.5184
Desorption Exponent	0.4925

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	51.68	0.96749226
100	97.49	1.02574623
250	123.70	2.021018593
500	237.20	2.107925801
1000	886.60	1.127904354
1500	1383.00	1.084598698
	avg	1.389114323

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

Input data in white cells only

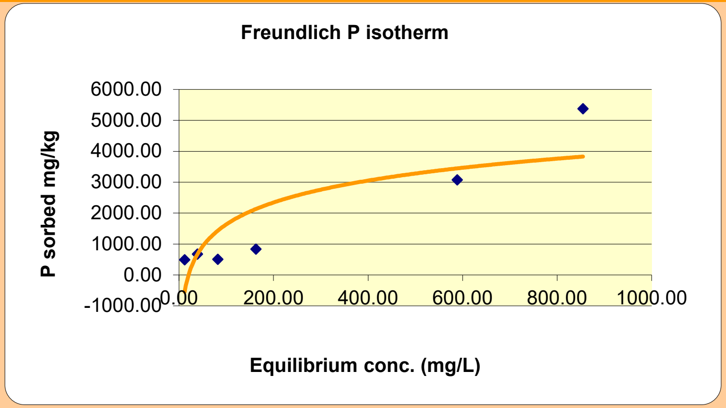
1 Colwell P

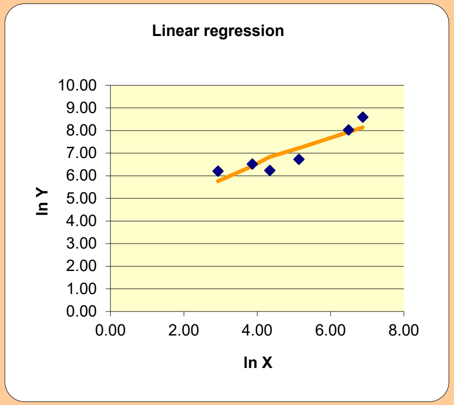
Colwell P mg/kg solution	Solution:soil ratio
9.51	10

R6974/30
20229/ MEDLI/ 20-40cm

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
51.68	11.88	493.12
97.49	39.17	678.32
123.70	82.20	510.12
237.20	162.95	837.62
886.60	588.60	3075.12
1383.00	854.70	5378.12





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.5561	4.3843	Equation is y = 0.5561x + 4.3843	0.8011

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**80.18**
Adsorption Exponent (B)	**0.5561**
Desorption Exponent	**0.5283**

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	51.68	0.96749226
100	97.49	1.02574623
250	123.70	2.021018593
500	237.20	2.107925801
1000	886.60	1.127904354
1500	1383.00	1.084598698
	avg	1.389114323

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

Input data in white cells only

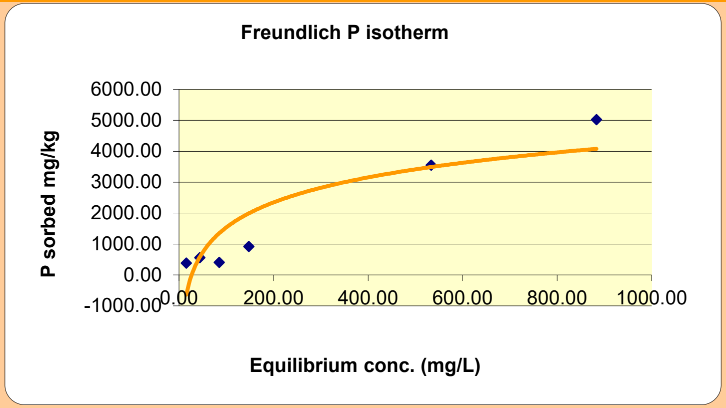
1 Colwell P

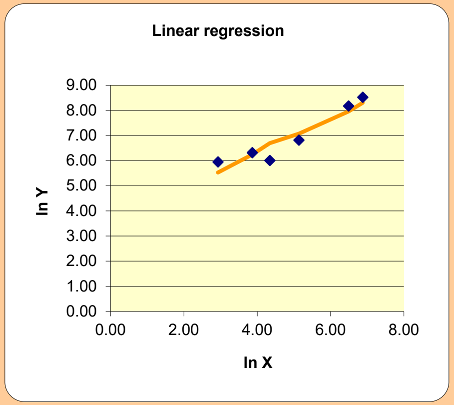
Colwell P mg/kg solution	Solution:soil ratio
2.30	10

R6974/31
20229/ MEDLI/ 40-70cm

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
51.68	15.50	384.76
97.49	43.99	557.96
123.70	85.10	408.96
237.20	147.50	919.96
886.60	533.70	3551.96
1383.00	883.10	5021.96





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.6860	3.6501	Equation is y = 0.6860x + 3.6501	0.8701

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	**38.48**
Adsorption Exponent (B)	**0.6860**
Desorption Exponent	**0.6517**

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	51.68	0.96749226
100	97.49	1.02574623
250	123.70	2.021018593
500	237.20	2.107925801
1000	886.60	1.127904354
1500	1383.00	1.084598698
	avg	1.389114323

MEDLI P ADSORPTION ISOTHERM PARAMETER CALCULATOR

Input data in white cells only

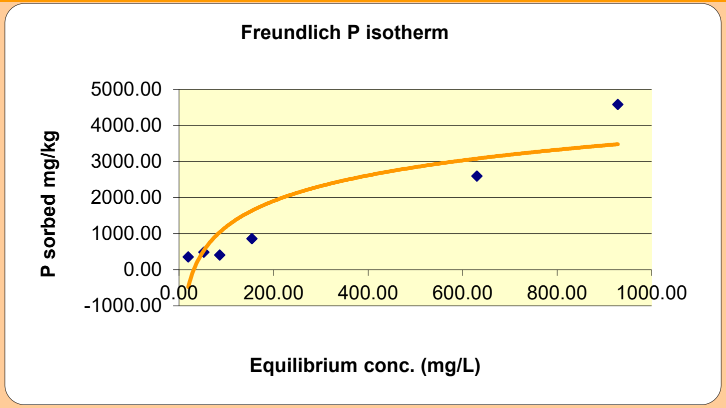
1 Colwell P

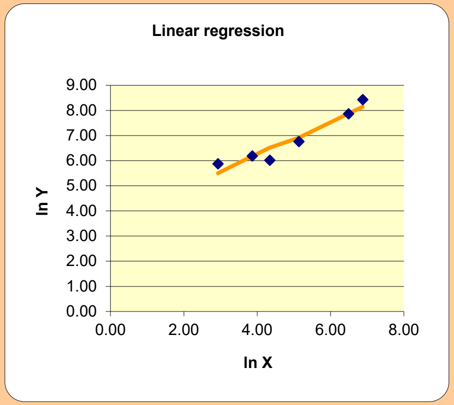
Colwell P mg/kg solution	Solution:soil ratio
3.61	10

R6974/32
20229/ MEDLI/ 70-100cm

2 Isotherm Data

Std Conc mg/L	Equil Conc mg/L X	P Sorbed mg/kg Y
51.68	19.58	357.08
97.49	52.56	485.38
123.70	86.25	410.58
237.20	154.35	864.58
886.60	630.00	2602.08
1383.00	928.40	4582.08





3 Linear regression of Ln(X) and Ln(Y)

The linear regression equation uses the form y=ax+b

a	b		r^2
0.6846	3.4658	Equation is y = 0.6846x + 3.4658	0.9115

4 MEDLI Parameters

MEDLI's isotherm equation $Y=AX^B$ is shown on the graph above.

Adsorption Coefficient (A)	32.00
Adsorption Exponent (B)	0.6846
Desorption Exponent	0.6504

Example 1 Orig soln	Soln dilution	soln:soil ratio ?
50	51.68	0.96749226
100	97.49	1.02574623
250	123.70	2.021018593
500	237.20	2.107925801
1000	886.60	1.127904354
1500	1383.00	1.084598698
	avg	1.389114323

REFERENCES

Johnson, R.C., J.C. Imhoff, J.L. Kittle and A.S. Donigan (1984). Hydrological Simulation Program - Fortran (HSPF):

Warrell, LA, and Moody, PW (1984). Automated determination of micro amounts of phosphate in dilute calcium chloride extracts of soils. Commun. Soil Sci. Plant Anal. **v** 15, *pp* 779-85.

Appendix B: MEDLI Output File

General Information

SCENARIO REPORT: Full run

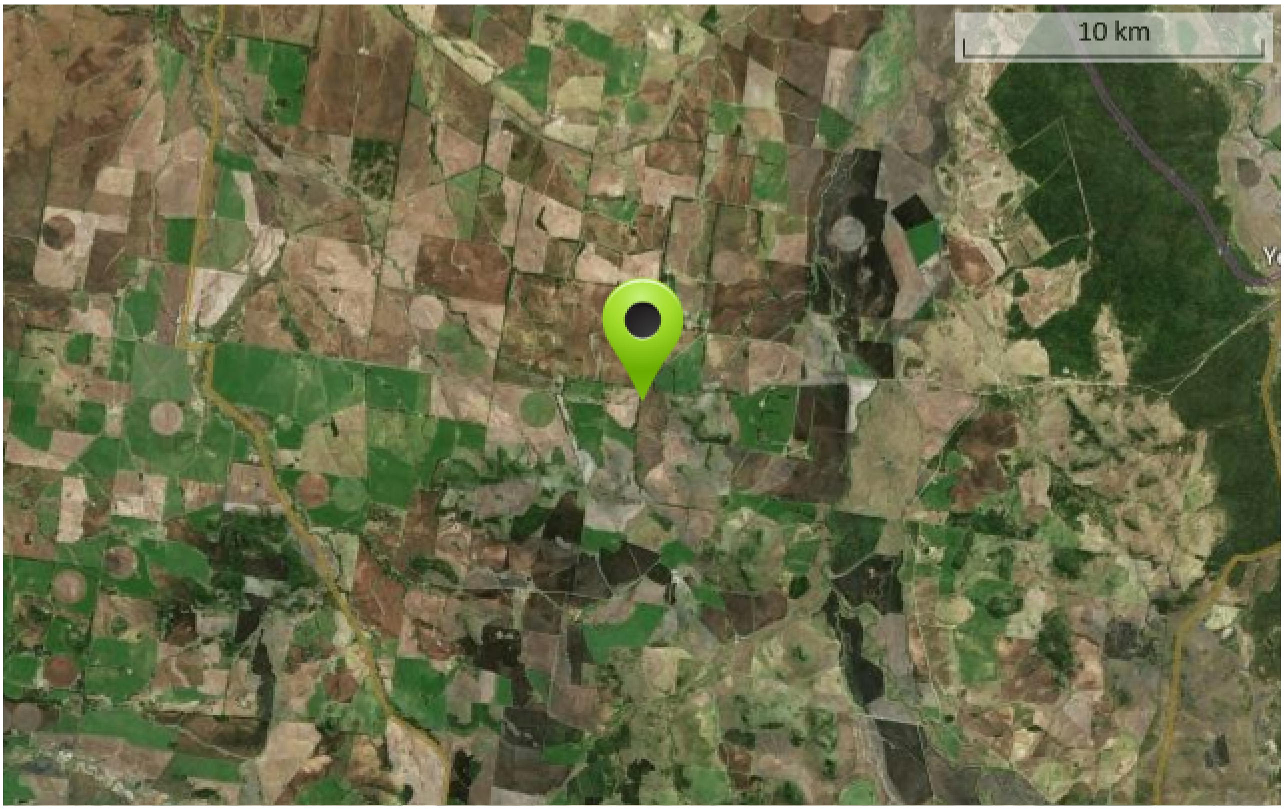
General information
Enterprise: Springfield Feedlot
Client: RDC Engineers
MEDLI user: JG

Description:
Stage 3

Scenario details:
3000 Head

Map of location:

Note: If the map above appears as a dark box, check that the network is accessible and that the coordinates are not for a location in the ocean.



Description

Climate information

Climate Data Location: Springfield -28.95 150.55, -28.95°, 150.55°

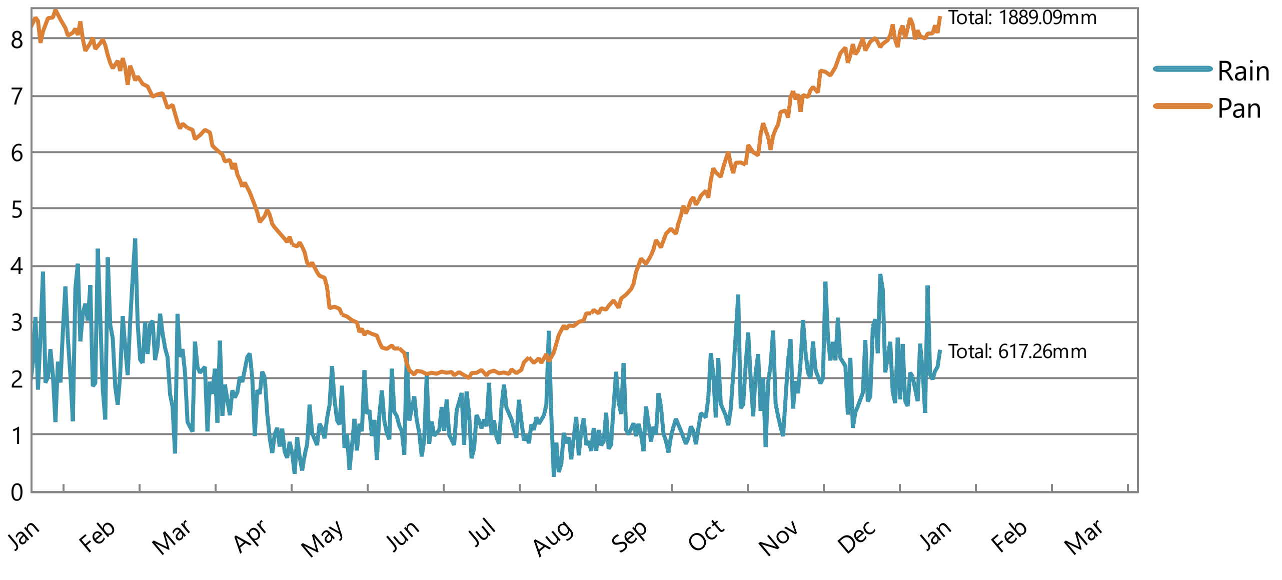
Run Period: 01/01/1924 to 31/12/2023 (100 years)

Climate statistics

	5th Percentile		50th Percentile		95th Percentile	
Rainfall (mm/year)	(Year 1957)	411.4	(Year 2020)	598.6	(Year 1956)	869.4
Pan evaporation (mm/year)	(Year 1978)	1618.5	(Year 1972)	1872.4	(Year 2009)	2129.2

Climate data

Daily average across run period:



Description

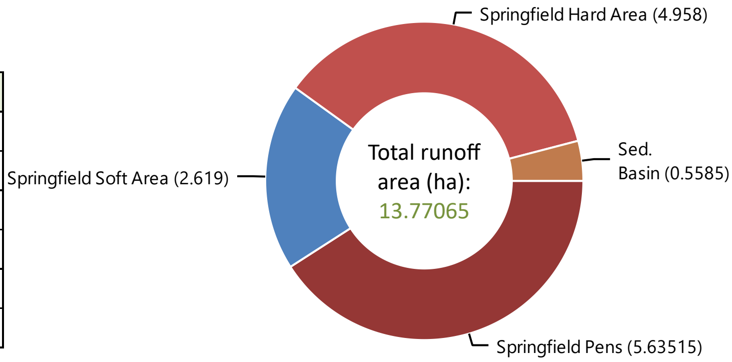
Livestock yard information

Enterprise Name: Springfield Feedlot

Design of cattle feedlot

Name	Value
Maximum capacity (SCU)*	2621
Number of pens (pens)	27
Pen area (m2/pen)	2087.09
Stocking density (m2/SCU)	21.5
Working head (head)	3000
Calculated mortality rate (%)	0.25

*SCU - Standard Cattle Unit (kg/head) is 600



Herd details for each market type (before any mortalities)

	DF Ex 150d
Proportion of total SCUs (fraction)	1
SCU factor (factor)	0.87
Proportion of pens occupied (fraction)	0.95
Av. no. per occupied pen (head)	92.08
No. occupied pens (pens)	26
Working head (head)	2394
Entry weight (kg/head)	370
Exit weight (kg/head)	633
Daily weight gain (kg/head)	1.75

Raw manure production (kg/head/year)

	DF Ex 150d
Excreted nitrogen	100.7
Excreted phosphorus	12.6
Excreted salt	9
Excreted volatile solids	541.4
Excreted total solids	761.7
Excreted water	4316.2

Drinking Water Salinity (dS/m): 1

Drinking Water Used: 41.68 ML/year or 0.02 ML/SCU/year

Manure management

Name	Value
Minimum number of days between cleaning events for a pen (days)	91
Pad depth above base after cleaning (mm)	20
Pad moisture content range suitable for pen cleaning (%g/g dry basis) (min - max)	20.00 - 120.00
Pad moisture content range suitable for pen cleaning (%g/g wet basis) (min - max)	16.67 - 54.55
Maximum number of pens cleaned in one day (pens)	5

Pad details (applies to both surface and subsurface layer)

Name	Value
Moisture content range (air dry to maximum) (%g/g dry basis)	7.00 - 190.00
Moisture content range (air dry to maximum) (%g/g wet basis)	6.54 - 65.52
Maximum percolation rate (mm/hour)	0.417

Description

Wastestream information

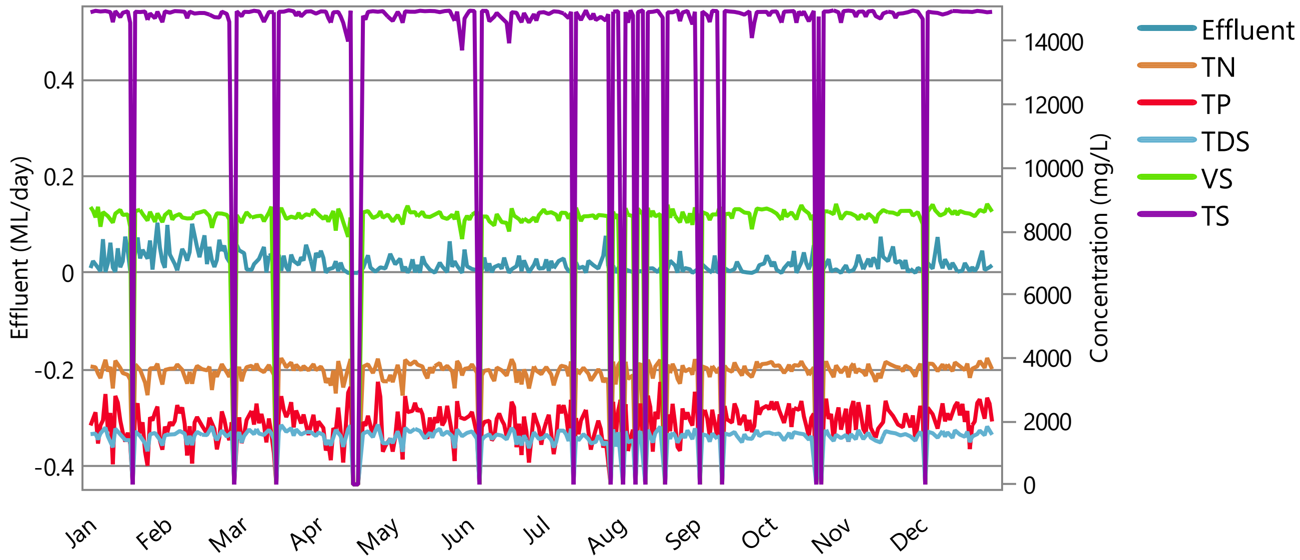
Wastestream Name: Waste estimation system - Springfield Pens

Wastestream production description

Runoff from Springfield Pens, a manure pad (impermeable) surface, with area 5.6352 ha with maximum capacity of 2621 SCU, 0.2500 % mortality, drinking water at 1.0000 dS/m salinity, and with 0.4000 (fraction) of total nitrogen in urine, and 0.6000 (fraction) of urine total nitrogen volatilised. Runoff quality assumes a nutrient enrichment ratio of 3.50 for total nitrogen, 15.00 for total phosphorus and 5.00 for salt. This wastestream is not separately pretreated. The sedimentation basin was used to treat the runoff.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream (before sedimentation basin)

Effluent Quantity: 6.89 ML/year or 0.02 ML/day (Min-Max 0.00 - 8.68)

Flow-Weighted Average (Min - Max) Daily Effluent Quality:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	3608.97 (0.00 - 4173.28)	24856.41 (245.35 - 78958.64)
Total phosphorus	1938.80 (0.00 - 3478.84)	13353.30 (196.21 - 30037.66)
Total dissolved salts	1548.33 (0.00 - 2200.63)	10663.96 (112.87 - 30926.81)
Volatile solids	8526.77 (0.00 - 8999.76)	58727.32 (533.68 - 204968.60)
Total solids	14877.27 (0.00 - 14986.16)	102465.78 (909.01 - 358626.68)

Description

Wastestream information

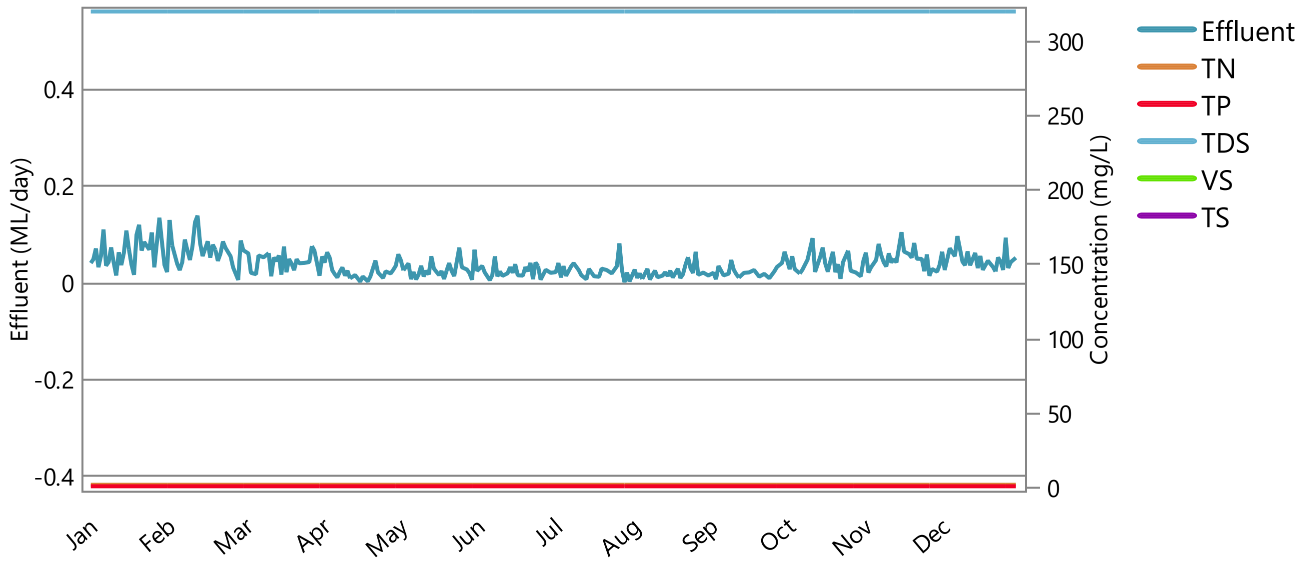
Wastestream Name: Waste estimation system - Springfield Hard Area

Wastestream production description

Runoff from Springfield Hard Area, a hard surface, with area 4.96 ha and assuming concentrations of 2.00 mg/L for total nitrogen, 1.00 mg/L for total phosphorus and 320.00 mg/L for total dissolved salt. This wastestream is not separately pretreated. The sedimentation basin was used to treat the runoff.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream (before sedimentation basin)

Effluent Quantity: 13.72 ML/year or 0.04 ML/day (Min-Max 0.00 - 7.66)

Flow-Weighted Average (Min - Max) Daily Effluent Quality:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	2.00 (2.00 - 2.00)	27.44 (4.73 - 54.26)
Total phosphorus	1.00 (1.00 - 1.00)	13.72 (2.37 - 27.13)
Total dissolved salts	320.00 (320.00 - 320.00)	4389.81 (757.34 - 8681.38)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Description

Wastestream information

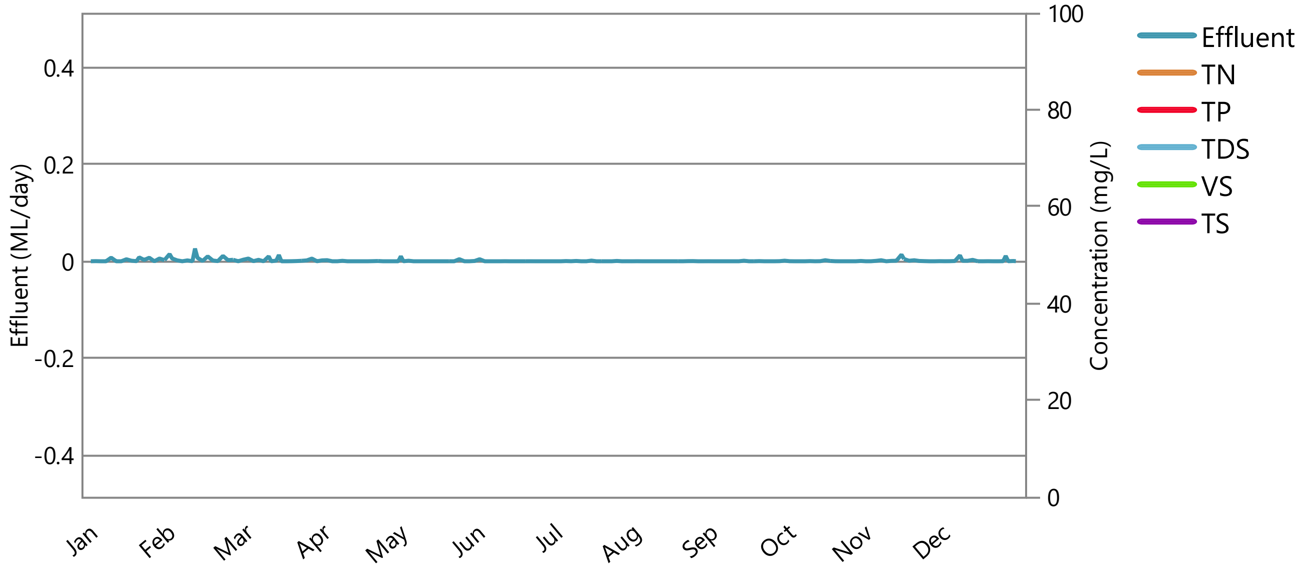
Wastestream Name: Waste estimation system - Springfield Soft Area

Wastestream production description

Runoff from Springfield Soft Area, a soft surface, with area 2.62 ha and assuming concentrations of 0.00 mg/L for total nitrogen, 0.00 mg/L for total phosphorus and 0.00 mg/L for total dissolved salt. This wastestream is not separately pretreated. A sedimentation basin was defined but not used to treat this runoff.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream

Effluent Quantity: 0.41 ML/year or 0.00 ML/day (Min-Max 0.00 - 2.50)

Flow-Weighted Average (Min - Max) Daily Effluent Quality:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total phosphorus	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total dissolved salts	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Description

Wastestream information

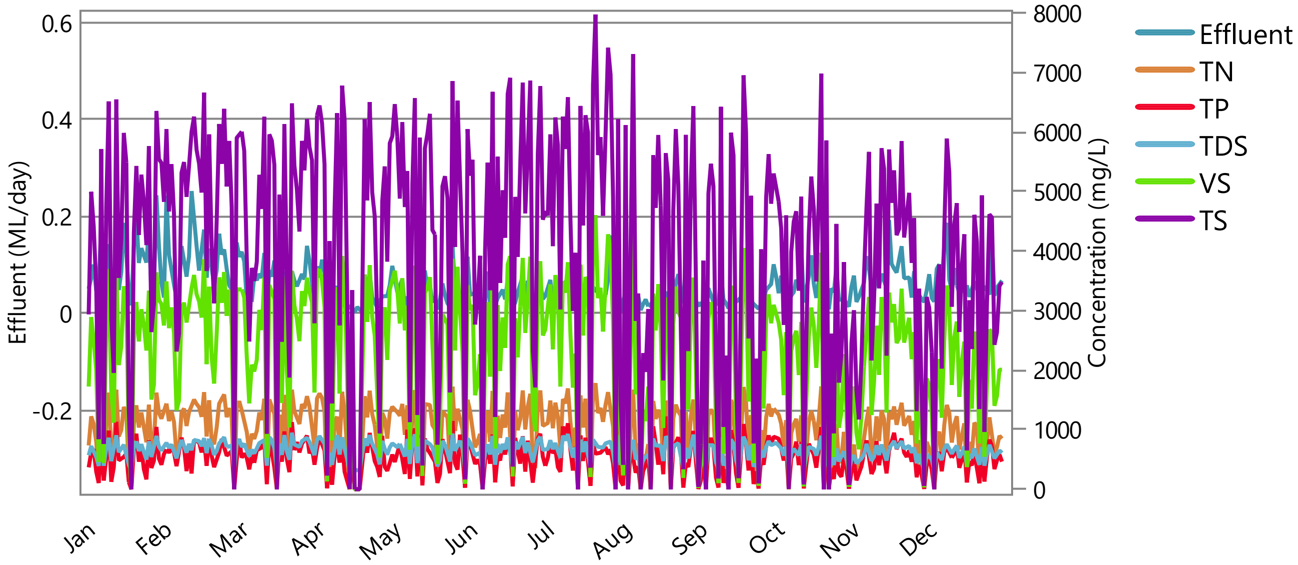
Combined Wastestream Name: Springfield Feedlot - Waste estimation system

Wastestream production description

The enterprise Waste estimation system has a combined wastestream primarily consisting of flows from Springfield Pens and with additional flows from Springfield Hard Area, and Springfield Soft Area. This includes runoff from a total of 13.77 ha of land when including the sedimentation basin area.

Wastestream before sedimentation basin

Average Daily Quantity and Flow-Weighted Average Quality:



Sedimentation basin

The sedimentation basin was assumed to remove 0.25 (fraction) of total nitrogen, 0.10 (fraction) of total phosphorus, 0.32 (fraction) of volatile solids, and 0.64 (fraction) of total solids from the effluent. Rainfall runoff from the 0.56 ha basin also contributed on average an additional 0.15 ML to the annual flow into the pond system.

Combined wastestream (after sedimentation basin)

Effluent Quantity: 21.16 ML/year or 0.06 ML/day (Min-Max 0.00 - 19.38)

Flow-Weighted Average (Min - Max) Daily Effluent Quality Entering the Pond System:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	881.89 (0.00 - 2667.13)	18662.88 (189.53 - 59259.67)
Total phosphorus	568.48 (0.00 - 2120.78)	12030.31 (179.90 - 27058.31)
Total dissolved salts	711.35 (0.00 - 1519.95)	15053.78 (1290.13 - 39608.19)
Volatile solids	1887.06 (0.00 - 5634.53)	39934.57 (362.90 - 139378.65)
Total solids	1743.08 (0.00 - 5250.36)	36887.68 (327.24 - 129105.60)

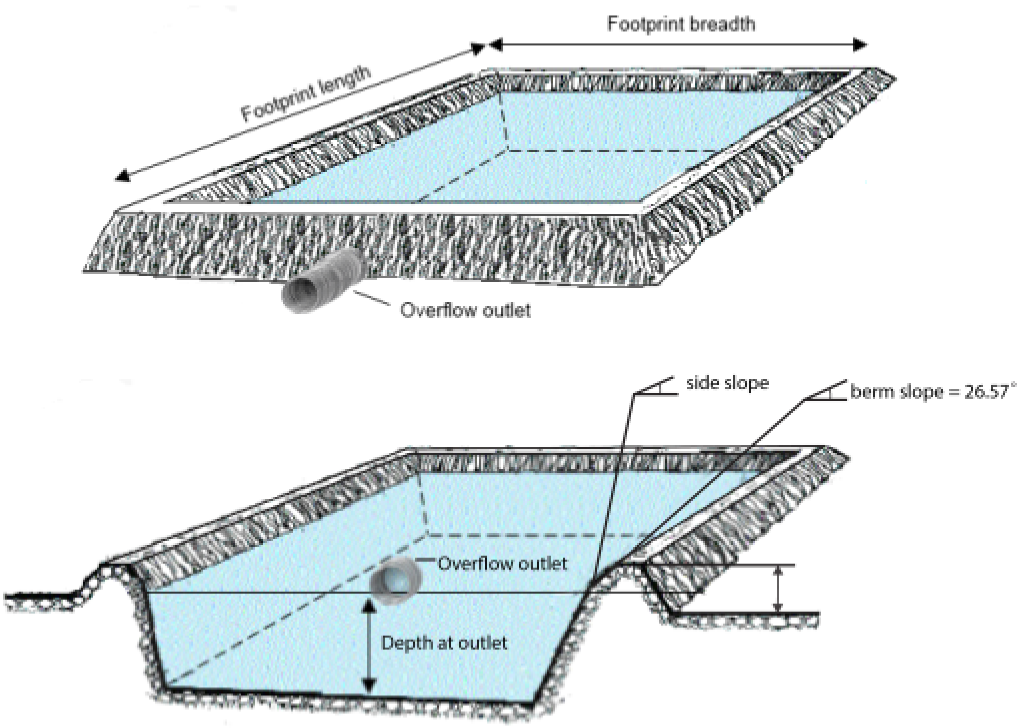
Description

Pond system information

Pond System Configuration: 1 anaerobic pond

Pond system details

	Pond 1
Maximum pond volume (ML)	20.00
Minimum allowable pond volume (ML)	1.60
Pond depth at overflow outlet (m)	3.50
Maximum water surface area (m2)	7499.53
Pond footprint length (m)	124.47
Pond footprint width (m)	63.24
Pond catchment area (m2)	7870.94
Average active volume (ML)	1.85



Irrigation pump limits

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate per area limit (ML/day/ha)	1.00

Shandying water

Annual allocation of fresh water available for shandying (ML/year)	1500.00
Maximum rate of application of fresh water (ML/day)	3.00
Nitrogen concentration (mg/L)	5.00
Salinity (dS/m)	0.70
Minimum shandy water is used	No

Description

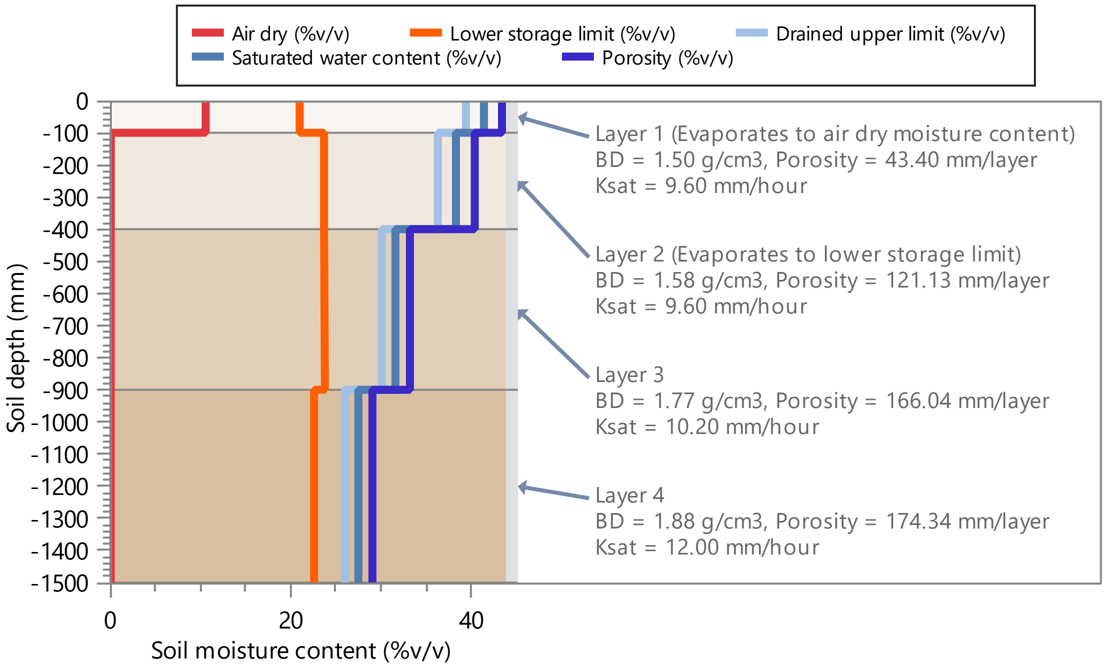
Paddock information

Paddock: Pivot, 120 ha

Soil type: Springfield Brown/Grey Dermosol, 1500.00 mm defined profile depth

Profile porosity (mm)	504.91
Profile saturation water content (mm)	479.30
Profile drained upper limit (or field capacity) (mm)	454.80
Profile lower storage limit (or permanent wilting point) (mm)	346.70
Profile available water capacity (mm)	108.10
Profile limiting saturated hydraulic conductivity (mm/hour)	9.60
Surface saturated hydraulic conductivity (mm/hour)	9.60
Runoff curve number II (coefficient)	85.00
Soil evaporation U (mm)	9.00
Soil evaporation Cona (mm/sqrt day)	4.00

Profile



Planting regime: Rotated Forage maize crop | Barley crop

Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 | 0.9 x Pan coefficient 1 | 1)	0.80 | 0.90
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.00 | 0.00
Potential rooting depth in defined soil profile (mm)	1500.00 | 1500.00
Salt tolerance	Moderately sensitive | Moderately tolerant
Salinity threshold (dS/m soil saturation extract)	1.80 | 6.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.07 | 0.07

Irrigation rules: Centre pivot

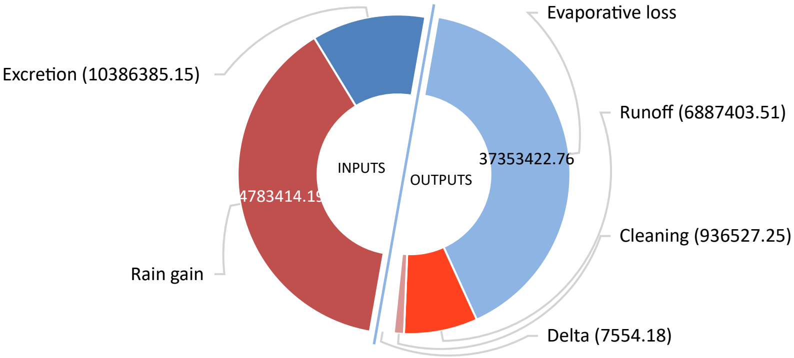
Rule 1. Irrigation triggered when soil water deficit reaches 30.00 mm and rainfall is less than or equal to 30.00 mm
Rule 2. Irrigate up to a soil water content of drained upper limit plus 0.00 mm
Rule 3. Irrigation window from 1/1 to 31/12 including the days specified
Rule 4. A minimum of 0 days must be skipped between irrigation events

Performance

Livestock yard information

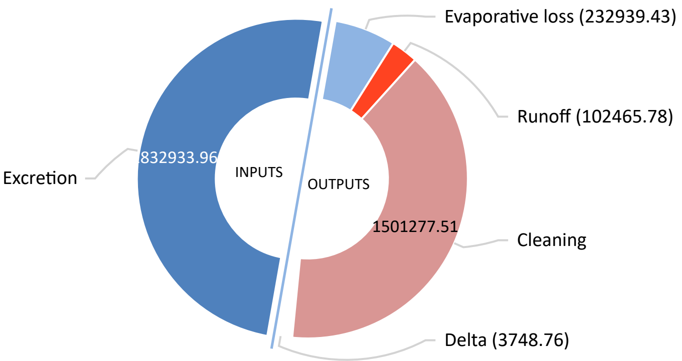
Enterprise Name: Springfield Feedlot - Springfield Pens

Yard water balance (kg/year)



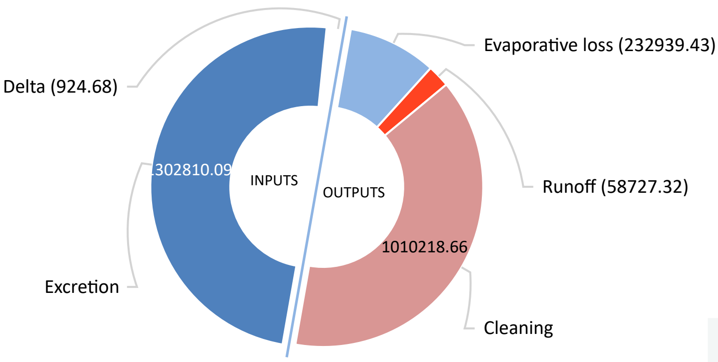
Name	Value
Rain gain	34783414.19
Excretion	10386385.15
Evaporative loss	37353422.76
Runoff	6887403.51
Cleaning	936527.25
Delta	7554.18

Yard total solids balance (kg/year)



Name	Value
Excretion	1832933.96
Evaporative loss	232939.43
Runoff	102465.78
Cleaning	1501277.51
Delta	3748.76

Yard volatile solids balance (kg/year)



Name	Value
Excretion	1302810.09
Evaporative loss	232939.43
Runoff	58727.32
Cleaning	1010218.66
Delta	-924.68

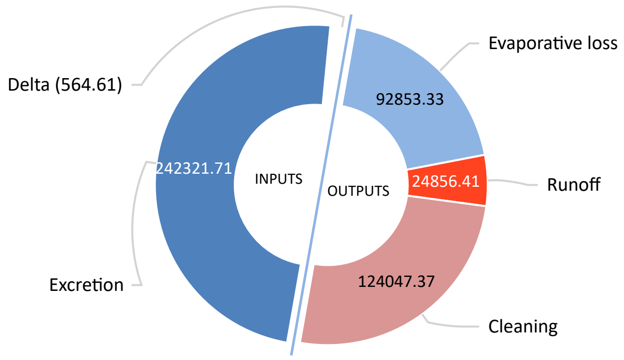
Pen cleaning: across the 27 -pen yard

No. Days When At Least One Pen Was Cleaned: Over the simulation, at least one pen was cleaned on 2093 days over 100 years or 20.93 days/year.

Livestock yard information

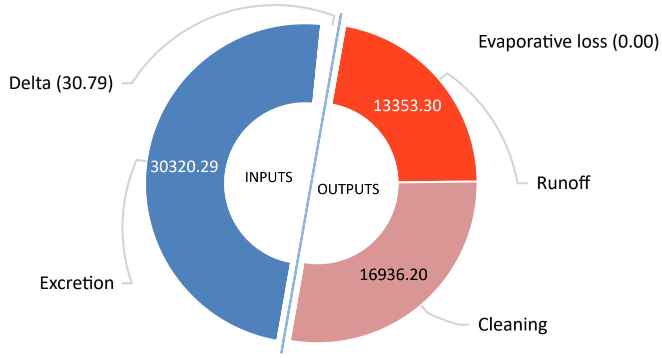
Enterprise Name: Springfield Feedlot - Springfield Pens

Yard total nitrogen balance (kg/year)



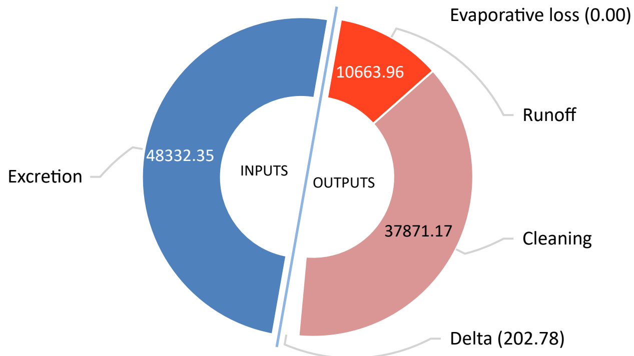
Name	Value
Excretion	242321.71
Evaporative loss	92853.33
Runoff	24856.41
Cleaning	124047.37
Delta	-564.61

Yard total phosphorus balance (kg/year)



Name	Value
Excretion	30320.29
Evaporative loss	0.00
Runoff	13353.30
Cleaning	16936.20
Delta	-30.79

Yard salts balance (kg/year)



Name	Value
Excretion	48332.35
Evaporative loss	0.00
Runoff	10663.96
Cleaning	37871.17
Delta	202.78

Enrichment ratios used

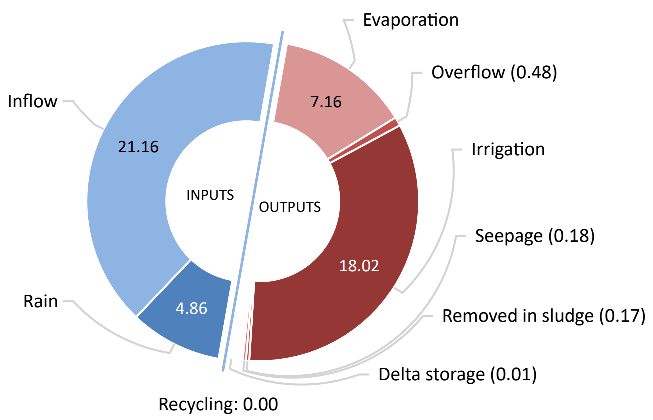
	Enrichment ratio
Total nitrogen	3.50
Total phosphorus	15.00
Salt	5.00

Performance

Pond system information

Pond System Configuration: 1 anaerobic pond (wet weather storage pond: 20 ML)

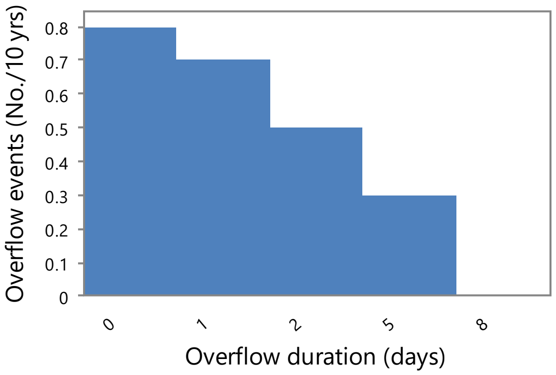
Pond system water balance (ML/year)

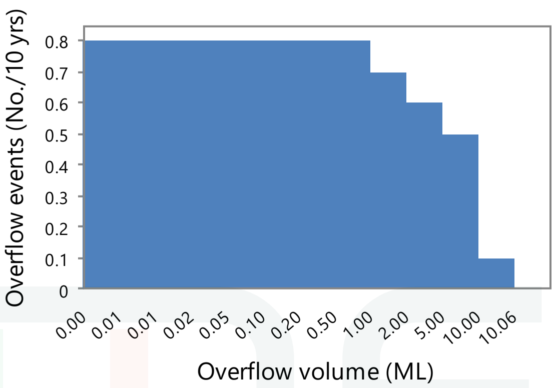


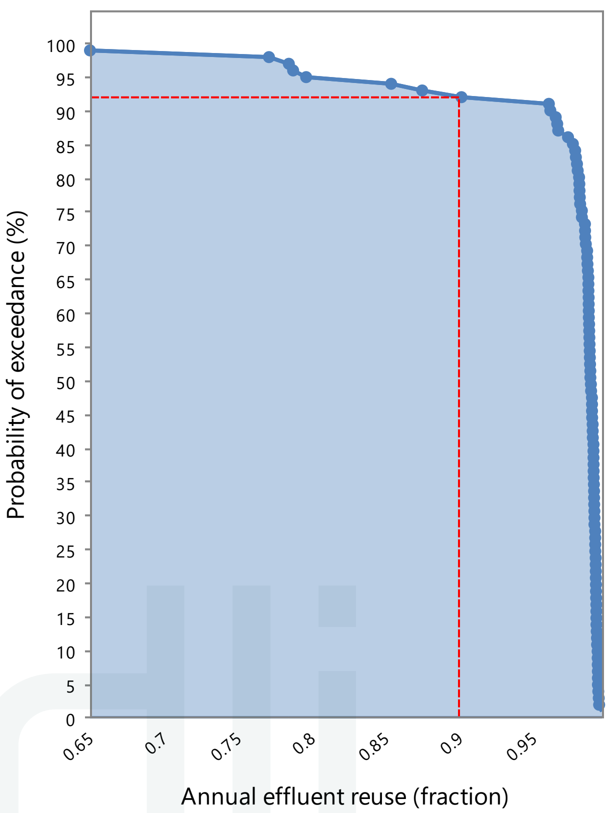
Name	Value
Rain	4.86
Inflow	21.16
Recycling	0.00
Evaporation	7.16
Overflow	0.48
Irrigation	18.02
Seepage	0.18
Removed in sludge	0.17
Delta storage	0.01

Overflow and reuse diagnostics

Metric	Value
Total volume of overflow (ML/10 years)	4.76
Total number of overflow events (events/10 years)	0.80
Total number of pond overflow days (days/10 years)	3.30
Probability of at least 90% effluent reuse (%)	92.13
Effluent reuse (Proportion of inflow + net gain in rain that is irrigated) (fraction)	0.97



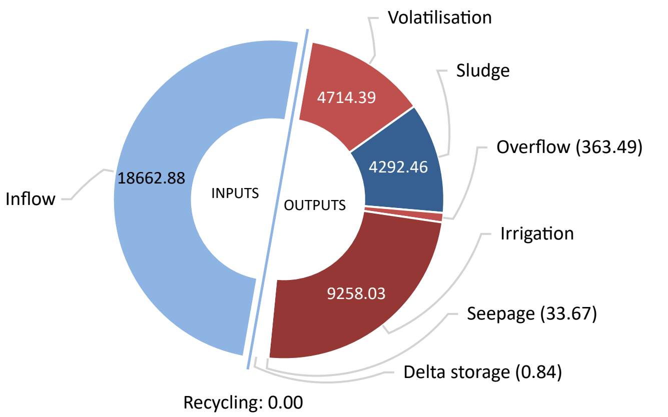




Pond system information

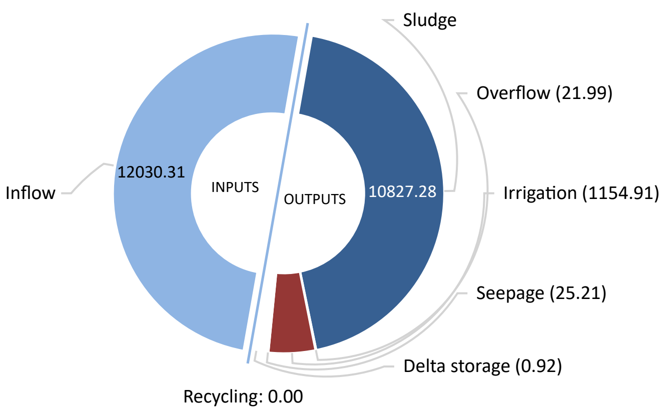
Pond System Configuration: 1 anaerobic pond

Pond system nitrogen balance (kg/year)



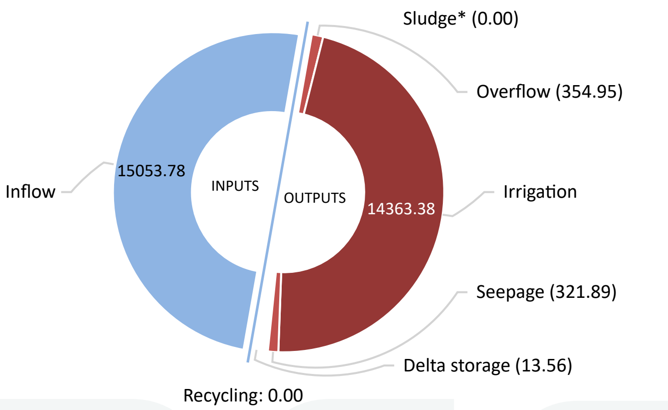
Name	Value
Inflow	18662.88
Recycling	0.00
Volatilisation	4714.39
Sludge	4292.46
Overflow	363.49
Irrigation	9258.03
Seepage	33.67
Delta storage	0.84

Pond system phosphorus balance (kg/year)



Name	Value
Inflow	12030.31
Recycling	0.00
Sludge	10827.28
Overflow	21.99
Irrigation	1154.91
Seepage	25.21
Delta storage	0.92

Pond system salt balance (kg/year)



Name	Value
Inflow	15053.78
Recycling	0.00
Sludge*	0.00
Overflow	354.95
Irrigation	14363.38
Seepage	321.89
Delta storage	13.56

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 38.73 kg/year

Pond system sludge accumulation: 102381.76 kg dwt/year

Performance

Pond system information

Pond System Configuration: 1 anaerobic pond

Pond nutrient concentrations and salinity

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	330.82
Average phosphorus concentration of pond liquid (mg/L)	69.02
Average salinity of pond liquid (dS/m)	1.47

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	58.34
Final phosphorus concentration of pond liquid (mg/L)	64.30
Final salinity of pond liquid (dS/m)	1.47

Performance

Water use (assumes 100% irrigation efficiency)

Metric	Value
Pond water irrigated (ML/year)	18.02
Average shandy water irrigation (ML/year) (minimum - maximum)	767.58 (446.21 - 1080.58)
Total water irrigated (ML/year)	785.60
Proportion of irrigation events requiring shandying (fraction of events)	1.00
Proportion of years shandying water allocation of 1500 ML/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation quality

Metric	Value
Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	16.67
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	15.80
Average phosphorus concentration of irrigation water (mg/L)	1.47
Average salinity of irrigation water (dS/m)	0.71

Irrigation diagnostics

Metric	Value
No. periods/year without any irrigable effluent in the wet weather storage pond (periods/year)	10.89
Average length of such periods (days)	25.36

Irrigation triggering and application

No. Days without Irrigation Applied per Year: 109.39 (with water demand too small to trigger irrigation [106.17] and rain exceeding specified rainfall threshold [3.22])
No. Days without Irrigation Applied per Year: 109.39 (with not triggered)
No. Days with Irrigation Applied per Year: 255.86 (with supply limited - partial application)
No. Days with Irrigation Triggered per Year: 255.86

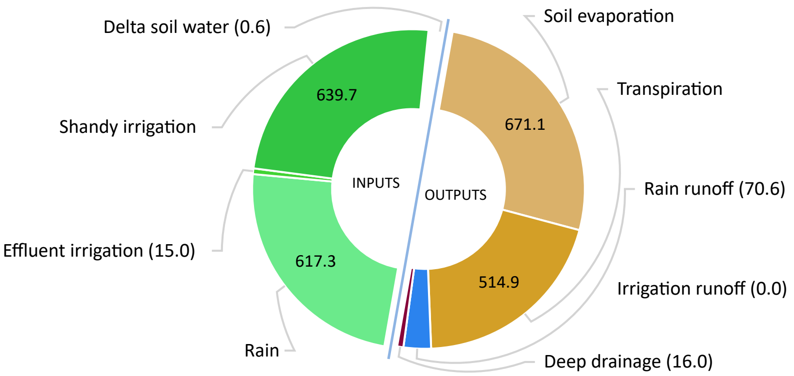
Performance

Paddock information

Paddock: Pivot, 120 ha

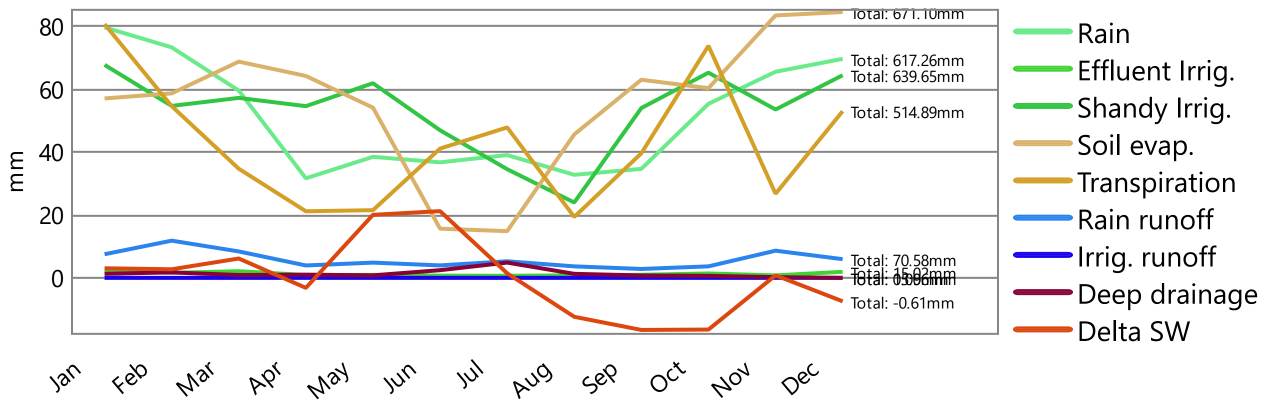
Soil Type: Springfield Brown/Grey Dermosol, 108.10 mm PAWC at maximum root depth

Soil water balance (mm/year)

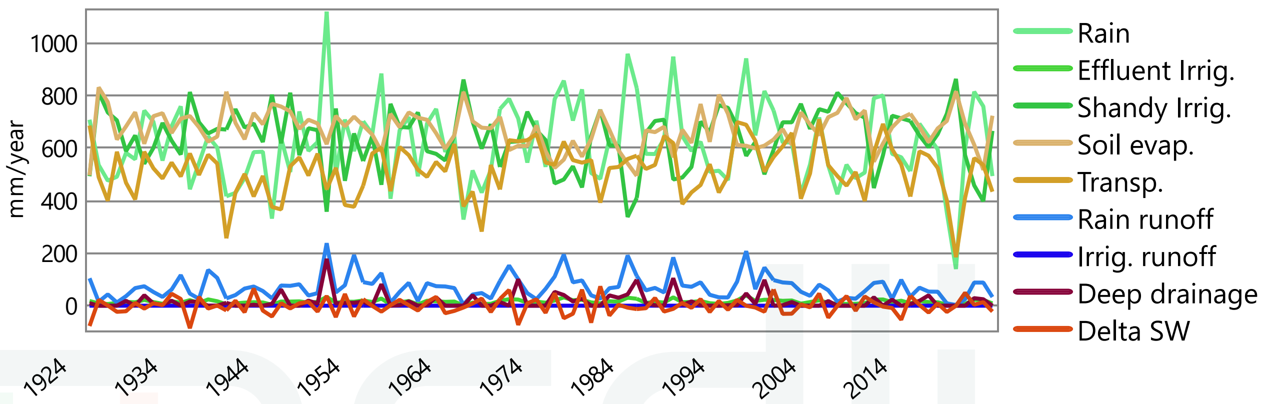


Name	Value
Rain	617.3
Effluent irrigation	15.0
Shandy irrigation	639.7
Soil evaporation	671.1
Transpiration	514.9
Rain runoff	70.6
Irrigation runoff	0.0
Deep drainage	16.0
Delta soil water	-0.6

Average monthly totals (mm)



Average annual totals (mm/year)

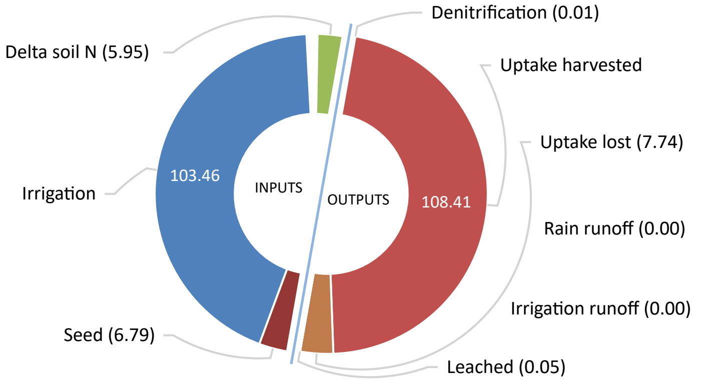


Performance

Paddock information

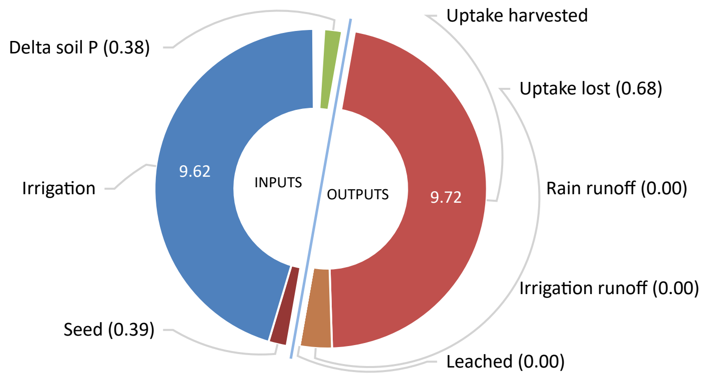
Paddock: Pivot, 120 ha
Soil Type: Springfield Brown/Grey Dermosol
Irrigation Ammonia-N Volatilisation Losses (kg/ha/year): 5.67
Proportion of Total Nitrogen in Irrigated Effluent as Ammonium (fraction): 0.20

Soil nitrogen balance (kg/ha/year)



Name	Value
Seed	6.79
Irrigation	103.46
Denitrification	0.01
Uptake harvested	108.41
Uptake lost	7.74
Rain runoff	0.00
Irrigation runoff	0.00
Leached	0.05
Delta soil N	-5.95

Soil phosphorus balance (kg/ha/year)



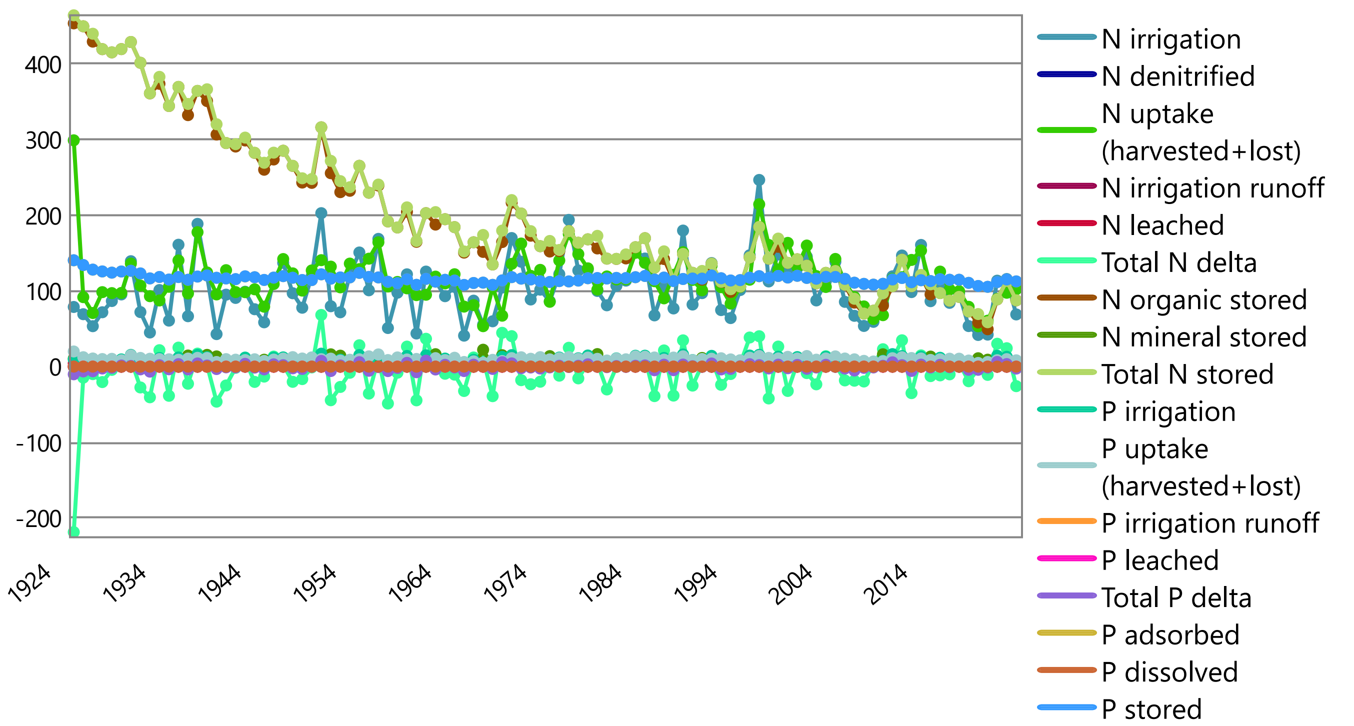
Name	Value
Seed	0.39
Irrigation	9.62
Uptake harvested	9.72
Uptake lost	0.68
Rain runoff	0.00
Irrigation runoff	0.00
Leached	1.62E-03
Delta soil P	-0.38

Performance

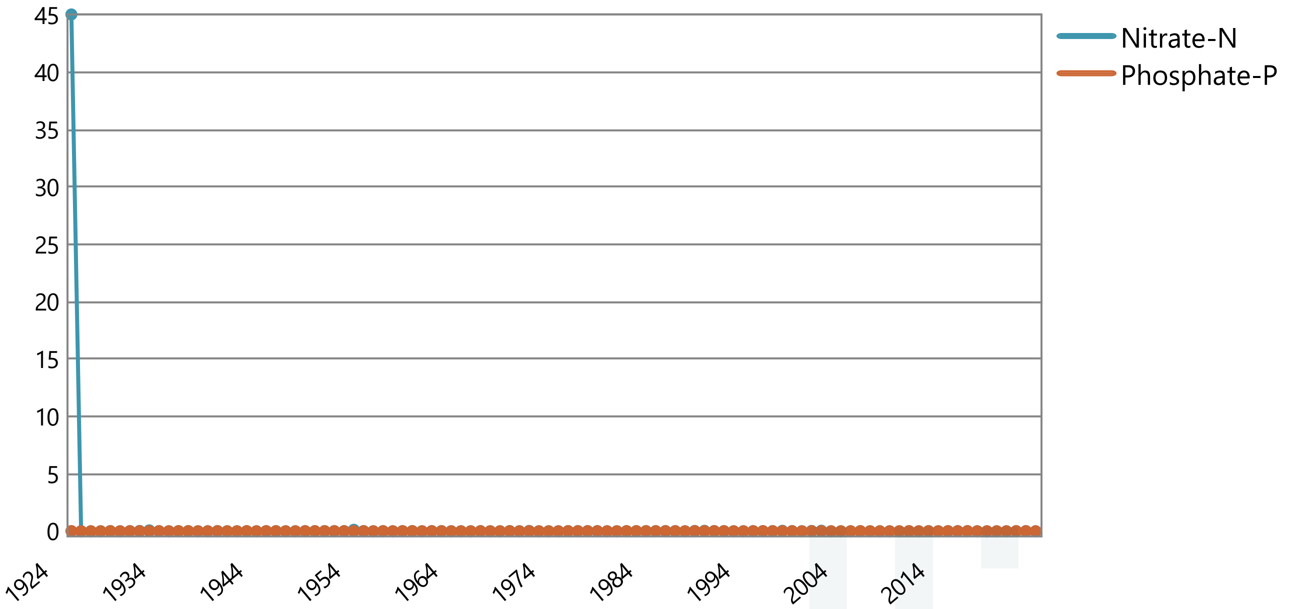
Paddock information

Paddock: Pivot, 120 ha
Soil Type: Springfield Brown/Grey Dermosol

Annual nutrient totals (kg/ha)



Annual nutrient leaching concentration (mg/L)



Performance

Paddock information

Paddock: Pivot, 120 ha

Soil Type: Springfield Brown/Grey Dermosol

Planting Regime: Rotated Forage maize crop & Barley crop

Plant growth (minimum - maximum)

Season one plant metrics	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	6684.68 (958.25 - 13183.73)
Average annual shoot dry matter lost (kg/ha/year)	470.95 (105.78 - 880.92)
Average monthly plant (green) cover (fraction)	0.26 (0.00 - 0.67)
Average monthly root depth (mm)	660.92 (101.70 - 1345.89)

Season two plant metrics	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	5795.86 (1728.73 - 10847.21)
Average annual shoot dry matter lost (kg/ha/year)	320.42 (0.00 - 1027.11)
Average monthly plant (green) cover (fraction)	0.44 (0.00 - 0.78)
Average monthly root depth (mm)	1120.18 (114.56 - 1500.00)

Plant nutrient uptake (minimum - maximum)

Season one plant metrics	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	56.91 (13.00 - 171.60)
Average annual shoot nitrogen lost (kg/ha/year)	3.93 (0.84 - 8.06)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	3.93 (0.89 - 8.05)
Average annual shoot phosphorus lost (kg/ha/year)	0.32 (0.05 - 0.54)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.001)

Season two plant metrics	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	51.50 (20.27 - 111.71)
Average annual shoot nitrogen lost (kg/ha/year)	3.80 (0.00 - 13.54)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	5.79 (2.59 - 10.97)
Average annual shoot phosphorus lost (kg/ha/year)	0.36 (0.00 - 0.80)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.001 - 0.002)

*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Performance

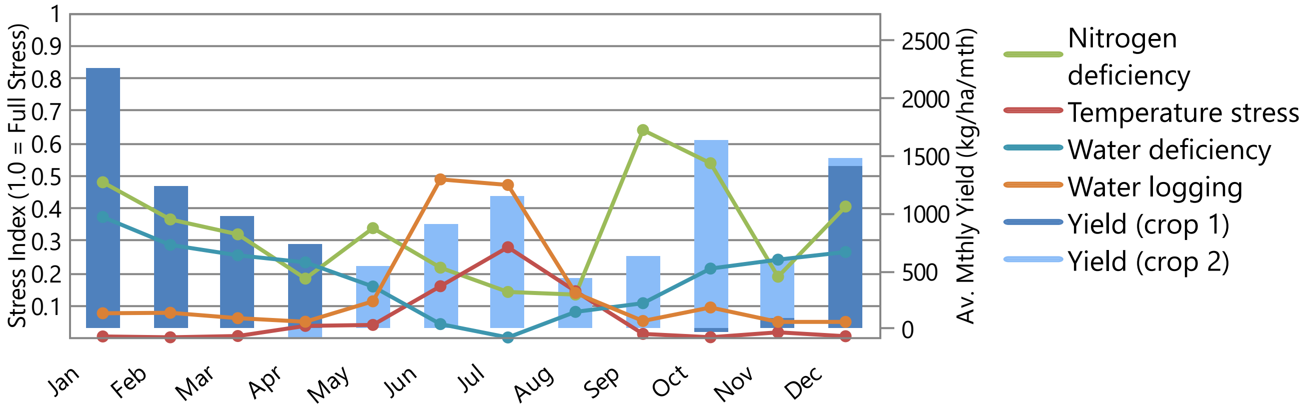
Paddock information

Paddock: Pivot, 120 ha

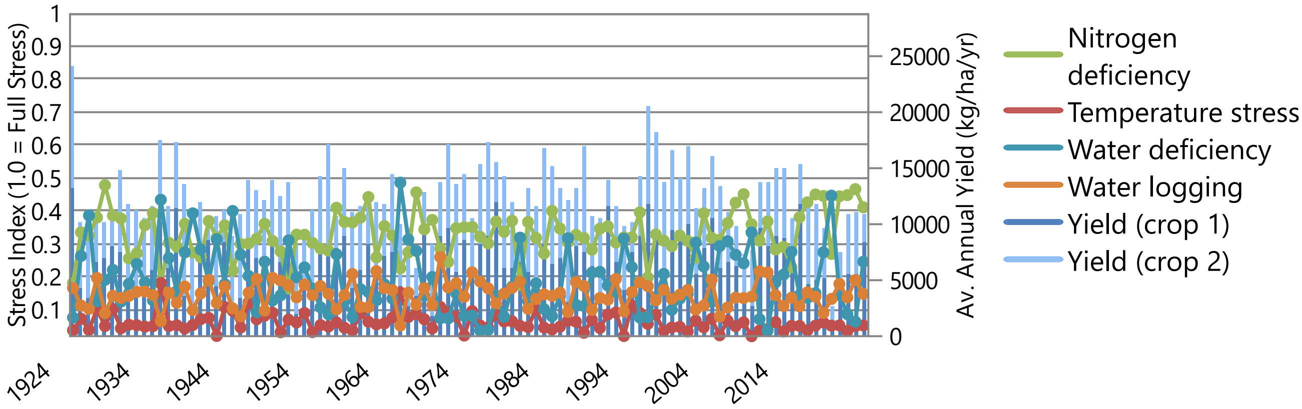
Soil Type: Springfield Brown/Grey Dermosol

Planting Regime: Rotated Forage maize crop & Barley crop

Av. monthly stresses & harvestable yield* (kg/ha/month)



Av. annual stresses & harvestable yield* (kg/ha/year)



*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Normal and forced harvest information

No. of Harvests per Year: 3.64 (normal), 0.73 (forced by crop death due to water stress [0.46] and nitrogen stress [0.27]).

No. Days without Crop per Year (no./year): 16.42 (due to water stress [16.26] and frosting [0.16])

Performance

Paddock information

Paddock: Pivot, 120 ha

Soil Type: Springfield Brown/Grey Dermosol

Planting Regime: Rotated Forage maize crop & Barley crop

Plant salinity tolerance

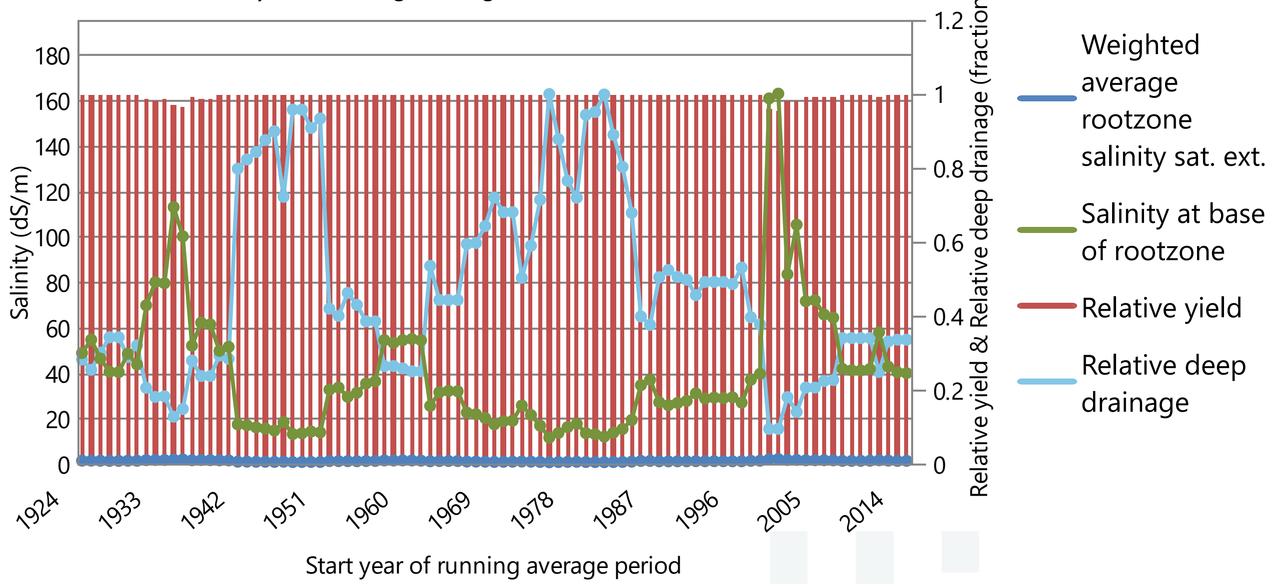
Metric	Value
Salt tolerance	Moderately sensitive | Moderately tolerant
Salinity threshold (dS/m soil saturation extract)	1.80 | 6.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.07 | 0.07
No. years assumed for leaching to reach steady-state (years)	10.00

Soil salinity

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.40
Salt added by rainfall (kg/ha/year)	104.96
Average annual salt added & leached at steady state (kg/ha/year)	3090.29
Average leaching fraction based on 10 -year running averages (fraction)	0.12
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.56
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	40.73
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average annual rootzone salinity and relative yield

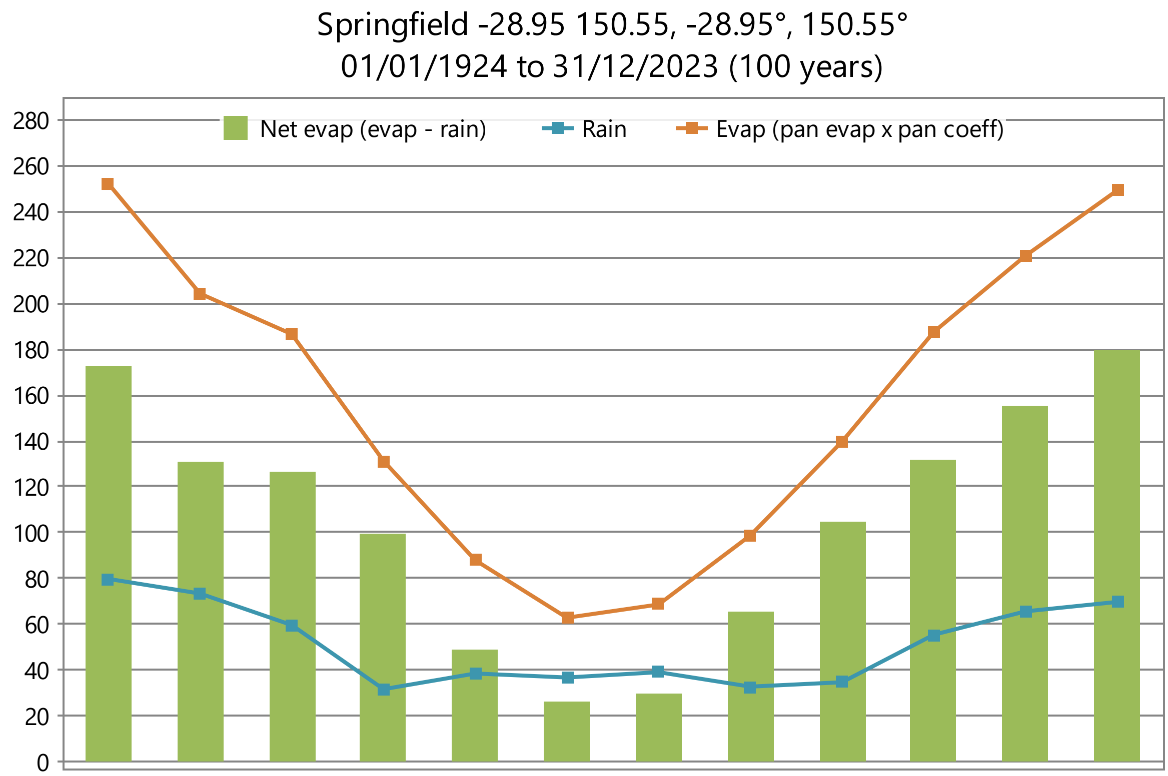
All values based on 10 -year running averages.



Scenario information

Enterprise: Springfield Feedlot

Climate long-term monthly averages (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	79.8	73.4	59.6	31.7	38.5	36.8	39.1	32.8	34.7	55.4	65.6	69.7	617.3
Evap	252.1	204.2	186.5	131.2	87.9	62.9	68.6	98.7	139.6	187.4	220.7	249.2	1889.1
Net evap	172.3	130.8	126.9	99.5	49.4	26.1	29.5	65.9	104.9	132.0	155.1	179.4	1271.8
Net evap/day	5.6	4.6	4.1	3.3	1.6	0.9	1.0	2.1	3.5	4.3	5.2	5.8	3.5

Diagnostics

Enterprise name:

Enterprise Name: Springfield Feedlot - Springfield Pens - 2490 SCU stocked - 0.250 % mortality

Key pad details

Name	Value
Pen pan factor for evaporation (at air dry MC - at max pugging MC)	0 - 1.2
Pad moisture content (at air dry MC - at max pad MC) (%g/g wet basis)	6.54 - 65.52
Bulk density (surface layer - subsurface layer) (g/cm3)	750 - 1000
Maximum percolation rate (mm/hour)	0.42
Baseline pad volatile solids decay rate (%pad VS/day)	0.15

Average pad manure composition

Component	Value	Powell (1994)	Sinclair (1994)
Dry matter content using wet basis (%g/g)	77.15	66	60
Water content using wet basis (%g/g)	22.85	34	40
Water content using dry basis (%g/g)	29.61	52	67
Total nitrogen content using dry basis (%g/g)	7.01	2.37	2.78
Total phosphorus content using dry basis (%g/g)	0.92	0.75	0.67
Salt content using dry basis (%g/g)	2.11	> 2.3	4.3

Note: The cattle used 41.68 ML/year of drinking water, at a salinity of 1.00 dS/m. The output assumes 0.40 (fraction) of total nitrogen excreted is in the urine, of which 0.60 (fraction) volatilises.

Pen cleaning (tonnes/head/year)

Name	Value	Expected
Excreted manure (dry matter basis)	0.76	0.6 - 1.6
Manure removed in cleaning (dry matter basis)	0.62	0.41 - 1.05
Water removed in cleaning	0.39	0.02 - 0.3
Wet manure removed in cleaning	1.01	0.7 - 1.07

Pen cleaning operation - Average cleaning interval (min. - max.): 107.0 (92.0 - 283.0) days

Reasons for not cleaning pens	Fraction of non-cleaning days for Pen 1	Fraction of non-cleaning days for Yard
Insufficient buildup / too soon to clean	0.00 / 0.88	0.00 / 0.86
Pad too dry / too wet	0.12 / 0.00	0.13 / 0.00
Skipped as too many pens to clean	0.00	0.01

Average runoff quantity (ML/year) and quality (mg/L) from each surface defined.

Livestock Yard Enrichment Ratios Used: Total nitrogen 3.5 , Total phosphorus 15 , Salt 5

Area Names	Runoff	TS	VS	TN	TP	Salt
Springfield Pens	6.9	14877.3	8526.8	3609.0	1938.8	1548.3
Springfield Hard Area	13.7	0.0	0.0	2.0	1.0	320.0
Springfield Soft Area	0.4	0.0	0.0	0.0	0.0	0.0

Mass lost in runoff as fraction of mass excreted

Runoff Expressed as a fraction of Rainfall, Yard: 0.20 , All Areas: 0.26

Area Names	TS	VS	TN	TP	Salt
Livestock yard	0.1	0.0	0.1	0.4	0.2
All defined areas	0.1	0.0	0.1	0.4	0.3

Diagnostics

Pond system information

Pond System Configuration: 1 anaerobic pond, desludging 2 times during the run according to the rule: "Maintain required active volume and desludge when sludge reaches 30% of pond volume"

Effluent Type: Waste estimation system - 21.16 ML/year or 0.06 ML/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 52.57 non-zero flow days/year.

Constituent	Concentration (mg/L)	Load (kg/year)
Total nitrogen	881.89 (0.00 - 2667.13)	18662.88 (189.53 - 59259.67)
Total phosphorus	568.48 (0.00 - 2120.78)	12030.31 (179.90 - 27058.31)
Total dissolved salts	711.35 (0.00 - 1519.95)	15053.78 (1290.13 - 39608.19)
Volatile solids	1887.06 (0.00 - 5634.53)	39934.57 (362.90 - 139378.65)
Total solids	1743.08 (0.00 - 5250.36)	36887.68 (327.24 - 129105.60)

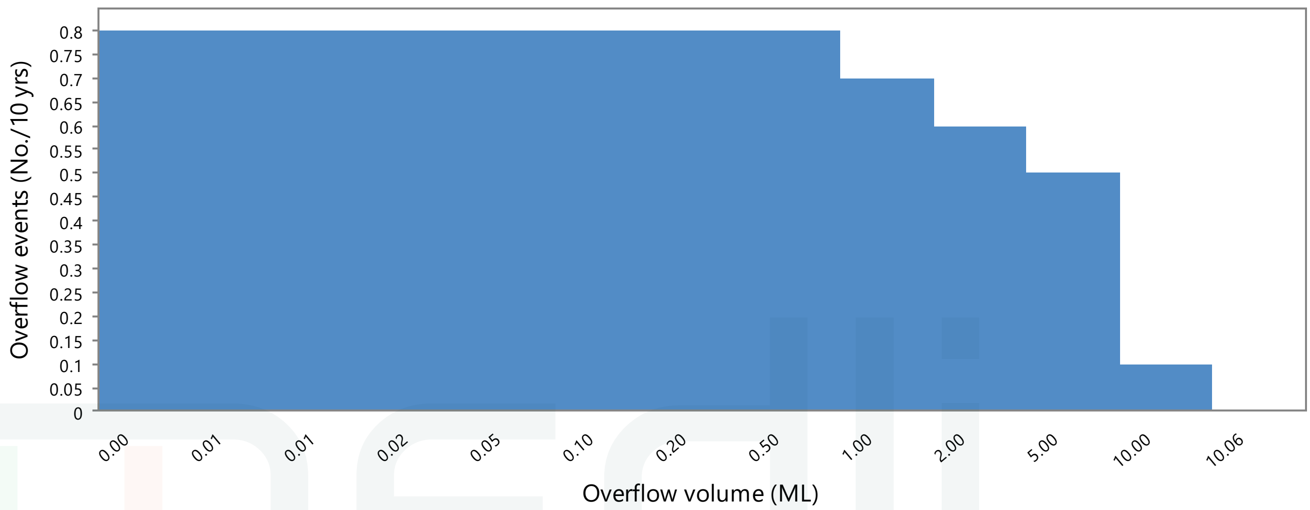
Ammonia-N loss from pond system water surface area: 94.73 kg/m2/year

Last pond (wet weather store): 20.00 ML

Metric	Value
Theoretical hydraulic retention time (days)	345.19
Volume of overflow (ML/year) Average (minimum-maximum)	0.48 (0.00 - 11.74)
Volume of overflow per day (m3/day) Average (minimum-maximum)	1.30 (0.00 - 7537.05)
No overflow days - Average per year (Total in run period)	0.33 (33)
No. overflow events per 10 years exceeding threshold of 0.010 ML* (events/10 years)	0.80
Average overflow event recurrence interval (years)	12.50
Average duration of overflow (days)	4.13
Probability of at least 90% effluent reuse (%)	92.13
Effluent reuse (proportion of inflow + net rain gain that is irrigated) (fraction)	0.97
Average salinity (dS/m)	1.47
Salinity on final day of simulation (dS/m)	1.47

* The overflow event is calculated as defined in WATBAL and based on the National Guidelines for Beef Cattle Feedlots in Australia

Volume distribution of the overflow events



Diagnostics

Scenario information

Area irrigated: 120 ha total area

Loading to whole irrigation area: (assuming 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (ML)	785.60	6.55
Total nitrogen applied (kg)	12414.94	103.46
Total phosphorus applied (kg)	1154.91	9.62
Total salts applied (kg)	358239.22	2985.33

Shandying

Metric	Value
Annual allocation of fresh water for shandying (ML/year)	1500.00
Average shandy water irrigation (ML/year) (minimum - maximum)	767.58 (446.21 - 1080.58)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Minimum shandy water is used	No

Irrigation issues

Metric	Value
Number of days without irrigation (days/year)	109.39
Number of periods without irrigatable water (periods/year)	10.89
Average length of such periods (days)	25.36

Paddock information

Paddock: - Pivot, 120 ha

Irrigation: Centre pivot with 0.26% ammonium loss during irrigation

Irrigation Rules
Irrigation triggered when soil water deficit reaches 30.00 mm and rainfall is less than or equal to 30.00 mm
Irrigate up to a soil water content of drained upper limit plus 0.00 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil water balance (mm): Springfield Brown/Grey Dermosol, 108.10 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	79.8	73.4	59.6	31.7	38.5	36.8	39.1	32.8	34.7	55.4	65.6	69.7	617.3
Efflt. irrg.	2.2	1.6	2.1	0.9	0.9	0.7	0.7	0.8	1.0	1.4	0.8	1.9	15.0
Shdy. irrg.	67.8	54.8	57.3	54.7	62.0	47.0	34.6	24.0	54.1	65.3	53.6	64.5	639.7
Soil evap	57.1	58.7	68.8	64.3	54.2	15.7	14.9	45.7	63.1	60.4	83.6	84.7	671.1
Transpn.	80.8	54.7	34.7	21.2	21.5	41.2	47.9	19.4	39.7	73.9	26.8	53.1	514.9
Rain runoff	7.5	11.8	8.4	3.9	4.8	4.0	5.3	3.7	2.8	3.7	8.7	5.9	70.6
Irr. runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	1.3	1.7	0.9	1.0	0.8	2.4	4.9	1.3	0.8	0.7	0.2	0.0	16.0
Delta SW	3.0	2.7	6.2	-3.2	20.1	21.2	1.5	-12.4	-16.6	-16.5	0.8	-7.5	-0.6

Soil nitrogen balance: (Concentrations are flow-weighted)

Metric	Value
Average annual nitrogen added in seed (kg/ha/year)	6.79
Average annual nitrogen added from irrigation (kg/ha/year)	103.46
Av. annual soil N removed by uptake (harvest + lost) (kg/ha/year)	116.15 (108.41, 7.74)
Av. annual soil nitrogen removed by denitrification (kg/ha/year)	0.01
Average annual soil nitrogen leached (kg/ha/year)	0.05
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.05
Soil organic-N kg/ha (Initial - Final)	419.40 - 87.66
Soil inorganic-N kg/ha (Initial - Final)	263.70 - 0.04
Average nitrate-N concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	0.29 (45.02)
Excluding first year of data (mg/L)	0.01 (0.13)

Soil phosphorus balance: (Concentrations are flow-weighted)

Metric	Value
Average annual phosphorus added in seed (kg/ha/year)	0.39
Average annual phosphorus added from irrigation (kg/ha/year)	9.62
Av. annual soil P removed by uptake (harvest + lost) (kg/ha/yr)	10.40 (9.72, 0.68)
Average annual soil phosphorus leached (kg/ha/year)	1.62E-03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.16 - 0.04
Adsorbed phosphorus (kg/ha) (Initial - Final)	150.57 - 112.68
Average phosphate-P concentration in rootzone (mg/L)	0.02
Average phosphate-P concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	0.00 (0.02)
Last year only (mg/L)	0.00 (N.D.*)
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.80 mg/L (years)	999.00

* Not determined

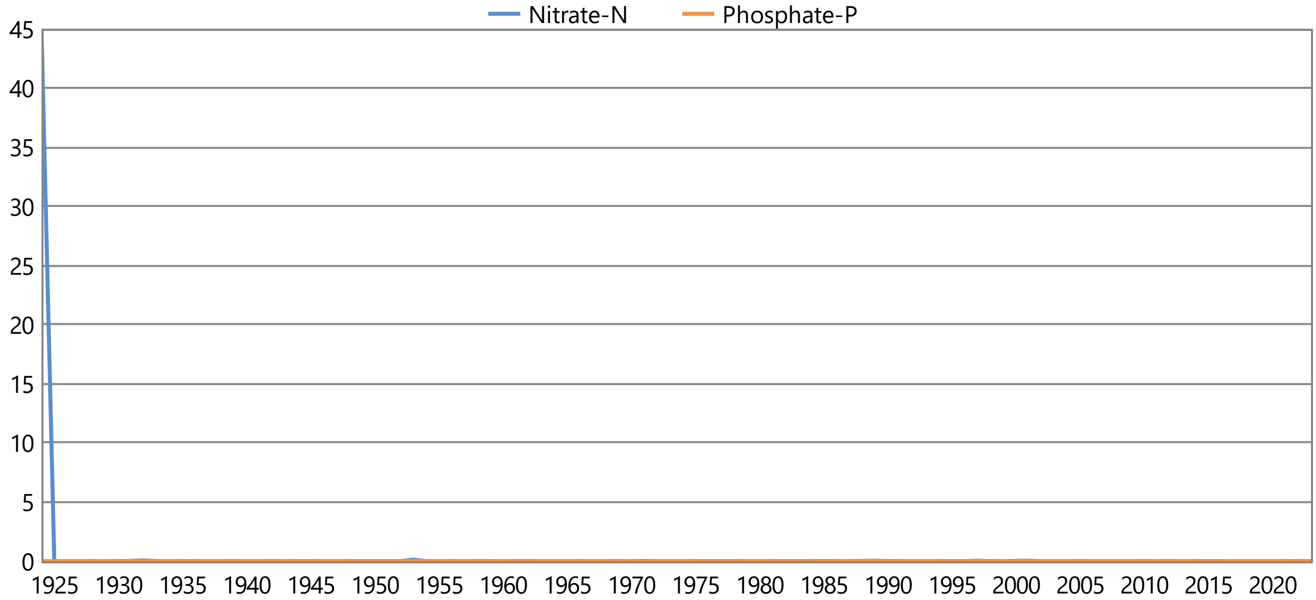
Diagnostics

Paddock information

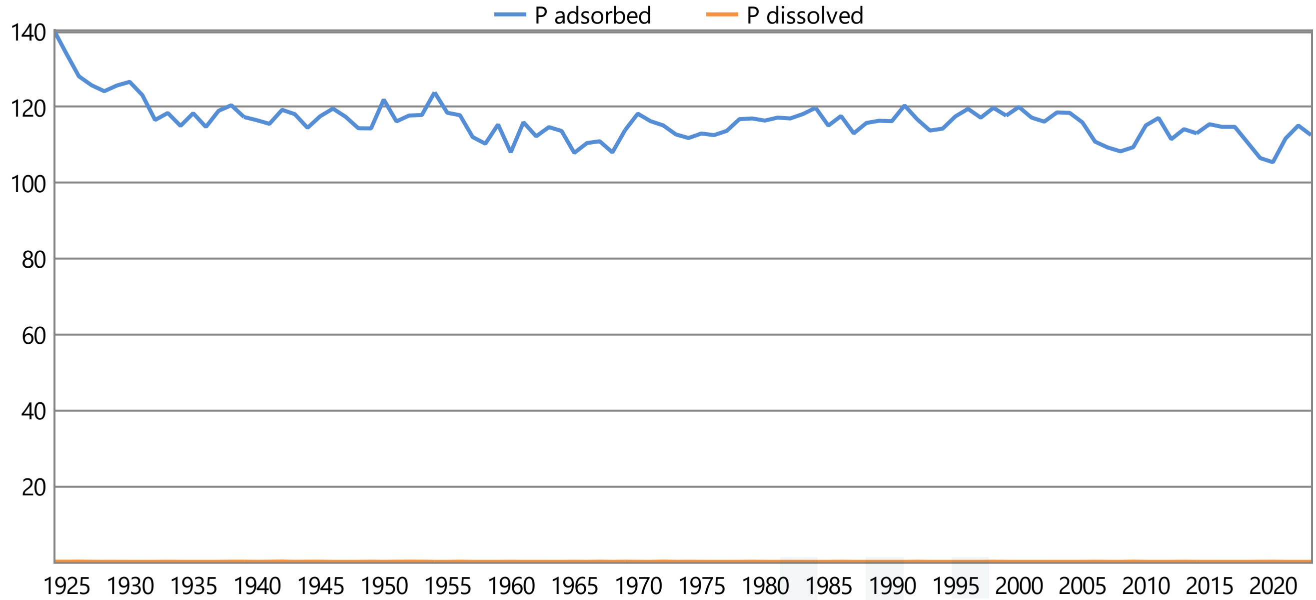
Paddock: Pivot, 120 ha

Irrigation: Centre pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual phosphate-P in soil (kg/ha)



Diagnostics

Paddock information

Paddock: Pivot, 120 ha

Planting Regime: Rotated Forage maize crop & Barley crop

Average plant performance (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield (kg/ha/year)	12480.54 (2686.97 - 24030.94)
Average annual shoot dry matter lost (kg/ha/year)	791.37 (411.77 - 1345.85)
Average monthly plant (green) cover (fraction)	0.44 (0.19 - 0.78)
Average monthly crop factor (fraction)	0.38 (0.17 - 0.70)
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.00 | 0.00
Average monthly root depth (mm)	962.74 (465.91 - 1417.38)
Average number of normal harvests per year (no./year)	3.64 (2.00 - 4.00)
Average number of normal harvests for last five years only (no./year)	3.40
Average number of forced harvests per year (no./year)	0.73 (0.00 - 3.00)
Average number of forced harvests for last five years only (no./year)	1.20
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.33 (0.16 - 0.48)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.09)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.28 (0.00 - 0.63)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.19 (0.00 - 0.37)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.15 (0.05 - 0.49)
No. days without crop per year. Excludes bare fallow days (days)	16.42

Soil salinity - plant salinity tolerance: Moderately sensitive | Moderately tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 10 -year running averages.

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.40
Salt added by rainfall (kg/ha/year)	104.96
Average annual salt added & leached at steady state (kg/ha/year)	3090.29
Average leaching fraction based on 10 -year running averages (fraction)	0.12
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.56
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	40.73
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Run information

Messages generated when the scenario was run
************************************** WASTESTREAM RESULTS **************************************
TABLE OF QUANTITY AND QUALITY OF EACH RUNOFF-BASED WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
____
Surface defined Runoff_ML/yr N conc_mg/L P conc_mg/L TDS conc_mg/L Area_ha Runoff_mm/yr Runoff as_%rainfall
Springfield Pens* 6.9 3609.0 1938.8 1548.3 5.6 122.2 19.8
Springfield Hard Area* 13.7 2.0 1.0 320.0 5.0 276.7 44.8
Springfield Soft Area 0.4 0.0 0.0 0.0 2.6 15.6 2.5
Combined runoff 21.0 1184.2 636.1 716.4 13.2 159.0 25.8
____
* Wastestreams flowing into sedimentation basin
TABLE OF QUANTITY AND QUALITY OF MANURE AND ALSO EACH RAINFALL-INDEPENDENT WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
____
Source Volume_m3/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
Manure removed from Springfield Pens 2437.8 50884.9 6947.3 15534.9 124047.4 16936.2 37871.2
____
(Dead carcasses removed from yard: 7321.9 kg/yr) (Average moisture content of manure removed: 38.4 %g/g wet basis) * Wastestreams flowing into sedimentation basin
TABLE OF WASTESTREAM FLOWS TREATED BY 0.6 HA SEDIMENTATION BASIN:
____
Value defined Volume_ML/yr N load_kg/yr P load_kg/yr TDS load_kg/yr
Additions and Removals +0.1 -6221.0 -1336.7 -0.0
Post-Sedimentation Basin flow 20.6 24883.8 13367.0 15053.8
____
TABLE OF FINAL COMBINED WASTESTREAM COMPOSITION (EXCLUDING IMPACT OF RECYCLING)
____
Total flow Volume_ML/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
Inflow to pond system 21.2 881.9 568.5 711.3 18662.9 12030.3 15053.8
____
************************************** END WASTESTREAM RESULTS ************************************
No. Days without Irrigation Applied per Year: 109.39 (with water demand too small to trigger irrigation [106.17] and rain exceeding specified rainfall threshold [3.22])
WARNING: Plant phosphorus deficiency. At shoot P concentrations below 0.2% dry weight, many plant species will show reduced yields due to phosphorus deficiency. Please check if this is true for the simulated species, as if so, the predicted plant yield and soil nutrient balances will be INVALID!
WARNING: CONDITIONAL FINISH!