Irrigation Management Plan

Lambells Lagoon Crocodile Farm

PRI Farming Pty Ltd

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Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council
BoM	Bureau of Meteorology
DEC	Department of Environment and Conservation (NSW)
DENR	Department of Environment and Natural Resources (Northern Territory) – now DEPaWS
DHAC	Darwin Harbour Advisory Community
DEPaWS	Department of Environment, Parks and Water Security – formerly DENR
DITT	Department of Industry, Tourism and Trade – formerly DPIR
DOEE	Department of the Environment and Energy (Commonwealth)
EC	Electrical Conductivity
ECi	Electrical Conductivity (irrigation)
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act (1999)* (Commonwealth)
EPL	Environment Protection Licence
ESCP	Erosion and Sediment Control Plan
ESP	Exchange Sodium Percentage
GDE	Groundwater Dependent Ecosystem
GEL	Groundwater Extraction Licence
LCA	Land capability assessment
LTV	Long-term trigger values
IMP	Irrigation Management Plan
NSW	New South Wales
NTEPA	Northern Territory Environmental Protection Authority
NT	Northern Territory
SOCS	Site of Conservation Significance

1 INTRODUCTION

1.1 Background

PRI Farming Pty Ltd (PRI) propose to operate the Lambells Lagoon Crocodile Farm (LLCF) for commercial production of saltwater crocodiles (*Crocodylus porosus*) for meat and skin products. The site is located in the Lambells Lagoon area on Section 1611 and 1688 Hundred of Guy, at the end of Alphatonia Road, 5.5 km north of the Arnhem Highway.

LLCF is currently being constructed and subsequently operated in two stages. Stage one encompasses the Incubation, hatchery and auxiliary infrastructure. Stage two encompasses the grow-out pens, finishing pens and auxiliary infrastructure.

1.2 Purpose and scope

PRI recognise the importance of finding a solution to manage wastewater produced on site and prevent the discharge of untreated wastewater off-site. As a wastewater management strategy, PRI propose to utilise irrigation practices to dispose of the wastewater from Stage one onto suitable crops.

This Irrigation Management Plan (IMP) has been developed to illustrate the management and reuse of wastewater by PRI at LLCF through irrigation application during both stage one and two operations. This plan is a requirement as part of the Environmental Protection Licence (EPL) application (amendment to EPL320).

2 WASTEWATER QUALITY

As there is no operational wastewater quality data for LLCF, anticipated effluent quality has been derived from monitoring undertaken at other existing farms. As the Stage one effluent will be generated directly from the hatchery and will undergo a solids screening process prior to irrigation, the effluent quality will differ from Stage 2 (growers and finishers) and the combined operations (hatchery, growers and finishers) undertaken at the other farms. Therefore, for the purpose of assessing irrigation requirements, effluent quality has been derived from sampling undertaken directly from the hatchery at three existing crocodile farms and limited sampling undertaken from hatchery effluent post solids screening at Lagoon Crocodile Farm (as part of a wastewater treatment trial). Effluent from the growers and finishers has been taken from Janamba Crocodile farm and used to provide an estimate of predicted effluent quality for LLCF (Table 2-1).

The anticipated effluent quality for irrigation and the effluent strength when assessed against the *Environmental Guidelines – use of effluent by irrigation (DEC 2004)* is detailed in Table 2-1. The anticipated wastewater concentration for Stage one-hatchery is classified as "medium" strength due to the high nutrient concentration. Stage 2 – growers and finishers and the combined wastewater (whole of farm effluent) is classed as "low" strength.

Table 2-1. Classification of effluent based on DEC 2004 criteria

Analyte	**Irrigation water quality – stage 1**	**Irrigation water quality – stage 2 (wet season / dry season)**	**Combined wastewater streams -**	**Strength (average concentration mg/L)**		
				Low	**Medium**	**High**
Total Nitrogen	100	6 / 13	18	<50	50-100	>100
Total Phosphorus	13	0.7 / 4	4	<10	10-20	>20
Biological oxygen demand (BOD)	<2	ND	7	<40	40-1500	>1500
Total dissolved solids (TDS)	470	153	267	<600	600-1000	>1000
Metals	see Section 3.4			Concentrations > 5 times the long-term trigger value (see Section 3.4) must be considered high strength		
Grease and oil	<5			Concentrations > 1500mg/L must be considered high strength		
Effluent strength	Medium strength	Low strength	Low strength			

3 IRRIGATION SUITABILITY ASSESSMENT

This section assesses all of the factors that need to be taken into consideration under the New South Wales (NSW) *Environmental Guidelines – use of effluent by irrigation (DEC 2004)* (NSW guideline).

3.1 Organic content

Organic material is present in many effluent waste streams and when applied at a suitable rate, can assist in the physical and chemical health of soils. Normally, organic material concentrations are low enough to prohibit any short-term detrimental effects on soil and vegetation characteristics. However, if soil is continually overloaded with organic material this can result in the blocking of soil pores, favour anaerobic soil microbes and lead to a slimy bacterial scum crust on the soil (DEC 2004).

The average maximum daily organic material loading was calculated from the irrigation rate and the BOD (mg/L) concentration of the applied effluent. The NSW guideline suggests that an average loading rate of 1,500 kg/ha/month can be taken as the maximum organic loading for most soils.

The median BOD content of the wastewater for irrigation is estimated at 100 mg/L. This value was used as a conservative approach until site specific data can be determined. The minimum irrigation area required based on organic loading can be estimated as follows:

A = CQ / (1,000 x Lc)

Where:

A = irrigation area (h)

C = concentration of BOD^5 (mg/L)

Q = average effluent flow rate (kL/month)

Lc = critical loading rate of constituent (kg/ha/month)

For LLCF Stage 1:

A = 100 mg/L x 3,000 kL / month / (1,000 x 1,500 kg/ha/month)

A = 0.2 hectares

The above calculation indicates that a minimum area of 0.2 ha is required to manage the organic content of LLCF wastewater in Stage 1.

For LLCF Stage 2:

A = 100 mg/L x 37,950 kL / month / (1,000 x 1,500 kg/ha/month)

A = 2.53 hectares

The above calculation indicates that a minimum area of 2.53 ha is required to manage the organic content of LLCF wastewater in Stage 2.

3.2 Suspended solids

The Total Suspended Solids (TSS) concentration is expected to be < 100 mg/L post solids screening. There is no water quality limit or concentration of concern for TSS in the NSW guidelines for irrigation.

Recommendations for concentrations of suspended solids to avoid clogging in localised (drip) irrigation systems are available from Ayers and Wescot (1985). The recommendations are based on the degree of restriction of use:

- <50 mg/L = no restriction
- 50-100 mg/L = slight to moderate restriction
- >100 mg/L = severe restriction

The anticipated low levels of suspended solids are not expected to present a problem in regards to the irrigation system getting clogged or the coating of leaf surfaces. In conjunction with solids treatment, an appropriately sized nozzle will be used to prevent potential clogging.

3.3 pH

The NSW guideline suggests effluent with a pH between 5.0 and 8.5 is generally acceptable for use in irrigation. If the effluent is very acidic (pH less than 5), or very alkaline (pH greater than 8.5), the wastewater may need to be neutralised before being used for irrigation as soil pH affects the availability of nutrients and other elements to plants. The pH of the irrigation water is expected to be 7.5 – 8.0.

3.4 Metals

ANZECC (2000) Guidelines, Volume 3, Section 9.2.5 identify the maximum concentrations of metals in irrigation waters considered acceptable for continuous use. The current concentration of metals in the wastewater is shown below (Table 3-1) along with the long-term trigger value (LTV) and short-term trigger value (STV) guidelines adapted from the Guidelines. The majority of metal levels in the groundwater and similar wastewaters are all below the detectable limit and are therefore well below the LTV.

Table 3-1. Summary of irrigation water long-term trigger value (LTV) and short-term trigger value (STV) guidelines for heavy metals and metalloids

Metal	LTV in irrigation water (mg/L)	STV in irrigation water (mg/L)	Project wastewater quality
As	0.1	2.0	<0.001
Cd	0.01	0.05	<0.0001
Cr(VI)	0.1	1	<0.001
Cu	0.2	5	0.03
Pb	2	5	<0.001
Hg	0.002	0.002	<0.0001
Ni	0.2	2	<0.001
Zn	2	5	0.05

3.5 Mineral salts and specific ions

The EC and concentration of salts and specific ions (sodium, chloride, alkalinity etc) in the wastewater are relatively low (see Table 3-2). The aim is to protect soil structure and downstream surface and groundwater, and to not exceed the salt tolerance of pasture grasses.

Table 3-2. Salt and ion concentrations in irrigation water

Ca	Mg	Na	K	SO4	Chloride	Alkalinity
mg/L	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*
40	23	15	6	5	26	224

3.6 Oil and grease

The levels of oil and grease in the wastewater are currently below detection limits. These low levels will not present problems in regards to clogging irrigation systems or coating leaf surfaces of irrigated crops.

3.7 Pathogens

The concentration of *E.coli* and other pathogens in the wastewater for irrigation is expected to be high. Bacterial movement through soils is extremely limited and the harsh sunlight and climatic conditions typical of Australia rapidly diminish viable populations of bacteria. The irrigation area is off-limits to the public, therefore any pathogens in the wastewater are not expected to cause any harm to human receptors. Irrigation application is to be managed appropriately to avoid potentially harmful runoff. Chlorination of the wastewater to assist in pathogen removal can be introduced if required.

3.8 Salinity & sodicity

3.8.1 Salinity

Salinity is the term for the presence of soluble salts in soils or water. Salinity is a land-use issue when the concentrations of salt adversely affect plant growth, therefore salt content can affect the ability to reuse water for irrigation.

In order to assess the suitability of a water sources and soil for irrigation the following need to be considered;

- The quality of the irrigation water.
- Characteristics of the soil being irrigated.
- Salt tolerance of the crop to be grown.

EC is a measure of the total soluble salts in water. Some general irrigation electrical conductivity (ECi) ratings for wastewater are shown in Table 3-3. The anticipated average ECi of LLCF wastewater to be used for irrigation is 0.5 dS/m, which is considered low for irrigation according to ANZECC (2000).

Table 3-3. Salinity ratings for water (ANZECC 2000)

ECi (dS/m)	Water salinity rating
<0.65	Low
0.65-1.3	Moderate
1.3-2.9	High
2.9-5.2	Very high
>5.2	Extremely high

3.8.2 Sodicity

Sodicity is a term for the high concentrations of sodium ions relative to other cations in the exchangeable and / or soluble form in soil or water. Sodic soils have a range of adverse properties including poor soil structure and stability; surface crusting; poor aggregation; increased runoff and erosion; poor seedling emergence and slow water infiltration. Soil sampling was undertaken in the proposed irrigation area and the results of sampling identified that the exchange sodium percentage (ESP) was less than 1%. Soils with an ESP less than 6% are considered non-sodic, an ESP between 6 and 15% are considered sodic, and an ESP greater than 16% is considered strongly sodic.

Irrigation water with a high sodium concentration can result in the degradation of soil structure. The potential for excess sodium effecting soils is commonly assessed using sodium adsorption ratio (SAR). The SAR is used to calculate projected potential of sodium accumulation in soil, which is the end product of continual use of sodic water.

The SAR in LLCF wastewater for irrigation is expected to be 0.5 which is not considered an issue, as outlined in Table 3-4.

Table 3-4. Sodicity classes for irrigation water (Mills 2001)

SAR	Sodicity class
<3	No sodium problem
3-6	Low sodium, few problems except with sodium sensitive crops
6-8	Medium sodium, increasing problems
8-14	High sodium, not generally recommended
>14	Very high sodium - unsuitable

3.8.3 Relationship between salinity and sodicity

Based on the low salinity rating of the proposed irrigation site soil and the low SAR of the irrigation water, it is not expected that the irrigation will have an impact on the soil structure. When plotted on the EC/SAR relationship graph detailed in the ANZECC 2000 guidelines, the levels fall within the “stable soil structure” category (Figure 3-1).

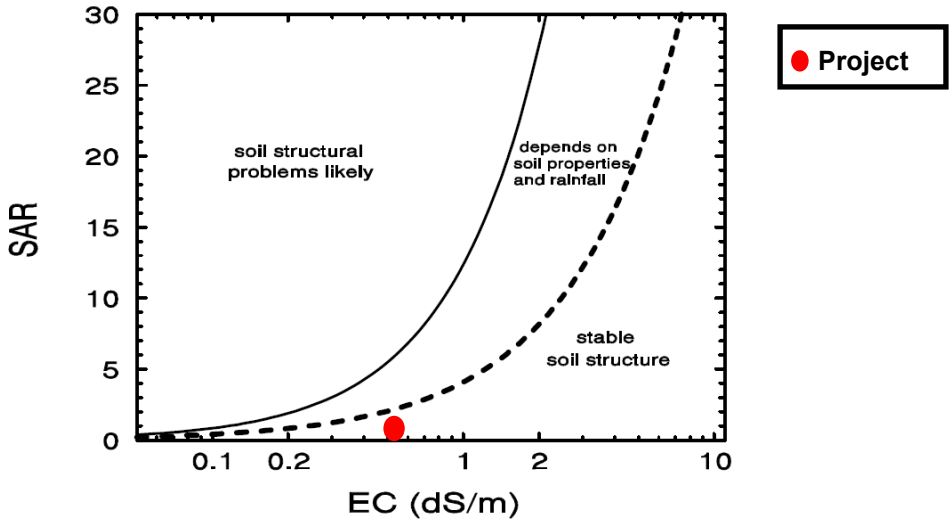


Figure 3-1. Relationship between SAR and EC for irrigation water for prediction of soil structure stability

Based on the relationship between SAR and EC for irrigation water being within the stable soil structure region and the water quality being of very low EC, salinity is not expected to be an issue for irrigation and salinity modelling is not required in this case.

4 MODELLING OF EFFLUENT REUSE

The Model for Effluent Disposal using Land Irrigation (MEDLI) is a program for designing effluent reuse schemes. The model addresses many factors impacting on effluent irrigation, such as the quality and quantity of effluent, climate, storage, irrigation frequency and amount, nitrogen, phosphorus and salt components and plant growth. The MEDLI program was used on LLCF wastewater to assess the viability of irrigation as a method of wastewater management.

The model has been updated from the initial MEDLI model provided in the CEMP in August 2020, with more accurate data including water quality and refined water demand data from other crocodile farms within the Northern Territory, site specific soil data from LLCF and appropriate methods and rates of irrigation. As the construction of Marpu is staged (i.e Stage 1 and Stage 2), the MEDLI modelling has been developed to reflect this.

4.1 Stage 1

The MEDLI program was used to inform design requirements for the effluent land irrigation scheme for Stage 1 of the LLCF. In this instance, Stage 1 refers to the development and operation of the hatchery components of the farming operations.

4.1.1 Input data

Climate

The quantity of effluent and current quality outlined in the sections above was used in the MEDLI assessment. A 60-year climate file for LLCF area was obtained from the SILO database (a climate database managed by the Queensland Department of Environment and Science) to input rainfall and evaporation data. The model was run using climate data from 1950 to 2019, to account for recent impacts of climate change that may affect the model outputs.

Inflow

The effluent inflow was set at 100 m^3 a day based on predicted water use once the hatchery is at peak capacity (early operational months may produce significantly less effluent). Inflow volumes were only set for March to December to coincide with the current programmed Stage one operational period. By December it is anticipated that Stage two will come online, which includes a full-scale wastewater management system and the Stage one irrigation activities will no longer be required. PRI have since decided that stage 1 and stage 2 wastewater will remain separate, this stage 1 no longer a temporary irrigation area.

Storage

A 6x6x3 m open concrete storage tank was used in the scenario to represent the proposed storage and step screen solids removal tank. The tank is uncovered and therefore model parameters allowed for rainfall infiltration and evaporation over the exposed surface area.

Soil

Soil samples were collected from LLCF area on 10 July 2020 and sent a laboratory specialising in MEDLI analysis suites (see Appendix A). The analyses undertaken directly related to the required MEDLI inputs and allowed for site specific soil information to be incorporated into the model.

Crop selection

The default planting parameters for Forage Sorghum Crop were used in the model as they are representative of the crop selection for the proposed irrigation area. The default crop also has a maximum crop coefficient of 0.8, and according to the NT *Guidelines for Land Capability Assessment for On-site Wastewater Management* (DOH, 2014), a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT.

Irrigation method

The irrigation method modelled was a centre pivot system over varying irrigation areas to determine the minimum irrigation area required. The irrigation was applied on a daily frequency at a rate of 5 mm per day.

A "dry-run" was also modelled for both irrigation areas, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the area without any irrigation inputs.

4.1.2 Modelling results

The results of the water and nutrient balances modelled by MEDLI are outlined in Table 4-1 to

Table 4-3 respectively. Based on the nutrient balance, a minimum irrigation area of 15 ha is recommended to manage the nutrient loading of the wastewater, therefore the outputs of the 15 ha irrigation area scenario have been provided. The full MEDLI report is included in 0.

Table 4-1. Land water balance

	Unit	With irrigation	Dry-run
Rain	mm/year	1544	1544
Irrigation	mm/year	203	0
Soil evaporation	mm/year	489	601
Transpiration	mm/year	461	0
Rain runoff	mm/year	41	114
Irrigation runoff	mm/year	0	0
Deep drainage	mm/year	758	829

Table 4-2. Pond system water balance

	Unit	Value
Rain	m3/year	51.47
Inflow	m3/year	30524
Evaporation	m3/year	75
Overflow	m3/year	22
Irrigation	m3/year	30479
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	1
Probability of at least 90% reuse	Fraction	1

Table 4-3. Land nutrient balance

	Unit	N balance	P balance
Irrigation (effluent load added)	kg/ha/year	161	26
Denitrification	kg/ha/year	0.12	-
Irrigation runoff	kg/ha/year	0	0
Plant uptake	kg/ha/year	140	19
Leached	kg/ha/year	24	0.07

The MEDLI results indicate that the proposed irrigation scheme is sufficient to manage the daily effluent volumes produced without creating any irrigation runoff or significant increases to the deep drainage. The proposed concrete tank is sufficient in size to store the wastewater without causing significant overflows and ensuring 100% reuse of the effluent produced (through irrigation).

The application rate of nutrients is slightly higher than the predicted plant uptake rates which results in some leaching of nitrogen. The predicted average nitrate concentration of the deep drainage based on current soil concentrations and effluent irrigation, is 3.2 mg/L which is still considered low. The concentration of nutrients in the wastewater is to be monitored to ensure that if concentrations increase significantly above the predicted values, the irrigation area is adjusted accordingly, or alternative treatment methods are assessed.

4.2 Stage 2

The MEDLI program was used to inform design requirements for the effluent land irrigation scheme for Stage 2 of the LLCF. In this instance, Stage 2 refers to the development and operation of the grower and finisher components of the farming operations.

4.2.1 Input data- general

The following inputs were used for the Stage 2 MEDLI model:

Climate

A 60-year climate file for LLCF area was obtained from the SILO database to input rainfall and evaporation data. The model was run using climate data from 1958 to 2019, to account for recent impacts of climate change that may affect the model outputs.

Soil type

Soil samples were collected from LLCF area on 10 July 2020 and sent a laboratory specialising in MEDLI analysis suites. The analyses undertaken directly related to the required MEDLI inputs and allowed for site specific soil information to be incorporated into the model.

Crop type

The default planting parameters for Forage Sorghum Crop were used in the model as they are representative of the crop selection for the proposed irrigation area. The default crop also has a maximum crop coefficient of 0.8, and according to the NT *Guidelines for Land Capability Assessment for On-site Wastewater Management* (DOH, 2014), a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT.

Irrigation method

The irrigation method modelled was a centre pivot system with irrigation triggered when the soil water deficit (SWD) reaches 5mm. The irrigation was applied at a depth of 5mm at each irrigation event, until the SWD is reached. Irrigation cannot occur when a rainfall event occurs and rainfall reaches a total of 10mm per event (likely during most of the wet season) to prevent over saturation of the soil. The model was run using different irrigation sizes in order to determine the best outcome for the water and nutrient balance.

A "dry-run" was also modelled for the irrigation area, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the area without any irrigation inputs.

The model was set to turn-off irrigation when rainfall reaches a total of 10mm (likely during most of the wet season) to prevent over saturation of the soil.

4.2.2 Input data- effluent volumes and quality

Since the initial MEDLI modelling was completed, a number of inputs relating to effluent volumes and quality have been updated for the LLCF. The following assumptions were made by PRI Farming, in determining the final effluent quality and volumes in the model:

- The feeding programs of the grower and finisher pens will be the same as the Janamba Crocodile Farm in the Northern Territory, whereby water usage is reduced by half in the wet season, due to the change in crocodile behaviour that occurs when there is increased rainfall and semi cooler temperatures from December to March.
- Allowance was made in the wet season months (December to March) for rainfall inputs into the pens. PRI Farming Pty Ltd have advised that the pens are to be constructed with a shade cloth roofing, shedding 70% of rainfall away from the pens. The volume inputs were derived from data from BoM and the impact a low permeability shade cloth, which allows for 30% of rainfall to enter the pens during the months of December to March.
- During the drier months (i.e April to Nov), the forecast water use for the stage 2 component of the crocodile farm is 1,265kL/day (as provided by PRI Farming Pty Ltd, based on extrapolation of data from Janamba Crocodile Farm).
- Effluent quality (i.e. nutrient concentrations) will be similar to that produced from the grower and finisher pens at Janamba Crocodile Farm (as provided by PRI Farming Pty Ltd).

The effluent quality is based on the estimated combined effluent quality prior to any treatment. The actual wastewater quality to be irrigated would be lower in nutrients following primary treatment. However, this will not make a difference to the model outputs because the limiting factor at the LLCF is water volumes not nutrient concentrations.

4.2.3 Modelling results

The results of the water and nutrient balances modelled by MEDLI are outlined in Table 4-4 to Table 4-6, respectively. Based on the nutrient balance, a minimum irrigation area of 100 ha is recommended to manage the nutrient loading of the wastewater, therefore the outputs of the 100 ha irrigation area scenario have been provided.

Table 4-4. Land water balance

	Unit	60ML	Dry-run
Rain	mm/year	1544	1544
Irrigation	mm/year	391.23	0

Soil evaporation	mm/year	626.59	570.95
Transpiration	mm/year	510.78	24.88
Rain runoff	mm/year	29.40	86.11
Irrigation runoff	mm/year	0.00	0.00
Deep drainage	mm/year	769.60	861.89

Table 4-5. Pond system water balance

	Unit	60ML
Rain	m3/year	33,814
Inflow	m3/year	394,710
Evaporation	m3/year	35,045
Overflow	m3/year	2224
Irrigation	m3/year	391,226
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	0.99
Probability of at least 90% reuse	Fraction	0.98

Table 4-6. Land nutrient balance

	Unit	N balance	P balance
		60ML	
Irrigation (effluent load added)	kg/ha/year	33.58	7.89
Denitrification	kg/ha/year	0.00422	-
Irrigation runoff	kg/ha/year	0.00	0.00
Plant uptake	kg/ha/year	34.16	5.60
Leached	kg/ha/year	0.22	0.04

4.2.4 Discussion

Irrigation area

The MEDLI results indicate that the proposed irrigation schemes provided are sufficient to manage the daily effluent volumes produced without creating any irrigation runoff or significant increases to the deep drainage.

The application rate of nutrients is slightly higher than the predicted plant uptake rates which results in some leaching of phosphorous. The predicted average phosphorous concentration of the deep drainage based on current soil concentrations and effluent irrigation is considered low.

The concentration of nutrients in the wastewater is to be monitored to ensure that if concentrations increase significantly above the predicted values, the irrigation area is adjusted, or alternative treatment methods are reviewed.

A large WWS and land irrigation area is required for wetter than average wet seasons. During the drier seasons (i.e May to September), higher volumes of water are likely to be required to be applied to smaller areas of the irrigation area, to maintain crop growth. This may require a rotational program to be implemented to avoid nutrient accumulation in those areas.

Wet weather storage

The MEDLI results indicate that 60 ML of WWS capacity should be large enough to minimise uncontrolled release of effluent, excepting during extreme weather events. Assuming the effluent volumes entering the system align with those used in the modelling, the results indicate that overflow events may occur at a rate of 0.18 events/year, or 1.8 events every ten years.

Increasing the WWS size to 80 ML or 100 ML in the model, reduces the overflow events down to less than one every ten years. However, the model results indicate there would still be some overflow during extreme weather events. Whilst there is sufficient land availability to construct large storages, the cost and feasibility of managing such storages may be limiting. Assuming the treated effluent will contain very low concentrations of nutrients, which would be further diluted by rainfall in the storage, it is considered that there is minimal environmental benefit to be achieved by constructing zero discharge storages.

The modelling of different reuse scenarios indicates that reuse of effluent could further reduce the frequency and volume of overflows from the WWS. Treatment and reuse are an option that can be further investigated by PRI Farming as the farm is developed and site-specific effluent data become available. However, while there is uncertainty about the levels of reuse that can be achieved, it is recommended that the design criteria for WWS capacity are based on the worst-case scenario of zero reuse.

If the actual effluent volumes or quality are found to be higher than predicted, then the staging of the development and large available land area allows for additional irrigation areas and/or storages to be added progressively as the farm reached its 5 year operational capacity to achieve the water quality objectives established in the EPL.

4.3 Summary and recommendations

It is imperative to LLCF that the results of the modelling and ultimate decision on sizing of the WWS both take into consideration environmental factors and operational requirements. The results of the MEDLI model and its outputs in both models reflect the information made available at the time of modelling and do include a number of assumptions and limitations.

The staged nature of the development provides an opportunity to add WWS capacity over time in response to actual conditions experienced during operations. The following recommendations are made for future improvements to the model and ultimate design of the LLCF, to ensure that the WWS and irrigation area are appropriate.

- Sampling of LLCF effluent volumes and quality in the Stage 1 and Stage 2 pens and effluent storages should be undertaken to verify model inputs. These results can be adopted in later re-runs of the MEDLI to reflect site specific conditions (as currently all data used within the MEDLI model are from Lagoon and Janamba Crocodile Farms).
- PRI Farming Pty Ltd to actively monitor the water levels, inputs and outputs of the WWS over the course of increasing operations of LLCF over the next 5 years (particularly during the wet season months of December to March) to determine whether the WWS can hold the volumes of water required.

5 IRRIGATION AND CROP MANAGEMENT

5.1 Irrigation infrastructure

Stage 1

The Pierce C600 centre pivot system has been selected to be used as the irrigation mechanism for wastewater disposal over the proposed crop irrigation area. The system is a self-propelled system that rotates around a fixed central point. The system is a remote irrigation management product that uses the Global System for Mobile Communications (GSM) technology to monitor and manage the irrigation system. The technology allows for remote access to the current end pressure, speed percentage, angle, endgun, total hours running and total hours with water. This system will be fitted with a Zenner Flanged meter attached to the water extraction pump and is for loaded water, i.e. agriculture, wastewater treatment plants or sewage works. The meter enables readings to be recorded with each extraction.

The benefits of using a centre pivot system are:

- Irrigation water is applied gently to reduce the risk of puddling or surface runoff.
- Water coverage is evenly distributed over the irrigation area selected.
- The system continuously moves over the crops.
- An alignment control valve is attached to stop irrigation if the system faults, with a sensor shutting down the water at the same time.

To achieve a minimum 15 ha area, one pivot system has been installed half reach to each achieve an 8 ha span. The control panel features forward and reverse controls, variable application rates, GPS monitoring and the ability to stop in a set position as well as an SMS alert system. The sprinkler system is comprised of nylon goosenecks, flexible drops, 10spi regulators and I-Wob sprinklers. The pivot system will rest on a heavy duty concrete pivot pad.

Irrigation will commence at a rate of 5mm/day as calculated by the site water balance and as recommended by the Australian Standard for *On-site domestic wastewater management* (AS/NZS 1547:2012) for drip or spray irrigation. The irrigation rate will be monitored alongside soil moisture levels to ensure appropriate application rates to avoid runoff.

The proposed irrigation areas for Stage one area outlined on Figure 5-1.

Stage 2

An in-line drip system has been selected to be used as the irrigation mechanism for wastewater disposal over the proposed 100 ha crop irrigation area. The construction of the irrigation infrastructure will be progressively staged in 20 ha intervals.

Similarly to the centre pivot system above, irrigation will commence at a rate of 5mm/day as calculated by the site water balance and as recommended by the Australian Standard for *On-site domestic wastewater management* (AS/NZS 1547:2012) for drip or spray irrigation. The irrigation rate will be monitored alongside soil moisture levels to ensure appropriate application rates to avoid runoff.

The proposed irrigation areas for Stage two are outlined on Figure 5-2.

5.2 Irrigation management

PRI recognise the importance of finding a solution to wastewater management and preventing discharge of untreated wastewater offsite which has the potential to impact the receiving environment. Sustainable wastewater management involves the selection of suitable irrigation infrastructure to the water and nutrient requirements of the crops, while also preventing oversaturation resulting in uncontrolled run off, damaging of the soil and unsustainable crops.

A procedure regarding monitoring and the reuse of wastewater via land irrigation has been developed to ensure the activities are managed appropriately (see Appendix D).

5.2.1 Runoff control

LLCF will control and manage runoff of effluent by:

- Using a spray/drip irrigation system, that applies the irrigation water at a low rate.
- Apply the effluent water over an area large enough to absorb the capacity of water.
- Daily visual inspections of irrigation area for evidence of potential runoff (also mist/overspray and odour).
- Only apply effluent at the rate identified applicable to each season (i.e. dry season and wet season).
- Buffer zone of 50 m around the irrigation area, to prevent impact on sensitive receptors and neighbouring properties.

During the wet season (November to April) rainfall in the area increases, resulting in the soils becoming saturated and the wastewater no longer can infiltrate at the same rate as the dry season, leading to runoff. Irrigation will not be undertaken during rain events and will only recommence once soil moisture conditions allow as per the procedures in Appendix D.

5.2.2 Storage contingencies

Stage 1

The outcomes of the MEDLI water balance indicate that 100 m^3 of storage is required to prevent overflows and irrigation runoff. Where this storage requirement cannot be achieved in one tank (i.e. the concrete tank modelled), additional storage tanks will be kept on site with emergency overflow valves fitted to direct water as required.

In the event of infrastructure maintenance or breakdown, water ingress into the hatchery will cease until repairs can be undertaken. As the generation of wastewater will be interrupted, this will reduce reliance on storages to accommodate additional wastewater flows during the maintenance process. Likewise, in the event of large monsoonal events that may hinder irrigation activities, water inputs can be managed to try and reduce the volume of wastewater generated during this period.

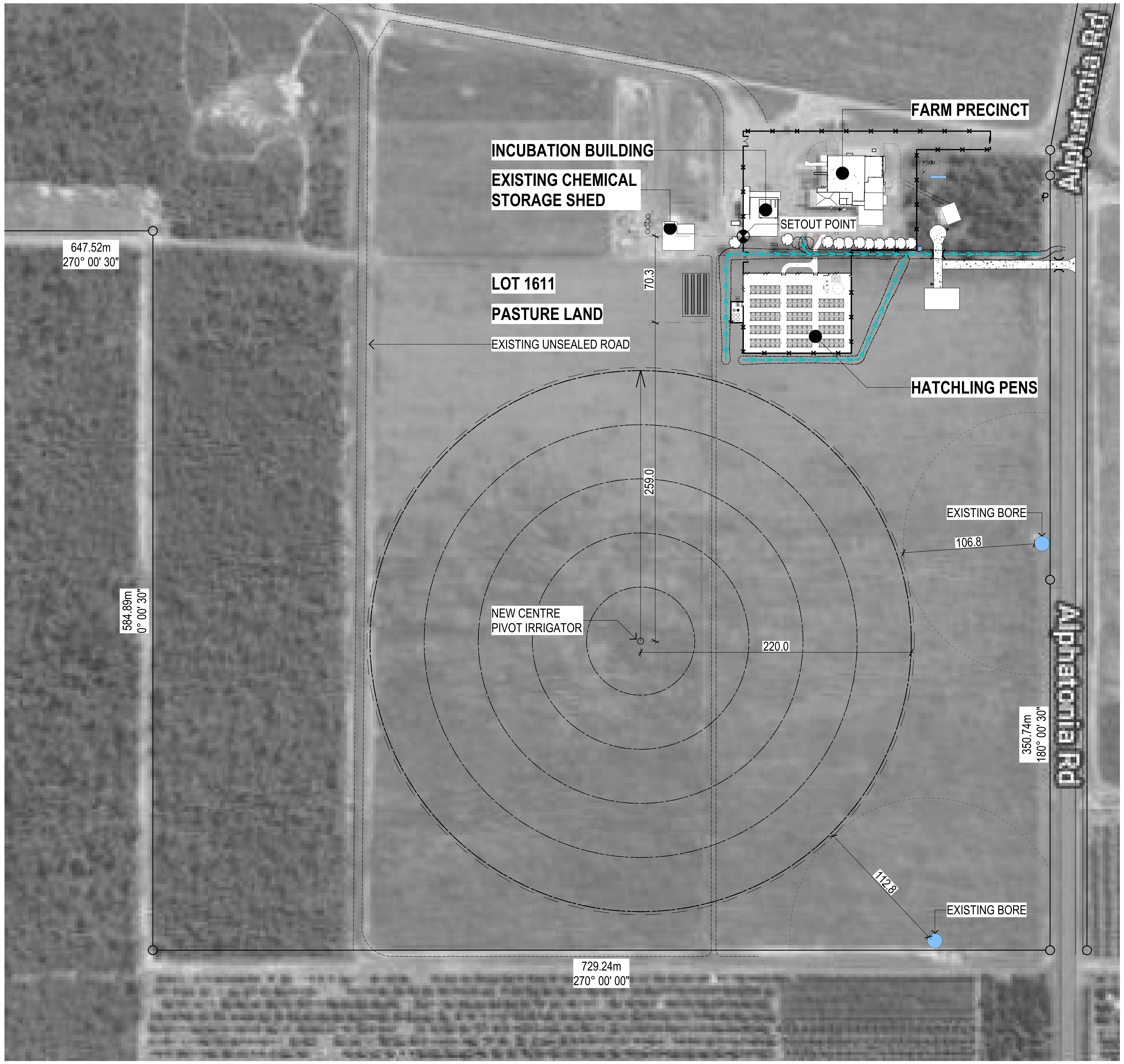
Stage 2

The outcomes of the MEDLI modelling for Stage indicate that a 60ML dam is sufficient cater for the volume of water proposed to be used at Marpu when in full operation. The design of the dam will incorporate a sump, to cater for the times when there is only a small volume of water available for irrigation purposes. Additional WWS can be assessed in the future if the need arises.

5.3 Crop management

The irrigation area is to be managed by a specialist agricultural technician, who will be responsible for the harvesting when required. The crops proposed to be used in Stages 1 irrigation area is Mariner Rhodes grass and Stage 2 irrigation area is African Mahogany plantation. The crops will be inspected regularly to monitor their growth as well as plant health to determine any visual impacts of nutrient supply.

Crops will be harvested regularly to encourage growth and nutrient uptake and will then be processed for stockfeed.



SPECIFICATIONS:

- 600 MICRON WEDGE WIRE JOHNSON SIEVE BED SCREEN.
- 5ml PER m^2 IRRIGATION RATE.
- 16ha (220M RADIUS) CENTRE PIVOT IRRIGATOR.
- 8ha TRIAL AREA WITH CAPACITY TO INCREASE TO 16HA.
- 110kL DAILY EXPECTED FLOW AT MAX CAPACITY.
- 4 X 25m^3 STORAGE TANKS FOR EMERGENCY REDUNDANCY.
- 9800L CAPACITY IN PUMP STATIONS.

NOTE:

- ALL DIMENSIONS TO BE CHECK ON SITE AND CONFIRM LOCATION WITH SUPERINTENDENT. CENTRE PIVOT IRRIGATION AND EXISTING BORES ARE INDICATIVELY DRAWN.
- SETOUT POINT STARTS FROM EDGE OF CONCRETE HARDSTAND OF THE INCUBATION BUILDING.

KEY:

- STORMWATER SWALE DRAIN. REFER TO CIVIL ENGINEER'S FOR DETAILS.
- EXISTING UNSEALED TRACKS.
- PERIMETER OF CENTRE PIVOT IRRIGATOR.
- CONCENTRIC IRRIGATION LINES.
- DASHED LINES DENOTES CLEARANCE DISTANCES BETWEEN EXISTING BORES AND IRRIGATION AREA.
- FLOW DIRECTION OF IRRIGATION.

N

STAGE 1 IRRIGATION PLAN

SCALE @ A1 - 1:2000

0 50 100 150 200 250m

BENNETT ARCHITECTURE

contact@bennettarchitecture.com.au
www.bennettarchitecture.com.au
tel 08 8948 4607
fax 08 8918 8113
abn 46636247768

JOB NO: BA2665

CLIENT:

SITZLER

REV	DESCRIPTION	DATE	INIT.
00	ISSUE FOR CONSTRUCTION	01/04/2021	DV

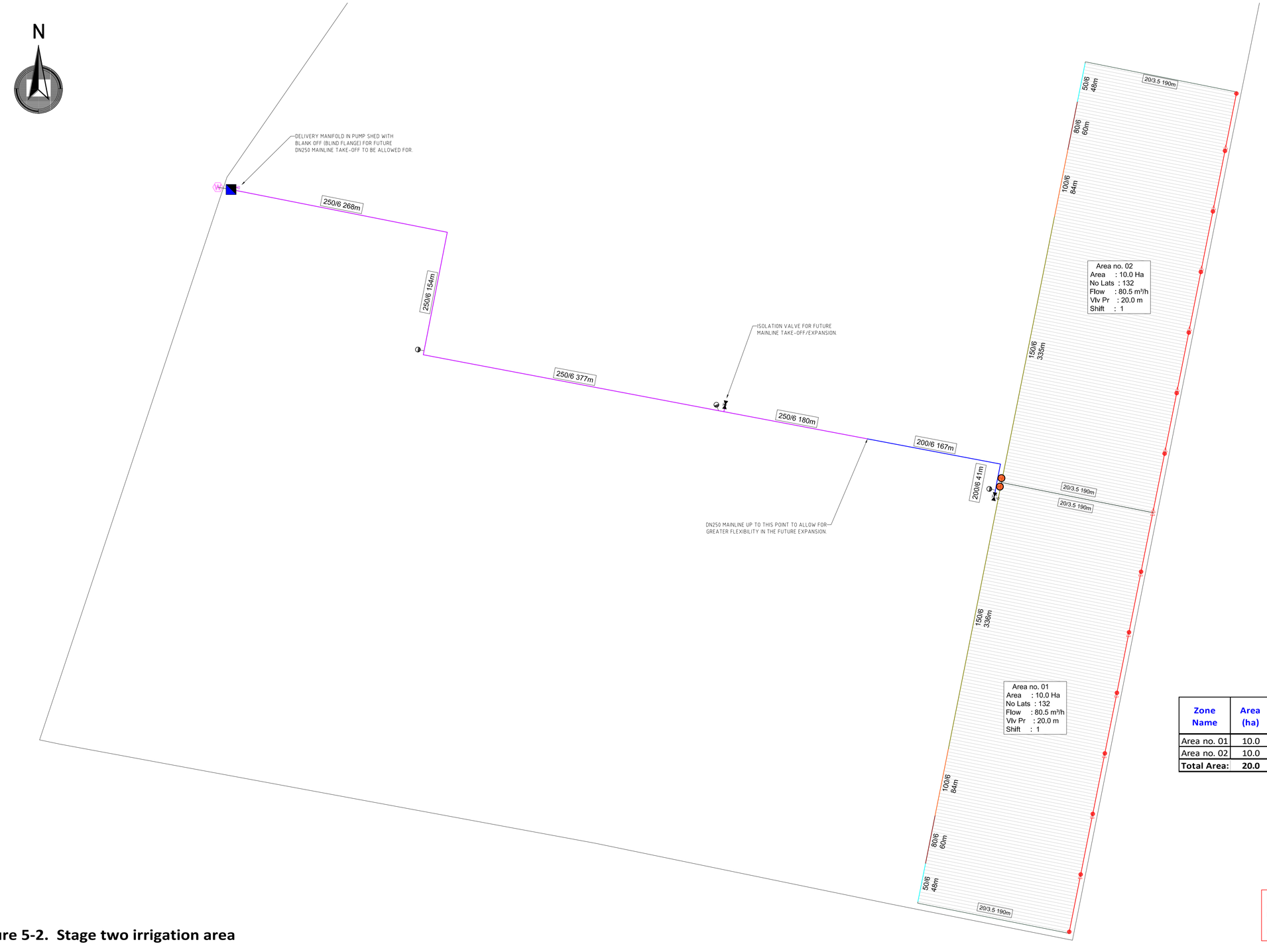
AMENDMENTS

PROJECT:
CROCODILE FARMING PROJECT
CLIENT:
SITZLER
ADDRESS:
SEC 1611 (255) ALPHATONIA ROAD,
HUMPTY DOO NT 0836

DRAWING:
Figure 5-1. Stage one irrigation area

PROJECT DATE:	SCALE:	DESIGNED/DRAWN:	CHECKED:	SHEET SIZE:
OCT 2020	AS SHOWN	DV	PW	A1

SITZLER DRAWING No:	SHEET No:	REVISION:
A-SW-012	012 of 11	00



IRRIGATION DATA TABLE

Description	Units	Initial 20 ha	Final 200 ha
Crop		Mahogany Tree	
Irrigation Area (Net)	ha	20.0	200.0
Rows/Beds Spacing	Mtr.	4.0	4.0
Plants Spacing	Mtr.	2.0	2.0
Irrigation System		In-line Drip	In-line Drip
Emitter Type		Uniram 20010 AS	Uniram 20010 AS
Minimum Emitter Pressure	Mtr.	13.0	13.0
Emitter Discharge	L/H	1.60	1.60
Emitter Spacing	Mtr.	0.50	0.50
Laterals Average Spacing	Mtr.	4.0	4.0
No. of Laterals per Row/Bed	No.	1	1
Application Rate	mm/h	0.80	0.80
Max. Daily Consumption	mm/day	4.0	4.0
Irrigation Cycle	Days	1	1
Duration of one Operation	Hrs.	5.0	5.0
Number of Operations	No.	1	4
Max. Daily Operation Duration	Hrs.	5.0	20.0
Available Daily Duration	Hrs.	24	24
Mainline Flexibility		Medium/Maximum	
Max Number of Laterals per Flush Tap	No.	20 Laterals Per Manifold & Tap	
Pump Duty (Excludes Backflush Requirements)		**Initial 20 ha**	**Final 200 ha**
Maximum Discharge Required	m3/h	161.0	414.0
Maximum Discharge Required	lps	44.7	115.0
Required Pressure at Water Source	Mtr.	38.0	55.0
Required Pressure After Filtration	Mtr.	26.0	43.0
Assumed Filter Station RL:	Mtr.	0.0	0.0
Assumed Lowest Water RL:	Mtr.	-2.0	-2.0

Allowances For Calculation of Total Dynamic Head:			
Suction Line	Mtr.	3.0	3.0
Filtration - (Disk)	Mtr.	7.0	7.0
Miscellaneous/Headworks	Mtr.	2.0	2.0
Field Valve Assembly	Mtr.	4.0	4.0

Allowances in Calculation of Total Dynamic Head Required (TDH) - Final 200 ha

TDH For Final Pump Duty (m)	Critical (Furthest) Valve Pressure Required (m)	Total Mainline loss (m)	Total Mainline Distance (m)	Elevation (m)	Valve Assy Loss (m)	Headworks Losses (m)
55.0	22.0	11.0	2200.0	6.0	4.0	12.0
	Loss Allowed/100m=	0.5				

Zone Name	Area (ha)	Valve Size	Flow (m3/h)	Reg Pressure (m)	Min Pressure (m)	Max Pressure (m)	Mean Flow (lph)	Flow Var. (%)
Area no. 01	10.0	100mm	80.5	20.0	13.2	20.0	1.6	0.0
Area no. 02	10.0	100mm	80.5	20.0	13.2	20.0	1.6	0.0
Total Area:	**20.0**	**(ha)**						

NOTE: **SYSTEM DESIGNED FLAT**
LIMITED SITE DATA HAS BEEN PROVIDED TO NETAFIM TO CARRY OUT THIS DESIGN. NETAFIM TAKES NO RESPONSIBILITY FOR ERRORS THAT ARISE FROM THE USE OF THIS DATA AND RECOMMENDS THAT ACCURATE HYDRAULIC DESIGNS REQUIRE A FULL SITE SURVEY TO BE CARRIED OUT BY A LICENSED SURVEYOR.

Figure 5-2. Stage two irrigation area

- Uniram 20010 AS 1.6 lph @ 0.5m
- 50mm PVC Class 6
- Collect Manif - 50mm PVC Class 6
- 80mm PVC Class 6
- 100mm PVC Class 6
- 150mm PVC Class 6
- 200mm PVC Class 6
- 250mm PVC Class 6
- Suction/Delivery Manifold
- Valve Take Off - TBD

DIAL BEFORE YOU DIG www.1100.com.au The Essential First Step

- 100mm Valve Assy
- 50mm Air Valve Assy (AV50-xx)
- 50mm Threaded AV-10 Vacuum Breaker
- 50mm Collection Manifold (CF50-01)
- 150mm Purge Valve Assy (PV150-xx)
- Pump / Disc Filter Station
- Isolation Valve - Line Sized
- Water Supply

CERTIFIED IRRIGATION DESIGNER — IRRIGATION AUSTRALIA — ADM2570 — AGRICULTURAL DRIP MICRO

NOTES:
1. ALL NOTES SHALL BE READ IN CONJUNCTION WITH THE CONTRACT SPECIFICATIONS, DESIGN DRAWINGS, TECHNICAL SPECIFICATIONS AND OTHER RELEVANT STANDARDS. PRECEDENCE IS GIVEN TO SPECIFICATIONS AND STANDARDS, THEN DRAWINGS, THEN NOTES.
2. THE PLANS ARE A SCHEMATIC REPRESENTATION OF THE DESIGNED IRRIGATION SYSTEM.
3. RETAIN AND PROTECT ALL EXISTING SERVICES. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO LOCATE AND IDENTIFY ALL SERVICES PRIOR TO COMMENCEMENT OF WORK AND PROTECT ALL DURING WORK. PRIOR TO COMMENCEMENT OF WORK THE CONTRACTOR SHALL PERFORM A 'DIAL BEFORE YOU DIG' ENQUIRY. IT IS NOT GUARANTEED THAT ALL SERVICES HAVE BEEN SHOWN ON THE DRAWING.
4. ALL CONTROL CABLE CROSSING HARDSTAND AREAS TO BE INSTALLED WITHIN CONDUIT.

0 25.0 50.0 100.0 150.0 200.0
ORIGINAL SCALE @ A1 : 1:2500

ISSUED FOR CONSTRUCTION

REVISION	DATE	REVISION DESCRIPTION	BY
D	14/09/21	ISSUE FOR CONSTRUCTION	GV
C	21/07/21	REVISED AND APPROVED ISSUE FOR TENDER	GV
B	21/06/21	APPROVED ISSUE FOR TENDER	GV
A	17/06/21	PRELIMINARY ISSUE FOR REVIEW	GV

NETWORKS DESIGN • SERVICE • PROJECTS

Project:	Description:
Mahogany's Anzac Parade	Stage 1
Client:	System: / Location:
Water Dynamics	Irrigation / Lambells Lagoon NT

Sheet:	Design by:	Drawn:	Checked by:	Size:	Scale:	Date:	Rev:	Job No:	Org No.
1 of 1	GV	GV	KK	A1	1:2500	17/06/2021	D	0621002p1	01

6 MONITORING AND REPORTING

6.1 Daily monitoring

Monitoring of the irrigation area will be undertaken as per the procedures included in Appendix D.

Irrigation activities will only be conducted during work hours when the system can be monitored at all times.

6.2 Compliance water and soil monitoring

Monitoring and reporting for irrigation activities will be conducted in accordance with the EPL application and LLCF Environmental Management Plan. Water sampling includes the sampling of groundwater, surface water and wastewater to be irrigated, and soil sampling is a standardised regime aligned with the NSW Guideline *Use of Effluent by Irrigation* (DEC 2004).

6.3 Assessment of performance indicators

Annual nutrient balance calculations should be undertaken and compared with the soil monitoring results to assess the sustainability of the wastewater irrigation system. If the wastewater is managed so that the nitrogen and phosphorous input and output levels remain consistent, the overall soil nutrient concentrations should remain consistent.

The key parameters of soil should be graphed and compared annually, to identify any nutrient application issues or irrigation practices that may need to be altered.

Key parameters:

- Soil nitrogen
- Available phosphorus
- Salinity
- Sodicity.

6.4 Reporting

All routine wastewater and soil monitoring data along with incident/investigation monitoring data will be recorded in a water and soil quality database, and to be available upon request to the NT EPA.

6.4.1 Internal reporting

Details of environmental incidents, non-conformances or other relevant information are included in daily reports which are issued to the Farm Manager. Records of all incidents, inspections and reports are maintained through an electronic filing system.

All environmental monitoring records will be maintained in a water and soil quality database.

An annual report is also prepared which details and reviews annual water usage, waste generation (all streams) and energy use across the farm.

6.4.2 External reporting

All non-compliances of the EPL will be reported by PRI by completing a Non-Conformance Notification via the NT EPA website as soon as practicable after becoming aware of the non-conformance (and within 24 hours of the event), as per Section 14 of the *Waste Management and Pollution Control Act 1998 (NT)*.

Reporting will be undertaken in accordance with the EPL. An annual report will be submitted to the NT EPA on the anniversary data of the EPL which summaries the activities and outcomes of the previous 12 months of operation. Additionally, a monitoring report will be prepared and submitted in conjunction with the Annual report, which will include a trend analysis of the water quality monitoring data and an assessment of any environmental impacts from LLCF operations.

7 REFERENCES

Australian and New Zealand Environment and Conservation Council (ANZECC) (2000), Australian and New Zealand Guidelines for fresh and marine water quality, Volume 3, Primary industries – rationale and background information, Agriculture and Resource Management Council of Australia and New Zealand.

Cameron A.G. and Lemcke B. (2008). *Agnote No. E29: Guinea Grass.* Department of Regional Development, Primary Industry, Fisheries and Resources, Northern Territory Government.

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

Department of Land Resource Management (LRM), *Soils of the Northern Territory factsheet*, LRM, Northern Territory Government, Darwin.

Hausler P., O'Gara F. and Price T. (2002) *Agnote No. C32: Growing Grain Sorghum in the Northern Territory.* Department of Primary Industry, Fisheries and Mines, Northern Territory Government.

Mills, B (2001), *DPI&F Notes: Interpreting water analysis for crop and pasture* (revised 2004), The State of Queensland Department of Primary Industry and Fisheries.

APPENDIX A SOIL SAMPLING RESULTS

ES2002110	Date Sampled	23/01/2020	Preferred Levels* for crop/plant growth (NSW DPI, 2004)	NEPM TABLE 1-A 2013 (SOIL) - HIL A (Residential) Guideline Limit	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12	SS13
Physio-chemistry	Units	LOR			ES2002110001	ES2002110002	ES2002110003	ES2002110004	ES2002110005	ES2002110006	ES2002110007	ES2002110008	ES2002110009	ES2002110010	ES2002110011	ES2002110012	ES2002110013
pH Value	pH Unit	0.1	-	-	7	7.5	6.5	6.9	7.1	6.7	6.5	6.1	6.7	5.6	6.4	6.9	6.7
Sodium Adsorption Ratio	-	0.01	-	-	0.21	0.2	0.12	0.1	0.12	0.17	0.24	0.2	0.06	0.16	0.16	0.15	0.18
Electrical Conductivity @ 25°C	µS/cm	1	-	-	29	45	22	31	36	18	25	15	24	12	22	30	30
Moisture Content	%	1	-	-	17.2	14	13.6	14.4	16.2	12	16.8	10.2	11.2	10.7	14.5	15.6	15.4
Color (Munsell)	-		-	-	Black (10YR 2/1)	Black (10YR 2/1)	Very Dark Gray (10YR 3/1)	Black (10YR 2/1)	Very Dark Gray (7.5YR 3/1)	Dark Brown (10YR 3/3)	Very Dark Brown (7.5YR 2.5/2)	Very Dark Gray (10YR 3/1)	Very Dark Grayish Brown (10YR 3/2)	Very Dark Gray (10YR 3/1)	Very Dark Brown (7.5YR 2.5/3)	Very Dark Brown (7.5YR 2.5/3)	Very Dark Brown (7.5YR 2.5/3)
Emerson Class Number	-		-	-	3	3	3	3	3	3	7	3	3	3	3	3	3
Texture	-		-	-	Clay Loam	Loam	Clay Loam	Loam	Sandy Clay Loam	Sandy Loam	Clay Loam	Clayey Sand	Clayey Sand	Loamy Sand	Clay Loam	Clay Loam	Clay Loam
Exchangeable Cations on Alkaline Soils																	
Cation Exchange Capacity	meq/100g	0.2	-	-	-	2.7	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Calcium	meq/100g	0.2	-	-	-	1.2	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Magnesium	meq/100g	0.2	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Potassium	meq/100g	0.2	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Sodium	meq/100g	0.2	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Sodium Percent	%	0.2	-	-	-	<0.2	-	-	-	-	-	-	-	-	-	-	-
Exchangeable Cations																	
Cation Exchange Capacity	meq/100g	0.1	-	-	7.1	-	4.4	6.6	7.4	2.2	4.2	1.3	3.7	0.5	3	6.5	5.1
Exchangeable Calcium	meq/100g	0.1	-	-	4.5	-	3	4.2	5.5	1.6	2.5	0.9	2.7	0.2	2	4.1	3.2
Exchangeable Magnesium	meq/100g	0.1	-	-	1.8	-	0.8	1.7	1.4	0.4	1.1	0.2	0.7	0.2	0.7	1.7	1.3
Exchangeable Potassium	meq/100g	0.1	-	-	0.8	-	0.5	0.7	0.5	0.2	0.6	0.1	0.2	<0.1	0.3	0.6	0.6
Exchangeable Sodium	meq/100g	0.1	-	-	0	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Exchangeable Sodium Percent	%	0.1	-	-	0.3	-	0.3	0.2	0.2	0.7	0.5	0.8	0.3	2.5	0.5	0.3	0.3
Total Metals																	
Arsenic	mg/kg	5	<20	100	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Cadmium	mg/kg	1		20	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

ES2002110	Date Sampled	23/01/2020	Preferred Levels* for crop/plant growth (NSW DPI, 2004)	NEPM TABLE 1-A 2013 (SOIL) - HIL A (Residential) Guideline Limit	SS1	SS2	SS3	SS4	SS5	SS6	SS7	SS8	SS9	SS10	SS11	SS12	SS13
Physio-chemistry	Units	LOR			ES2002110001	ES2002110002	ES2002110003	ES2002110004	ES2002110005	ES2002110006	ES2002110007	ES2002110008	ES2002110009	ES2002110010	ES2002110011	ES2002110012	ES2002110013
Chromium	mg/kg	2		-	11	49	18	36	42	25	11	54	25	27	14	16	14
Copper	mg/kg	5	2 - 50	6000	5	<5	<5	<5	<5	<5	7	<5	<5	<5	5	9	6
Lead	mg/kg	5	<35	300	7	7	5	6	7	5	9	5	5	<5	7	7	6
Nickel	mg/kg	2	1 - 20	400	2	<2	<2	<2	<2	<2	2	<2	<2	<2	<2	<2	<2
Zinc	mg/kg	5		7400	29	24	15	21	20	8	<5	<5	6	<5	<5	17	12
Mercury	mg/kg	0.1		40	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Nutrients																	
Nitrite + Nitrate as N (Sol.)	mg/kg	0.1		-	1.2	1.4	1.9	1.7	1.7	0.8	1.5	0.6	0.8	0.6	1.9	1.1	2.5
Total Kjeldahl Nitrogen as N	mg/kg	20		-	980	880	790	860	920	390	1310	850	520	580	800	930	760
Total Nitrogen as N	mg/kg	20	>10	-	980	880	790	860	920	390	1310	850	520	580	800	930	760
Total Phosphorus as P	mg/kg	2	20 - 30	-	**301**	**334**	**325**	**411**	**314**	**153**	**345**	**181**	**210**	**128**	**238**	**500**	**303**
Phosphate Sorption Capacity	mg P sorbed/kg	250		-	1610	1150	1030	1020	1350	562	1710	476	1010	862	1130	1280	1220
Phosphate Sorption Index	mgkg-1/log10ugL-1	1		-	51	27	43	35	50	26	67	45	40	58	66	41	46

Queensland Government

Department of Environment and Science - Chemistry Centre

Soil Analysis Report

Job No: 20-0715
Report ID: 20-0715-F-V1

Sample No	Customer's ID	Description	Method / Component / Units / Depth (m)	S_PSA Total %	S_AQ4_EL pH -	S_AQ4_EL EC dS/m	S_AQ4_AA Cl mg/kg	S_AQ4_AA NO3-N mg/kg	S_COLWELL P mg/kg	* S_PBI PBI col	* S_PBI PBI unadj	S_WALKLEY OC %	S_KJ_AA TKN %	S_KJ_AA TKP %	S_ADM_105 ADMC %	S_PSA Coarse sand %	S_PSA Fine sand %	S_PSA Silt %	S_PSA Clay %	S_03_BAR 1/3 Bar %	S_15_BAR 15 Bar %
20-0715-0001	S1-A	MEDLI Soil sampling for EZ191	0.30-0.50	105.8	6.39	0.02	<20	<1	16	112	109	0.85	0.038	<0.013	<1.5	32.3	49.5	8.7	15.3	12.9	6.7
20-0715-0002	S1-B	MEDLI Soil sampling for EZ191	1.20-1.40	100.3	5.57	<0.01	<20	<1	3	137	137	0.49	0.017	<0.013	2.2	23.9	31.8	8.9	35.6	21.2	13.4
20-0715-0003	S2-A	MEDLI Soil sampling for EZ191	0.30-0.50	104.6	5.97	0.02	<20	<1	15	94	91	1.06	0.049	0.013	<1.5	30.2	51.9	7.3	15.1	12.2	6.5
20-0715-0004	S2-B	MEDLI Soil sampling for EZ191	1.30-1.50	102.9	5.59	<0.01	<20	<1	3	120	119	0.35	0.017	<0.013	<1.5	27.9	42.3	5.9	26.8	15.7	9.7
20-0715-0005	S3-A	MEDLI Soil sampling for EZ191	0.10-0.30	101.0	6.17	0.03	<20	3	36	59	53	0.80	0.059	0.022	<1.5	27.5	57.8	2.6	13.2	9.8	6.4
20-0715-0006	S3-B	MEDLI Soil sampling for EZ191	0.50-0.70	100.7	6.21	0.02	<20	1	13	96	94	0.54	0.030	<0.013	1.6	30.6	45.9	7.6	16.6	16.2	9.4
20-0715-0007	S4-B	MEDLI Soil sampling for EZ191	0.20-0.40	102.0	6.03	0.02	<20	<1	55	77	67	1.11	0.065	0.027	<1.5	22.9	61.7	4.2	13.2	11.6	6.4
20-0715-0008	S4-A	MEDLI Soil sampling for EZ191	0.90-1.10	103.9	5.98	<0.01	<20	<1	11	137	135	0.46	0.023	<0.013	1.5	26.0	51.9	5.9	20.0	15.0	8.2

Name : Angus McElnea
Title : Team Leader Soil and Plant

NATA Accredited Laboratory
Number: 5072

This document is issued in accordance with NATA's accreditation requirements.
Accredited for compliance ISO/IEC 17025 - Chemical testing
The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.

APPENDIX B STAGE 1 MEDLI OUTPUTS

1 MEDLI SUMMARY: STAGE ONE

The Model for Effluent Disposal using Land Irrigation (MEDLI) is a program for designing effluent reuse schemes. The model addresses many factors impacting on effluent irrigation, such as the quality and quantity of effluent, climate, storage, irrigation frequency and amount, nitrogen, phosphorus and salt components and plant growth. The MEDLI program was used on the LLCF wastewater to assess the viability of irrigation as a method of wastewater management.

1.1 Input data

1.1.1 Climate

The quantity of effluent and current quality outlined in the sections above was used in the MEDLI assessment. A 60-year climate file for the Project area was obtained from the SILO database (a climate database managed by the Queensland Department of Environment and Science) to input rainfall and evaporation data. The model was run using climate data from 1950 to 2019, to account for recent impacts of climate change that may affect the model outputs.

1.1.2 Inflow

The effluent inflow was set at 100m^3 a day based on predicted water use once the hatchery is at peak capacity (early operational months may produce significantly less effluent). Inflow volumes were only set for March to December to coincide with the current programmed Stage one operational period. By December it is anticipated that Stage two will come online, which includes a full-scale wastewater management system and the Stage one irrigation activities will no longer be required.

1.1.3 Storage

A 6x6x3m open concrete storage tank was used in the scenario to represent the proposed storage and step screen solids removal tank. The tank is uncovered and therefore model parameters allowed for rainfall infiltration and evaporation over the exposed surface area.

1.1.4 Soil

Soil samples were collected from the Project area on 10 July 2020 and sent a laboratory specialising in MEDLI analysis suites. The analyses undertaken directly related to the required MEDLI inputs and allowed for site specific soil information to be incorporated into the model.

1.1.5 Crop selection

The default planting parameters for Forage Sorghum Crop were used in the model as they are representative of the crop selection for the proposed irrigation area. The default crop also has a maximum crop coefficient of 0.8, and according to the NT *Guidelines for Land Capability Assessment for On-site Wastewater Management* (DOH, 2014), a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT.

1.1.6 Irrigation method

The irrigation method modelled was a centre pivot system over varying irrigation areas to determine the minimum irrigation area required. The irrigation was applied on a daily frequency at a rate of 5 mm per day.

A “dry-run” was also modelled for both irrigation areas, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the area without any irrigation inputs.

1.2 Modelling results

The results of the water and nutrient balances modelled by MEDLI are outlined in Table 1-1 to Table 1-3 respectively. Based on the nutrient balance, a minimum irrigation area of 15 ha is recommended to manage the nutrient loading of the wastewater, therefore the outputs of the 15 ha irrigation area scenario have been provided.

Table 1-1. Land water balance

	Unit	With irrigation	Dry-run
Rain	mm/year	1544	1544
Irrigation	mm/year	203	0
Soil evaporation	mm/year	489	601
Transpiration	mm/year	461	0
Rain runoff	mm/year	41	114
Irrigation runoff	mm/year	0	0
Deep drainage	mm/year	758	829

Table 1-2. Pond system water balance

	Unit	Value
Rain	m3/year	51.47
Inflow	m3/year	30524
Evaporation	m3/year	75
Overflow	m3/year	22
Irrigation	m3/year	30479
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	1
Probability of at least 90% reuse	Fraction	1

Table 1-3. Land nutrient balance

	Unit	N balance	P balance
Irrigation (effluent load added)	kg/ha/year	161	26
Denitrification	kg/ha/year	0.12	-
Irrigation runoff	kg/ha/year	0	0
Plant uptake	kg/ha/year	140	19
Leached	kg/ha/year	24	0.07

The MEDLI results indicate that the proposed irrigation scheme is sufficient to manage the daily effluent volumes produced without creating any irrigation runoff or significant increases to the deep drainage. The proposed concrete tank is sufficient in size to store the wastewater without causing significant overflows and ensuring 100% reuse of the effluent produced (through irrigation).

The application rate of nutrients is slightly higher than the predicted plant uptake rates which results in some leaching of nitrogen. The predicted average nitrate concentration of the deep drainage based on current soil

concentrations and effluent irrigation, is 3.2mg/L which is still considered low. The concentration of nutrients in the wastewater is to be monitored to ensure that if concentrations increase significantly above the predicted values, the irrigation area is adjusted accordingly or alternative treatment methods are reviewed.

MEDLI REPORT - FULL RUN

Enterprise: **Stage 1 Hatchery**

Description:
Lambells Lagoon

Client: **PRI Farming Pty Ltd**

MEDLI User: ECOZ\emma.lewis

Scenario Details:

DESCRIPTION

Climate Data: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days

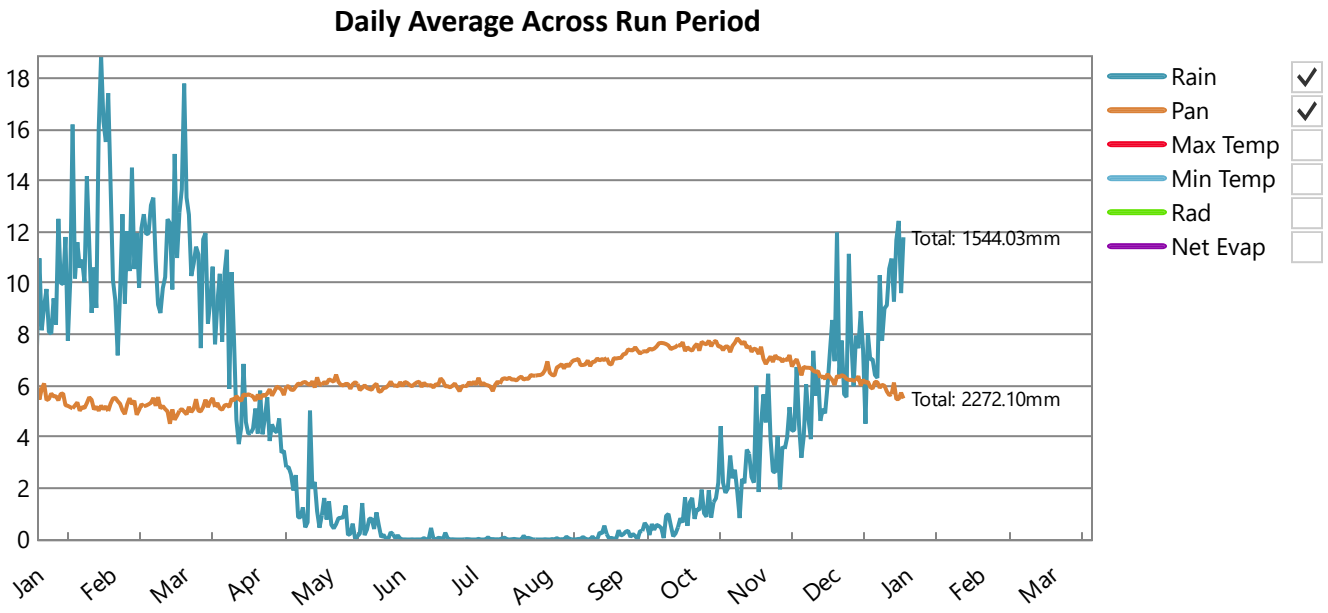
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1108	1521	2163
Pan Evaporation (mm/year)	2100	2273	2448

Climate Data:

Chart Table

Monthly Daily

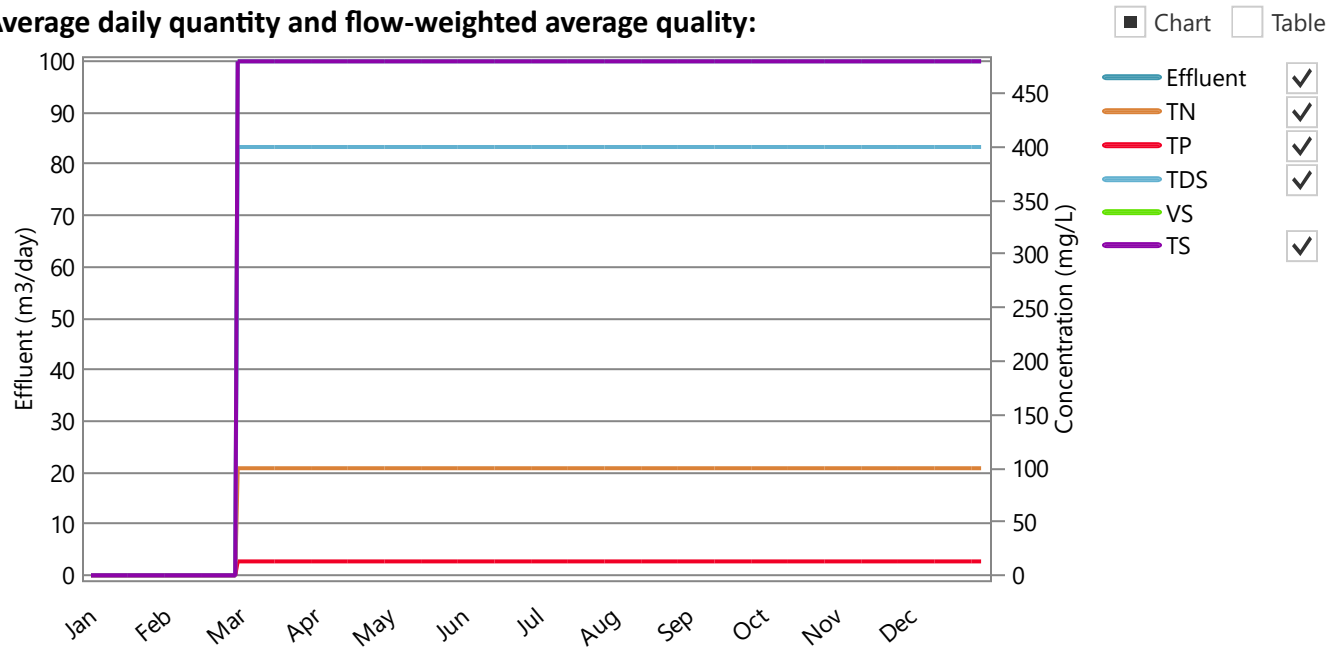


DESCRIPTION

Effluent type: Lambells Lagoon Hatchery

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **30524.19 m3/year** or 83.57 m3/day (Min-Max: 0.00 - 100.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

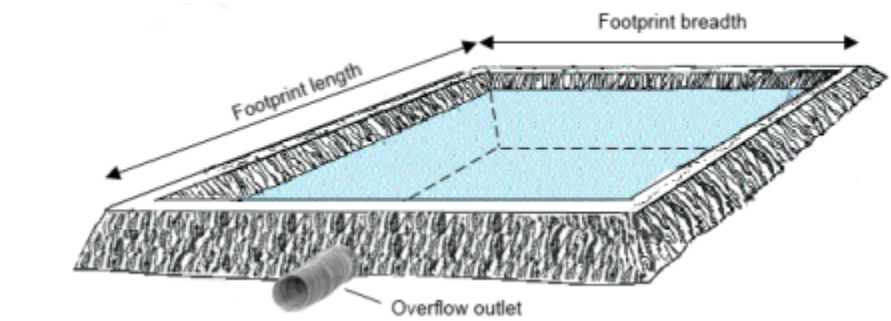
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	100.00 (0.00 - 100.00)	3052.42 (3050.00 - 3060.00)
Total Phosphorus	13.00 (0.00 - 13.00)	396.81 (396.50 - 397.80)
Total Dissolved Salts	400.00 (0.00 - 400.00)	12209.68 (12200.00 - 12240.00)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	480.00 (0.00 - 480.00)	14651.61 (14640.00 - 14688.00)

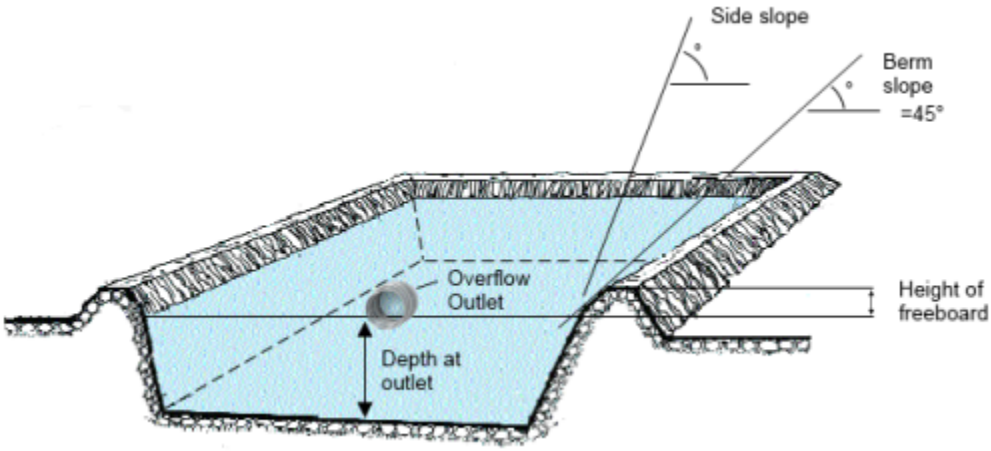
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (m3)	100.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	33.33
Pond footprint length (m)	5.77
Pond footprint width (m)	5.77
Pond catchment area (m2)	33.33
Average active volume (m3)	1.02





Irrigation pump limits:

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

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

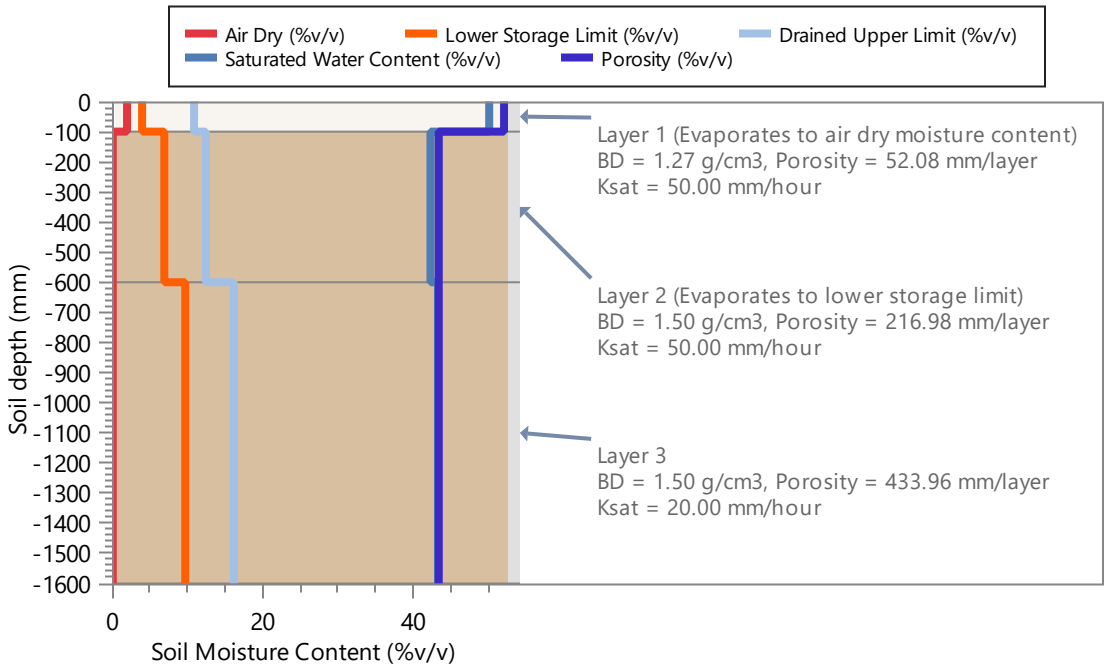
DESCRIPTION

Land: Stage 1 irrigation

Area (ha): 15.00

Soil Type: Lambells, 1600.00 mm defined profile depth

Profile Porosity (mm)	703.02
Profile saturation water content (mm)	694.60
Profile drained upper limit (or field capacity) (mm)	235.10
Profile lower storage limit (or permanent wilting point) (mm)	136.05
Profile available water capacity (mm)	99.05
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Forage Sorghum Crop

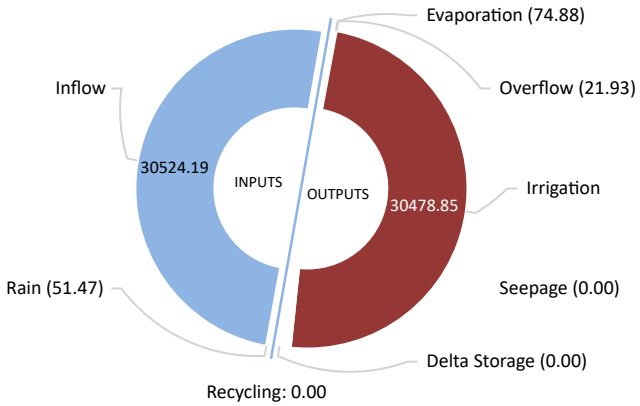
Average monthly cover (fraction) (minimum - maximum)	0.32 (0.00 - 0.67)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.00
Maximum potential root depth in defined soil profile (mm)	1600.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11

PERFORMANCE

Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **100 m3**

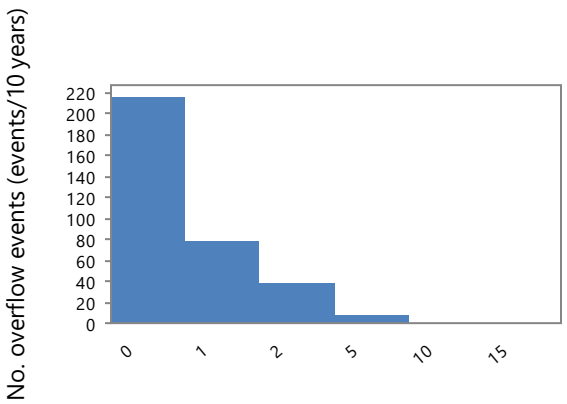
Pond System Water Balance (m3/year)



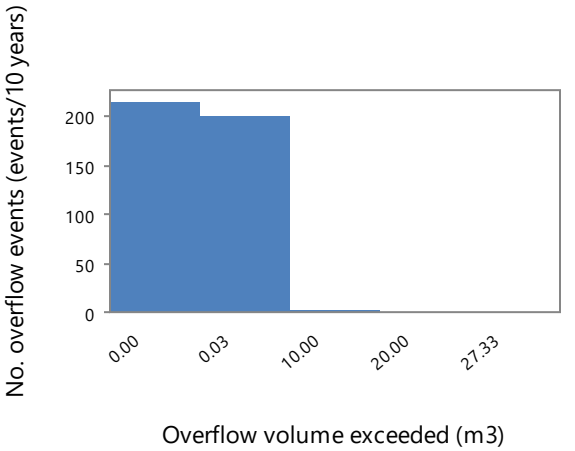
Name	Value
Rain	51.47
Inflow	30524.19
Recycling	0.00
Evaporation	74.88
Overflow	21.93
Irrigation	30478.85
Seepage	0.00
Delta Storage	0.00

Overflow Diagnostics

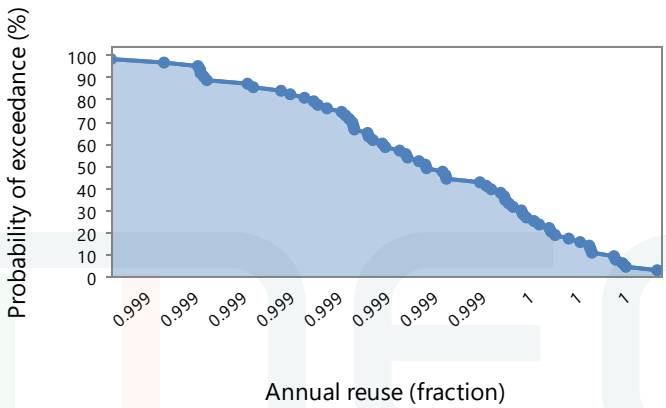
Volume of overflow (m3/year)	21.93
No. days pond overflows (days/year)	38.85
Average duration of overflow (days)	1.81
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00



Export plot



Export plot



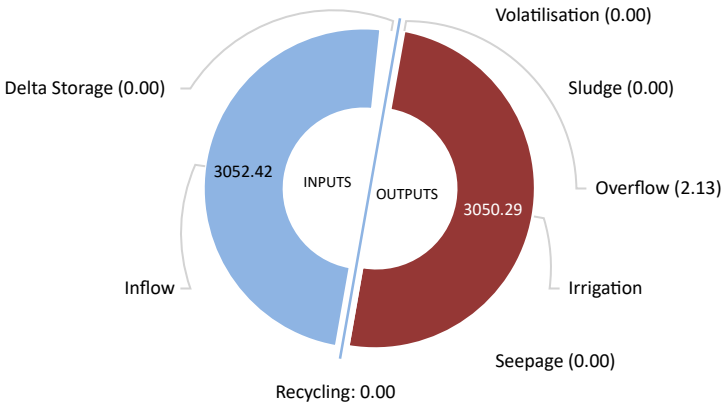
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

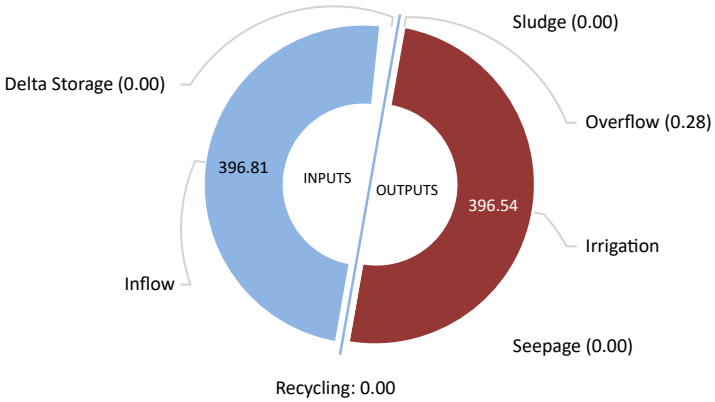
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



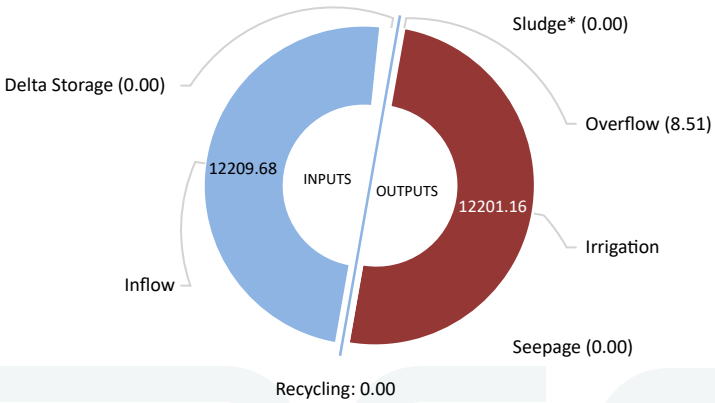
Name	Value
Inflow	3052.42
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	2.13
Irrigation	3050.29
Seepage	0.00
Delta Storage	0.00

Phosphorus Balance (kg/year)



Name	Value
Inflow	396.81
Recycling	0.00
Sludge	0.00
Overflow	0.28
Irrigation	396.54
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	12209.68
Recycling	0.00
Sludge*	0.00
Overflow	8.51
Irrigation	12201.16
Seepage	0.00
Delta Storage	0.00

* 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 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	0.10
Average phosphorus concentration of pond liquid (mg/L)	0.01
Average salinity of pond liquid (dS/m)	0.00

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	99.63
Final phosphorus concentration of pond liquid (mg/L)	12.95
Final salinity of pond liquid (dS/m)	0.62

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	30478.85
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	30478.85
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/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:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	100.08
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	79.26
Average phosphorus concentration of irrigation water (mg/L)	13.01
Average salinity of irrigation water (dS/m)	0.63

Irrigation Diagnostics:

Proportion Days Irrigation Turned Off (fraction)	0.16
Proportion of Days irrigation occurs (fraction)	0.84

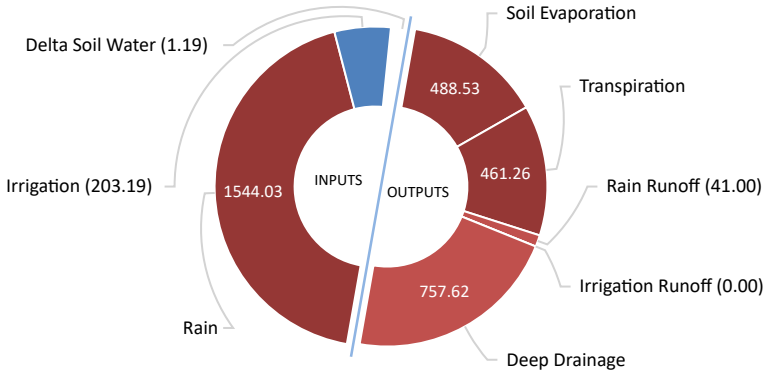
PERFORMANCE

Land Performance - Soil Water

Paddock: Stage 1 irrigation, 15 ha
Soil Type: Lambells, 99.05 mm PAWC at maximum root depth

Land Water Balance (mm/year):

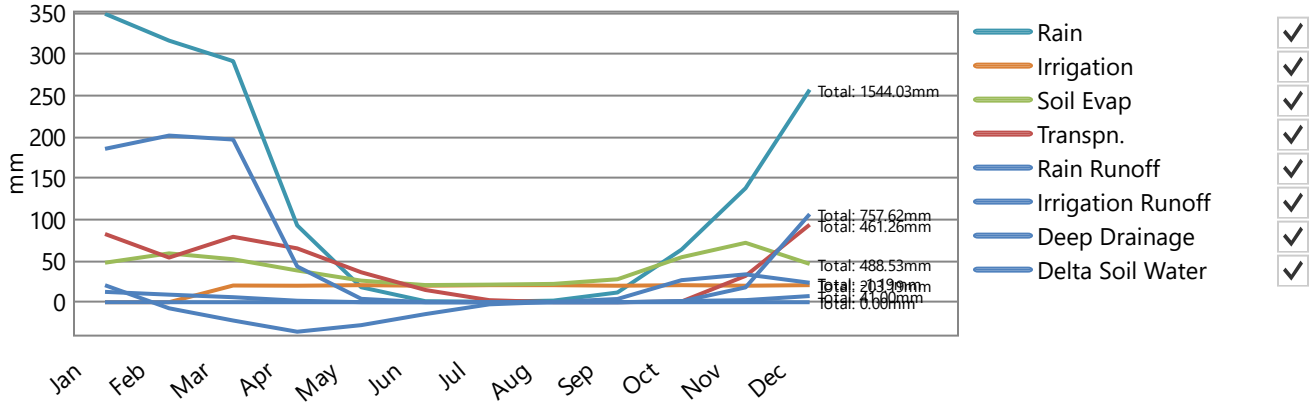
mm/year % Total inputs



Name	Value
Rain	1544.03
Irrigation	203.19
Soil Evaporation	488.53
Transpiration	461.26
Rain Runoff	41.00
Irrigation Runoff	0.00
Deep Drainage	757.62
Delta Soil Water	-1.19

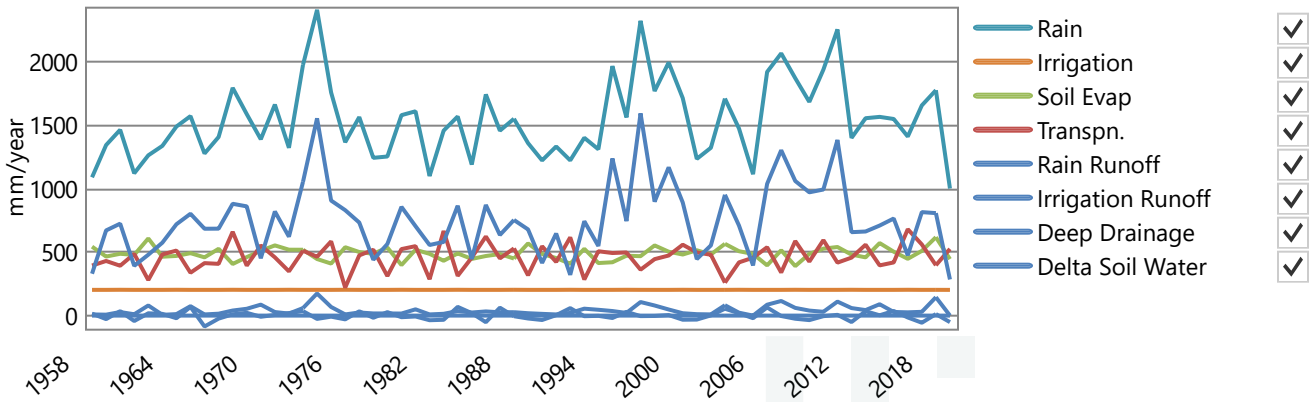
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



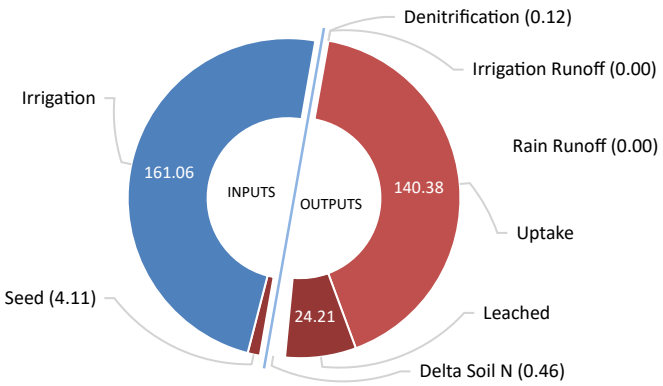
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: Stage 1 irrigation, 15 ha **Soil Type**: Lambells

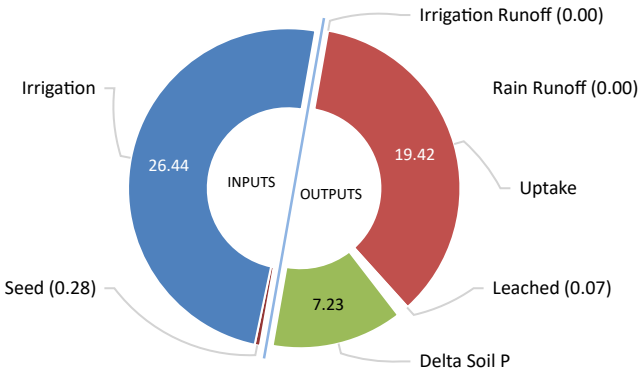
Irrigation ammonium volatilisation losses (kg/ha/year): 42.30
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.80

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	4.11
Irrigation	161.06
Denitrification	0.12
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	140.38
Leached	24.21
Delta Soil N	0.46

Land Phosphorus Balance (kg/ha/year)



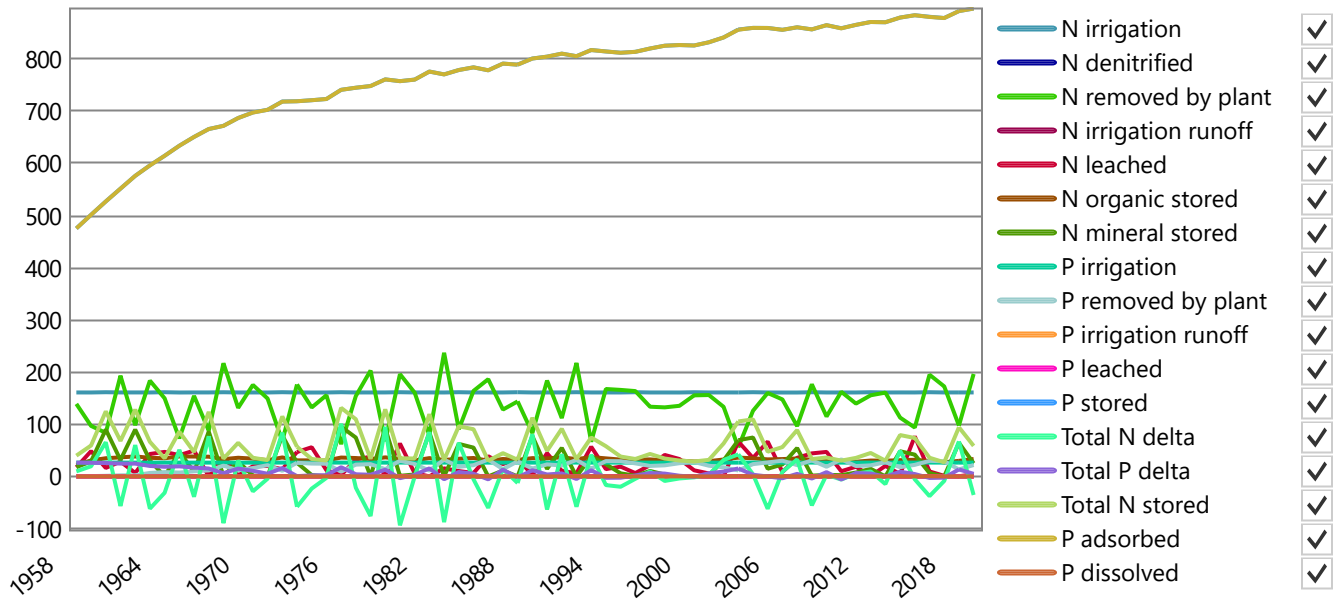
Name	Value
Seed	0.28
Irrigation	26.44
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	19.42
Leached	0.07
Delta Soil P	7.23

PERFORMANCE

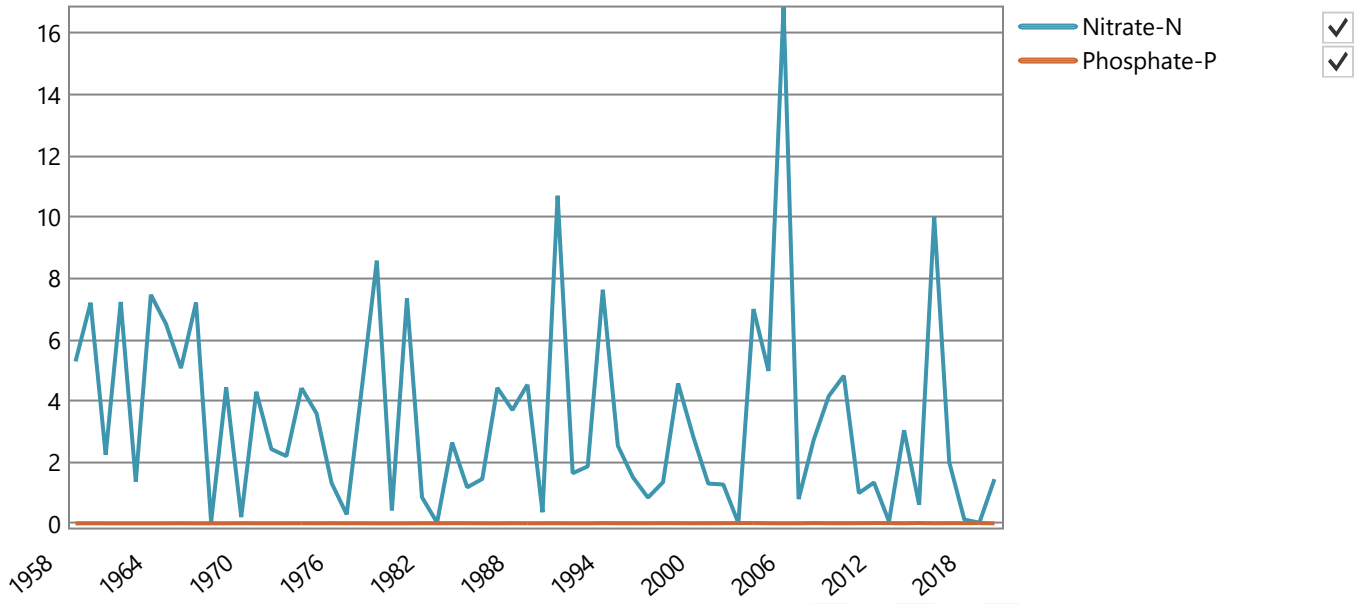
Land Performance - Soil Nutrient

Paddock: Stage 1 irrigation, 15 ha **Soil Type**: Lambells

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Stage 1 irrigation, 15 ha **Soil Type**: Lambells

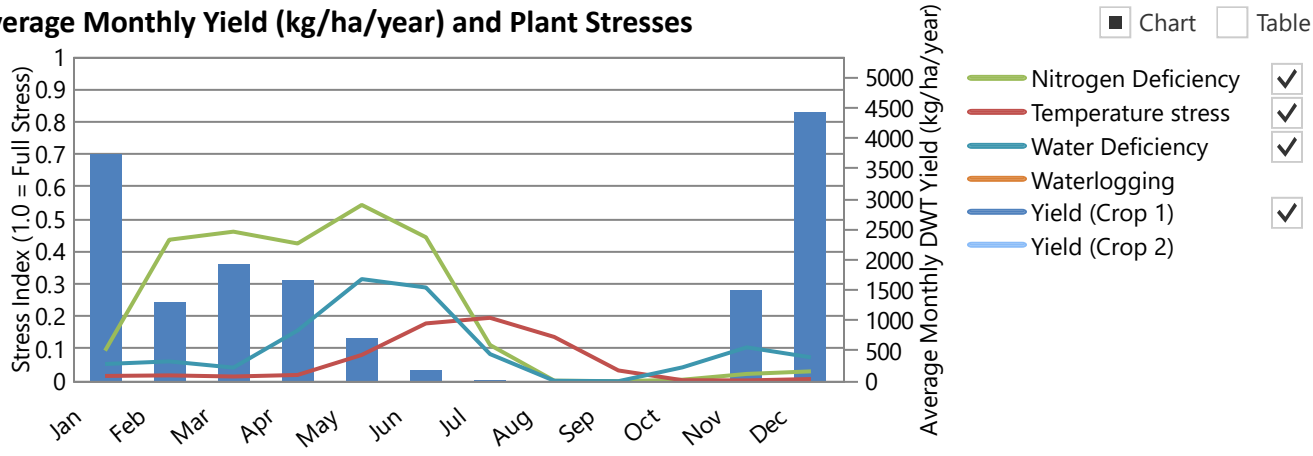
Plant: Continuous Forage Sorghum Crop

Average annual shoot dry matter yield (kg/ha/year)	15615.19 (4693.68 - 26433.23)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.32 (0.00 - 0.67)
Average monthly root depth (mm) (minimum - maximum)	680.52 (0.00 - 1312.90)

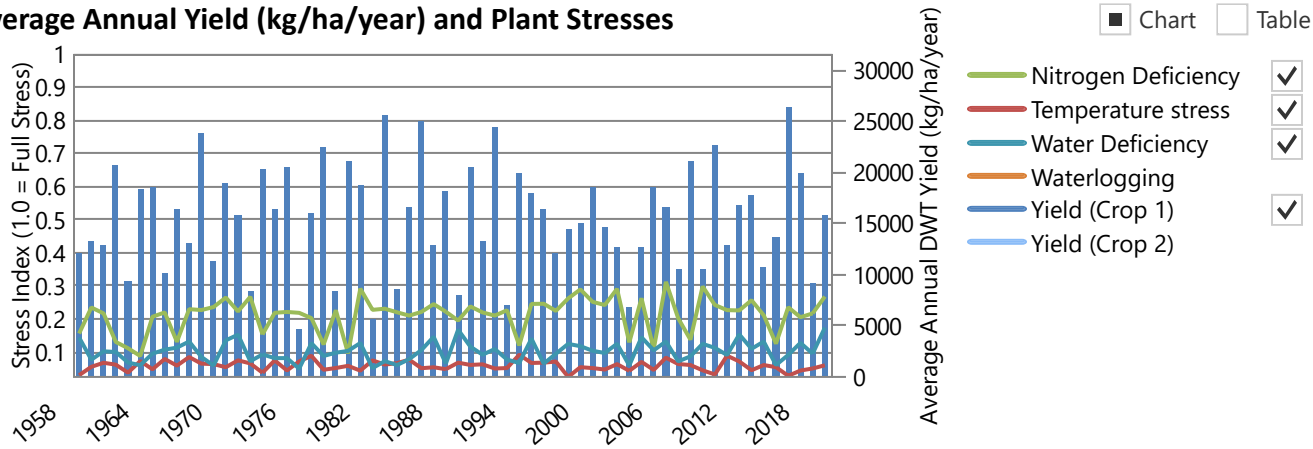
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	140.38 (55.56 - 237.05)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	19.42 (0.40 - 32.54)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.003)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 2.10 (normal), 1.00 (forced by crop death due to nitrogen stress (0.45), water stress (0.55))

No. days without crop/year (days/year): 141.45 due to water stress (141.45)

PERFORMANCE

Land Performance

Paddock: Stage 1 irrigation, 15 ha **Soil Type**: Lambells

Plant: Continuous Forage Sorghum Crop

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11
No. years assumed for leaching to reach steady-state (years)	10.00

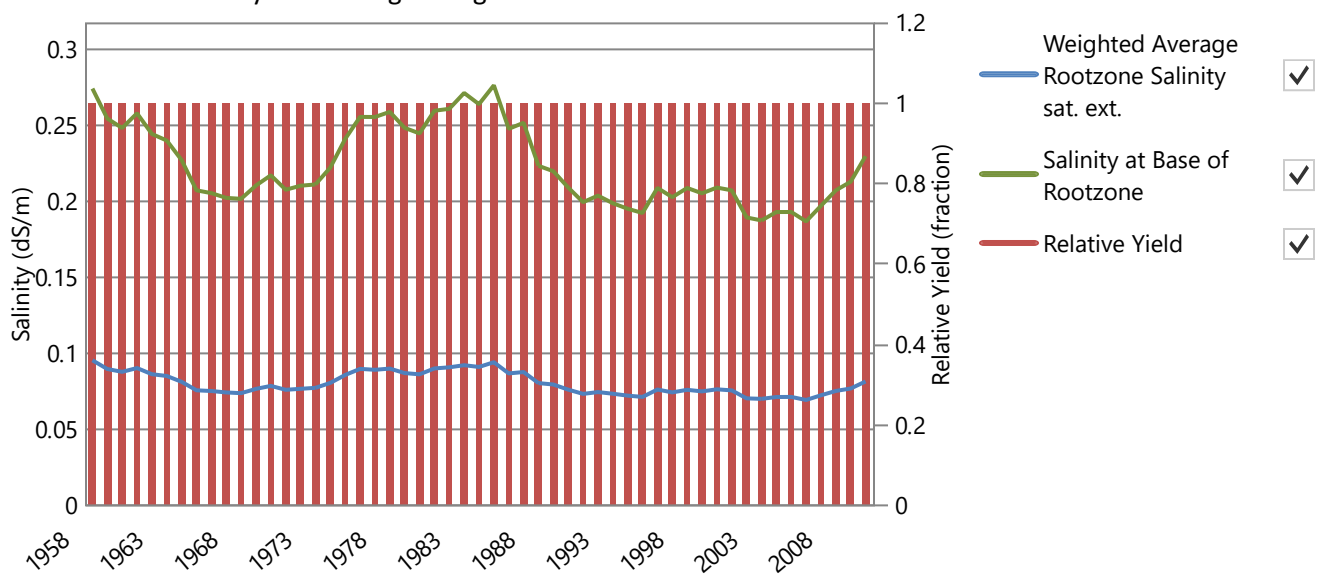
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.10
Salt added by rainfall (kg/ha/year)	288.58
Average annual effluent salt added & leached at steady state (kg/ha/year)	1101.99
Average leaching fraction based on 10 year running averages (fraction)	0.57
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.08
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.22
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:

Chart Table

All values based on 10 year running averages



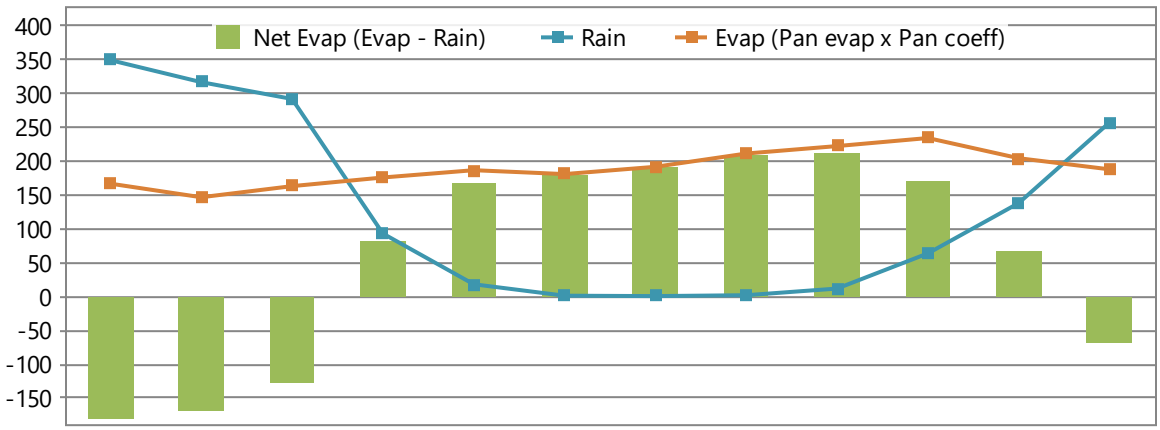
DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Evap	166.8	146.7	163.1	175.9	186.7	180.9	191.7	211.3	222.3	234.2	204.4	188.0	2272.1
Net Evap	-182.6	-170.1	-128.9	82.9	168.6	179.7	191.1	209.4	210.6	170.5	66.3	-69.4	728.1
Net Evap/day	-5.9	-6.0	-4.2	2.8	5.4	6.0	6.2	6.8	7.0	5.5	2.2	-2.2	2.0

DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

Pond System: 1 facultative, aerobic or storage pond

Lambells Lagoon Hatchery - 30524.19 m3/year or 83.57 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 305.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	100.00 (0.00 - 100.00)	3052.42 (3050.00 - 3060.00)
Total Phosphorus	13.00 (0.00 - 13.00)	396.81 (396.50 - 397.80)
Total Dissolved Salts	400.00 (0.00 - 400.00)	12209.68 (12200.00 - 12240.00)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	480.00 (0.00 - 480.00)	14651.61 (14640.00 - 14688.00)

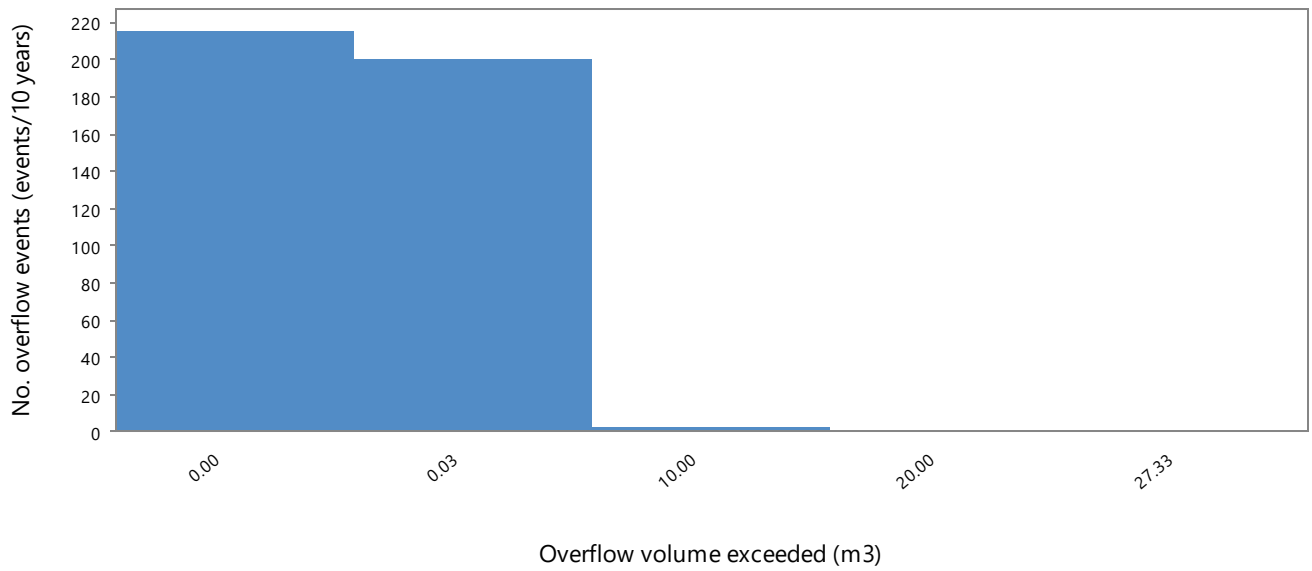
Last pond (Wet weather store): 100.00 m3

Theoretical hydraulic retention time (days)	1.20
Average volume of overflow (m3/year)	21.93
No. overflow events per year exceeding threshold* of 0.03 m3 (no./year)	20.03
Average duration of overflow (days)	1.81
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	0.00
Salinity of last pond on final day of simulation (dS/m)	0.62
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

Irrigation Information

Irrigation: 15 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	30478.85	2031.92
Total nitrogen applied (kg)	2415.83	161.06
Total phosphorus applied (kg)	396.54	26.44
Total salts applied (kg)	12201.16	813.41

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	0.16
Proportion of Days irrigation occurs (fraction)	0.84

DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

Paddock Land: Stage 1 irrigation: 15 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered every 1 days
Irrigate a fixed amount of 5.00 mm each day
Irrigation window from 1/3 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Lambells, 99.05 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Irrigation	0.0	0.0	20.2	20.0	20.6	20.0	20.6	20.6	20.0	20.6	20.0	20.6	203.2
Soil Evap	47.8	59.2	52.0	38.4	26.1	20.8	21.3	22.2	27.8	54.5	72.0	46.4	488.5
Transpn.	82.6	54.0	79.2	65.2	36.2	14.8	2.5	0.0	0.0	0.8	31.9	93.9	461.3
Rain Runoff	12.5	9.2	6.1	1.8	0.0	0.0	0.0	0.0	0.0	1.4	2.5	7.5	41.0
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	185.8	201.8	197.0	43.3	4.1	0.0	0.0	0.0	0.0	1.0	18.0	106.7	757.6
Delta	20.6	-7.4	-22.2	-35.7	-27.8	-14.4	-2.6	0.3	3.9	26.7	33.7	23.6	-1.2

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	161.06
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	140.38
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.12
Average annual soil nitrogen leached (kg/ha/year)	24.21
Average annual nitrate-N loading to groundwater (kg/ha/year)	24.21
Soil organic-N kg/ha (Initial - Final)	6.41 - 33.38
	23.77 - 25.15
Average nitrate-N concentration of deep drainage (mg/L)	3.20
Max. annual nitrate-N concentration of deep drainage (mg/L)	16.87

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	26.44
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	19.42
Average annual soil phosphorus leached (kg/ha/year)	0.07
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	449.15 - 897.11
Average phosphate-P concentration in rootzone (mg/L)	0.04
Average phosphate-P concentration of deep drainage (mg/L)	0.01
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.02
Design soil profile storage life based on average infiltrated water phosphorus concn. of 1.55 mg/L (years)	144.49

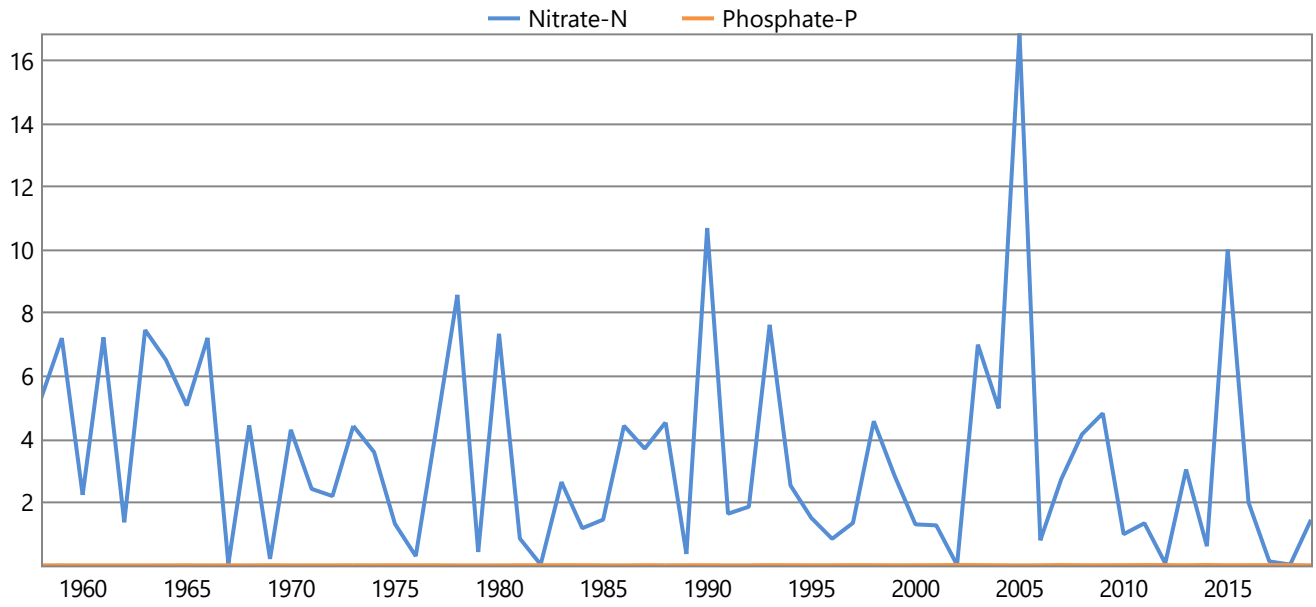
DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

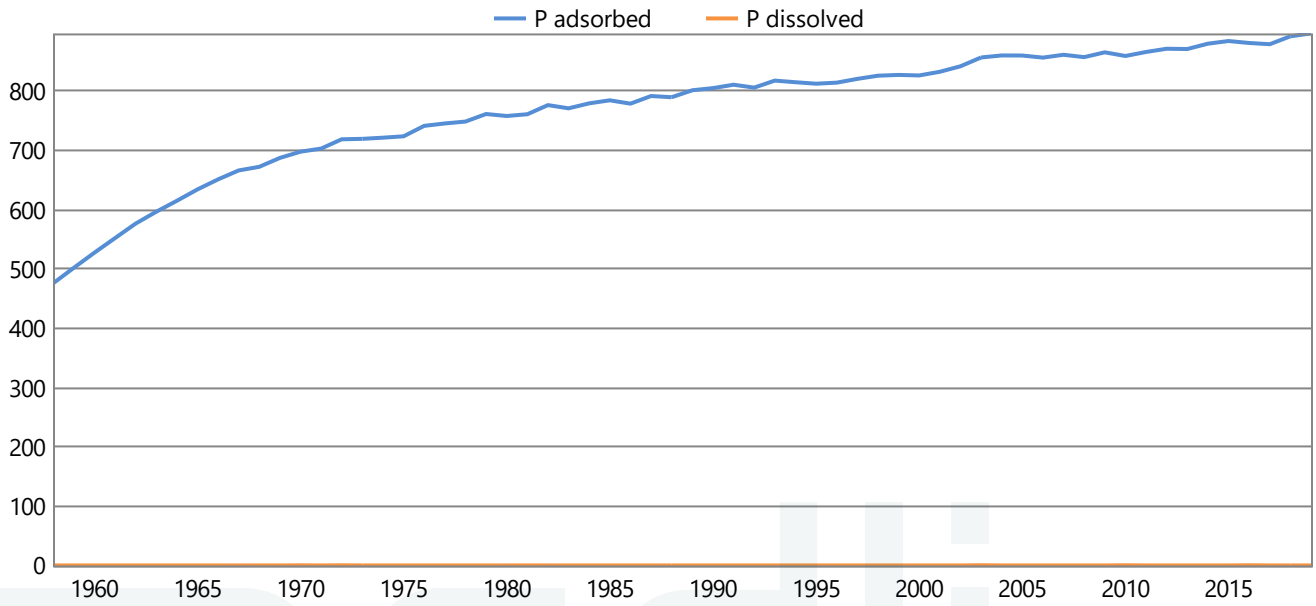
Paddock Land: Stage 1 irrigation: 15 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: Stage 1 Hatchery

Paddock Plant Performance: Stage 1 irrigation: 15 ha

Average Plant Performance (Minimum - Maximum): Continuous Forage Sorghum Crop

Average annual shoot dry matter yield (kg/ha/year)	15615.19 (4693.68 - 26433.23)
Average monthly plant (green) cover (fraction)	0.32 (0.00 - 0.67)
Average monthly crop factor (fraction)	0.26 (0.00 - 0.53)
Total plant cover (both green and dead) left after harvest (fraction)	0.00
Average monthly root depth (mm)	680.52 (0.00 - 1312.90)
Average number of normal harvests per year (no./year)	2.10 (1.00 - 3.00)
Average number of normal harvests for last five years only (no./year)	2.20
Average number of crop deaths per year (no./year)	1.00 (1.00 - 1.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.21 (0.09 - 0.31)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.05)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.20 (0.07 - 0.33)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.10 (0.00 - 0.31)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	141.45

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.10
Salt added by rainfall (kg/ha/year)	288.58
Average annual effluent salt added & leached at steady state (kg/ha/year)	1101.99
Average leaching fraction based on 10 year running averages (fraction)	0.57
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.08
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.22
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

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

APPENDIX C STAGE 2 MEDLI OUTPUTS

1.1 MEDLI Summary: Stage 2 Lambells Lagoon Crocodile Farm (LLCF)

The Model for Effluent Disposal using Land Irrigation (MEDLI) is a program for designing effluent reuse schemes. The model addresses many factors impacting on effluent irrigation, such as the quality and quantity of effluent, climate, storage, irrigation frequency and amount, nitrogen, phosphorus and salt components and plant growth. The MEDLI program was used to inform design requirements for the effluent land irrigation scheme for Stage 2 of the LLCF. In this instance, Stage 2 refers to the development and operation of the grower and finisher components of the farming operations (i.e. it excludes the hatchery operations effluent stream which was covered in Stage 1).

The model has been updated from the initial MEDLI model provided in the CEMP in August 2020, with more accurate data including water quality and refined water demand data from other crocodile farms within the Northern Territory, site specific soil data from LLCF and appropriate methods and rates of irrigation. The model was run with different effluent reuse assumptions (0%, 25%, 50% and 75%) and is summarised in the following sections.

Overall, the wet weather storage (WWS) volume has reduced from the volume and area provided for the entire farm in the CEMP (submitted to the NT EPA in August 2020), due to the changes in inputs, as provided by PRI Farming Pty Ltd. See the 'effluent assessment' section below for information regarding the changes in inputs.

1.2 General model inputs

The following inputs were used for the MEDLI model:

Climate: A 60-year climate file for the Project area (Lambells Lagoon) was obtained from the SILO database (a climate database managed by the Queensland Department of Environment and Science) to input rainfall and evaporation data. The model was run using climate data from 1958 to 2019, to account for recent impacts of climate change that may affect the model outputs.

Soil type: Soil samples were collected from the Project area on 10 July 2020 and sent a laboratory specialising in MEDLI analysis suites. The analyses undertaken directly related to the required MEDLI inputs and allowed for site specific soil information to be incorporated into the model.

Crop type: The default planting parameters for Forage Sorghum Crop were used in the model as they are representative of the crop selection for the proposed irrigation area. The default crop also has a maximum crop coefficient of 0.8, and according to the NT *Guidelines for Land Capability Assessment for On-site Wastewater Management* (DOH, 2014), a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT.

Irrigation method: The irrigation method modelled was a centre pivot system with irrigation triggered when the soil water deficit (SWD) reaches 5mm. The irrigation was applied at a depth of 5mm at each irrigation event, until the SWD is reached. Irrigation cannot occur when a rainfall event occurs and rainfall reaches a total of 10mm per event (likely during most of the wet season) to prevent over saturation of the soil. The model was run using different irrigation sizes in order to determine the best outcome for the water and nutrient balance.

A "dry-run" was also modelled for the irrigation area, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the area without any irrigation inputs.

The model was set to turn-off irrigation when rainfall reaches a total of 10mm (likely during most of the wet season) to prevent over saturation of the soil. In reality, with high evaporation rates, it is possible that irrigation

may still occur on days that experience minor rainfall events provided conditions in a site-specific Irrigation Management Plan are adhered to.

1.2.1 Assumptions and limitations

Assumptions and limitations to the general inputs in the MEDLI model include:

- Future weather will behave like past weather as supplied in the historical data (i.e from 1958 to 2019). This model does not account for the uncertainty regarding future climate conditions.
- Data obtained for the rainfall and evaporation at the site, is assumed to be as close as possible to the site as the site does not have its own weather station (SILO data obtained for Lambells Lagoon).
- Data provided by PRI Farming Pty Ltd is accurate and reflects project operating conditions.
- A SWD rate of 5mm was adopted based on general conditions of the tropics in the absence of SWD data from the site.
- 10mm of rainfall was adopted as a conservative measure to ensure the impact of rainfall on soil saturation is reflective of site conditions in the wet season when irrigation may occur.

1.3 Effluent volumes and quality

Effluent volumes and water quality data were obtained from PRI Farming Pty Ltd. The effluent volumes and water quality used in the modelling are summarised in Table 1-1 and Table 1-2.

The following assumptions were made by PRI Farming Pty Ltd in determining these inputs:

- The feeding programs of the grower and finisher pens will be the same as at the Janamba Crocodile Farm in the Northern Territory, whereby water usage is reduced by half in the wet season, due to the change in crocodile behaviour that occurs when there is increased rainfall and semi cooler temperatures from December to March.
- Allowance was made in the wet season months (December to March) for rainfall inputs into the pens. PRI Farming Pty Ltd have advised that the pens are to be constructed with a shade cloth roofing, shedding 70% of rainfall away from the pens. The volume inputs were derived from data from BoM and the impact a low permeability shade cloth, which allows for 30% of rainfall to enter the pens during the months of December to March. See Table 1-1 for input volumes
- During the drier months (i.e April to Nov), the forecast water use for the stage 2 component of the crocodile farm is 1,265kL/day (as provided by PRI Farming Pty Ltd, based on extrapolation of data from Janamba Crocodile Farm).
- Effluent quality (i.e. nutrient concentrations) will be similar to that produced from the grower and finisher pens at Janamba Crocodile Farm (as provided by PRI Farming Pty Ltd).

The effluent quality is based on the estimated combined effluent quality prior to any treatment. The actual wastewater quality to be irrigated would be lower in nutrients following primary treatment. However, this will not make a difference to the model outputs because the limiting factor at the LLCF site is water volumes not nutrient concentrations.

Table 1-1. Daily effluent volumes per month (m^3)
(data obtained from PRI Farming Pty Ltd and BoM)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Inflow	632.5	632.5	632.5	1265	1265	1265	1265	1265	1265	1265	1265	632.5
*Rainfall**	107.7	102	62.7	0	0	0	0	0	0	0	0	37.2
Total	740.2	734.5	695.2	1265	1265	1265	1265	1265	1265	1265	1265	669.7

**Rainfall inputs accounts for 70% reduction in rainfall volume entering the pens daily per month, based on low permeability shade cloth, as advised by PRI Farming Pty Ltd.*

Table 1-2. Effluent quality entering pens
(data obtained from PRI Farming Pty Ltd)

Contaminant	Wet Season (Oct – Apr) Concentration (mg/L)	Dry Season (May – Sep) Concentration (mg/L)
Total nitrogen	6	13
Total phosphorus	0.7	4
Total dissolved salts	153	153
Total solids	500	500

1.3.1 Assumptions and limitations

Several assumptions include

- The volume of daily influent has been provided by PRI Farming Pty Ltd based on data from Janamba Crocodile Farm, however day to day operations may include less or more influent in response to system operations and requirements.
- Data provided by PRI Farming Pty Ltd is accurate and reflects project conditions. Currently, water quality data has been obtained from the Janamba Crocodile Farm and not site-specific data.
- Rainfall inputs into the pens may vary due to varying climatic conditions (i.e. prolonged drier or wetter periods may be experienced) and quality of low permeability shade cloth.
- Reuse in MEDLI is defined as the daily recycling volume, which adopts the minimum inflow volume as the maximum upper limit to determine reuse volumes. In this case, the lowest inflow volume is 669.7kL/day, therefore 25%, 50% and 75% reuse scenarios were based off this value.

1.4 Modelling results

Various different scenarios were modelled to determine the storage and irrigation area combinations required to minimise release of nutrients to the environment by effluent overflow, or as a result of runoff or seepage from the irrigation areas. The design criteria adopted for the MEDLI model is to achieve as close as possible to zero overflow from the WWS.

The MEDLI model was run for four scenarios with different reuse assumptions (0%, 25%, 50% and 75%). WWS, irrigation area, overflow volumes and duration derived for each scenario are documented in Table 1-3.

Table 1-3. WWS performance

% reuse for farm	WWS volume (ML)	Irrigation area (ha)	No. of overflow events (events/year)	Average duration of overflow (days)	Overflow volume (m3/year)
0%	60	100	0.18	12.73	2224.32
	80	100	0.08	14.60	1283.22
	100	100	0.06	8.25	568.04
25% (reuse = 168m^3/day)	60	100	0.06	14.25	757.29
	80	85	0.10	6.50	553.73
50% (reuse = 335m^3/day)	50	85	0.06	12.00	483.21
	60	100	0.03	9.50	260.53
75% (reuse = 502.5m^3/day)	60	100	No overflow	No overflow	No overflow

The most conservative WWS requirements from Table 1-3 (i.e calculated by the MEDLI model with 0% reuse) are further analysed in the below section. Whilst the LLCF will be aiming for a high level of water efficiency and reuse, the worst-case scenario is modelled here for the purpose of demonstrating the feasibility of a sustainable effluent reuse scheme at the site. MEDLI outputs for reuse scenarios can be provided upon request.

Table 1-4. Land water balance

	Unit	100ML	80ML	60ML	Dry-run
Rain	mm/year	1544	1544	1544	1544
Irrigation	mm/year	390.55	391.05	391.23	0
Soil evaporation	mm/year	623.68	621.74	626.59	570.95
Transpiration	mm/year	507.91	512.00	510.78	24.88
Rain runoff	mm/year	30.50	26.69	29.40	86.11
Irrigation runoff	mm/year	0.00	0.00	0.00	0.00
Deep drainage	mm/year	773.60	772.75	769.60	861.89

Table1-5. Pond system water balance

	Unit	100ML	80ML	60ML
Rain	m3/year	55,237	44,552	33,814
Inflow	m3/year	394,710	394,710	394,710
Evaporation	m3/year	58,795	46,901	35,045
Overflow	m3/year	568	1283	2224
Irrigation	m3/year	390,551	391,047	391,226
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	1.00	1.00	0.99
Probability of at least 90% reuse	Fraction	1.00	1.00	0.98

Table 1-6. Land nutrient balance

	Unit	N balance	P balance	N balance	P balance	N balance	P balance
		100ML		80ML		60ML	
Irrigation (effluent load added)	kg/ha/year	33.66	7.90	33.63	7.89	33.58	7.89
Denitrification	kg/ha/year	0.003	-	0.00414	-	0.00422	-
Irrigation runoff	kg/ha/year	0.00	0.00	0.00	0.00	0.00	0.00
Plant uptake	kg/ha/year	34.26	5.62	34.22	5.60	34.16	5.60
Leached	kg/ha/year	0.20	0.04	0.21	0.04	0.22	0.04

1.5 Discussion

The implications of the model results for irrigation area sizing and WWS volumes are summarised below.

1.5.1 Irrigation area

The MEDLI results indicate that the proposed irrigation schemes provided are sufficient to manage the daily effluent volumes produced without creating any irrigation runoff or significant increases to the deep drainage.

The application rate of nutrients is slightly higher than the predicted plant uptake rates which results in some leaching of phosphorous. The predicted average phosphorous concentration of the deep drainage based on current soil concentrations and effluent irrigation is considered low.

The concentration of nutrients in the wastewater is to be monitored to ensure that if concentrations increase significantly above the predicted values, the irrigation area is adjusted, or alternative treatment methods are reviewed.

A large WWS and land irrigation area is required for wetter than average wet seasons. During the drier seasons (i.e May to September), higher volumes of water are likely to be required to be applied to smaller areas of the irrigation area, to maintain crop growth. This may require a rotational program to be implemented to avoid nutrient accumulation in those areas.

1.5.2 Wet weather storage

The MEDLI results indicate that 60 ML of WWS capacity should be large enough to minimise uncontrolled release of effluent, excepting during extreme weather events. Assuming the effluent volumes entering the system align with those used in the modelling, the results indicate that overflow events may occur at a rate of 0.18 events/year, or 1.8 events every ten years.

Increasing the WWS size to 80 ML or 100 ML in the model, reduces the overflow events down to less than one every ten years. However, the model results indicate there would still be some overflow during extreme weather events. Whilst there is sufficient land availability to construct large storages, the cost and feasibility of managing such storages may be limiting. Assuming the treated effluent will contain very low concentrations of nutrients, which would be further diluted by rainfall in the storage, it is considered that there is minimal environmental benefit to be achieved by constructing zero discharge storages.

The modelling of different reuse scenarios indicates that reuse of effluent could further reduce the frequency and volume of overflows from the WWS. Treatment and reuse are an option that can be further investigated by PRI Farming as the farm is developed and site-specific effluent data become available. However, while there is uncertainty about the levels of reuse that can be achieved, it is recommended that the design criteria for WWS capacity are based on the worst-case scenario of zero reuse.

If the actual effluent volumes or quality are found to be higher than predicted, then the staging of the development and large available land area allows for additional irrigation areas and/or storages to be added progressively to achieve the water quality objectives established in the EPL.

1.6 Summary and recommendations

It is imperative to the project that the results of the modelling and ultimate decision on sizing of the WWS both take into consideration environmental factors and operational requirements. The results of this model and its outputs are a reflection of the information made available at the time of modelling and do include a number of assumptions and limitations.

The staged nature of the development provides an opportunity to add WWS capacity over time in response to actual conditions experienced during operations. The following recommendations are made for future improvements to the model and ultimate design of the LLCF, in order to ensure that the WWS and irrigation area are appropriate.

- Once operational, sampling of effluent volumes and quality in the Stage 2 pens and effluent storages should be undertaken to verify model inputs. These results can be adopted in later re-runs of the MEDLI to reflect site specific conditions (as currently all data used within the MEDLI model are from Janamba Crocodile Farm).
- PRI Farming Pty Ltd to actively monitor the size of the WWS over the course of increasing operations of LLCF over the next 5 years (particularly during the wet season months of December to March) to determine whether the WWS can hold the volumes of water required without negatively impacting the identified receiving environments.

Attachment A. MEDLI Report: Dry-run scenario

MEDLI REPORT - FULL RUN

Enterprise: **MARPU - Lambells Lagoon Crocodile Farm**

Description:
Marpu Stage 2 irrigation and storage modelling

Client: **PRI Farming Pty Ltd**

MEDLI User: ECOZ\adele.faraone

Scenario Details:
Updated inflows = dry run

DESCRIPTION

Climate Data: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days

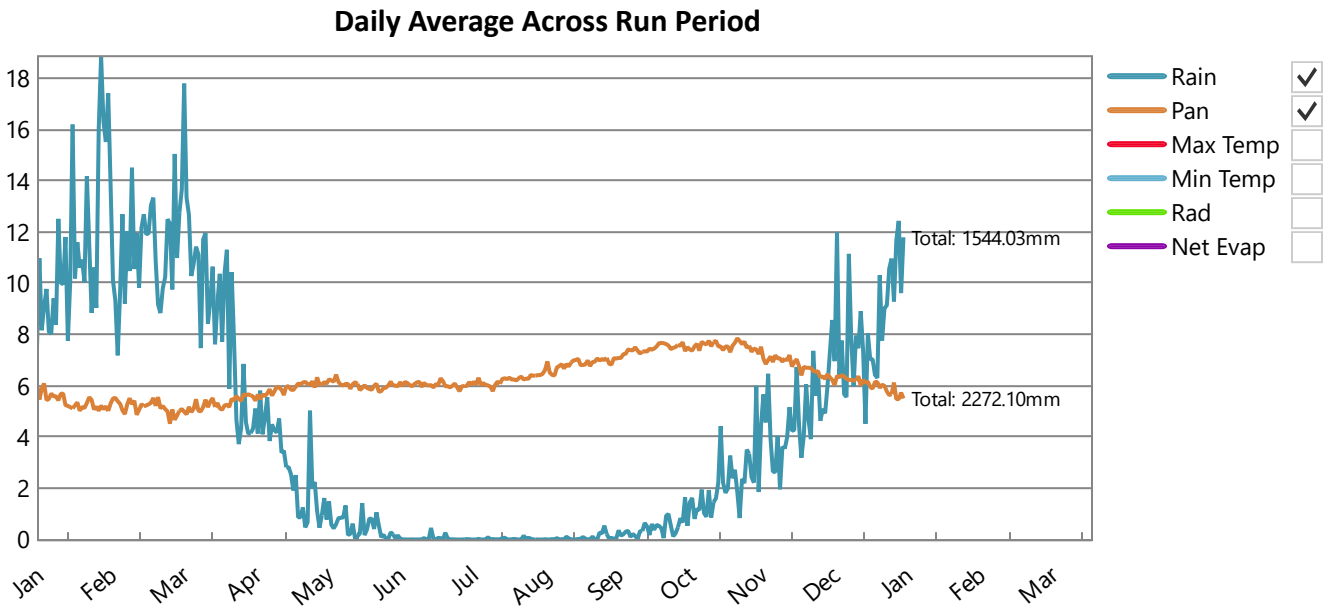
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1108	1521	2163
Pan Evaporation (mm/year)	2100	2273	2448

Climate Data:

Chart Table

Monthly Daily

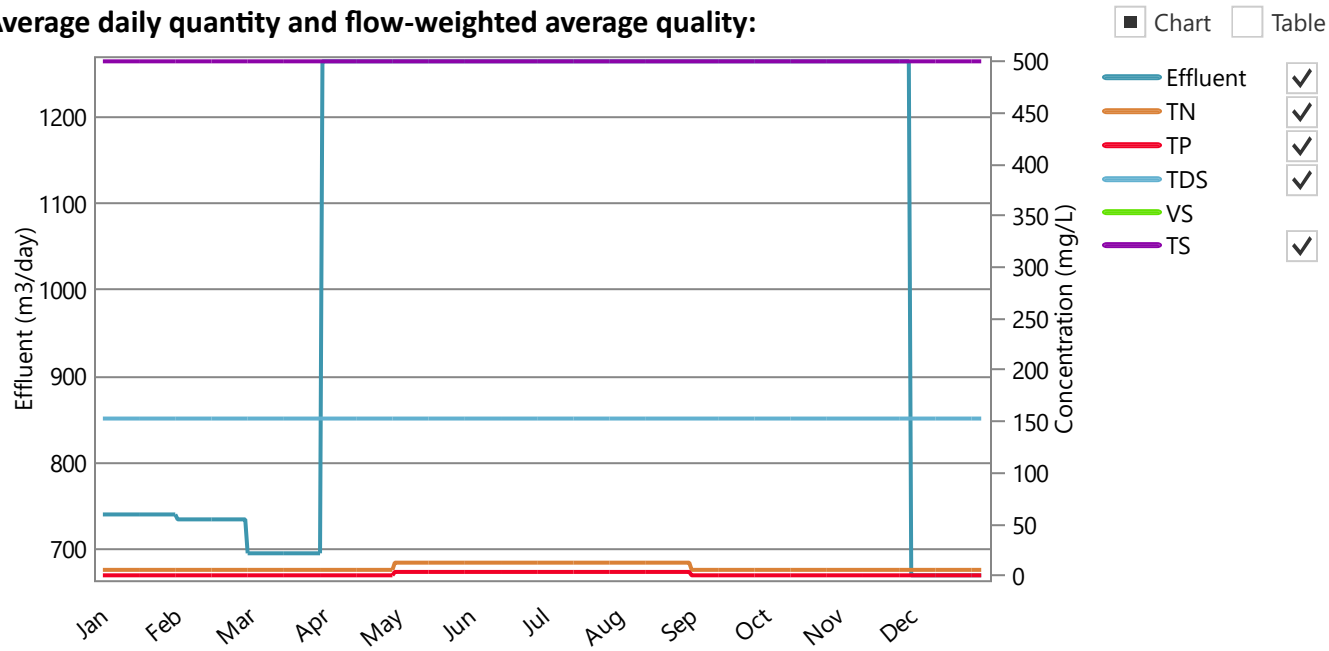


DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 394710.92 m3/year or 1080.68 m3/day (Min-Max: 669.70 - 1265.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

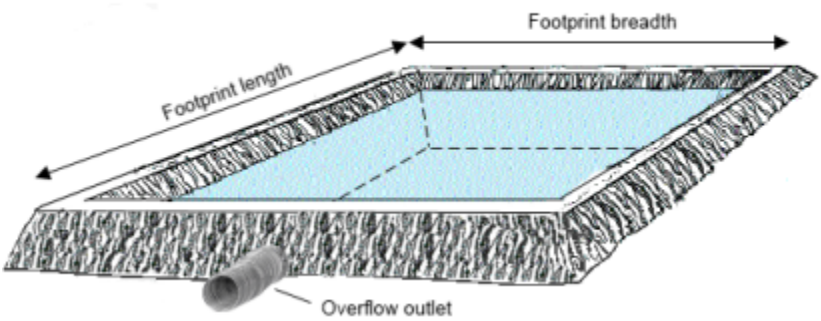
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

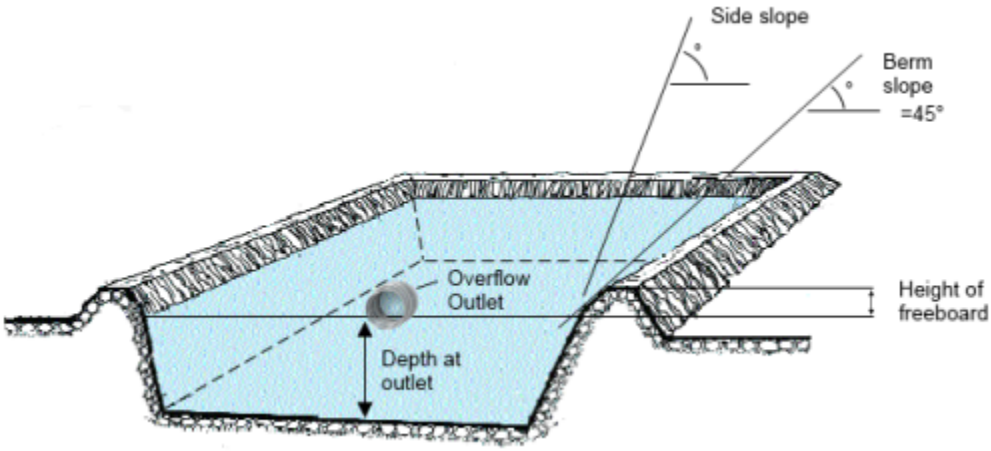
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (m3)	60000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	20908.21
Pond footprint length (m)	207.69
Pond footprint width (m)	105.45
Pond catchment area (m2)	21900.00
Average active volume (m3)	59897.74





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 (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

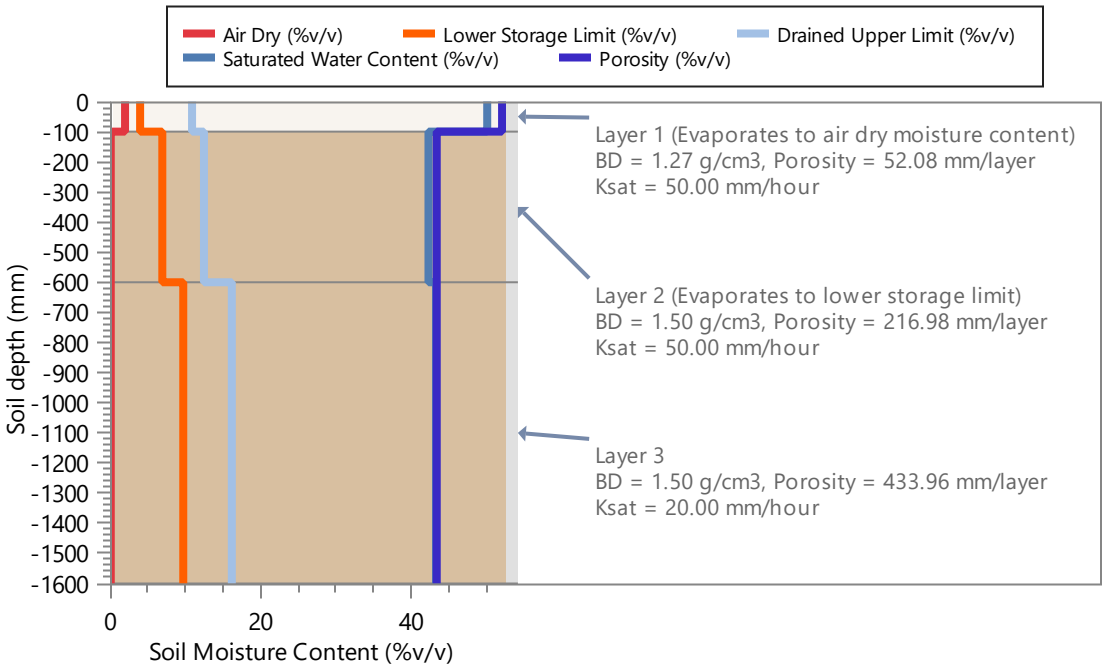
DESCRIPTION

Land: Stage 2 irrigation

Area (ha): 100.00

Soil Type: Lambells, 1600.00 mm defined profile depth

Profile Porosity (mm)	703.02
Profile saturation water content (mm)	694.60
Profile drained upper limit (or field capacity) (mm)	235.10
Profile lower storage limit (or permanent wilting point) (mm)	136.05
Profile available water capacity (mm)	99.05
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Forage Sorghum Pasture

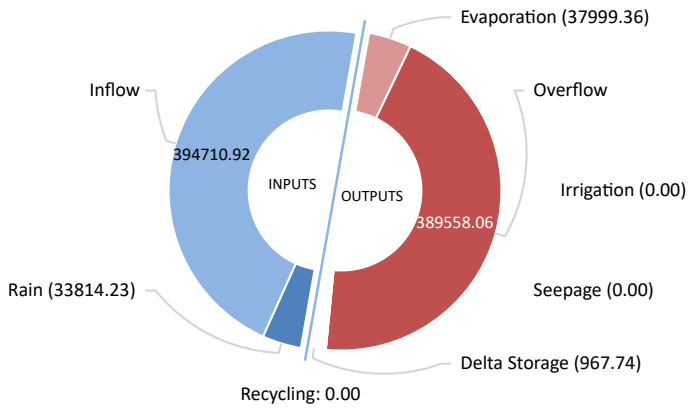
Average monthly cover (fraction) (minimum - maximum)	0.02 (0.00 - 0.04)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	1548.13
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11

PERFORMANCE

Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **60000 m3**

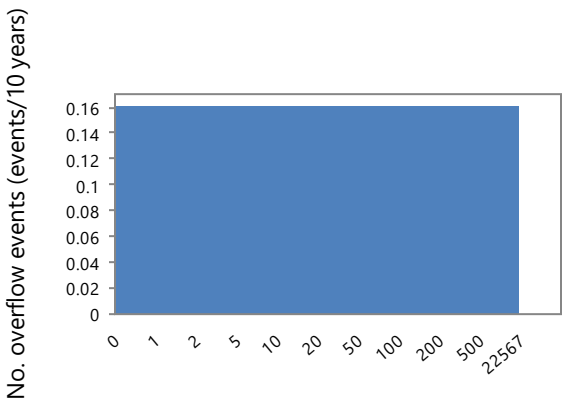
Pond System Water Balance (m3/year)



Name	Value
Rain	33814.23
Inflow	394710.92
Recycling	0.00
Evaporation	37999.36
Overflow	389558.06
Irrigation	0.00
Seepage	0.00
Delta Storage	967.74

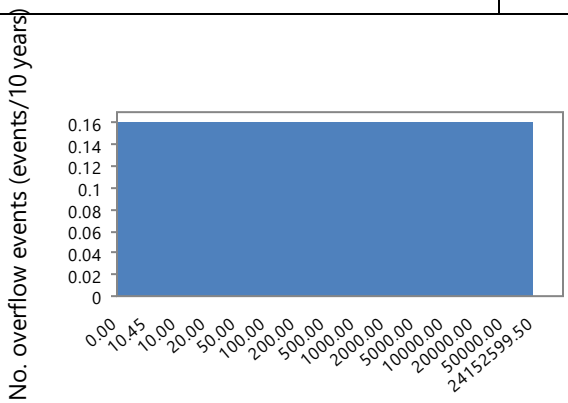
Overflow Diagnostics

Volume of overflow (m3/year)	389558.06
No. days pond overflows (days/year)	363.98
Average duration of overflow (days)	22567.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% reuse (fraction)	0.00



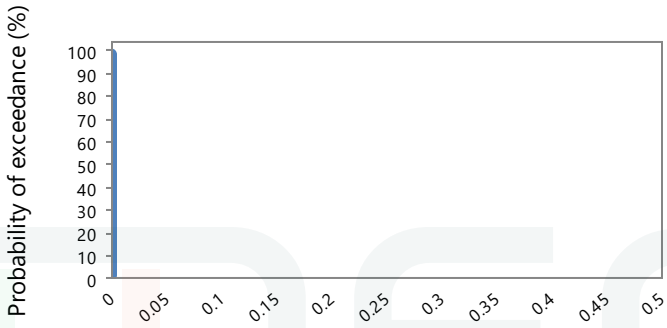
Overflow event duration exceeded (days)

Export plot



Overflow volume exceeded (m3)

Export plot



Annual reuse (fraction)

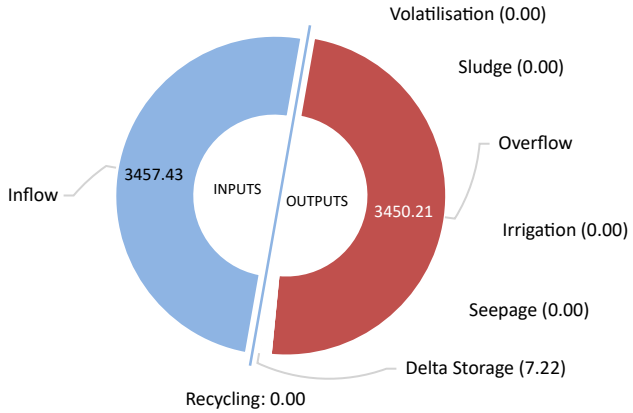
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

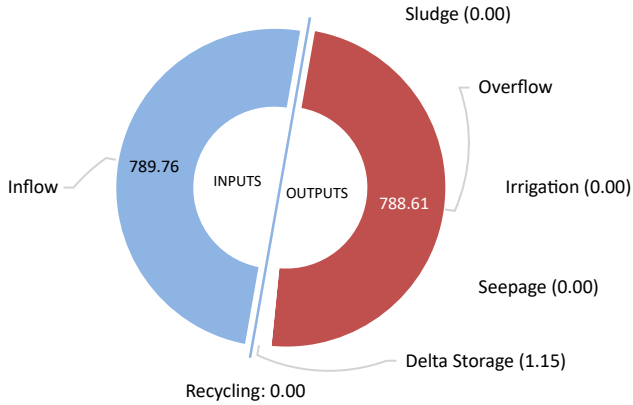
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



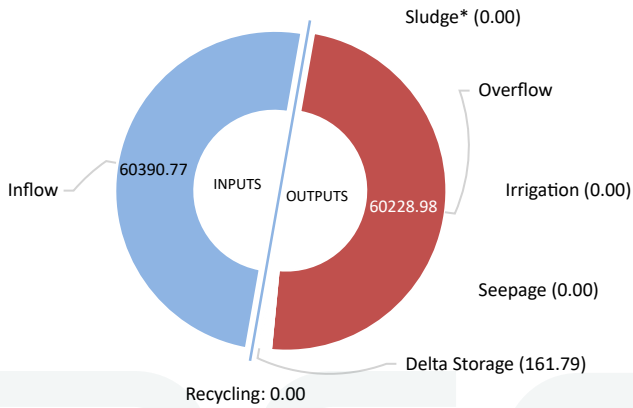
Name	Value
Inflow	3457.43
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	3450.21
Irrigation	0.00
Seepage	0.00
Delta Storage	7.22

Phosphorus Balance (kg/year)



Name	Value
Inflow	789.76
Recycling	0.00
Sludge	0.00
Overflow	788.61
Irrigation	0.00
Seepage	0.00
Delta Storage	1.15

Salt Balance (kg/year)



Name	Value
Inflow	60390.77
Recycling	0.00
Sludge*	0.00
Overflow	60228.98
Irrigation	0.00
Seepage	0.00
Delta Storage	161.79

* 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 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	8.66
Average phosphorus concentration of pond liquid (mg/L)	1.94
Average salinity of pond liquid (dS/m)	0.24

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	7.46
Final phosphorus concentration of pond liquid (mg/L)	1.19
Final salinity of pond liquid (dS/m)	0.26

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	0.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/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:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	0.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	0.00
Average phosphorus concentration of irrigation water (mg/L)	0.00
Average salinity of irrigation water (dS/m)	0.00

Irrigation Diagnostics (No effluent irrigation occurred!):

Proportion Days Irrigation Turned Off (fraction)	1.00 (Hence no irrigation!)
Proportion of Days irrigation occurs (fraction)	0.00

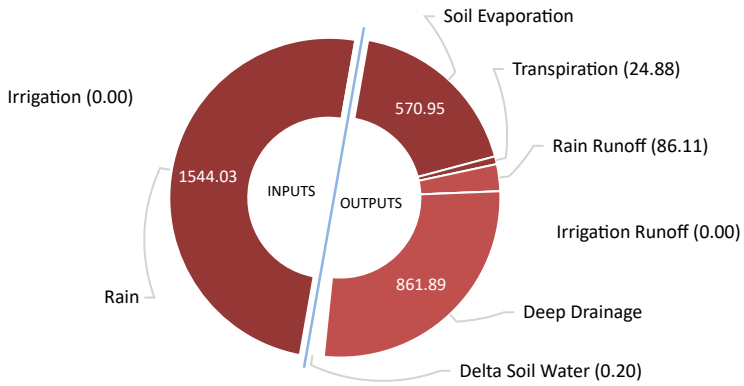
PERFORMANCE

Land Performance - Soil Water

Paddock: Stage 2 irrigation, 100 ha
Soil Type: Lambells, 95.70 mm PAWC at maximum root depth

Land Water Balance (mm/year):

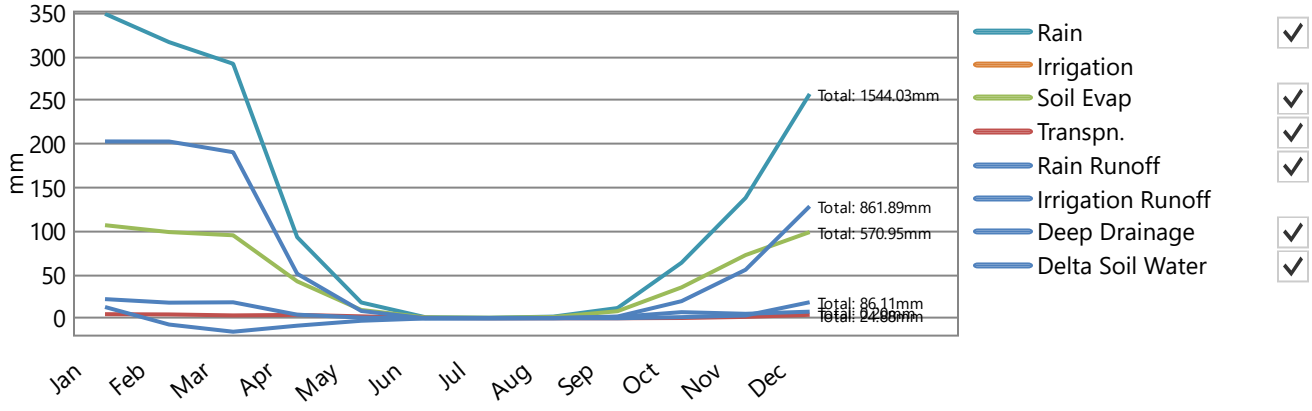
mm/year % Total inputs



Name	Value
Rain	1544.03
Irrigation	0.00
Soil Evaporation	570.95
Transpiration	24.88
Rain Runoff	86.11
Irrigation Runoff	0.00
Deep Drainage	861.89
Delta Soil Water	0.20

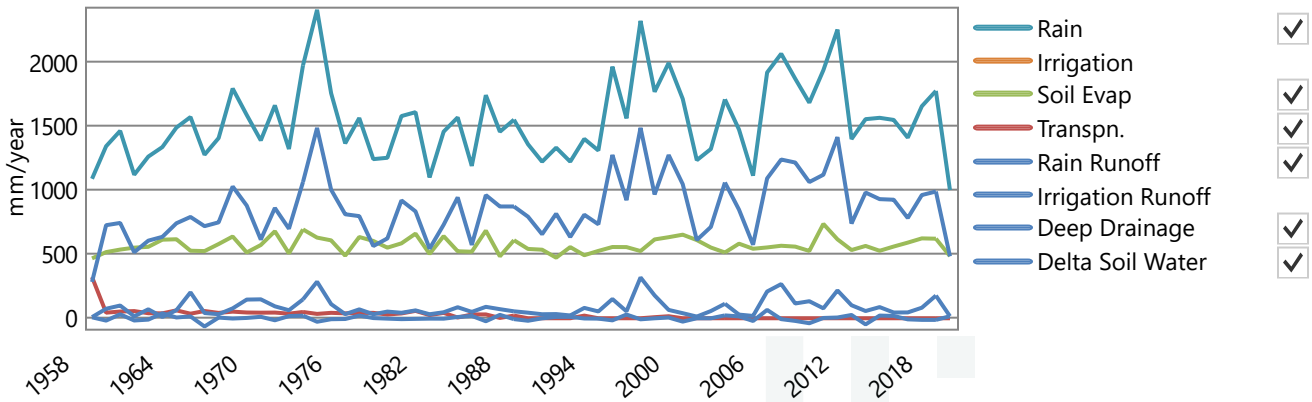
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



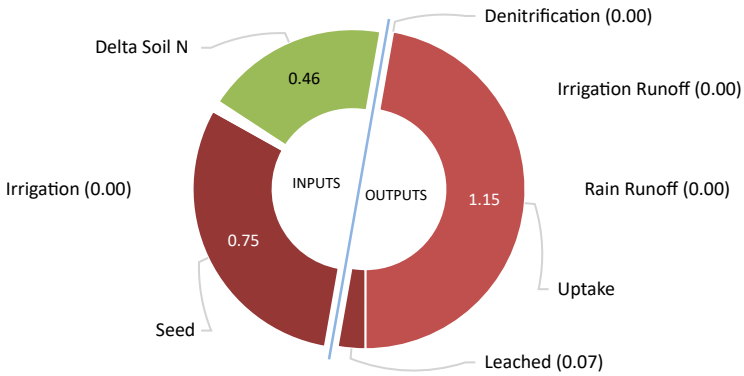
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

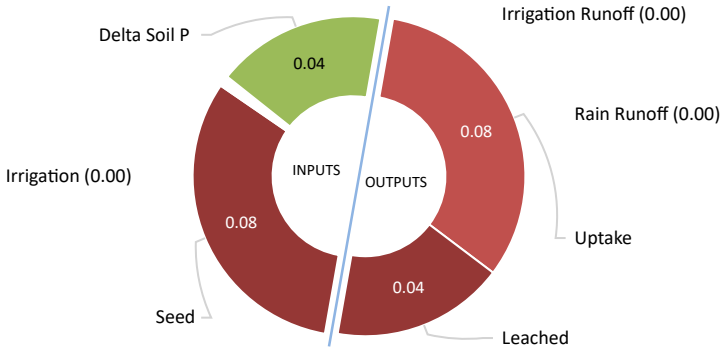
Irrigation ammonium volatilisation losses (kg/ha/year): 0.00
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.75
Irrigation	0.00
Denitrification	1.13E-04
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	1.15
Leached	0.07
Delta Soil N	-0.46

Land Phosphorus Balance (kg/ha/year)



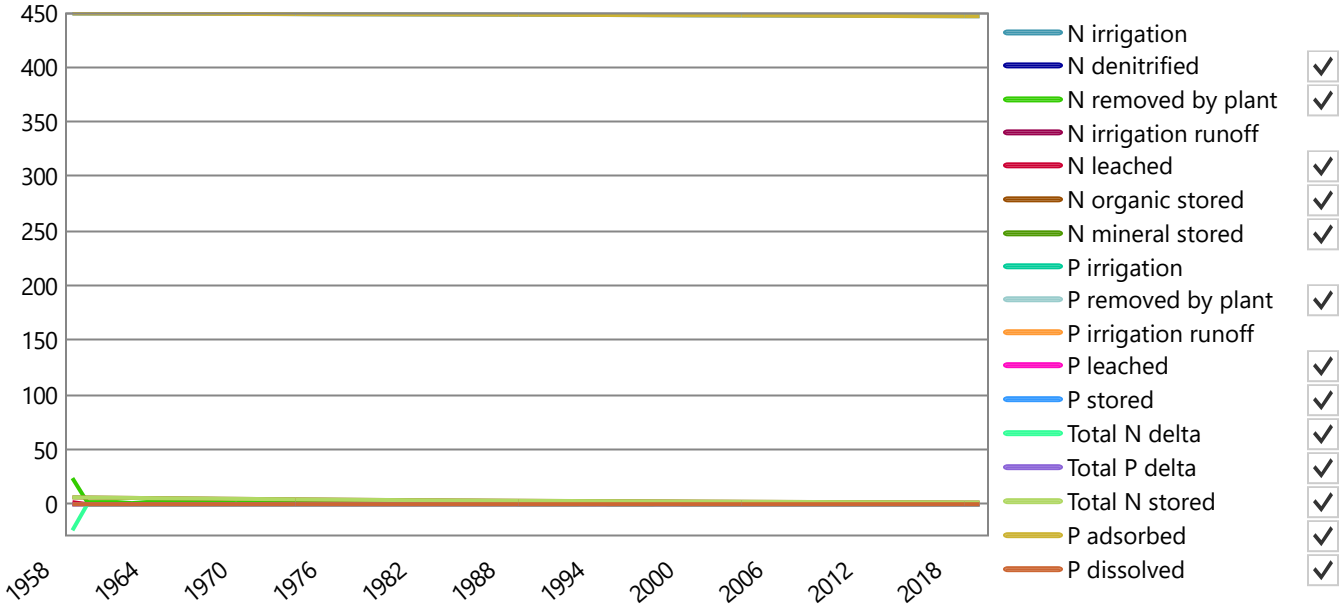
Name	Value
Seed	0.08
Irrigation	0.00
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	0.08
Leached	0.04
Delta Soil P	-0.04

PERFORMANCE

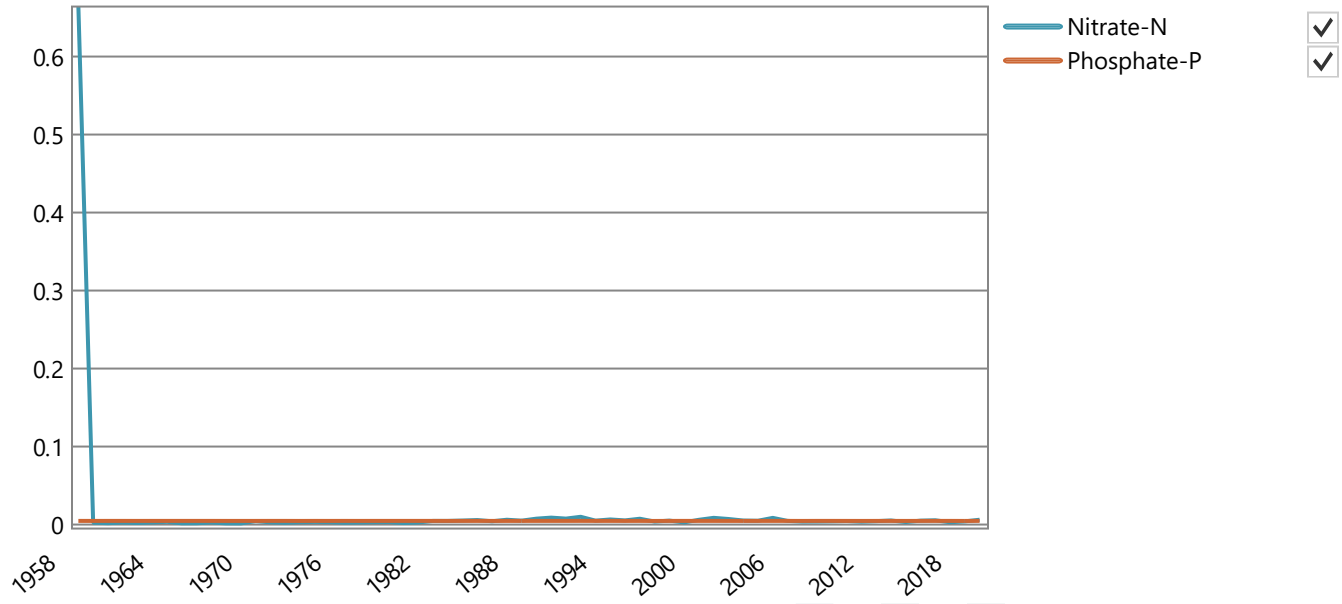
Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

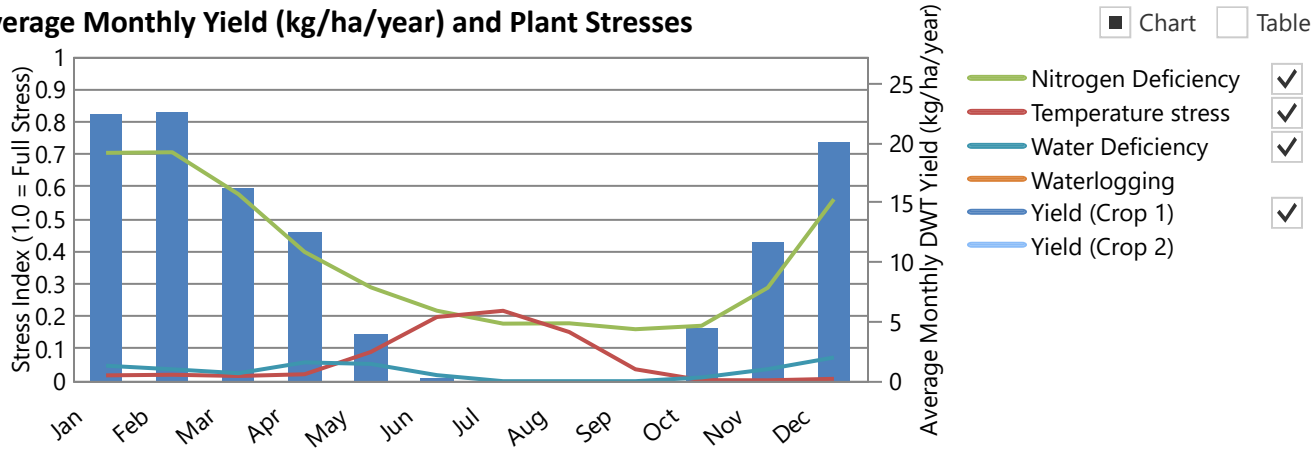
Plant: Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	139.72 (0.00 - 2821.17)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.02 (0.00 - 0.04)
Average monthly root depth (mm) (minimum - maximum)	54.04 (0.00 - 119.09)

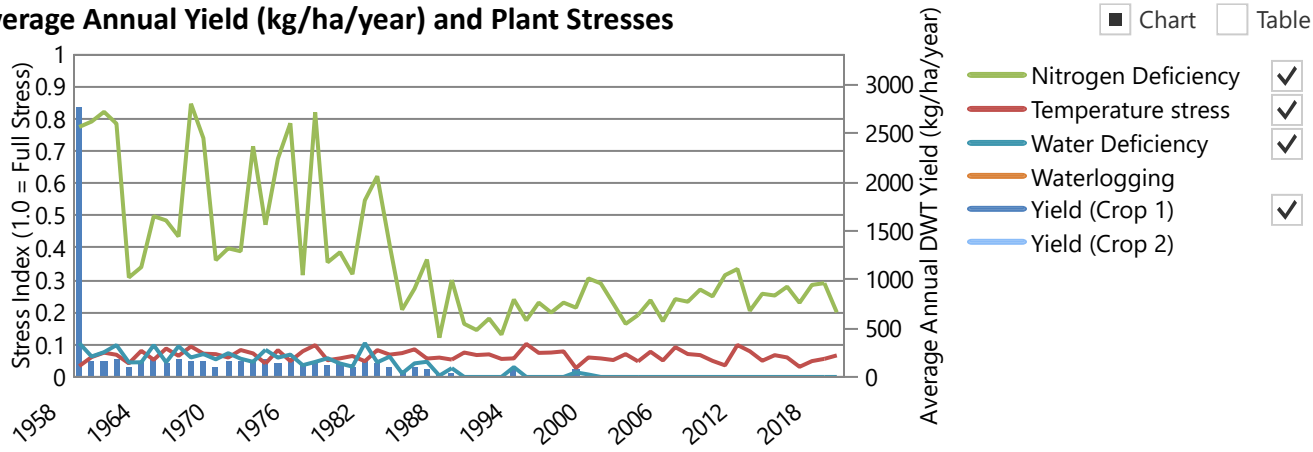
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	1.15 (0.00 - 23.85)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	0.08 (0.00 - 0.18)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.00 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.002)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 0.84 (forced by crop death due to nitrogen stress (0.82), water stress (0.02))
No. days without crop/year (days/year): 299.81 due to nitrogen stress (29.53), water stress (270.27)

PERFORMANCE

Land Performance

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Plant: Continuous Forage Sorghum Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11
No. years assumed for leaching to reach steady-state (years)	10.00

Soil Salinity:

Average Infiltrate Salinity (dS/m)	0.03

Insufficient deep drainage to run steady state salinity calculations.

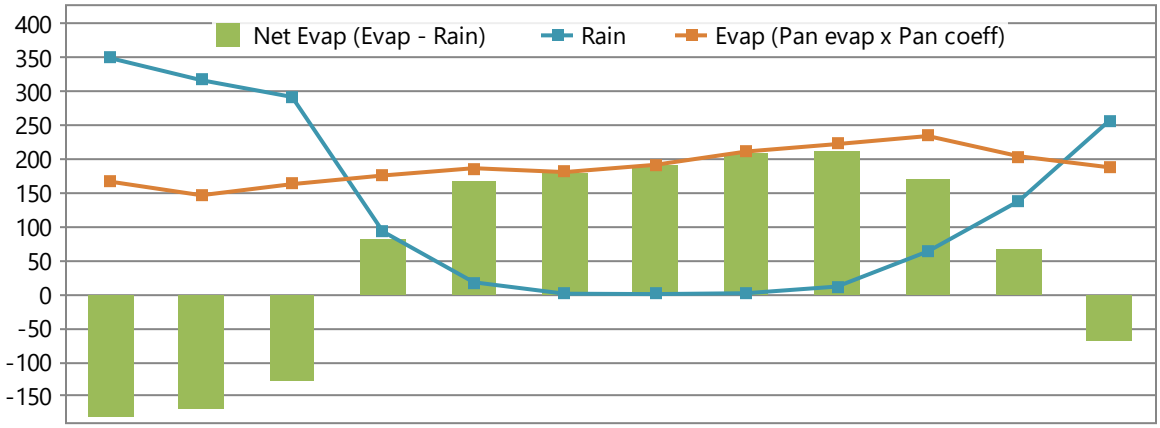
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Evap	166.8	146.7	163.1	175.9	186.7	180.9	191.7	211.3	222.3	234.2	204.4	188.0	2272.1
Net Evap	-182.6	-170.1	-128.9	82.9	168.6	179.7	191.1	209.4	210.6	170.5	66.3	-69.4	728.1
Net Evap/day	-5.9	-6.0	-4.2	2.8	5.4	6.0	6.2	6.8	7.0	5.5	2.2	-2.2	2.0

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Pond System: 1 facultative, aerobic or storage pond

New Generic System - 394710.92 m3/year or 1080.68 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

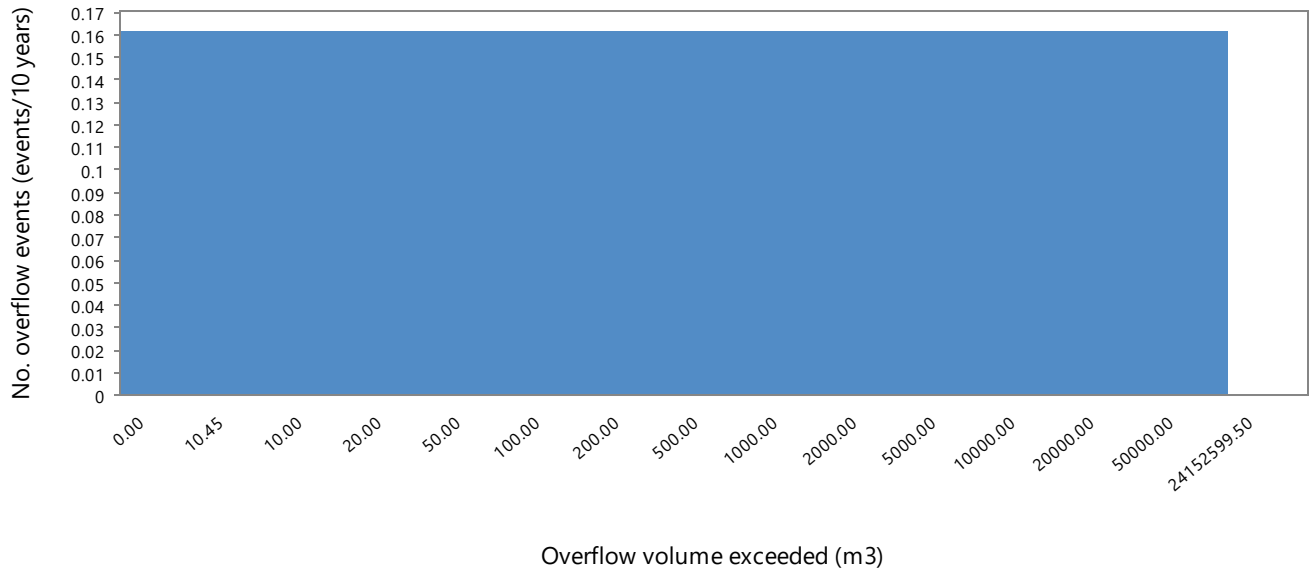
Last pond (Wet weather store): 60000.00 m3

Theoretical hydraulic retention time (days)	55.52
Average volume of overflow (m3/year)	389558.06
No. overflow events per year exceeding threshold* of 10.45 m3 (no./year)	0.02
Average duration of overflow (days)	22567.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% effluent reuse (fraction)	0.00
Average salinity of last pond (dS/m)	0.24
Salinity of last pond on final day of simulation (dS/m)	0.26
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Irrigation Information

Irrigation: 100 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	0.00	0.00
Total nitrogen applied (kg)	0.00	0.00
Total phosphorus applied (kg)	0.00	0.00
Total salts applied (kg)	0.00	0.00

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	1.00

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered every 0 days
Irrigate a fixed amount of 0.00 mm each day
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): Lambells, 95.70 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Irrigation	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
Soil Evap	106.8	98.9	95.2	42.4	9.6	1.0	0.6	1.5	8.1	35.5	72.5	98.9	570.9
Transpn.	4.7	4.4	3.3	3.9	2.2	0.4	0.0	0.0	0.0	0.3	1.6	4.0	24.9
Runoff	22.0	17.9	18.3	4.1	0.8	0.0	0.0	0.0	0.0	1.3	3.2	18.4	86.1
Drainage	202.9	202.8	190.5	51.1	8.4	0.0	0.0	0.4	2.0	19.6	55.7	128.5	861.9
Delta	12.9	-7.2	-15.4	-8.5	-2.9	-0.2	0.0	0.1	1.6	7.0	5.1	7.6	0.2

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	0.00
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	1.15
Average annual soil nitrogen removed by denitrification (kg/ha/year)	1.13E-04
Average annual soil nitrogen leached (kg/ha/year)	0.07
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.07
Soil organic-N kg/ha (Initial - Final)	6.41 - 1.51
	23.77 - 0.02
Average nitrate-N concentration of deep drainage (mg/L)	0.01
Max. annual nitrate-N concentration of deep drainage (mg/L)	0.66

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	0.00
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	0.08
Average annual soil phosphorus leached (kg/ha/year)	0.04
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	449.15 - 446.63
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	4.71E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	4.74E-03
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.00 mg/L (years)	0.00

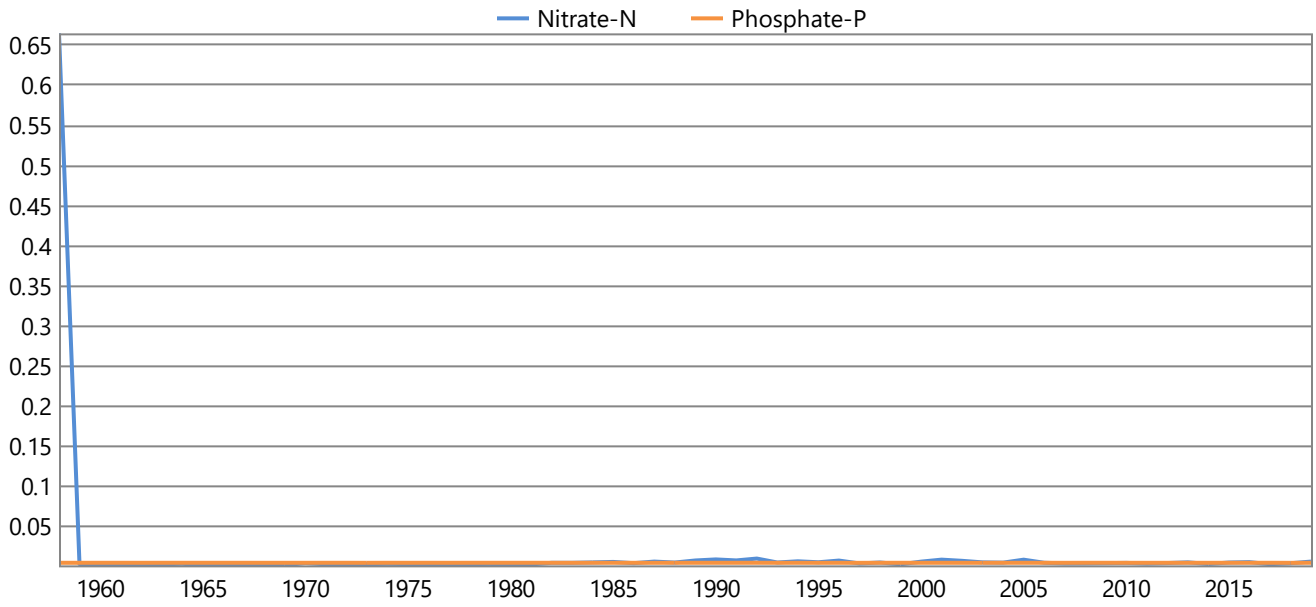
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

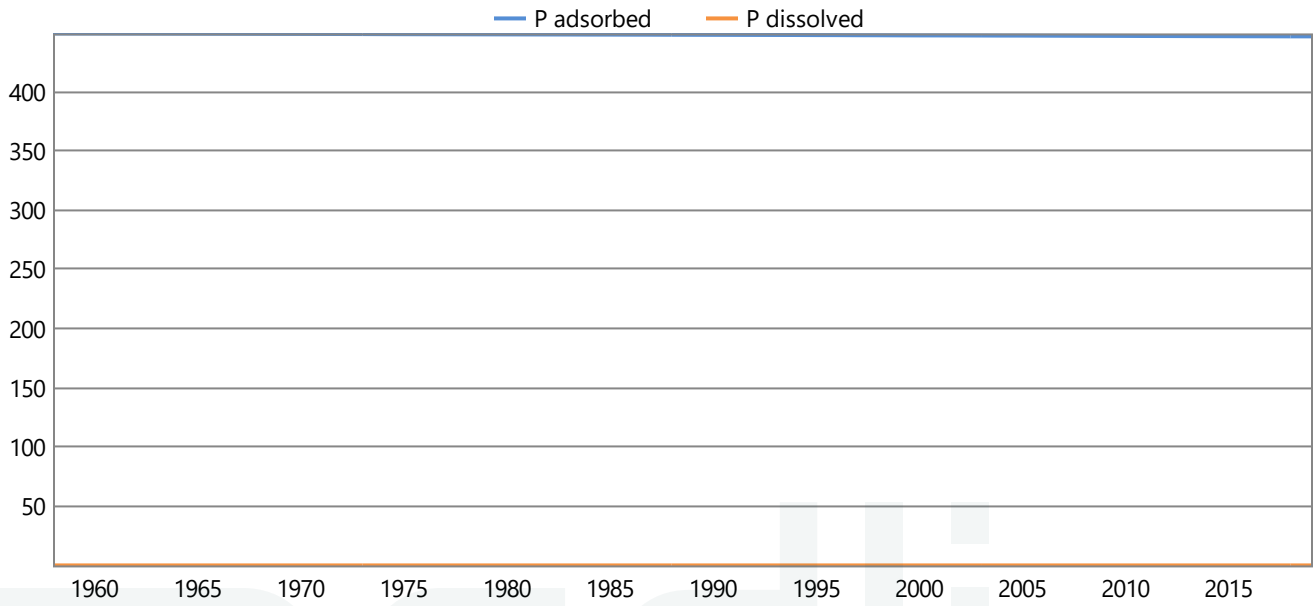
Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Plant Performance: Stage 2 irrigation: 100 ha

Average Plant Performance (Minimum - Maximum): Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	139.72 (0.00 - 2821.17)
Average monthly plant (green) cover (fraction)	0.02 (0.00 - 0.04)
Average monthly crop factor (fraction)	0.02 (0.00 - 0.03)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	54.04 (0.00 - 119.09)
Average number of normal harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of crop deaths per year (no./year)	0.84 (0.00 - 3.00)
Average number of crop deaths for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.37 (0.12 - 0.85)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.05)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.22 (0.07 - 0.37)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.03 (0.00 - 0.07)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	299.81

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Insufficient deep drainage to run steady state salinity calculations.

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

This is a Dryland scenario
No effluent irrigation has occurred!
Full run chosen

Attachment B. MEDLI Report: 0% reuse, 100ML storage, 100ha irrigation area

MEDLI REPORT - FULL RUN

Enterprise: **MARPU - Lambells Lagoon Crocodile Farm**

Description:
Marpu Stage 2 irrigation and storage modelling

Client: **PRI Farming Pty Ltd**

MEDLI User: ECOZ\adele.faraone

Scenario Details:
Updated inflows = 30% rainfall infiltration

DESCRIPTION

Climate Data: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days

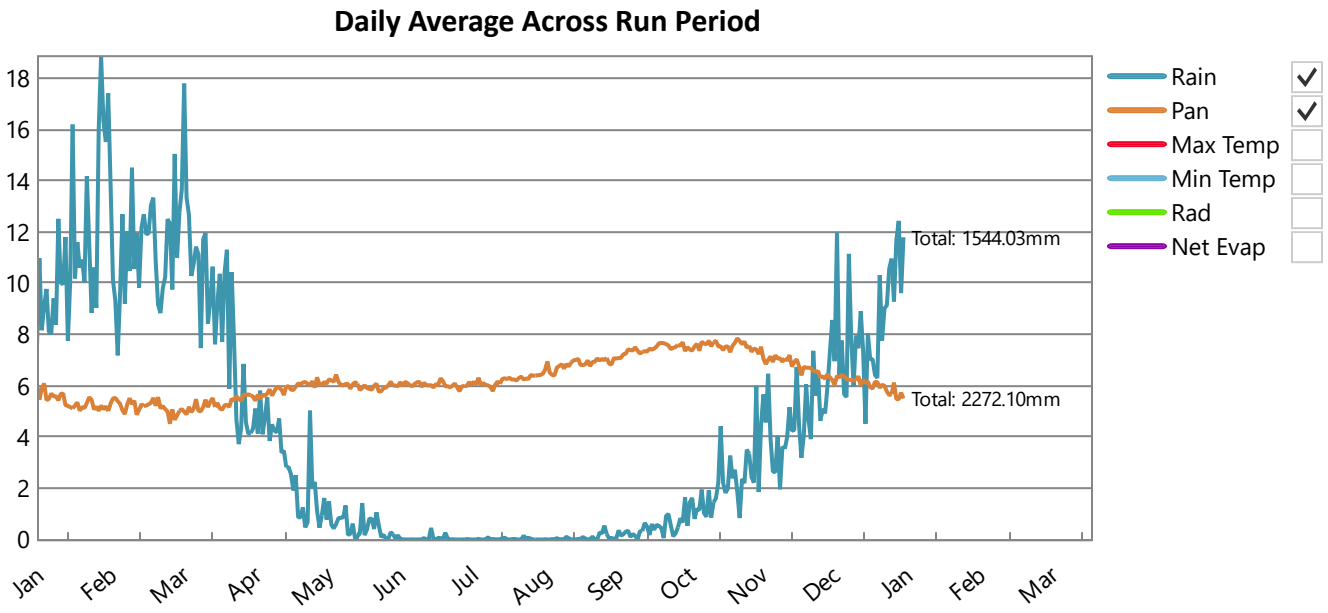
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1108	1521	2163
Pan Evaporation (mm/year)	2100	2273	2448

Climate Data:

Chart Table

Monthly Daily

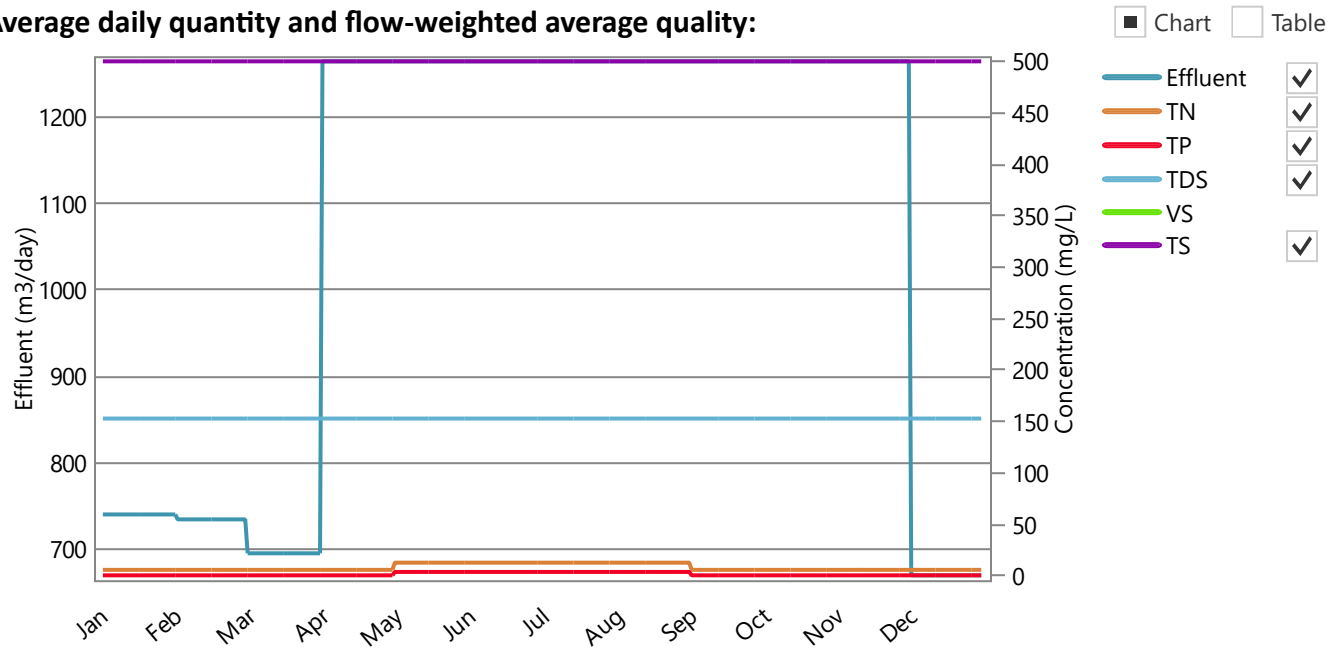


DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 394710.92 m3/year or 1080.68 m3/day (Min-Max: 669.70 - 1265.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

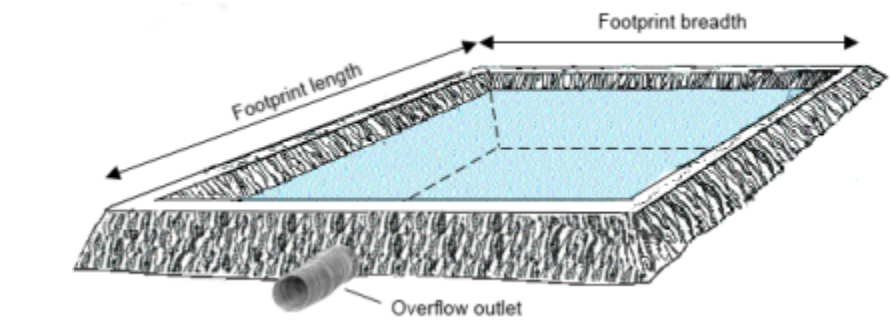
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

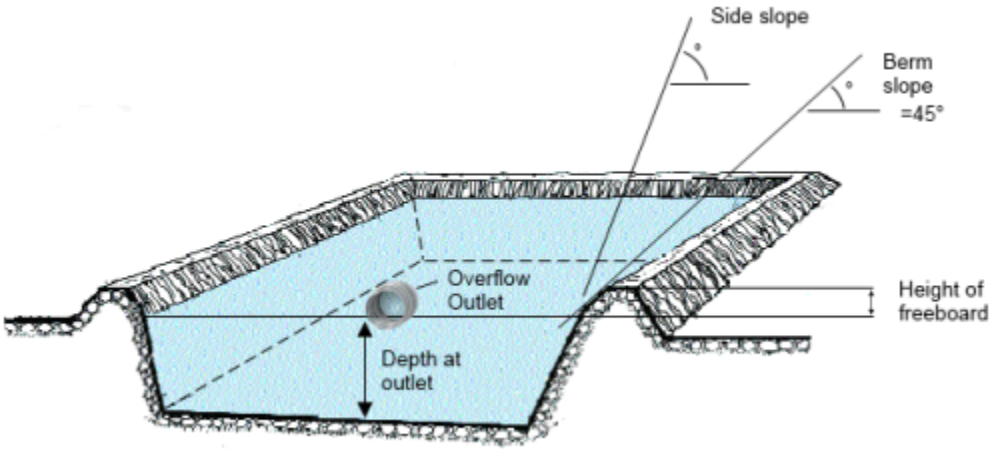
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (m3)	100000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	34503.45
Pond footprint length (m)	265.89
Pond footprint width (m)	134.55
Pond catchment area (m2)	35774.60
Average active volume (m3)	7261.69





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 (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

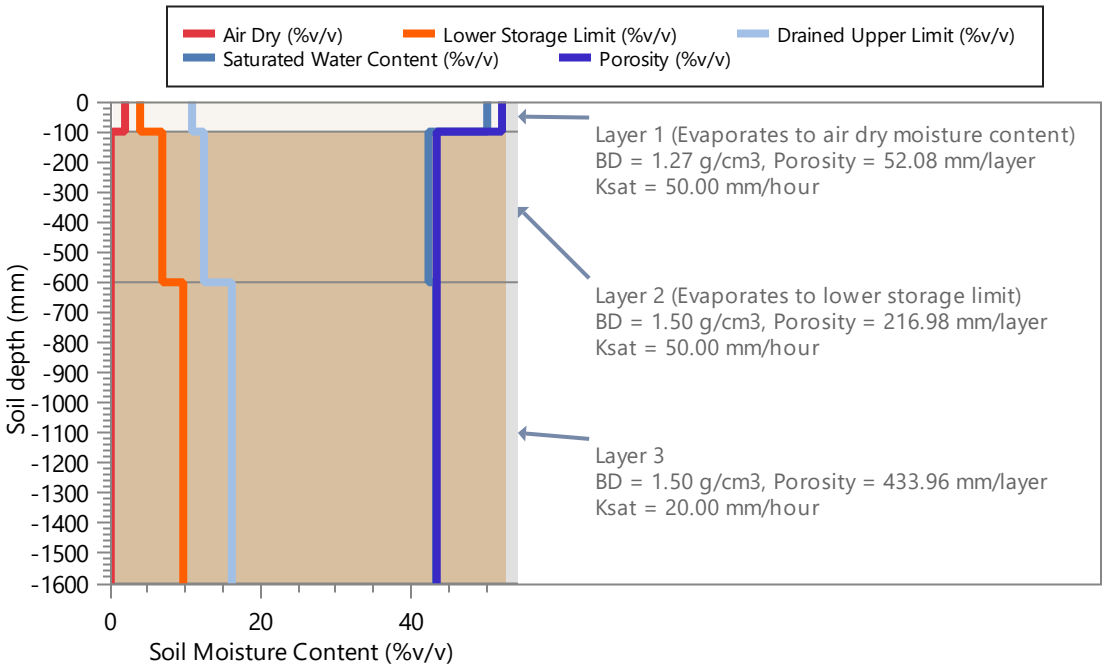
DESCRIPTION

Land: Stage 2 irrigation

Area (ha): 100.00

Soil Type: Lambells, 1600.00 mm defined profile depth

Profile Porosity (mm)	703.02
Profile saturation water content (mm)	694.60
Profile drained upper limit (or field capacity) (mm)	235.10
Profile lower storage limit (or permanent wilting point) (mm)	136.05
Profile available water capacity (mm)	99.05
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Forage Sorghum Pasture

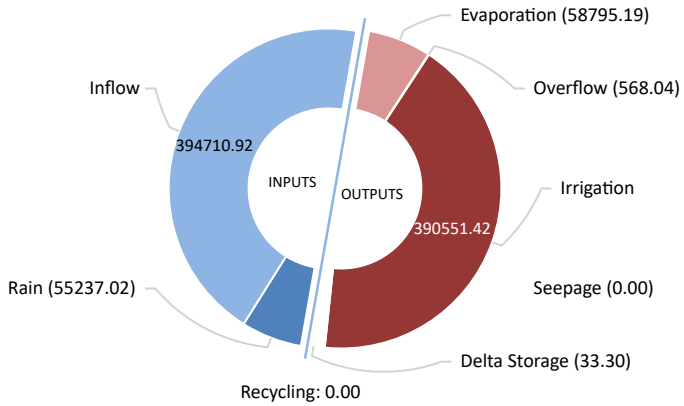
Average monthly cover (fraction) (minimum - maximum)	0.42 (0.00 - 0.78)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	1600.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11

PERFORMANCE

Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **100000 m3**

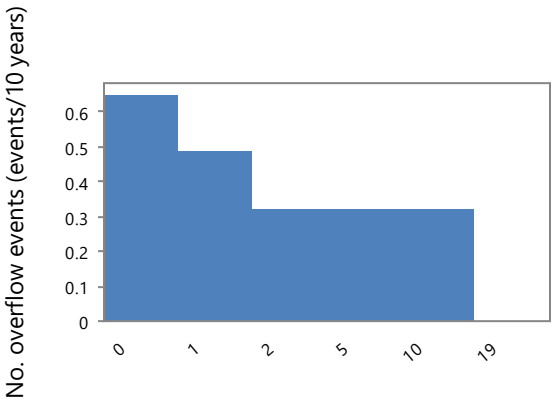
Pond System Water Balance (m3/year)



Name	Value
Rain	55237.02
Inflow	394710.92
Recycling	0.00
Evaporation	58795.19
Overflow	568.04
Irrigation	390551.42
Seepage	0.00
Delta Storage	33.30

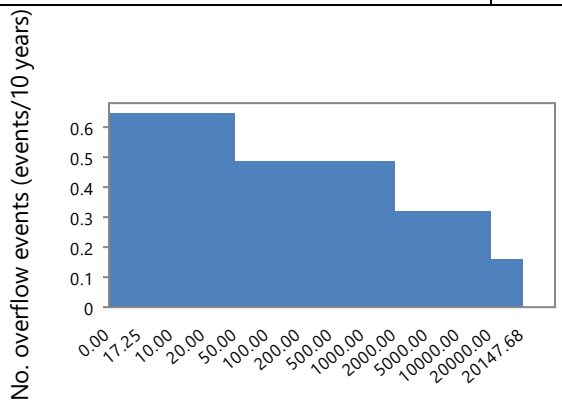
Overflow Diagnostics

Volume of overflow (m3/year)	568.04
No. days pond overflows (days/year)	0.53
Average duration of overflow (days)	8.25
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00



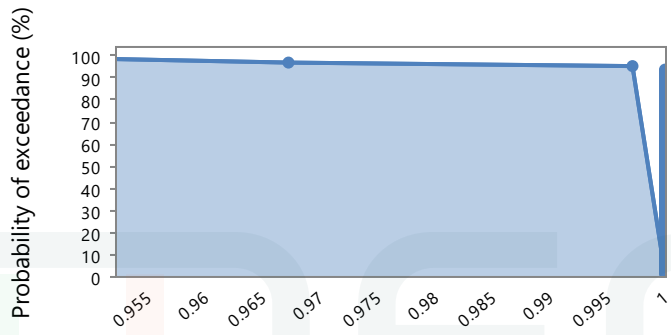
Overflow event duration exceeded (days)

Export plot



Overflow volume exceeded (m3)

Export plot



Annual reuse (fraction)

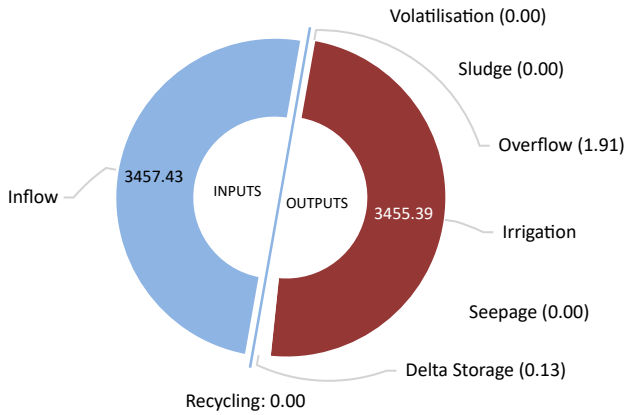
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

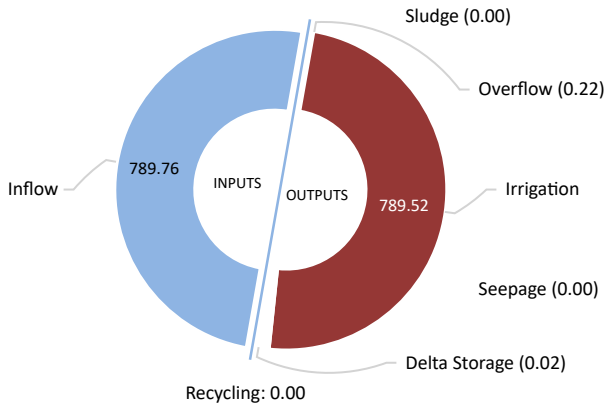
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



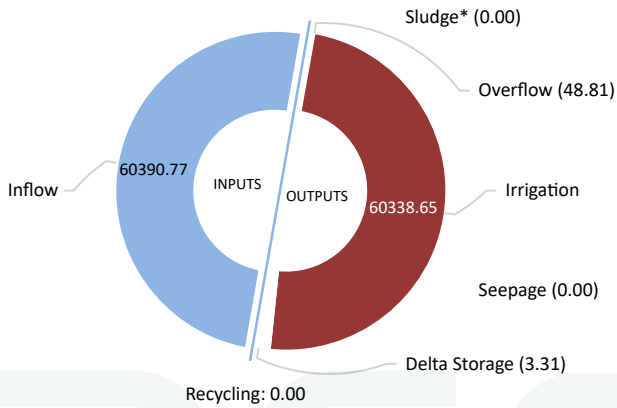
Name	Value
Inflow	3457.43
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	1.91
Irrigation	3455.39
Seepage	0.00
Delta Storage	0.13

Phosphorus Balance (kg/year)



Name	Value
Inflow	789.76
Recycling	0.00
Sludge	0.00
Overflow	0.22
Irrigation	789.52
Seepage	0.00
Delta Storage	0.02

Salt Balance (kg/year)



Name	Value
Inflow	60390.77
Recycling	0.00
Sludge*	0.00
Overflow	48.81
Irrigation	60338.65
Seepage	0.00
Delta Storage	3.31

* 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 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	3.94
Average phosphorus concentration of pond liquid (mg/L)	0.47
Average salinity of pond liquid (dS/m)	0.16

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	3.89
Final phosphorus concentration of pond liquid (mg/L)	0.45
Final salinity of pond liquid (dS/m)	0.16

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	390551.42
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	390551.42
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/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:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	8.85
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	8.62
Average phosphorus concentration of irrigation water (mg/L)	2.02
Average salinity of irrigation water (dS/m)	0.24

Irrigation Diagnostics:

Proportion of Days rain prevents irrigation (fraction)	0.13
Proportion of Days water demand too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

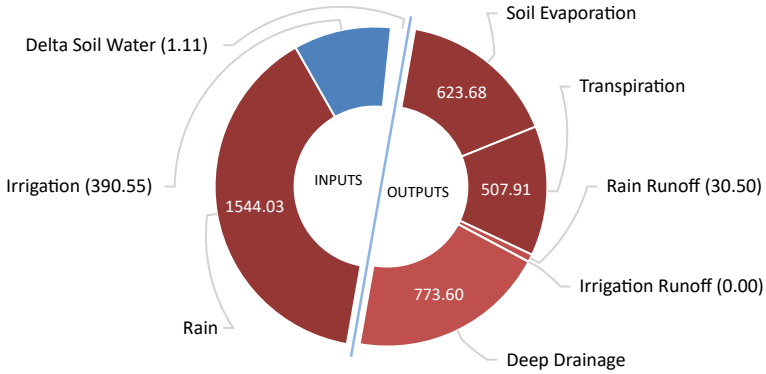
PERFORMANCE

Land Performance - Soil Water

Paddock: Stage 2 irrigation, 100 ha
Soil Type: Lambells, 99.05 mm PAWC at maximum root depth

Land Water Balance (mm/year):

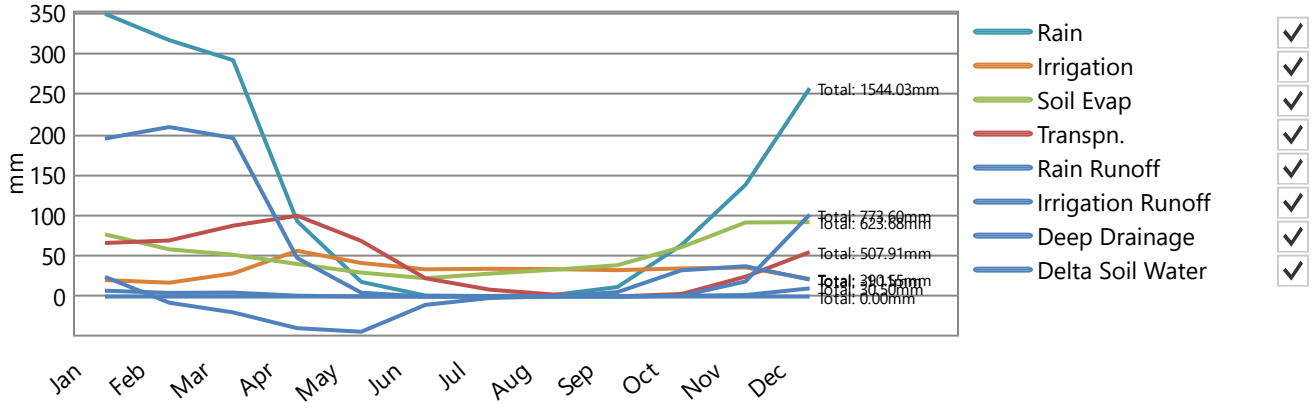
mm/year % Total inputs



Name	Value
Rain	1544.03
Irrigation	390.55
Soil Evaporation	623.68
Transpiration	507.91
Rain Runoff	30.50
Irrigation Runoff	0.00
Deep Drainage	773.60
Delta Soil Water	-1.11

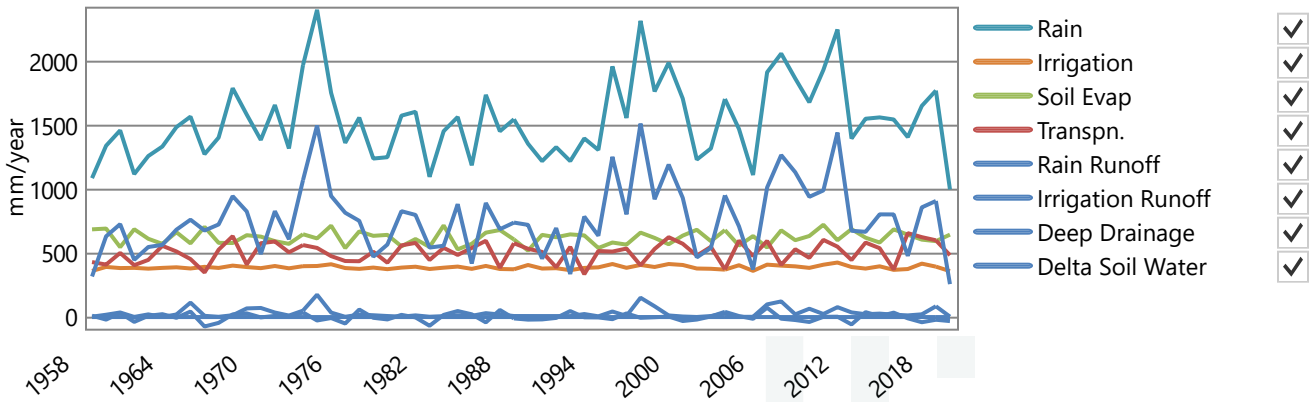
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



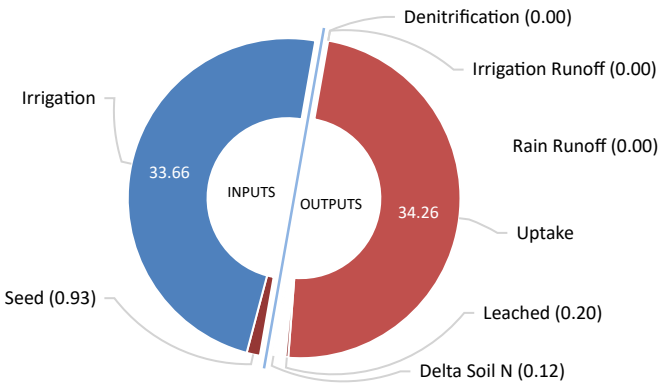
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

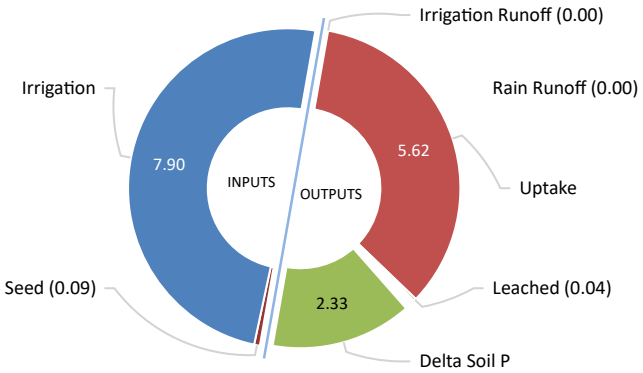
Irrigation ammonium volatilisation losses (kg/ha/year): 0.90
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.93
Irrigation	33.66
Denitrification	3.77E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	34.26
Leached	0.20
Delta Soil N	0.12

Land Phosphorus Balance (kg/ha/year)



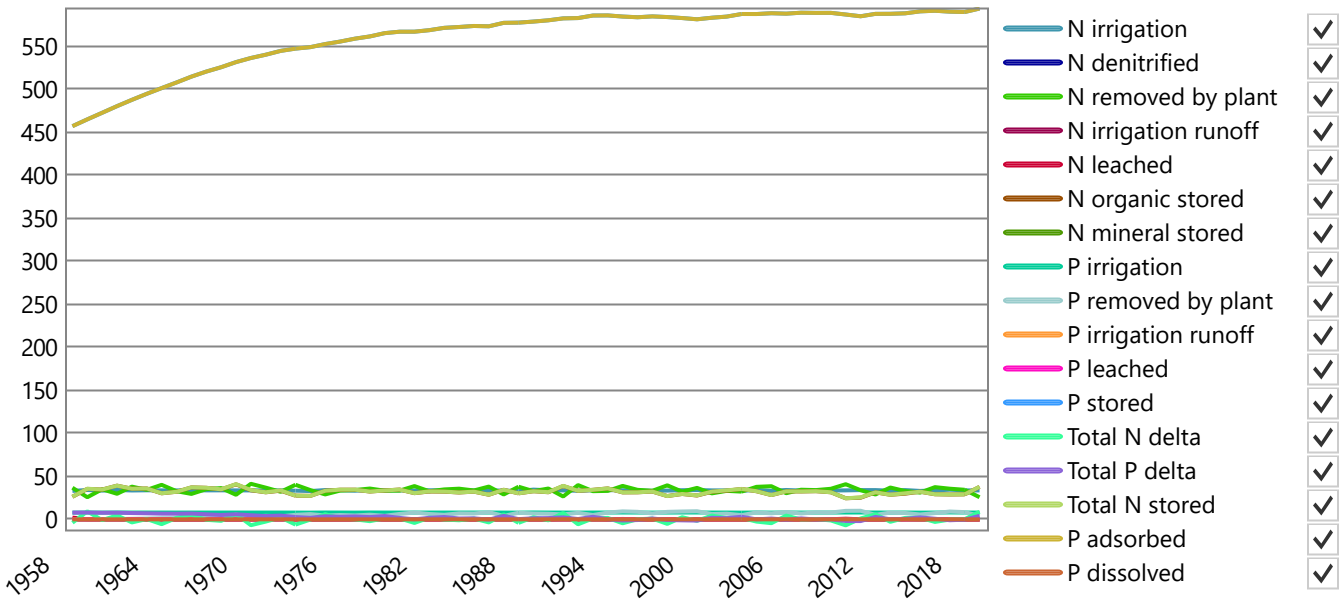
Name	Value
Seed	0.09
Irrigation	7.90
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	5.62
Leached	0.04
Delta Soil P	2.33

PERFORMANCE

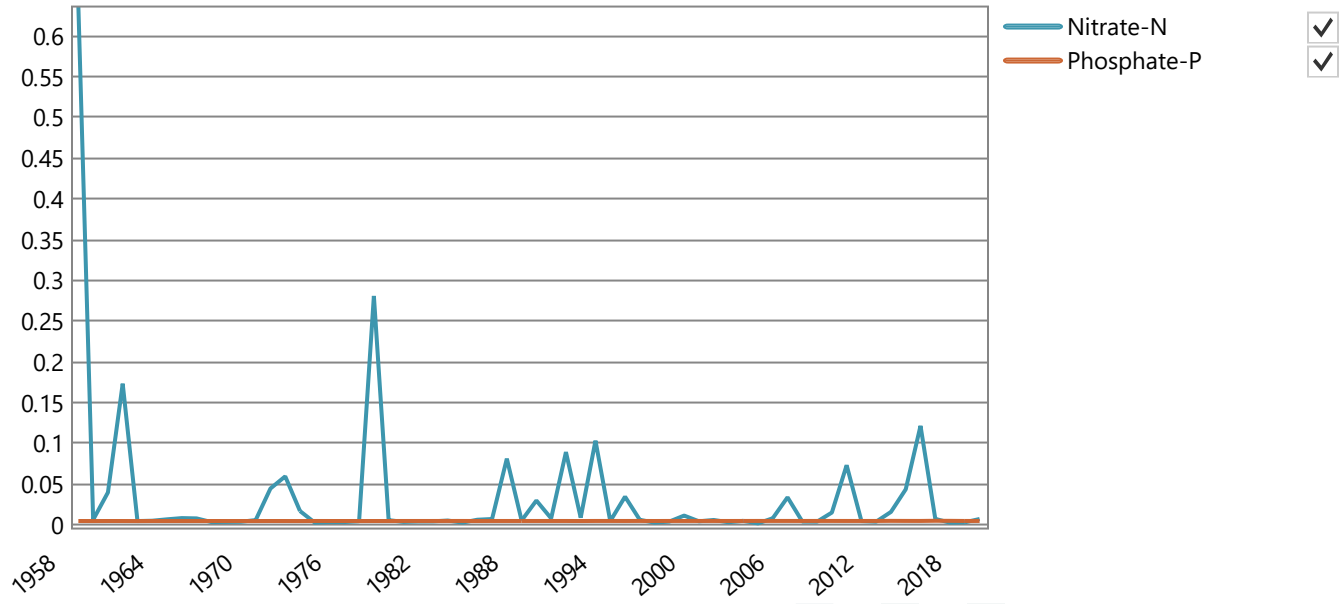
Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

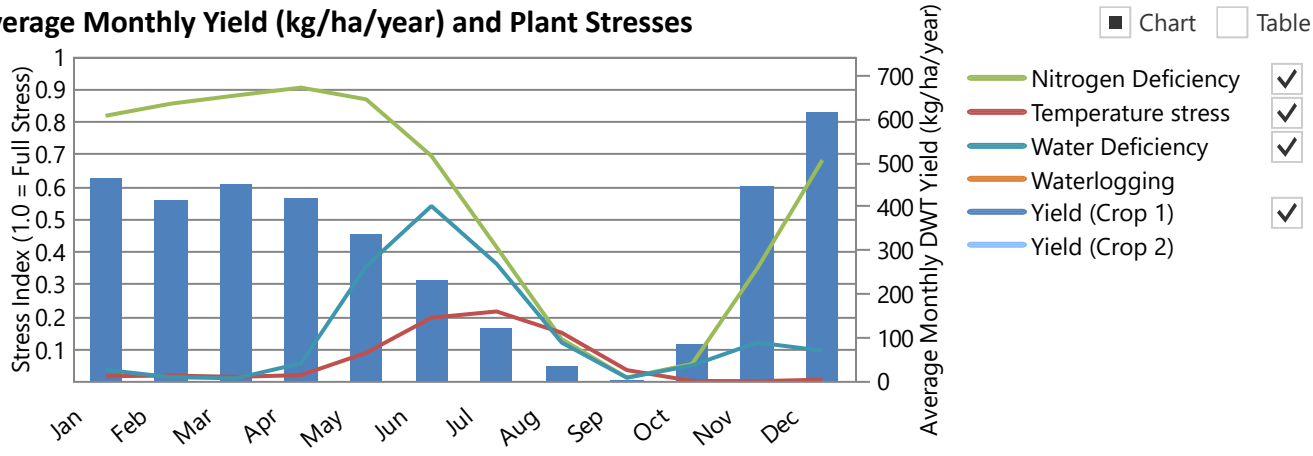
Plant: Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3663.65 (2591.92 - 4546.51)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.42 (0.00 - 0.78)
Average monthly root depth (mm) (minimum - maximum)	845.51 (21.94 - 1519.39)

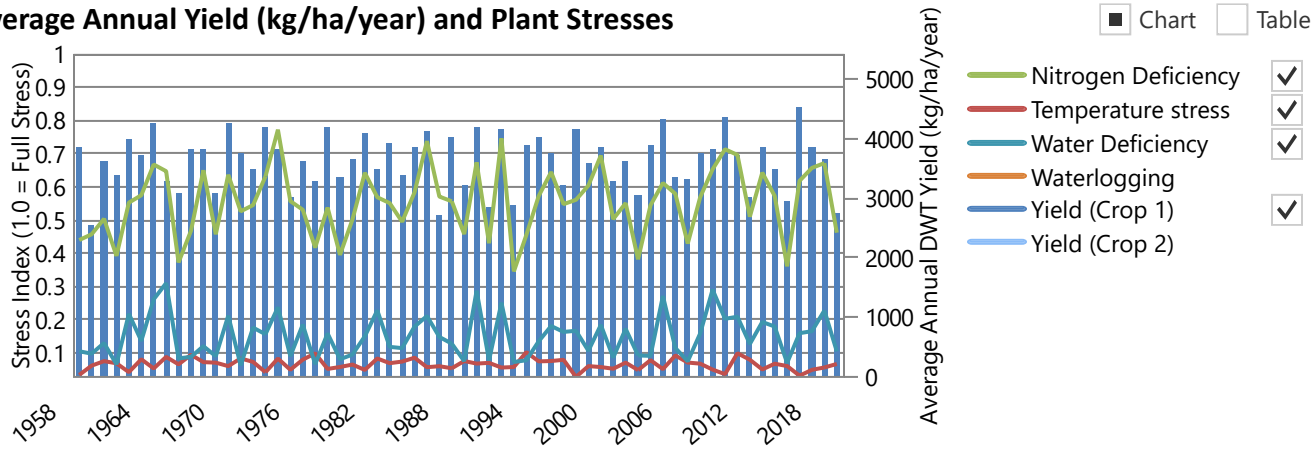
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	34.26 (25.68 - 41.31)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	5.62 (0.11 - 9.97)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.003)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 0.69 (normal), 1.02 (forced by crop death due to nitrogen stress (0.02), water stress (1.00))

No. days without crop/year (days/year): 113.52 due to water stress (113.52)

PERFORMANCE

Land Performance

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Plant: Continuous Forage Sorghum Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11
No. years assumed for leaching to reach steady-state (years)	10.00

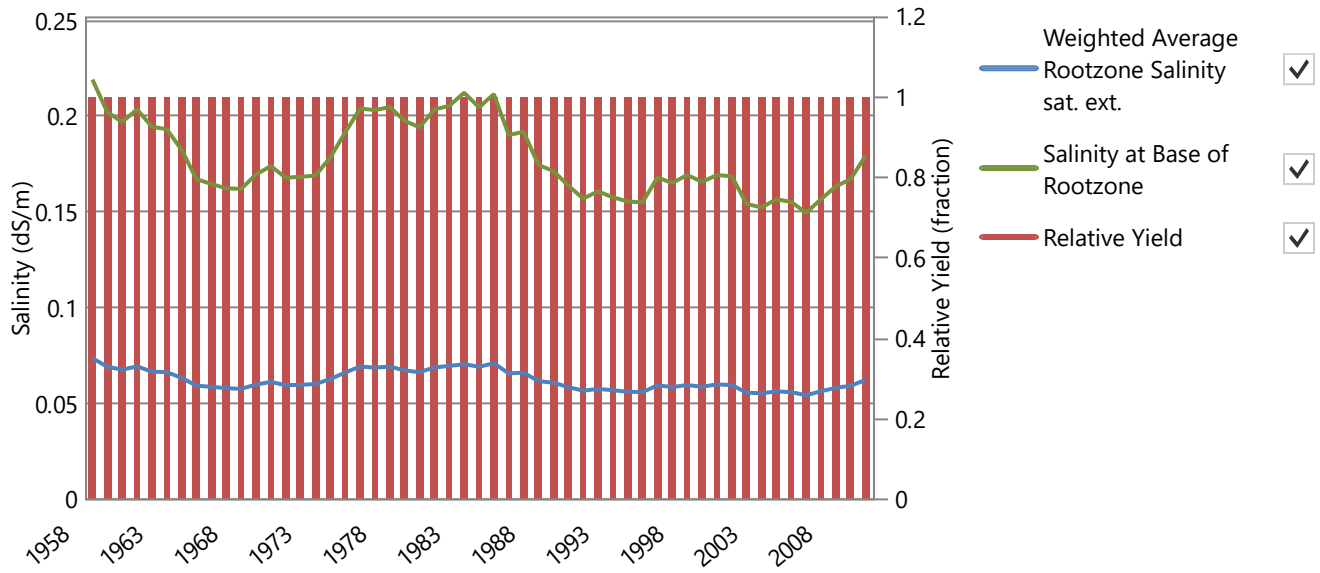
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.60
Average annual effluent salt added & leached at steady state (kg/ha/year)	893.98
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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:

Chart Table

All values based on 10 year running averages



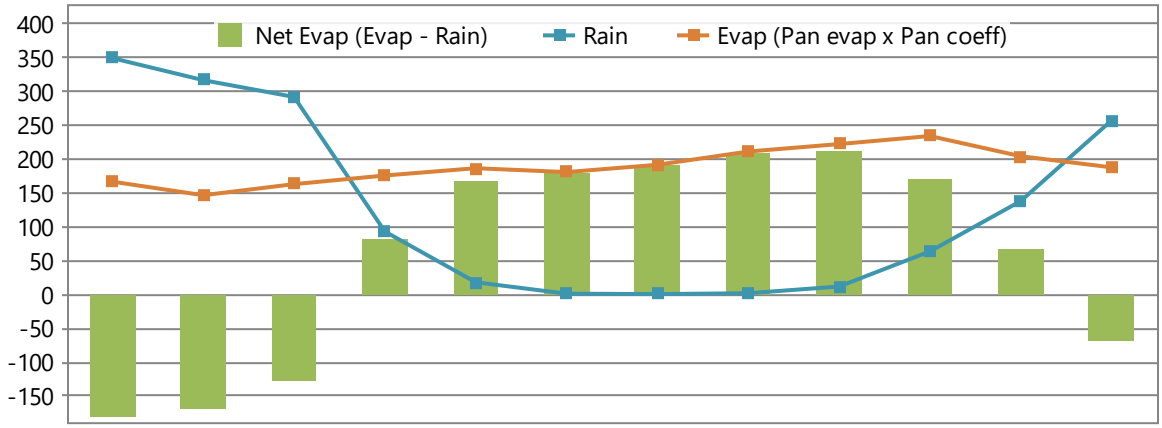
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Evap	166.8	146.7	163.1	175.9	186.7	180.9	191.7	211.3	222.3	234.2	204.4	188.0	2272.1
Net Evap	-182.6	-170.1	-128.9	82.9	168.6	179.7	191.1	209.4	210.6	170.5	66.3	-69.4	728.1
Net Evap/day	-5.9	-6.0	-4.2	2.8	5.4	6.0	6.2	6.8	7.0	5.5	2.2	-2.2	2.0

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Pond System: 1 facultative, aerobic or storage pond

New Generic System - 394710.92 m3/year or 1080.68 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

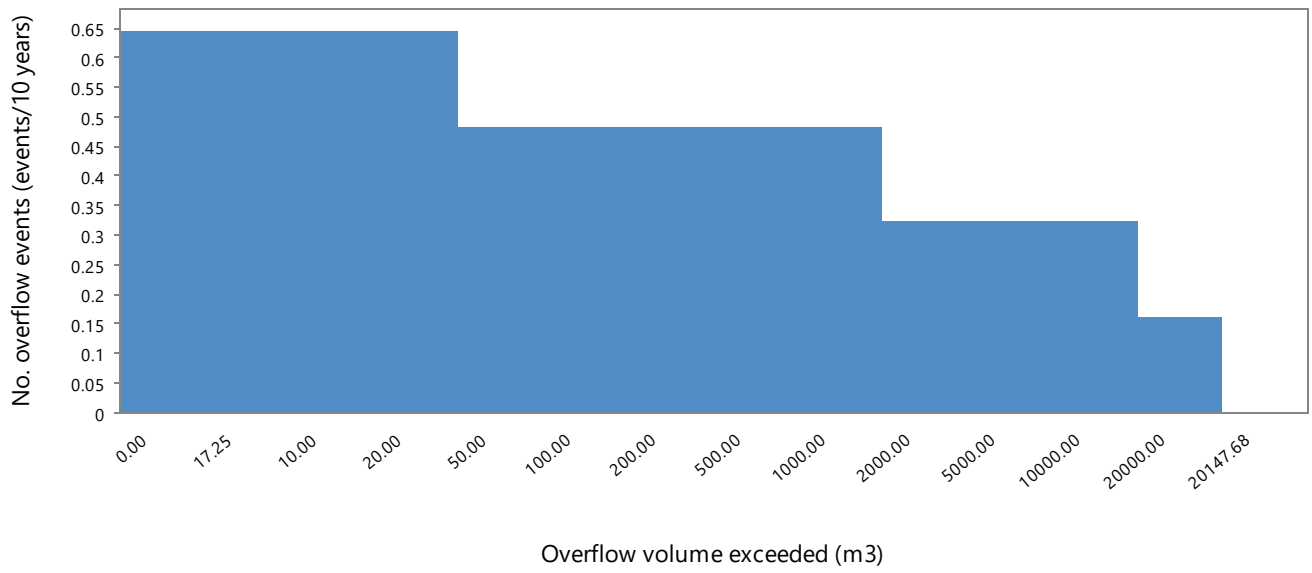
Last pond (Wet weather store): 100000.00 m3

Theoretical hydraulic retention time (days)	92.53
Average volume of overflow (m3/year)	568.04
No. overflow events per year exceeding threshold* of 17.25 m3 (no./year)	0.06
Average duration of overflow (days)	8.25
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	0.16
Salinity of last pond on final day of simulation (dS/m)	0.16
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Irrigation Information

Irrigation: 100 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	390551.42	3905.51
Total nitrogen applied (kg)	3365.55	33.66
Total phosphorus applied (kg)	789.52	7.90
Total salts applied (kg)	60338.65	603.39

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is prevented when triggered (fraction)	0.13
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 5.00 mm and rainfall is less than or equal to 10.00 mm
Irrigate a fixed amount of 5.00 mm each day
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): Lambells, 99.05 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Irrigation	20.3	17.1	28.5	56.5	41.5	33.6	34.3	33.8	32.6	34.7	35.9	21.7	390.6
Soil Evap	76.8	58.3	51.7	40.2	29.6	22.5	28.2	33.1	38.7	61.0	91.5	91.9	623.7
Transpn.	66.1	69.2	87.6	99.8	68.7	22.6	8.5	2.5	0.1	3.2	24.6	54.9	507.9
Rain Runoff	7.2	4.5	4.9	1.0	0.1	0.0	0.0	0.0	0.0	0.9	1.9	10.1	30.5
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	195.2	209.4	196.0	47.6	4.7	0.0	0.0	0.0	0.0	1.0	18.7	101.1	773.6
Delta	24.4	-7.6	-19.6	-39.1	-43.5	-10.3	-1.9	0.2	5.5	32.4	37.4	21.0	-1.1

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	33.66
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	34.26
Average annual soil nitrogen removed by denitrification (kg/ha/year)	3.77E-03
Average annual soil nitrogen leached (kg/ha/year)	0.20
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.20
Soil organic-N kg/ha (Initial - Final)	6.41 - 37.74
	23.77 - 0.07
Average nitrate-N concentration of deep drainage (mg/L)	0.03
Max. annual nitrate-N concentration of deep drainage (mg/L)	0.64

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	7.90
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	5.62
Average annual soil phosphorus leached (kg/ha/year)	0.04
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	449.15 - 593.68
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	4.78E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.01
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.41 mg/L (years)	264.79

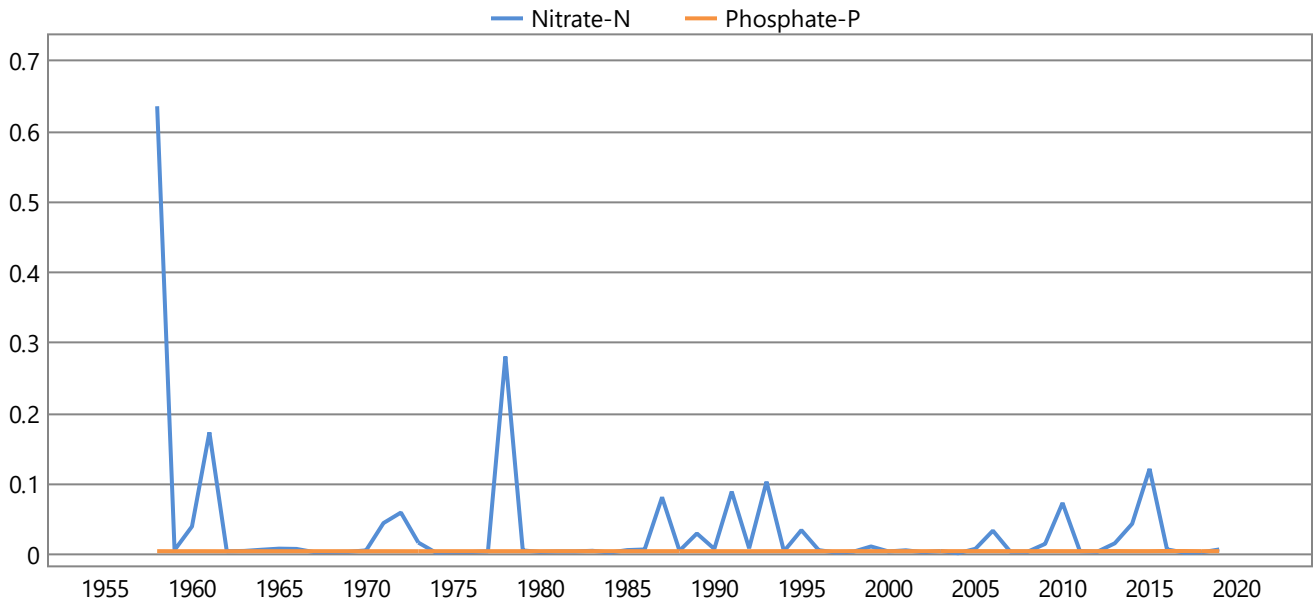
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

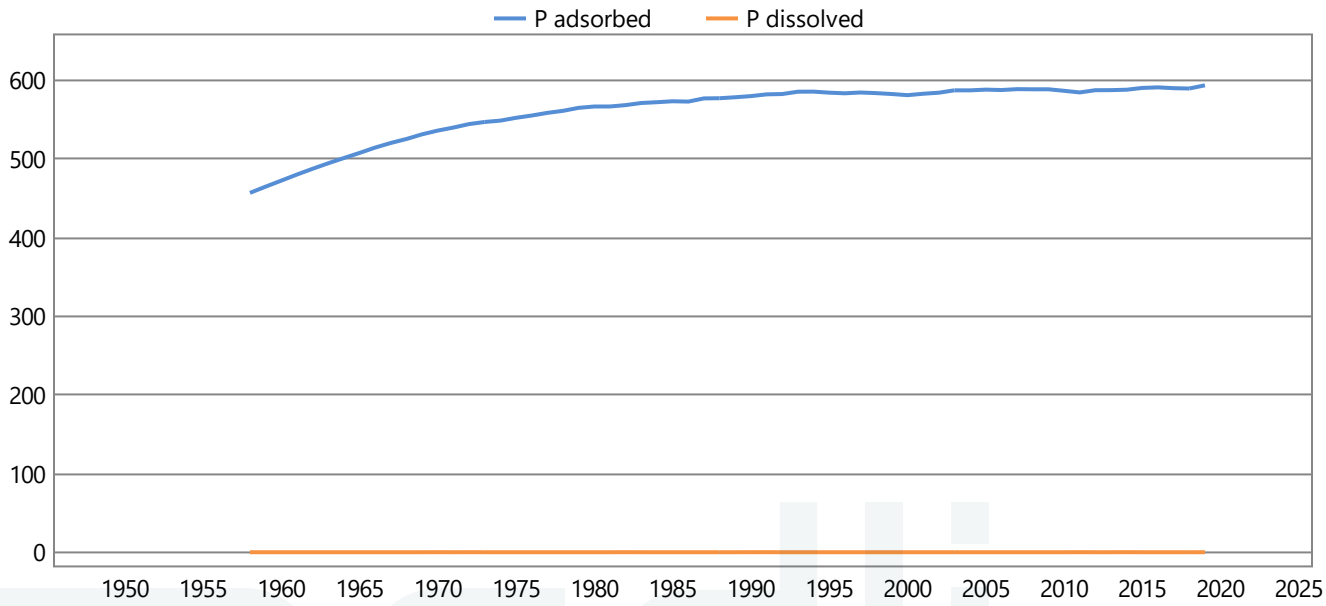
Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Plant Performance: Stage 2 irrigation: 100 ha

Average Plant Performance (Minimum - Maximum): Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3663.65 (2591.92 - 4546.51)
Average monthly plant (green) cover (fraction)	0.42 (0.00 - 0.78)
Average monthly crop factor (fraction)	0.33 (0.00 - 0.62)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	845.51 (21.94 - 1519.39)
Average number of normal harvests per year (no./year)	0.69 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.60
Average number of crop deaths per year (no./year)	1.02 (1.00 - 2.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.55 (0.35 - 0.77)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.05)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.22 (0.07 - 0.37)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.15 (0.01 - 0.54)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	113.52

Soil Salinity - Plant salinity tolerance: Tolerant

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

All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.60
Average annual effluent salt added & leached at steady state (kg/ha/year)	893.98
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

Attachment C. MEDLI Report: 0% reuse, 80ML storage, 100ha irrigation area

MEDLI REPORT - FULL RUN

Enterprise: **MARPU - Lambells Lagoon Crocodile Farm**

Description:
Marpu Stage 2 irrigation and storage modelling

Client: **PRI Farming Pty Ltd**

MEDLI User: ECOZ\adele.faraone

Scenario Details:
Updated inflows = 30% rainfall infiltration

DESCRIPTION

Climate Data: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days

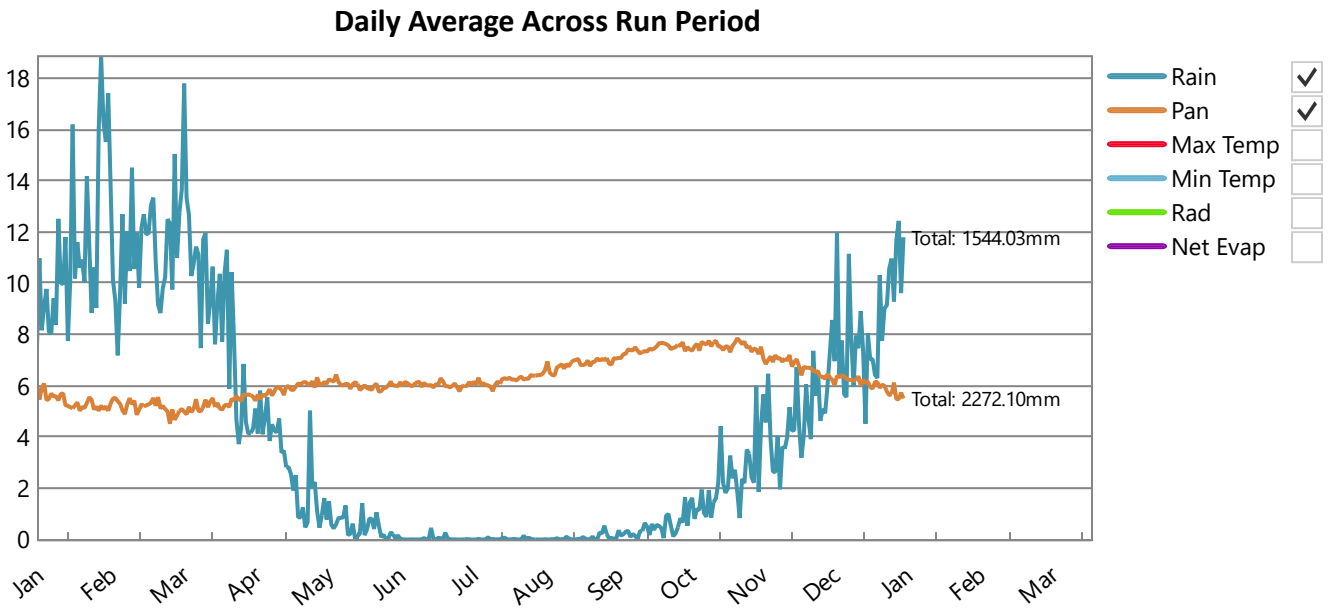
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1108	1521	2163
Pan Evaporation (mm/year)	2100	2273	2448

Climate Data:

Chart Table

Monthly Daily

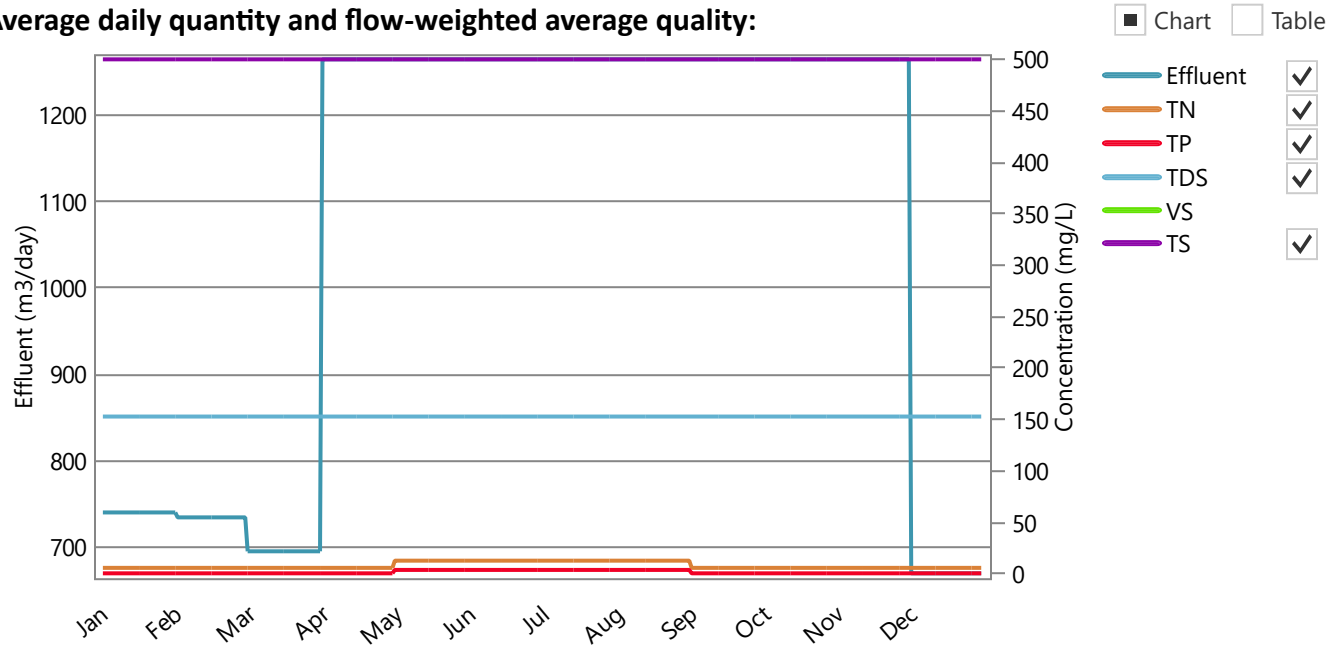


DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 394710.92 m3/year or 1080.68 m3/day (Min-Max: 669.70 - 1265.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

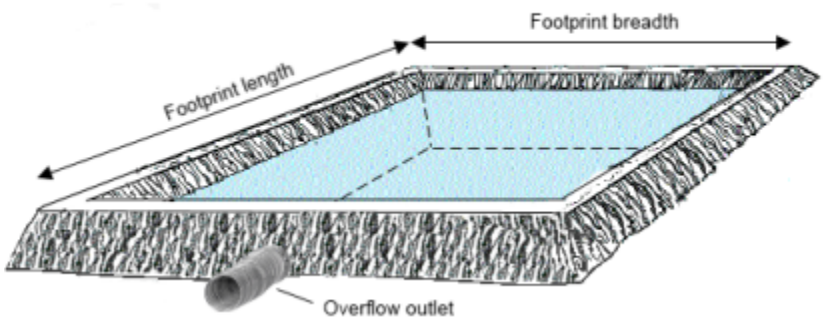
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

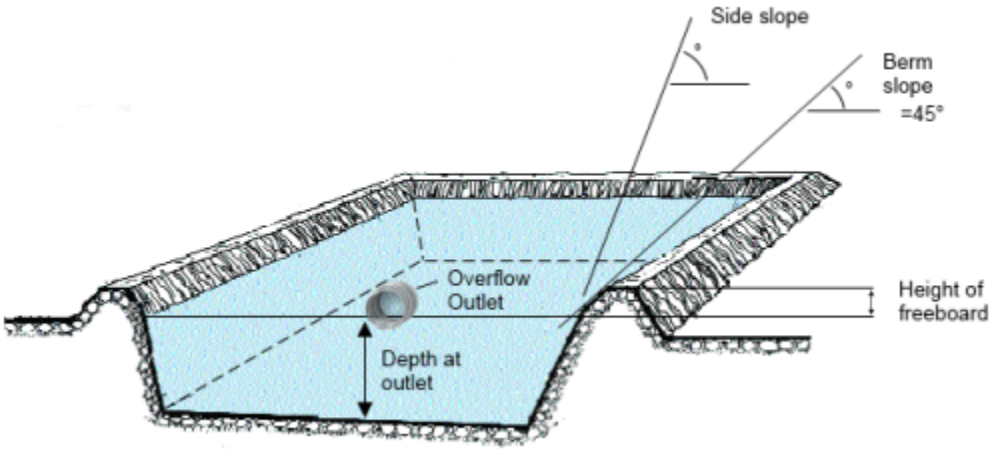
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (m3)	80000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	27714.11
Pond footprint length (m)	238.63
Pond footprint width (m)	120.92
Pond catchment area (m2)	28854.42
Average active volume (m3)	6369.39





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 (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

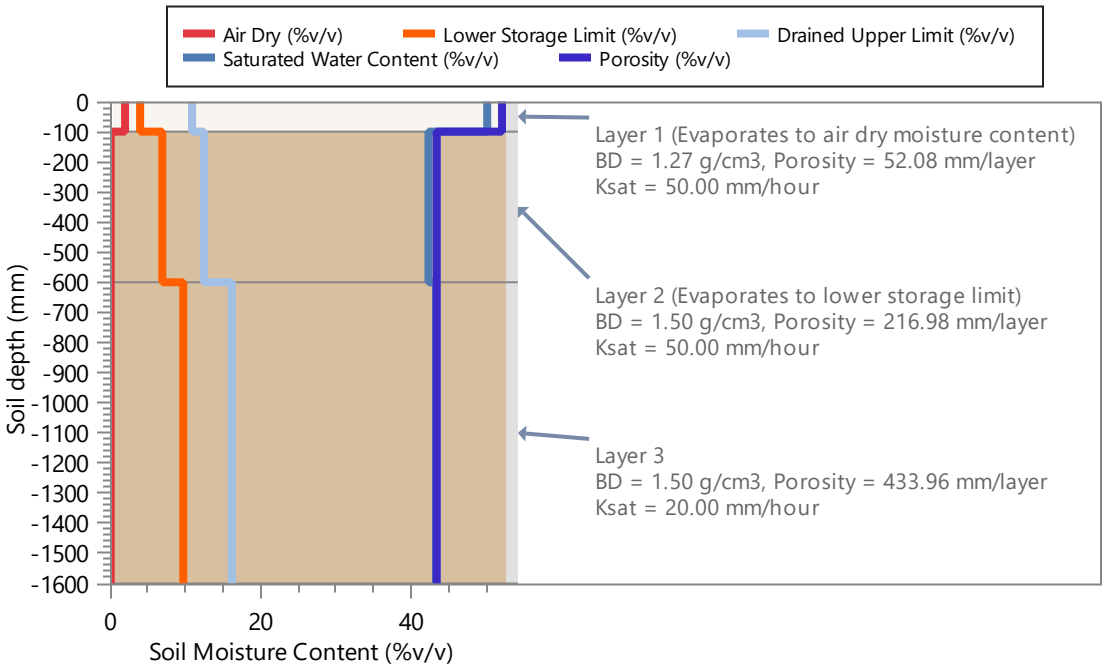
DESCRIPTION

Land: Stage 2 irrigation

Area (ha): 100.00

Soil Type: Lambells, 1600.00 mm defined profile depth

Profile Porosity (mm)	703.02
Profile saturation water content (mm)	694.60
Profile drained upper limit (or field capacity) (mm)	235.10
Profile lower storage limit (or permanent wilting point) (mm)	136.05
Profile available water capacity (mm)	99.05
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Forage Sorghum Pasture

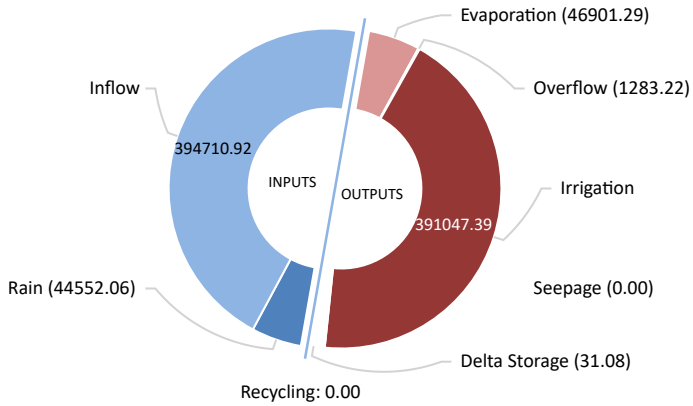
Average monthly cover (fraction) (minimum - maximum)	0.41 (0.00 - 0.77)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	1600.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11

PERFORMANCE

Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **80000 m3**

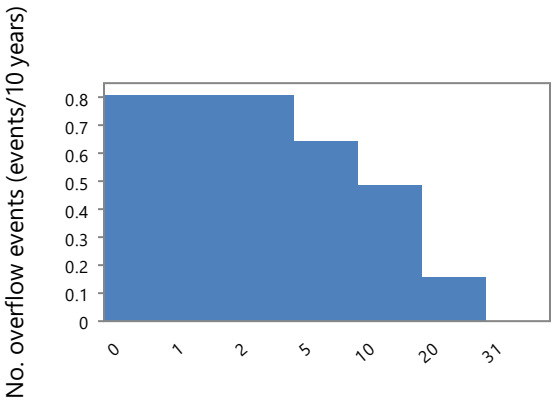
Pond System Water Balance (m3/year)



Name	Value
Rain	44552.06
Inflow	394710.92
Recycling	0.00
Evaporation	46901.29
Overflow	1283.22
Irrigation	391047.39
Seepage	0.00
Delta Storage	31.08

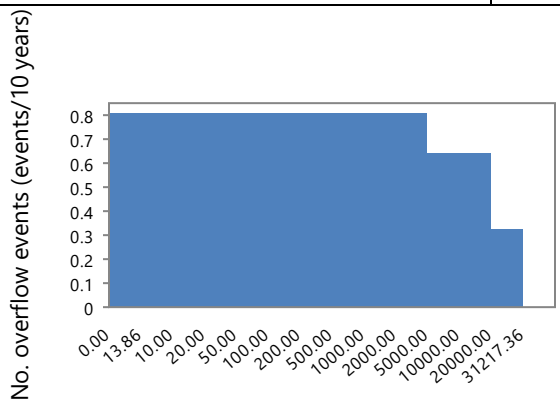
Overflow Diagnostics

Volume of overflow (m3/year)	1283.22
No. days pond overflows (days/year)	1.18
Average duration of overflow (days)	14.60
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00



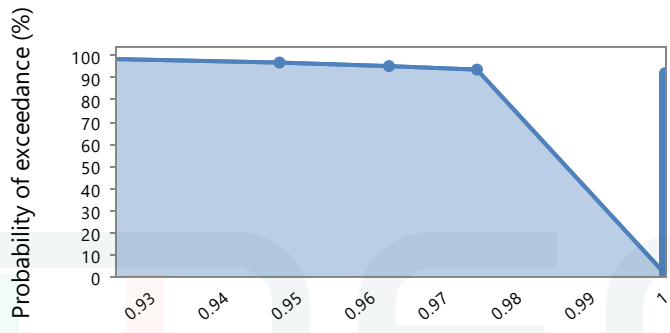
Overflow event duration exceeded (days)

Export plot



Overflow volume exceeded (m3)

Export plot



Annual reuse (fraction)

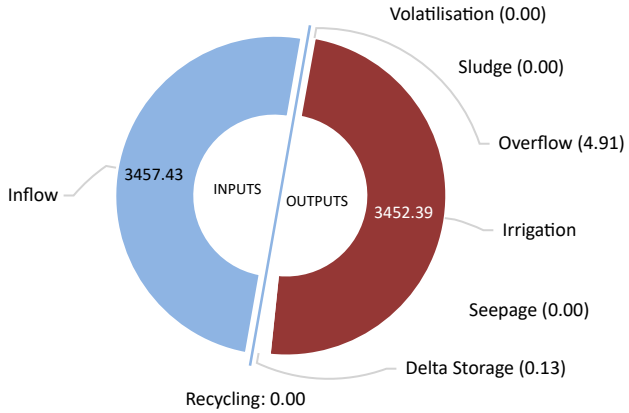
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

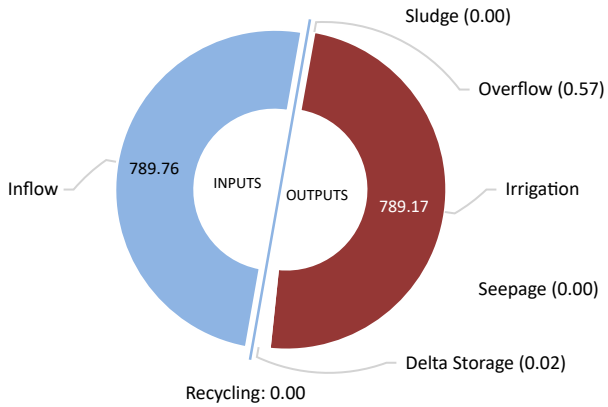
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



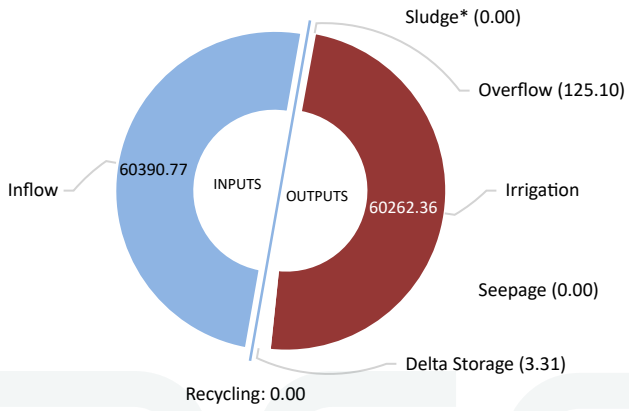
Name	Value
Inflow	3457.43
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	4.91
Irrigation	3452.39
Seepage	0.00
Delta Storage	0.13

Phosphorus Balance (kg/year)



Name	Value
Inflow	789.76
Recycling	0.00
Sludge	0.00
Overflow	0.57
Irrigation	789.17
Seepage	0.00
Delta Storage	0.02

Salt Balance (kg/year)



Name	Value
Inflow	60390.77
Recycling	0.00
Sludge*	0.00
Overflow	125.10
Irrigation	60262.36
Seepage	0.00
Delta Storage	3.31

* 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 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	4.20
Average phosphorus concentration of pond liquid (mg/L)	0.50
Average salinity of pond liquid (dS/m)	0.17

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	4.17
Final phosphorus concentration of pond liquid (mg/L)	0.49
Final salinity of pond liquid (dS/m)	0.17

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	391047.39
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	391047.39
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/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:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	8.83
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	8.60
Average phosphorus concentration of irrigation water (mg/L)	2.02
Average salinity of irrigation water (dS/m)	0.24

Irrigation Diagnostics:

Proportion of Days rain prevents irrigation (fraction)	0.13
Proportion of Days water demand too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

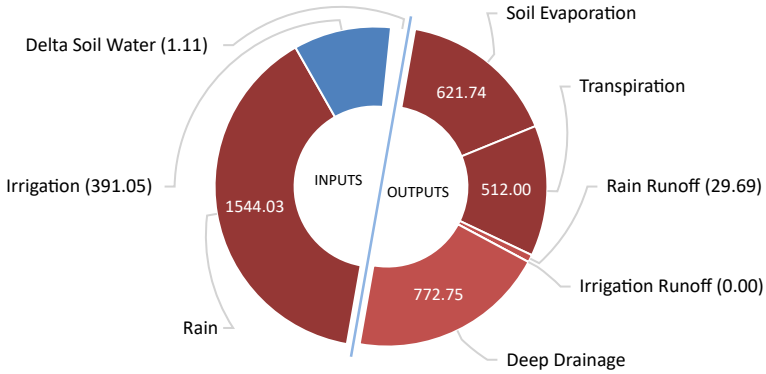
PERFORMANCE

Land Performance - Soil Water

Paddock: Stage 2 irrigation, 100 ha
Soil Type: Lambells, 99.05 mm PAWC at maximum root depth

Land Water Balance (mm/year):

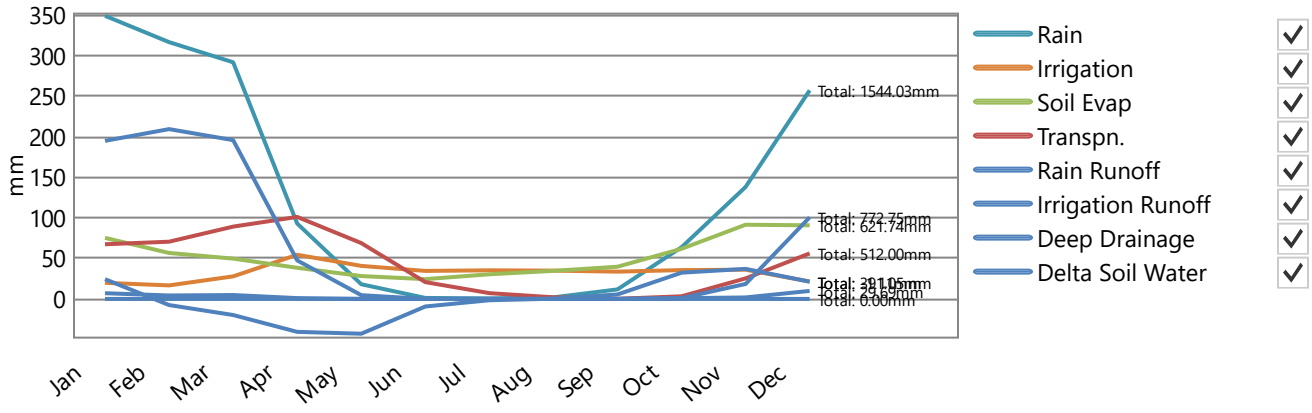
mm/year % Total inputs



Name	Value
Rain	1544.03
Irrigation	391.05
Soil Evaporation	621.74
Transpiration	512.00
Rain Runoff	29.69
Irrigation Runoff	0.00
Deep Drainage	772.75
Delta Soil Water	-1.11

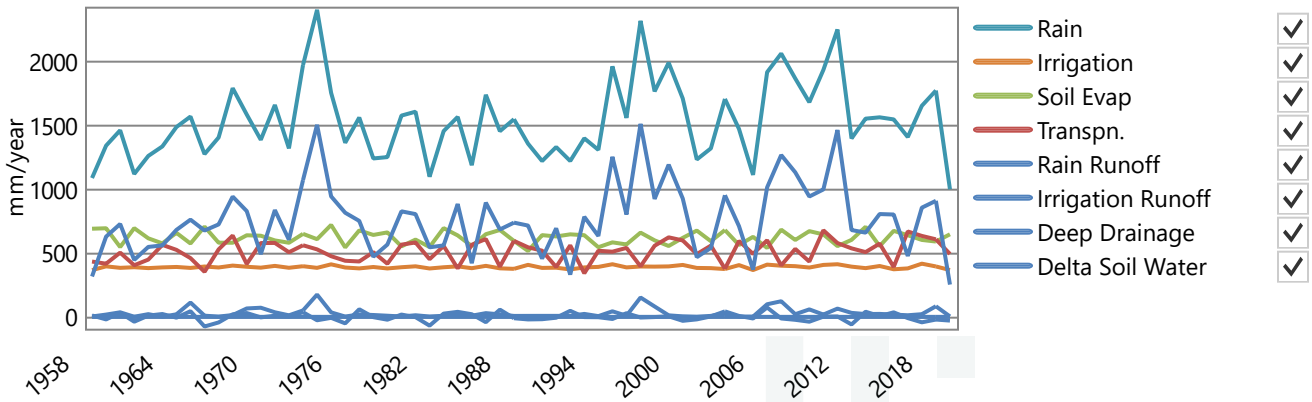
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



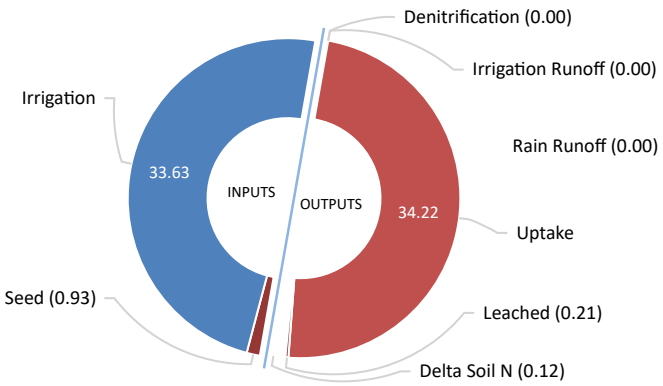
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

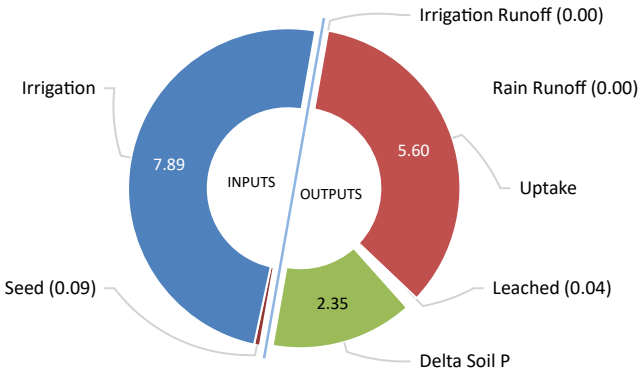
Irrigation ammonium volatilisation losses (kg/ha/year): 0.90
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.93
Irrigation	33.63
Denitrification	4.14E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	34.22
Leached	0.21
Delta Soil N	0.12

Land Phosphorus Balance (kg/ha/year)



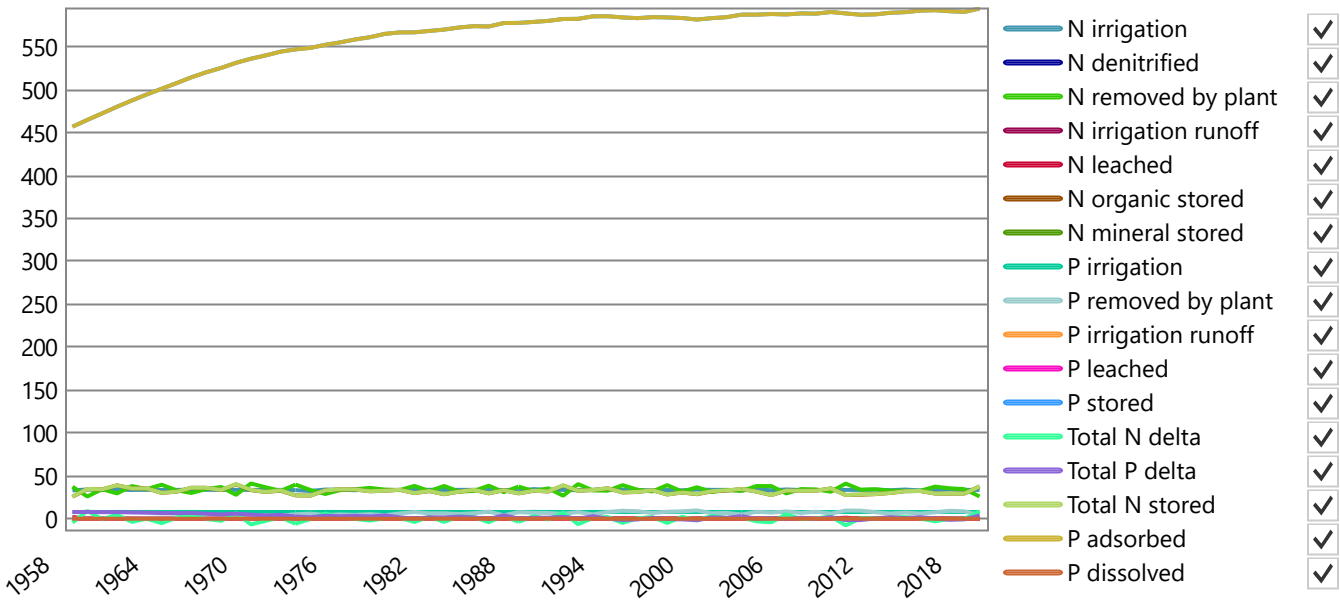
Name	Value
Seed	0.09
Irrigation	7.89
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	5.60
Leached	0.04
Delta Soil P	2.35

PERFORMANCE

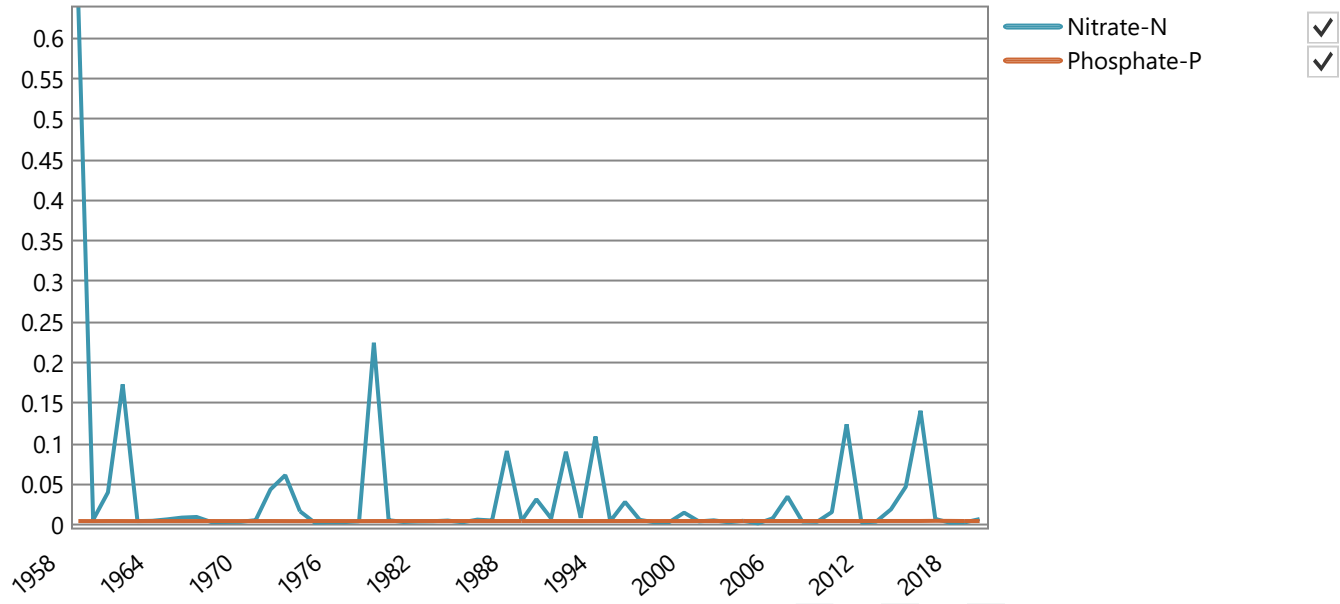
Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

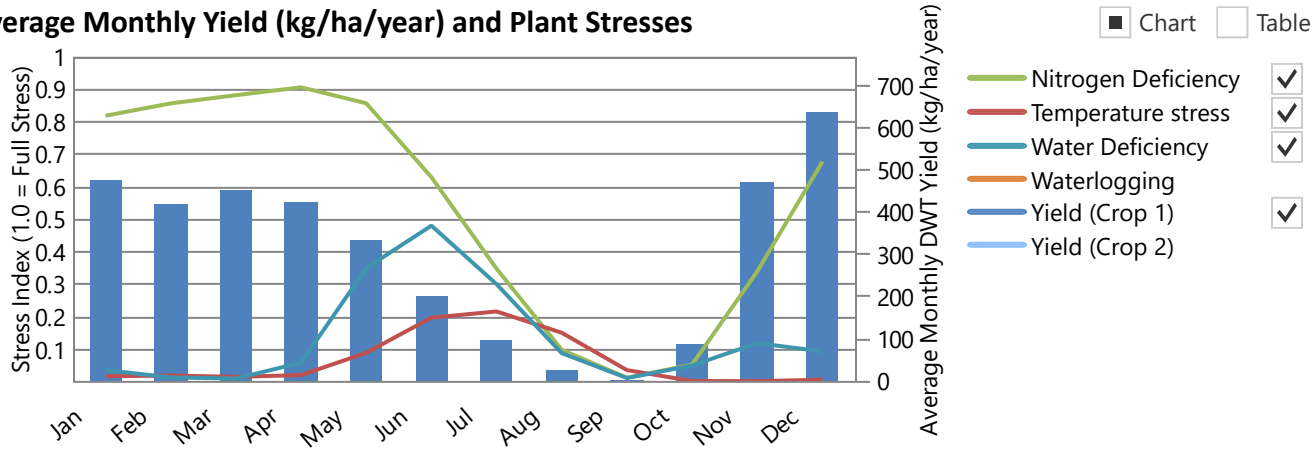
Plant: Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3659.84 (2601.93 - 4590.38)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.41 (0.00 - 0.77)
Average monthly root depth (mm) (minimum - maximum)	827.92 (19.37 - 1530.41)

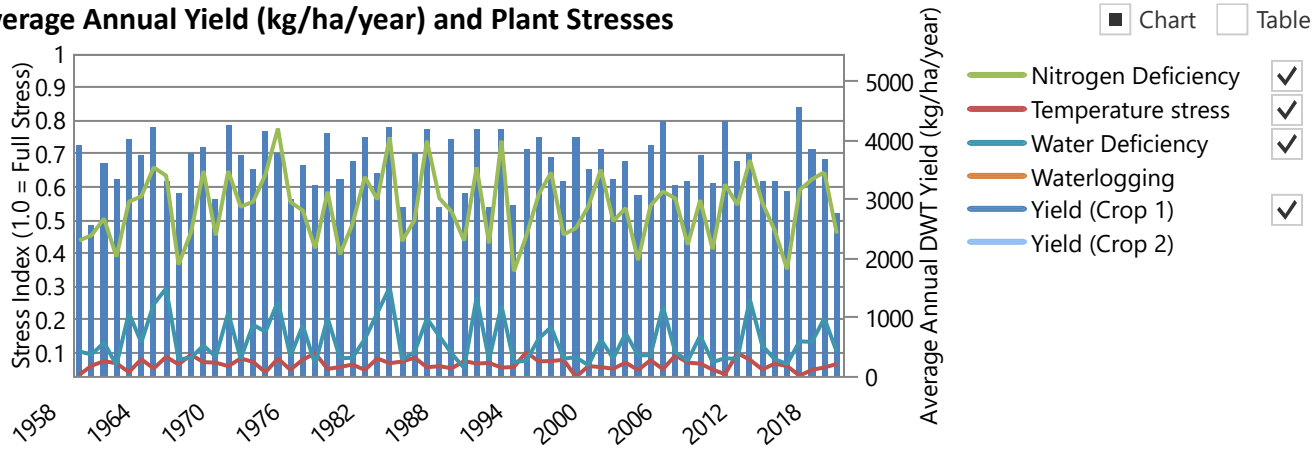
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	34.22 (25.93 - 41.12)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	5.60 (0.11 - 9.74)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.002)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 0.68 (normal), 1.02 (forced by crop death due to nitrogen stress (0.03), water stress (0.98))

No. days without crop/year (days/year): 119.42 due to water stress (119.42)

PERFORMANCE

Land Performance

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Plant: Continuous Forage Sorghum Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11
No. years assumed for leaching to reach steady-state (years)	10.00

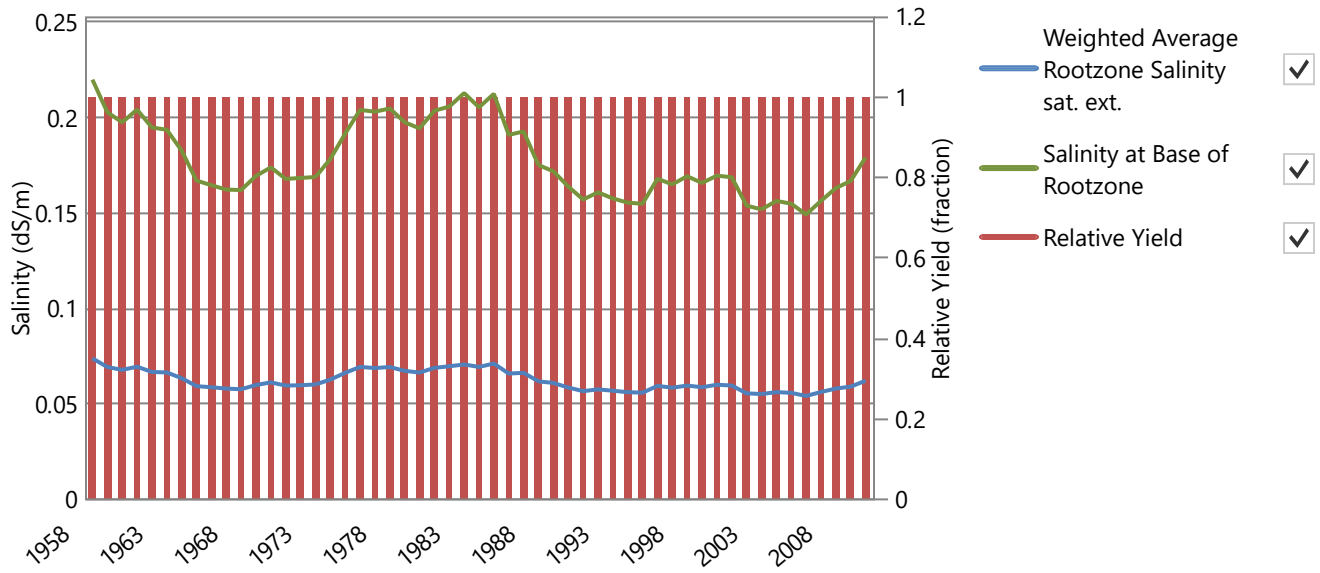
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.75
Average annual effluent salt added & leached at steady state (kg/ha/year)	893.38
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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:

Chart Table

All values based on 10 year running averages



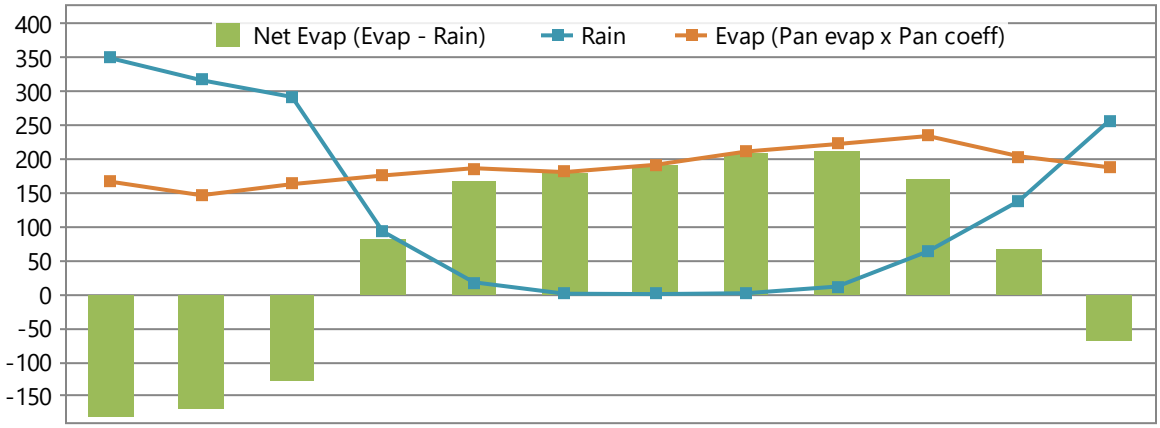
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Evap	166.8	146.7	163.1	175.9	186.7	180.9	191.7	211.3	222.3	234.2	204.4	188.0	2272.1
Net Evap	-182.6	-170.1	-128.9	82.9	168.6	179.7	191.1	209.4	210.6	170.5	66.3	-69.4	728.1
Net Evap/day	-5.9	-6.0	-4.2	2.8	5.4	6.0	6.2	6.8	7.0	5.5	2.2	-2.2	2.0

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Pond System: 1 facultative, aerobic or storage pond

New Generic System - 394710.92 m3/year or 1080.68 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

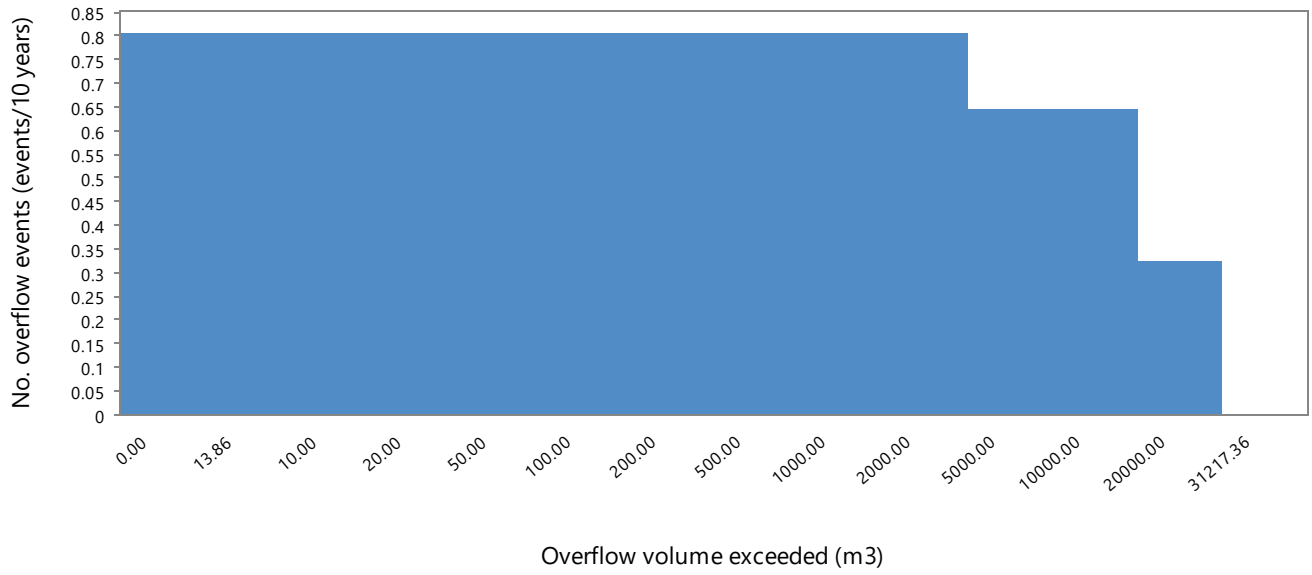
Last pond (Wet weather store): 80000.00 m3

Theoretical hydraulic retention time (days)	74.03
Average volume of overflow (m3/year)	1283.22
No. overflow events per year exceeding threshold* of 13.86 m3 (no./year)	0.08
Average duration of overflow (days)	14.60
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	0.17
Salinity of last pond on final day of simulation (dS/m)	0.17
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Irrigation Information

Irrigation: 100 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	391047.39	3910.47
Total nitrogen applied (kg)	3362.63	33.63
Total phosphorus applied (kg)	789.17	7.89
Total salts applied (kg)	60262.36	602.62

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is prevented when triggered (fraction)	0.13
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 5.00 mm and rainfall is less than or equal to 10.00 mm
Irrigate a fixed amount of 5.00 mm each day
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): Lambells, 99.05 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Irrigation	19.9	16.7	27.8	54.4	40.8	34.5	35.3	34.9	33.7	35.6	36.1	21.4	391.0
Soil Evap	75.3	56.7	49.7	38.4	28.2	24.4	30.4	34.6	39.7	61.8	91.5	90.8	621.7
Transpn.	67.4	70.6	89.2	101.2	68.9	20.7	7.1	2.0	0.2	3.2	25.3	56.1	512.0
Rain Runoff	7.0	4.2	4.8	1.0	0.1	0.0	0.0	0.0	0.0	0.9	1.8	9.9	29.7
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	195.0	209.5	195.9	47.5	4.6	0.0	0.0	0.0	0.0	1.0	18.5	100.7	772.8
Delta	24.4	-7.6	-19.9	-40.6	-42.9	-9.3	-1.6	0.3	5.5	32.4	37.1	21.3	-1.1

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	33.63
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	34.22
Average annual soil nitrogen removed by denitrification (kg/ha/year)	4.14E-03
Average annual soil nitrogen leached (kg/ha/year)	0.21
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.21
Soil organic-N kg/ha (Initial - Final)	6.41 - 37.77
	23.77 - 0.07
Average nitrate-N concentration of deep drainage (mg/L)	0.03
Max. annual nitrate-N concentration of deep drainage (mg/L)	0.64

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	7.89
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	5.60
Average annual soil phosphorus leached (kg/ha/year)	0.04
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	449.15 - 594.70
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	4.77E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.01
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.41 mg/L (years)	264.77

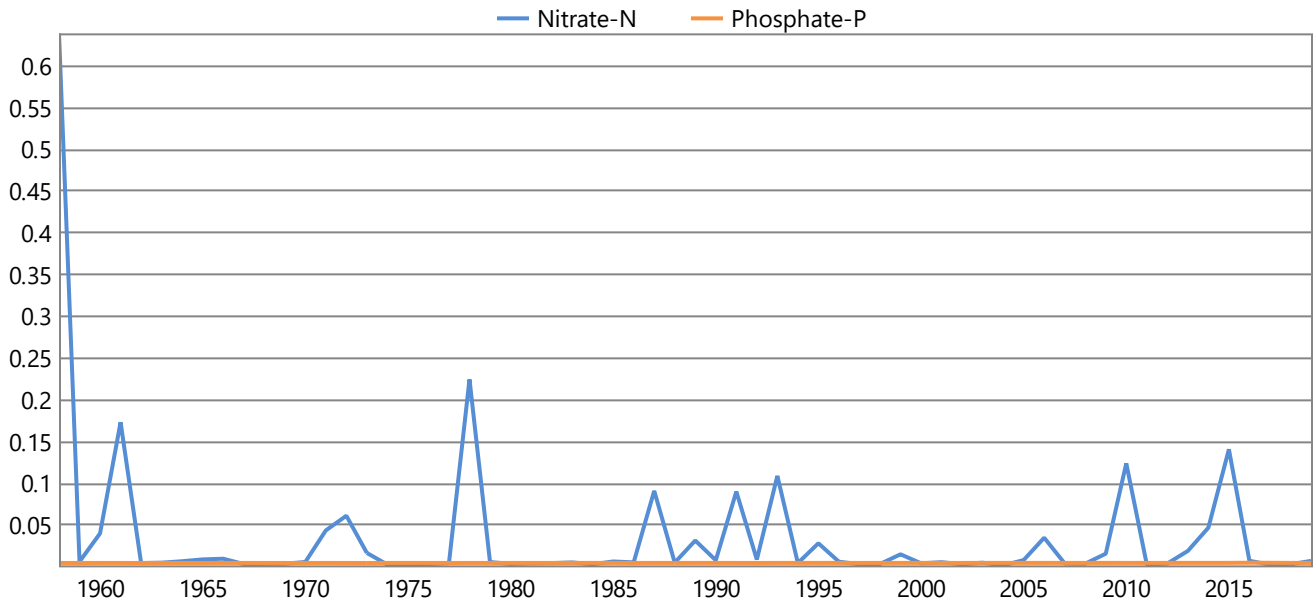
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

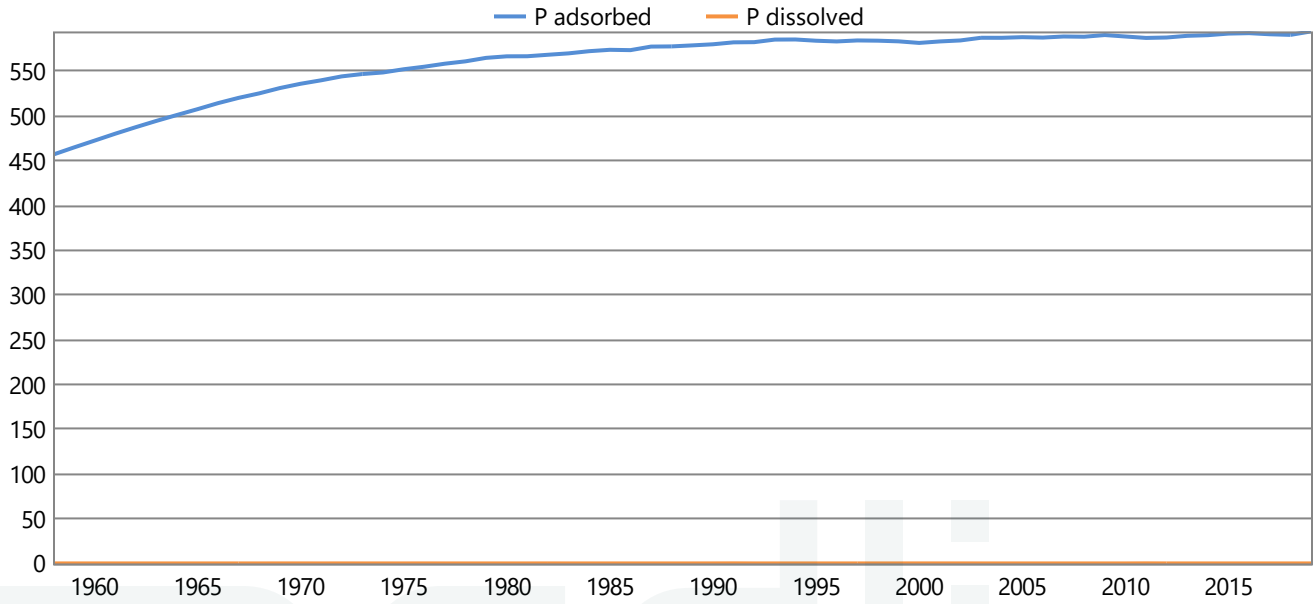
Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Plant Performance: Stage 2 irrigation: 100 ha

Average Plant Performance (Minimum - Maximum): Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3659.84 (2601.93 - 4590.38)
Average monthly plant (green) cover (fraction)	0.41 (0.00 - 0.77)
Average monthly crop factor (fraction)	0.33 (0.00 - 0.62)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	827.92 (19.37 - 1530.41)
Average number of normal harvests per year (no./year)	0.68 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.60
Average number of crop deaths per year (no./year)	1.02 (1.00 - 2.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.54 (0.35 - 0.78)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.05)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.22 (0.07 - 0.37)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.13 (0.01 - 0.48)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	119.42

Soil Salinity - Plant salinity tolerance: Tolerant

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

All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.75
Average annual effluent salt added & leached at steady state (kg/ha/year)	893.38
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

Attachment D. MEDLI Report: 0% reuse, 60ML storage, 100ha irrigation area

MEDLI REPORT - FULL RUN

Enterprise: **MARPU - Lambells Lagoon Crocodile Farm**

Description:
Marpu Stage 2 irrigation and storage modelling

Client: **PRI Farming Pty Ltd**

MEDLI User: ECOZ\adele.faraone

Scenario Details:
Updated inflows = 30% rainfall infiltration

DESCRIPTION

Climate Data: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days

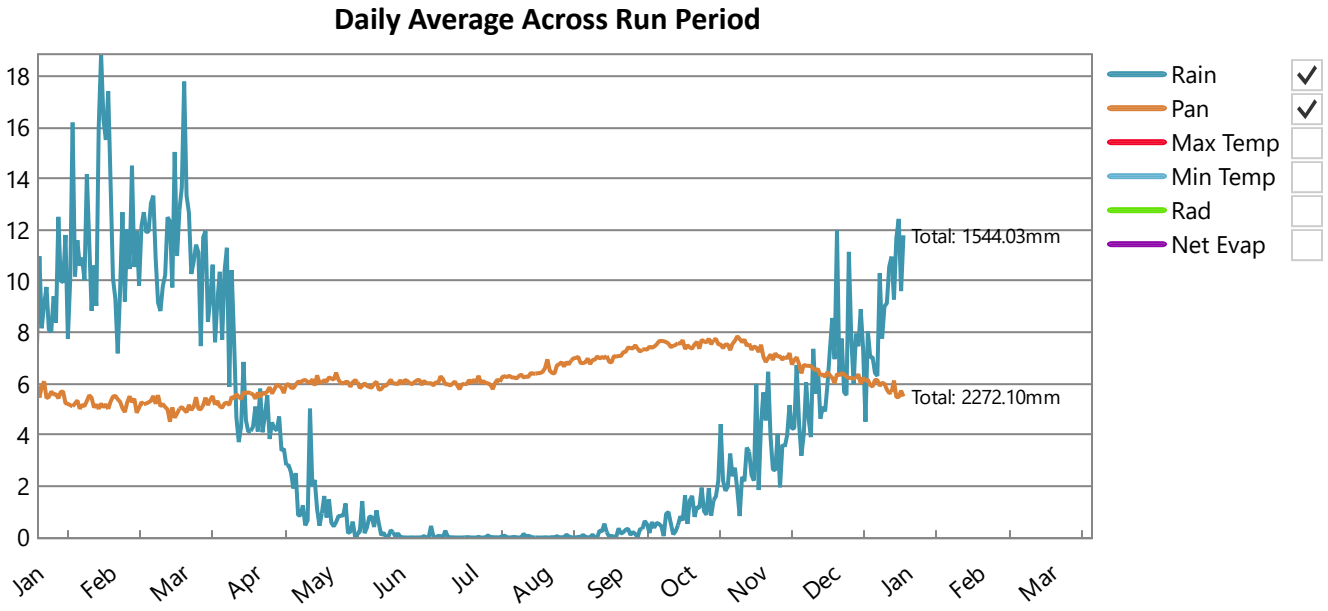
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1108	1521	2163
Pan Evaporation (mm/year)	2100	2273	2448

Climate Data:

Chart Table

Monthly Daily

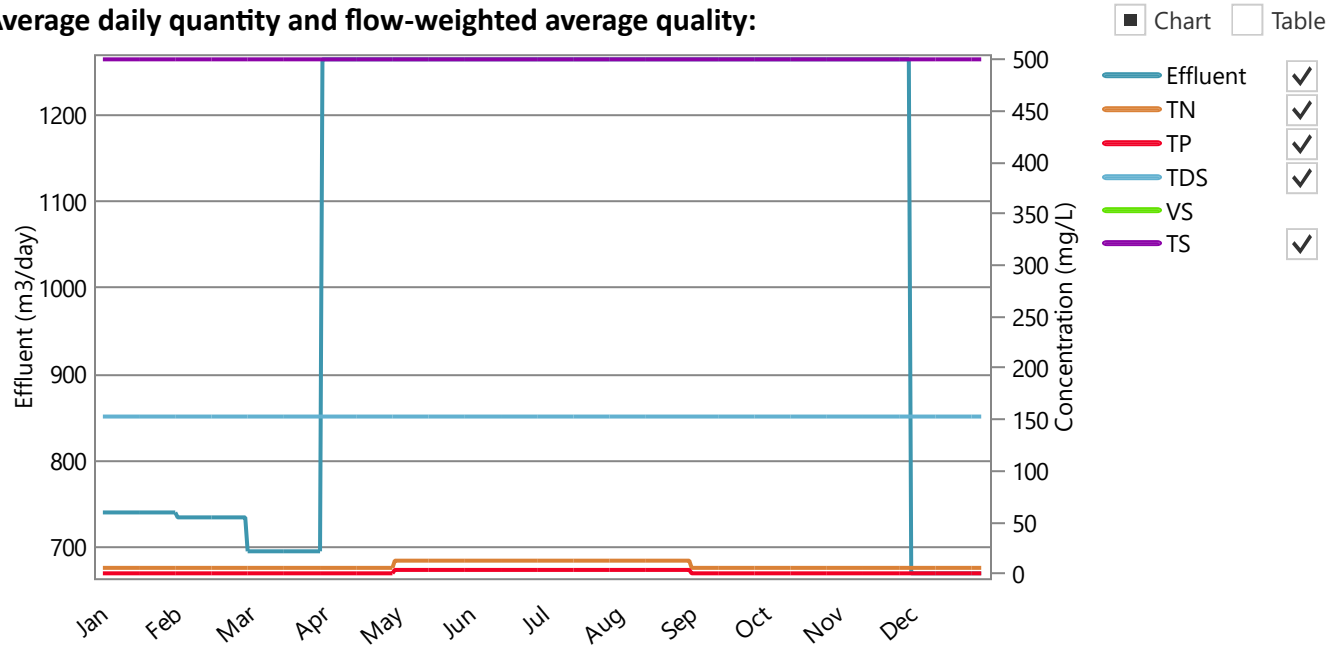


DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 394710.92 m3/year or 1080.68 m3/day (Min-Max: 669.70 - 1265.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

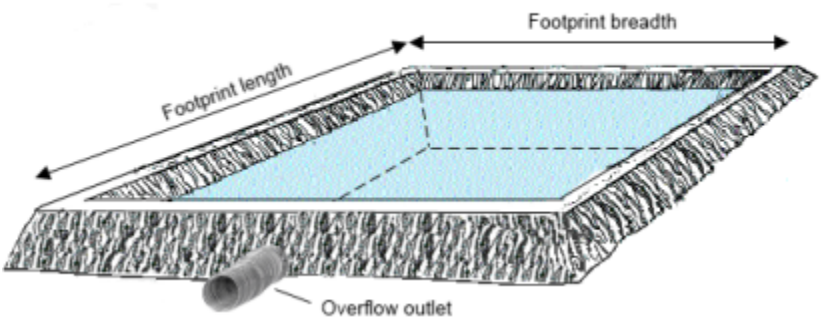
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

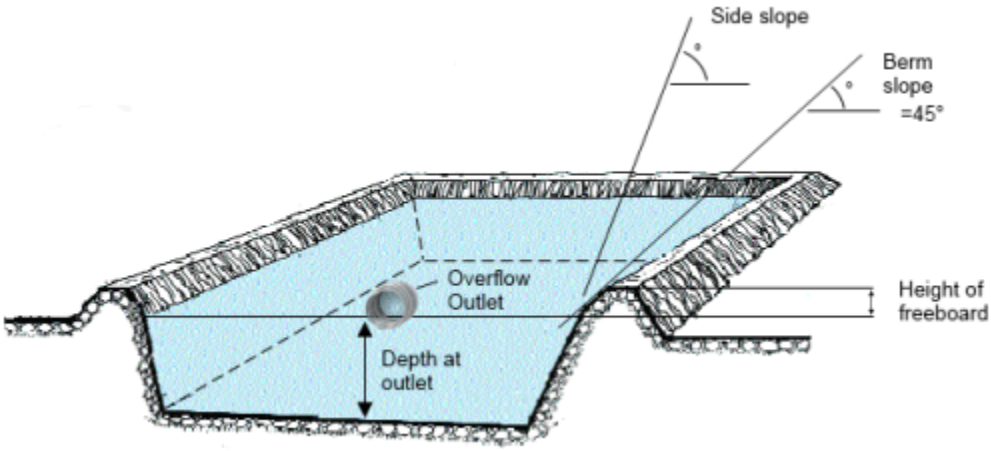
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (m3)	60000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	3.00
Maximum water surface area (m2)	20908.21
Pond footprint length (m)	207.69
Pond footprint width (m)	105.45
Pond catchment area (m2)	21900.00
Average active volume (m3)	5545.57





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 (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

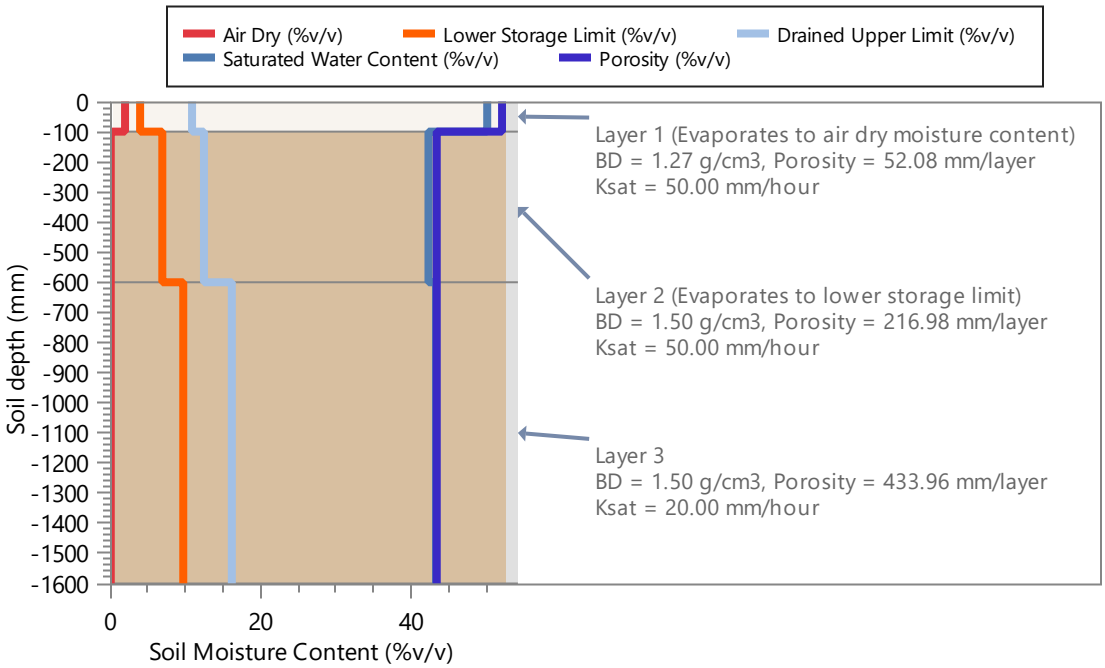
DESCRIPTION

Land: Stage 2 irrigation

Area (ha): 100.00

Soil Type: Lambells, 1600.00 mm defined profile depth

Profile Porosity (mm)	703.02
Profile saturation water content (mm)	694.60
Profile drained upper limit (or field capacity) (mm)	235.10
Profile lower storage limit (or permanent wilting point) (mm)	136.05
Profile available water capacity (mm)	99.05
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	10.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Forage Sorghum Pasture

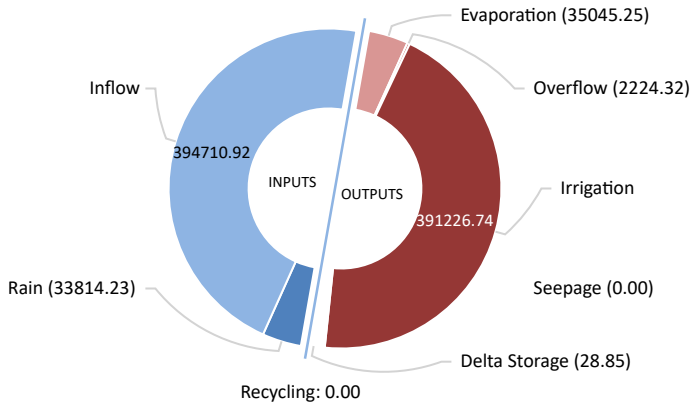
Average monthly cover (fraction) (minimum - maximum)	0.41 (0.00 - 0.78)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	1600.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11

PERFORMANCE

Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **60000 m3**

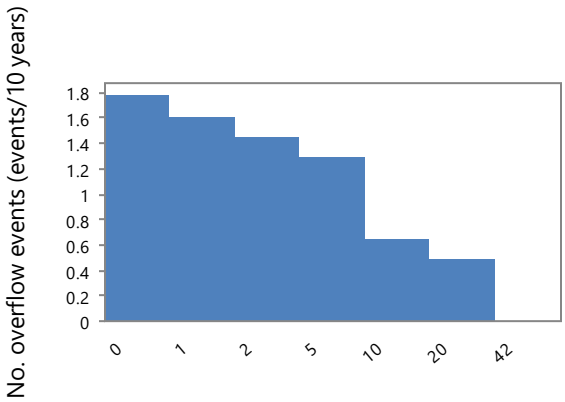
Pond System Water Balance (m3/year)



Name	Value
Rain	33814.23
Inflow	394710.92
Recycling	0.00
Evaporation	35045.25
Overflow	2224.32
Irrigation	391226.74
Seepage	0.00
Delta Storage	28.85

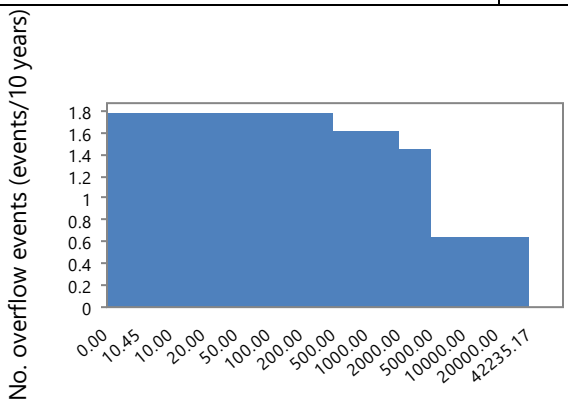
Overflow Diagnostics

Volume of overflow (m3/year)	2224.32
No. days pond overflows (days/year)	2.26
Average duration of overflow (days)	12.73
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.99
Probability of at least 90% reuse (fraction)	0.98



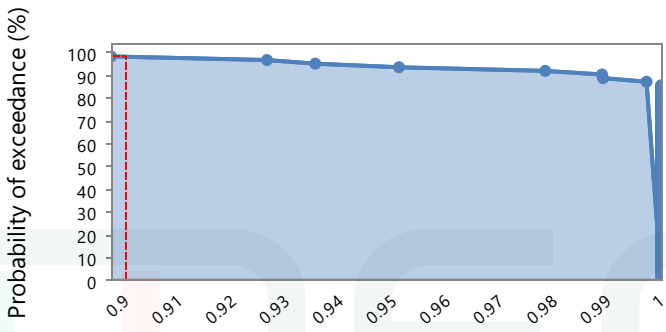
Overflow event duration exceeded (days)

Export plot



Overflow volume exceeded (m3)

Export plot



Annual reuse (fraction)

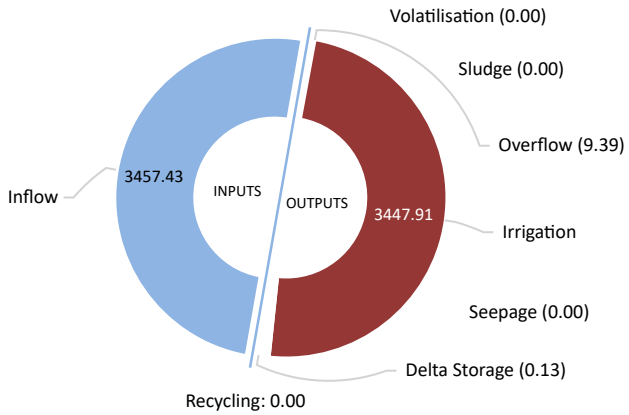
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

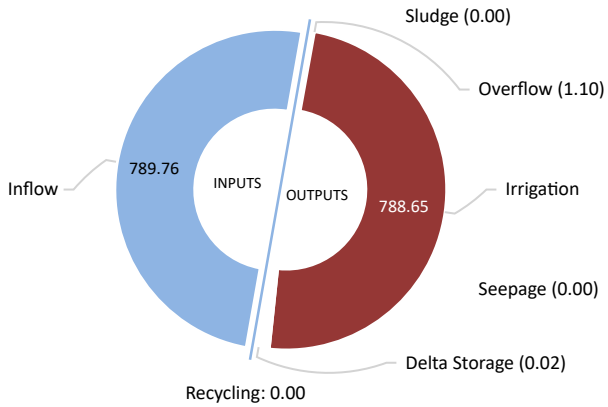
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



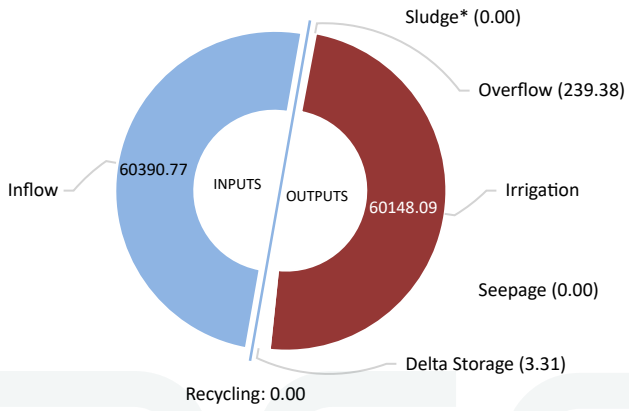
Name	Value
Inflow	3457.43
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	9.39
Irrigation	3447.91
Seepage	0.00
Delta Storage	0.13

Phosphorus Balance (kg/year)



Name	Value
Inflow	789.76
Recycling	0.00
Sludge	0.00
Overflow	1.10
Irrigation	788.65
Seepage	0.00
Delta Storage	0.02

Salt Balance (kg/year)



Name	Value
Inflow	60390.77
Recycling	0.00
Sludge*	0.00
Overflow	239.38
Irrigation	60148.09
Seepage	0.00
Delta Storage	3.31

* 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 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	4.51
Average phosphorus concentration of pond liquid (mg/L)	0.54
Average salinity of pond liquid (dS/m)	0.18

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	4.49
Final phosphorus concentration of pond liquid (mg/L)	0.52
Final salinity of pond liquid (dS/m)	0.18

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	391226.74
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	391226.74
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/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:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	8.81
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	8.58
Average phosphorus concentration of irrigation water (mg/L)	2.02
Average salinity of irrigation water (dS/m)	0.24

Irrigation Diagnostics:

Proportion of Days rain prevents irrigation (fraction)	0.13
Proportion of Days water demand too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

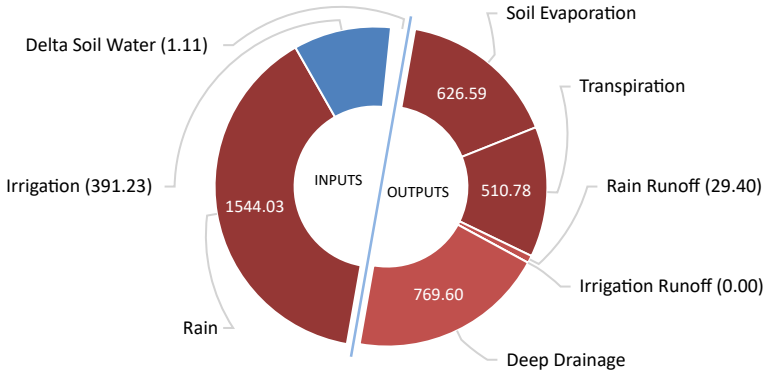
PERFORMANCE

Land Performance - Soil Water

Paddock: Stage 2 irrigation, 100 ha
Soil Type: Lambells, 99.05 mm PAWC at maximum root depth

Land Water Balance (mm/year):

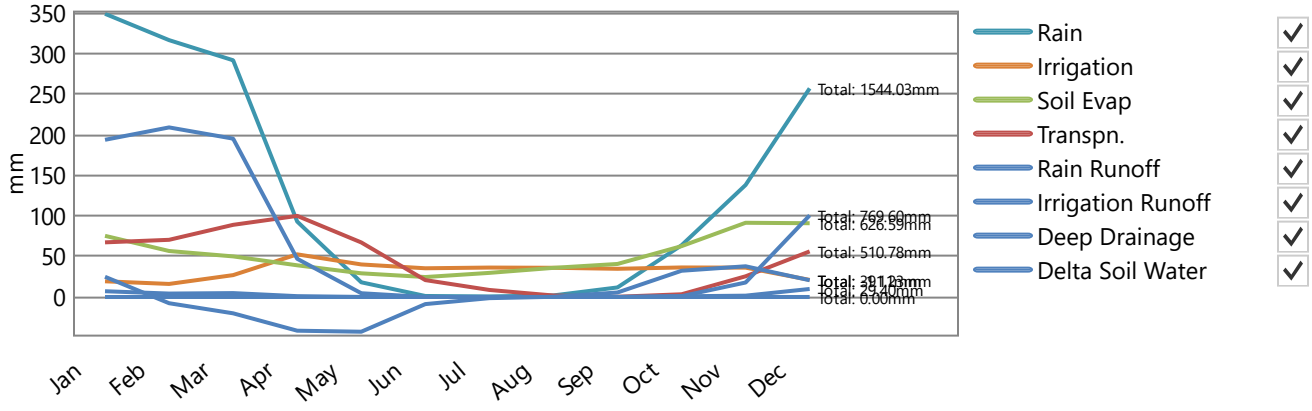
mm/year % Total inputs



Name	Value
Rain	1544.03
Irrigation	391.23
Soil Evaporation	626.59
Transpiration	510.78
Rain Runoff	29.40
Irrigation Runoff	0.00
Deep Drainage	769.60
Delta Soil Water	-1.11

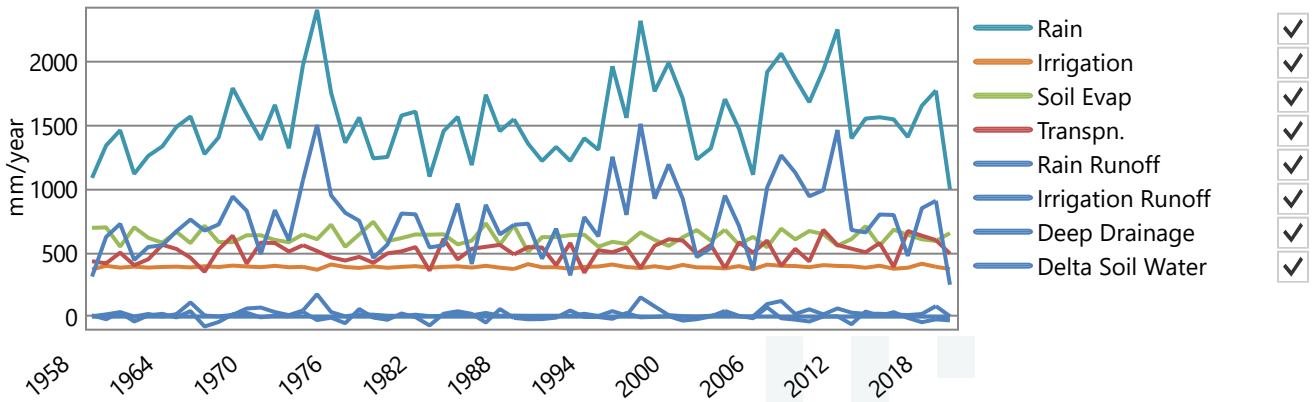
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



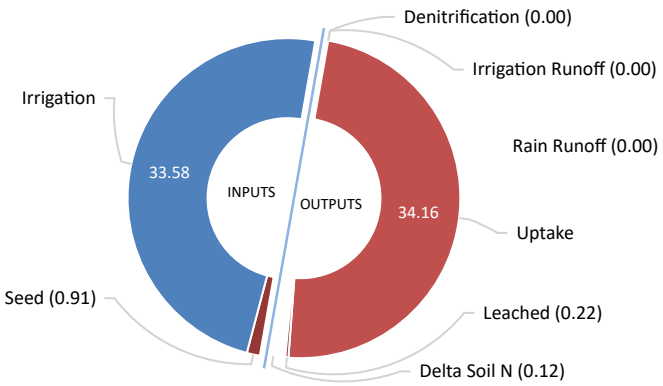
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

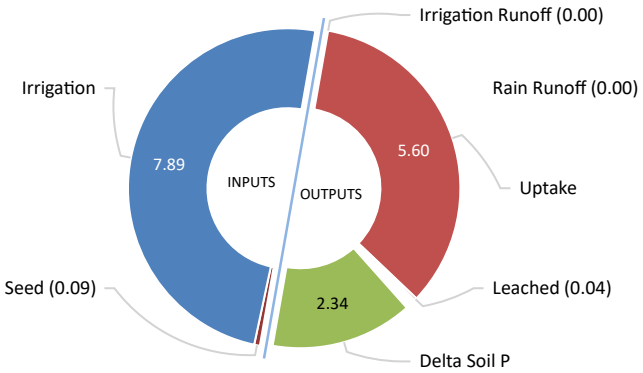
Irrigation ammonium volatilisation losses (kg/ha/year): 0.90
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.91
Irrigation	33.58
Denitrification	4.22E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	34.16
Leached	0.22
Delta Soil N	0.12

Land Phosphorus Balance (kg/ha/year)



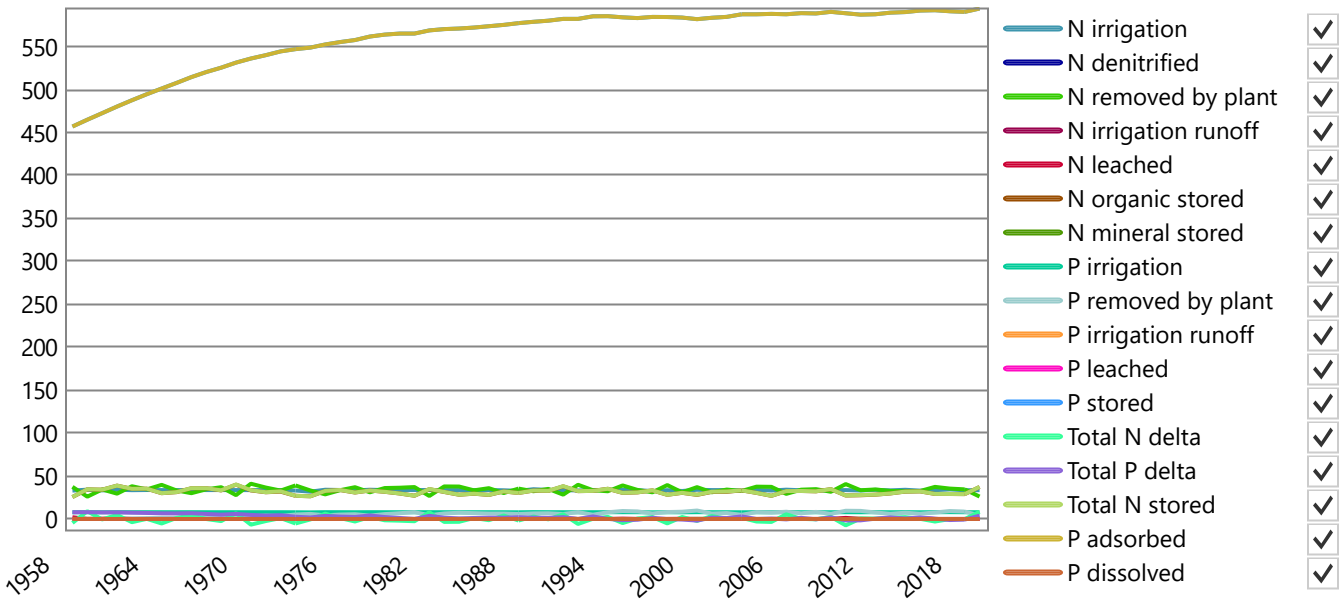
Name	Value
Seed	0.09
Irrigation	7.89
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	5.60
Leached	0.04
Delta Soil P	2.34

PERFORMANCE

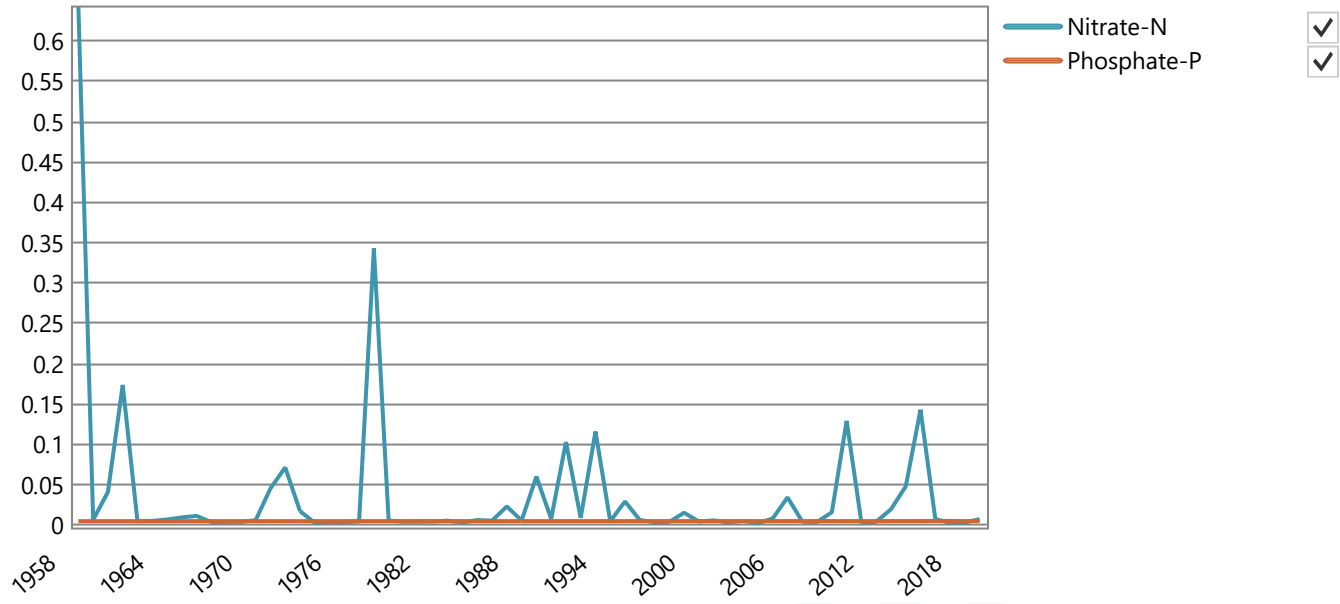
Land Performance - Soil Nutrient

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

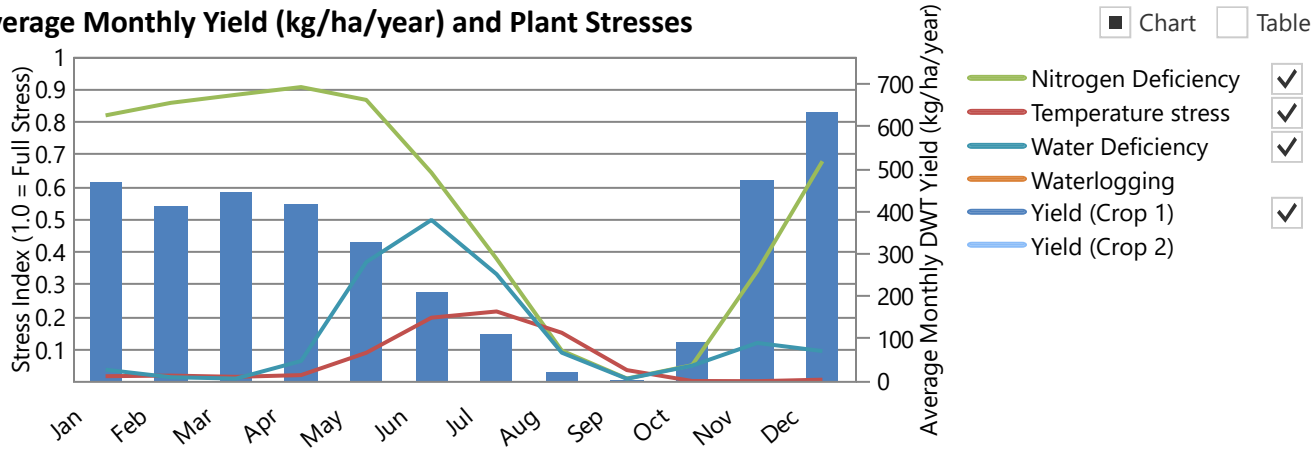
Plant: Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3658.96 (2603.38 - 4599.28)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.41 (0.00 - 0.78)
Average monthly root depth (mm) (minimum - maximum)	838.65 (17.66 - 1529.88)

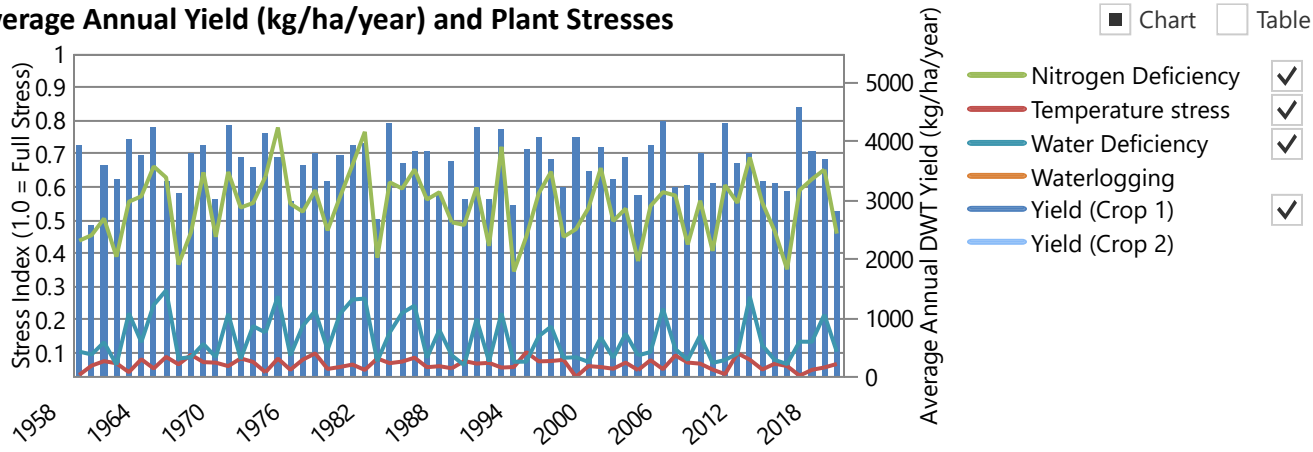
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	34.16 (25.98 - 41.08)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	5.60 (0.11 - 9.84)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.002)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 0.68 (normal), 1.00 (forced by crop death due to nitrogen stress (0.03), water stress (0.97))

No. days without crop/year (days/year): 118.02 due to water stress (118.02)

PERFORMANCE

Land Performance

Paddock: Stage 2 irrigation, 100 ha **Soil Type**: Lambells

Plant: Continuous Forage Sorghum Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	8.30
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.11
No. years assumed for leaching to reach steady-state (years)	10.00

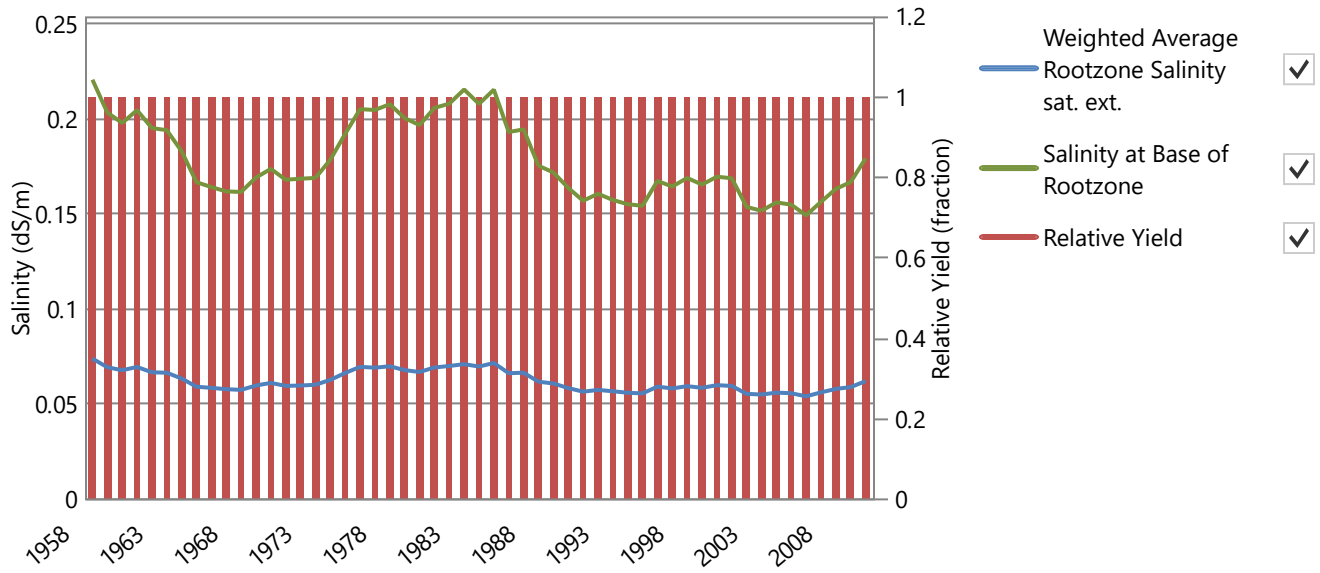
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.81
Average annual effluent salt added & leached at steady state (kg/ha/year)	892.29
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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:

Chart Table

All values based on 10 year running averages



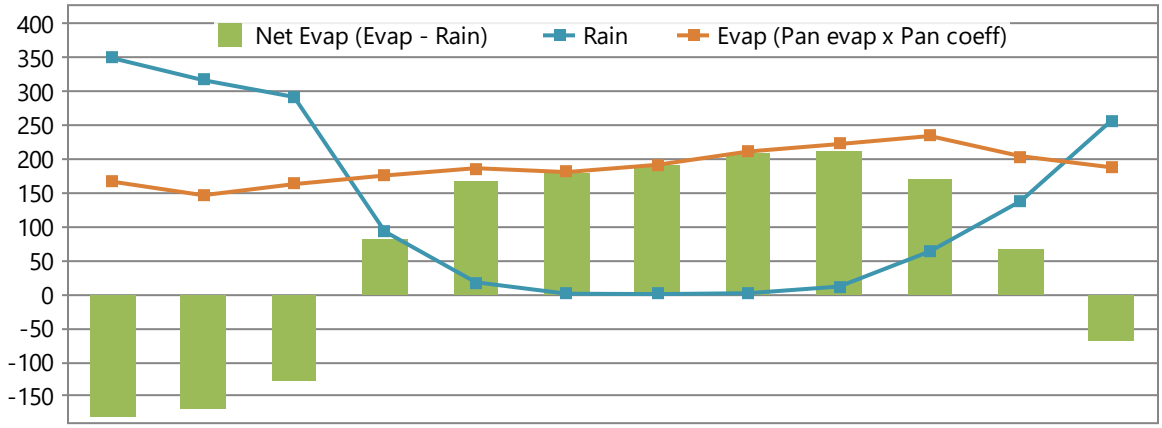
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Lambells Lagoon, -12.55°, 131.25°

Run Period: 01/01/1958 to 31/12/2019 62 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Evap	166.8	146.7	163.1	175.9	186.7	180.9	191.7	211.3	222.3	234.2	204.4	188.0	2272.1
Net Evap	-182.6	-170.1	-128.9	82.9	168.6	179.7	191.1	209.4	210.6	170.5	66.3	-69.4	728.1
Net Evap/day	-5.9	-6.0	-4.2	2.8	5.4	6.0	6.2	6.8	7.0	5.5	2.2	-2.2	2.0

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Pond System: 1 facultative, aerobic or storage pond

New Generic System - 394710.92 m3/year or 1080.68 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.24 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	8.76 (6.00 - 13.00)	3457.43 (3456.46 - 3460.48)
Total Phosphorus	2.00 (0.70 - 4.00)	789.76 (789.65 - 790.12)
Total Dissolved Salts	153.00 (153.00 - 153.00)	60390.77 (60365.98 - 60468.45)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	500.00 (500.00 - 500.00)	197355.46 (197274.45 - 197609.30)

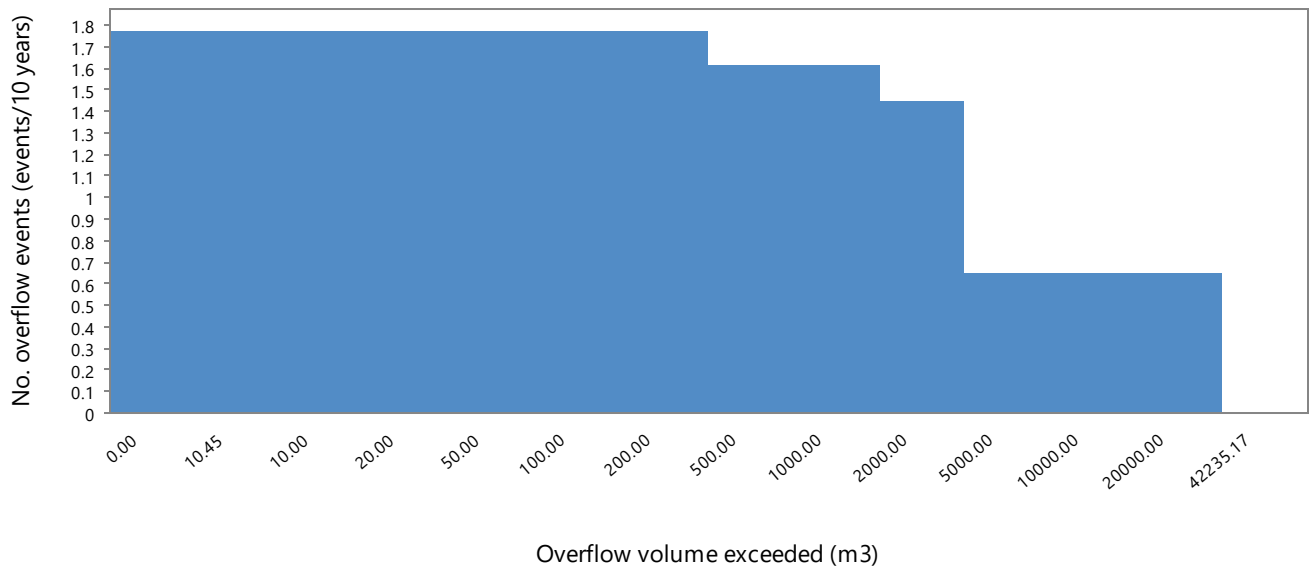
Last pond (Wet weather store): 60000.00 m3

Theoretical hydraulic retention time (days)	55.52
Average volume of overflow (m3/year)	2224.32
No. overflow events per year exceeding threshold* of 10.45 m3 (no./year)	0.18
Average duration of overflow (days)	12.73
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.99
Probability of at least 90% effluent reuse (fraction)	0.98
Average salinity of last pond (dS/m)	0.18
Salinity of last pond on final day of simulation (dS/m)	0.18
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Irrigation Information

Irrigation: 100 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	391226.74	3912.27
Total nitrogen applied (kg)	3358.27	33.58
Total phosphorus applied (kg)	788.65	7.89
Total salts applied (kg)	60148.09	601.48

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is prevented when triggered (fraction)	0.13
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.14
Proportion of Days irrigation occurs (fraction)	0.73

DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 5.00 mm and rainfall is less than or equal to 10.00 mm
Irrigate a fixed amount of 5.00 mm each day
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): Lambells, 99.05 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	349.3	316.8	292.0	93.0	18.1	1.2	0.6	1.9	11.8	63.8	138.2	257.3	1544.0
Irrigation	19.3	16.1	27.0	52.6	40.1	35.4	36.3	36.0	34.7	36.4	36.2	21.1	391.2
Soil Evap	75.4	56.7	50.0	39.1	29.2	24.6	29.7	35.9	40.7	62.7	91.5	91.0	626.6
Transpn.	67.4	70.5	89.0	100.0	67.3	20.8	8.7	1.8	0.3	3.3	25.5	56.2	510.8
Rain Runoff	7.1	4.2	4.8	1.0	0.0	0.0	0.0	0.0	0.0	0.8	1.6	9.8	29.4
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	193.9	209.2	195.3	47.1	4.6	0.0	0.0	0.0	0.0	1.0	17.8	100.7	769.6
Delta	24.9	-7.7	-20.2	-41.6	-42.9	-8.8	-1.5	0.2	5.5	32.3	37.9	20.7	-1.1

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	33.58
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	34.16
Average annual soil nitrogen removed by denitrification (kg/ha/year)	4.22E-03
Average annual soil nitrogen leached (kg/ha/year)	0.22
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.22
Soil organic-N kg/ha (Initial - Final)	6.41 - 37.25
	23.77 - 0.07
Average nitrate-N concentration of deep drainage (mg/L)	0.03
Max. annual nitrate-N concentration of deep drainage (mg/L)	0.64

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	7.89
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	5.60
Average annual soil phosphorus leached (kg/ha/year)	0.04
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	449.15 - 594.34
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	4.77E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	5.00E-03
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.41 mg/L (years)	264.88

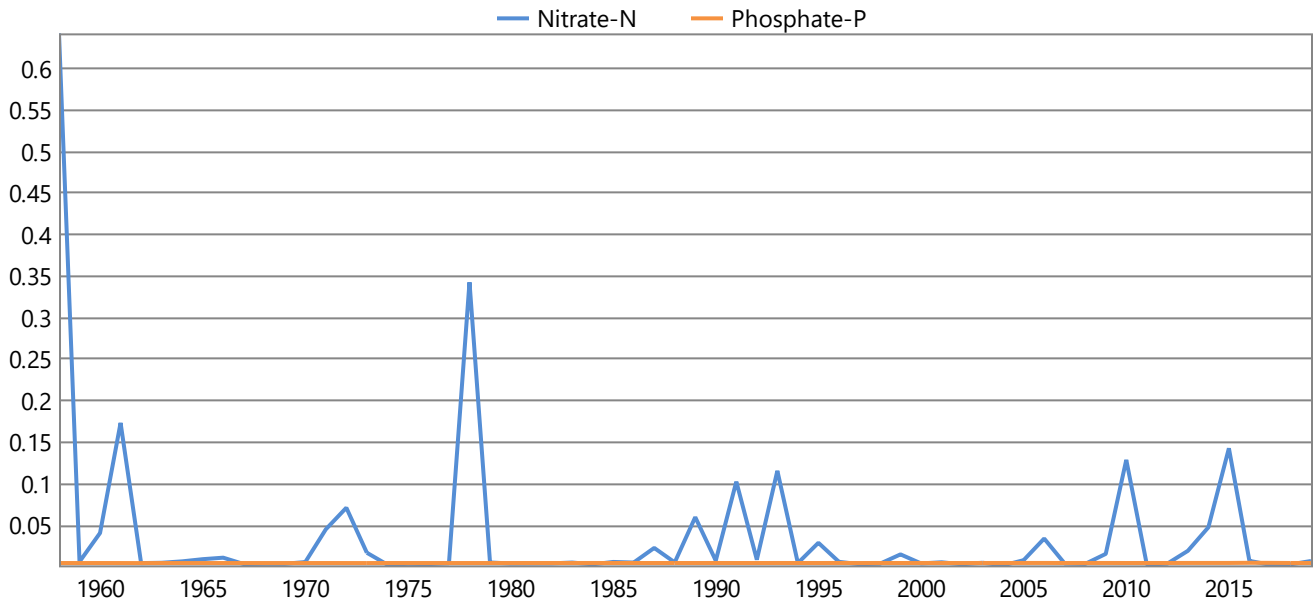
DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

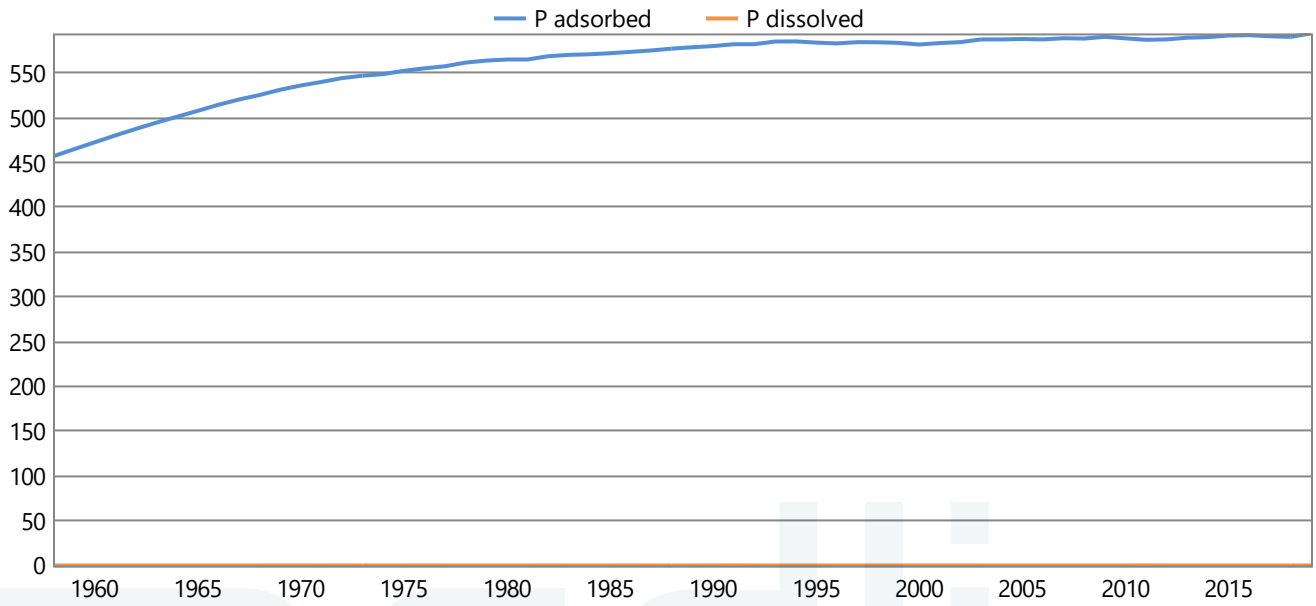
Paddock Land: Stage 2 irrigation: 100 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: MARPU - Lambells Lagoon Crocodile Farm

Paddock Plant Performance: Stage 2 irrigation: 100 ha

Average Plant Performance (Minimum - Maximum): Continuous Forage Sorghum Pasture

Average annual shoot dry matter yield (kg/ha/year)	3658.96 (2603.38 - 4599.28)
Average monthly plant (green) cover (fraction)	0.41 (0.00 - 0.78)
Average monthly crop factor (fraction)	0.33 (0.00 - 0.62)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	838.65 (17.66 - 1529.88)
Average number of normal harvests per year (no./year)	0.68 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.60
Average number of crop deaths per year (no./year)	1.00 (1.00 - 1.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.54 (0.35 - 0.78)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.05)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.22 (0.07 - 0.37)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.14 (0.01 - 0.50)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	118.02

Soil Salinity - Plant salinity tolerance: Tolerant

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

All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.07
Salt added by rainfall (kg/ha/year)	290.81
Average annual effluent salt added & leached at steady state (kg/ha/year)	892.29
Average leaching fraction based on 10 year running averages (fraction)	0.53
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.06
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.18
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

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

APPENDIX D IRRIGATION PROCEDURES

Irrigation Procedures
Lambells Lagoon Crocodile Farm
PRI Farming Pty Ltd

DOCUMENT CONTROL RECORD

Job	EZ19095
Document ID	194932-2
Author(s)	Britanny Crescentino

DOCUMENT HISTORY

Rev	Reviewed by	Approved by	Issued to	Date
1	Emma Lewis	Emma Lewis	PRI Farming	11/11/20

Recipients are responsible for eliminating all superseded documents in their possession.

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TABLE OF CONTENTS

Appendices

1 INTRODUCTION

This document lists procedures to be followed by PRI Farming management, staff and contractors to ensure that the reuse of wastewater via terrestrial irrigation is managed appropriately at the Lambells Lagoon Crocodile Farm (LLCF). This document has been developed in association with the Environmental Protection Licence (EPL) application and the Irrigation Management Plan (IMP). The EPL application for this project has been submitted to the Northern Territory Environmental Protection Authority (NT EPA), therefore the monitoring and trigger values for the irrigation activities will be conducted in accordance with the EPL application. These procedures will be updated once the EPL is issued, to the EPL conditions.

LLCF recognise the importance of finding a solution to wastewater management and preventing uncontrolled discharge of untreated wastewater offsite with the potential to impact the receiving environment. Sustainable wastewater management involves the selection of suitable irrigation infrastructure to the water and nutrient requirements of the crops, while also ensuring oversaturation does not occur, resulting in uncontrolled run off, damaging of the soil and unsustainable crops.

The list of procedures includes:

- Area of irrigation
- Timing of irrigation
- Application of irrigation
- Irrigation recording sheet

2 SELECTION OF AREA TO BE IRRIGATED PROCEDURE

2.1 Aim

The aim of this procedure is to ensure that suitable irrigation areas are selected for wastewater release, considering the factors important in minimising impact on surrounding neighbours and sensitive receptors in the environment. This is to be conducted daily and the Farm Manager is the responsible person. The important factors to consider are:

- Wind speed and direction
- Recent rainfall
- Soil saturation

2.2 Procedure

1) Check the daily weather forecast for wind speed and direction and potential rainfall in months December to March (when rain is more prevalent). Avoid irrigation activities being conducted when prevailing wind direction will carry any odours or off-spray towards surrounding neighbours and sensitive receptors.
2) Ensure daily visual inspections of potential irrigation areas are conducted as per daily visual inspection checklist (refer to Appendix A). Ensure area can adequately absorb the volume being applied as per irrigation rate. This can be achieved through digging a small hole and checking the soil moisture content or through soil moisture monitoring equipment such as a tensiometer.
3) Select appropriate location for irrigation activities.

3 TIMING OF IRRIGATION PROCEDURE

3.1 Aim

The aim of this procedure is to ensure irrigation activities occur at an appropriate time and does not directly result in run-off and impacting on surrounding neighbours and sensitive receptors in the environment. The Farm Manager is the responsible person for this procedure.

3.2 Procedure

This procedure is to be implemented in conjunction with the selection of area to be irrigated procedure.

1) Check the daily weather forecast for potential rainfall. Irrigation activities are not to be conducted two hours prior to when heavy rainfall (>50mm) is forecasted, or at the time of rain events or high winds. Used as a preventative measure for surface water run-off.
2) When heavy rain (>50mm) has been received within the previous 24 hours, a daily visual inspection and moisture test (tensiometer) is to be conducted to ensure the irrigation area is not saturated prior to the commencement of irrigation activities. If saturated, delay irrigation until sufficiently dried out, or apply the minimum irrigation flow rate of 1mm/day.
3) If after rainfall, a daily visual inspection is conducted, and determines the irrigation area is unsaturated (without conducting a moisture test) the irrigation activities can commence as normal as per the application of irrigation procedure.

4 APPLICATION OF IRRIGATION

4.1 Aim

The aim of this procedure is to ensure that the application of the wastewater through irrigation activities is a controlled task, and does not cause any run-off or impacts to surrounding neighbours and sensitive receptors in the environment. The Farm Manager is the responsible person for this procedure. This procedure is to be applied after the use of the Selection of Area to be Irrigated Procedure and Timing of Irrigation Procedure.

4.2 Procedure

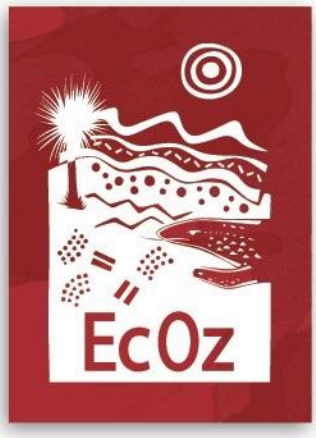
1) Conduct visual inspection and complete checklist (refer to Appendix A).
2) Record each irrigation event into irrigation recording sheet (refer to Appendix B).
3) Monitor the irrigation area during the irrigation application (every 1-2 hours), to ensure that surface ponding and runoff of wastewater does not occur.
4) If excess surface water ponding or run-off is identified, irrigation application is to cease immediately.
5) Control the surface ponding and run-off if there is potential for an uncontrolled release offsite, by installing diversion bunds where required and allowing the excess moisture to infiltrate or evaporate on-site.
6) Determine the likely cause of the surface water ponding or run-off (i.e. soil is too saturated or the correct irrigation application rate has not been set).
7) Review the irrigation application rate settings to determine if the correct irrigation rate was set. If the incorrect irrigation rate was set, adjust accordingly.
8) Using the Selection of Area to be Irrigated Procedure and Timing of Irrigation Procedure to identify if soil saturation is the likely cause.
9) Recommence irrigation application – and complete an irrigation recording sheet record (refer to Appendix B).

APPENDIX A VISUAL INSPECTION CHECKLIST

	Day: Date:	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Comments
#	Visual inspection Items	Y/ N	Y/ N	Y/ N	Y/ N	Y/ N	Y/ N	Y/ N	
1.	Are there any areas too saturated for irrigation application?								
2.	Is there any water pondng? (if yes, cease application until soil moisture conditions are suitable)								
3.	Is there any odour present during irrigation application? (If yes, cease application and conduct wastewater sampling).								
4.	Is there any overspray/mist? (if yes, cease application and review weather forecast)								
5.	Is there any surface water run-off present? (if yes, cease application and review soil moisture content).								

APPENDIX B IRRIGATION RECORDING SHEET

Date	Approx. Area Irrigated (m^2)	Pumping time (mins)	Volume pumped (kL)	Application rate (mm)	Check for saturation, run-off or surface ponding	Weather observations (i.e. rainfall, wind direction/speed, sunny, cloudy etc).	Checked by:



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