Irrigation Management Plan
Darwin Crocodile Farm

Porosus Pty Ltd

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ACRONYMS

ANZECC	Australian and New Zealand Environment and Conservation Council
BoM	Bureau of Meteorology
DCF	Darwin Crocodile Farm
DENR	Department of Environment and Natural Resources (Northern Territory)
DHAC	Darwin Harbour Advisory Community
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
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
RL	Rural Living
SAR	Sodium Adsorption Ratio
STV	Short-term trigger values

1 INTRODUCTION

1.1 Background

Porosus Pty Ltd (Porosus) operates the Darwin Crocodile Farm (the DCF) in Noonamah, Northern Territory (NT). The DCF was first established in 1981 as a tourism and farming business for saltwater crocodiles (*Crocodylus porosus*). Over time, the operations have expanded to meet the increasing demand for crocodile products and the farm currently has capacity for more than 70,000 animals.

DCF is a commercial production farm, including the incubation of eggs to hatchling stage and to full grown individuals, as well as a captive breeding program. The animals are culled on-site and sent to an off-site location for further processing and packaging. The end use markets include raw crocodile skin, meat and by-products. The DCF is no longer open for tourists.

The nature of the farming operation results in the generation of animal effluent, a listed waste under Schedule 2 of the *Waste Management and Pollution Control (Administration) Regulations*. In accordance with the requirements of the NT *Waste Management and Pollution Control Act 1998*.

1.2 Purpose and scope

DCF recognise the importance in finding a solution to manage wastewater produced on site and preventing the uncontrolled discharge of untreated wastewater off-site. As a wastewater management strategy, Porosus propose to use an irrigation method to control the wastewater onto suitable crops.

This Irrigation Management Plan (IMP) has been developed to illustrate the management and reuse of effluent wastewater by Porosus at the DCF through irrigation method. This plan is a requirement as part of the Environmental Protection Licence (EPL) application.

2 EXISTING ENVIRONMENT

2.1 Location

DCF is located at Section 6094 and Lot A Hundred of Strangways (1340 Stuart Highway and 45 Gulnare Road, Bees Creek) (Figure 2-1). The DCF occupies the majority of Section 6094, whilst the proposed area of irrigation is located to the north of the DCF operation on part of Section 6094 and the entire Lot A (Figure 2-2). Both lots were zoned for commercial tourism and combined are approximately 85 ha in area. An amendment to the planning scheme for the part of Section 6094 that contains the DCF infrastructure was submitted and the section was rezoned Zone RL (Rural Living).

Land use surrounding the site includes privately owned lots zoned RL to the north, south and west with the Stuart Highway bordering the site to the east. Many of these lots are rural subdivision that are used for private rural living, while some lots north and south of DCF are used for horticultural and agricultural purposes. The lots located to the north of DCF are divided by Gulnare Road.

The site is located approximately 1.7 km east of the edge of Darwin Harbour Conservation Area. The Howard sand plains conservation area is located approximately 2.5 km east of DCF, separated by the Stuart Highway. The north-west corner of Lot A is approximately 170 m from the Bees Creek minor stream that flows into the main Elizabeth River.

2.2 Climate

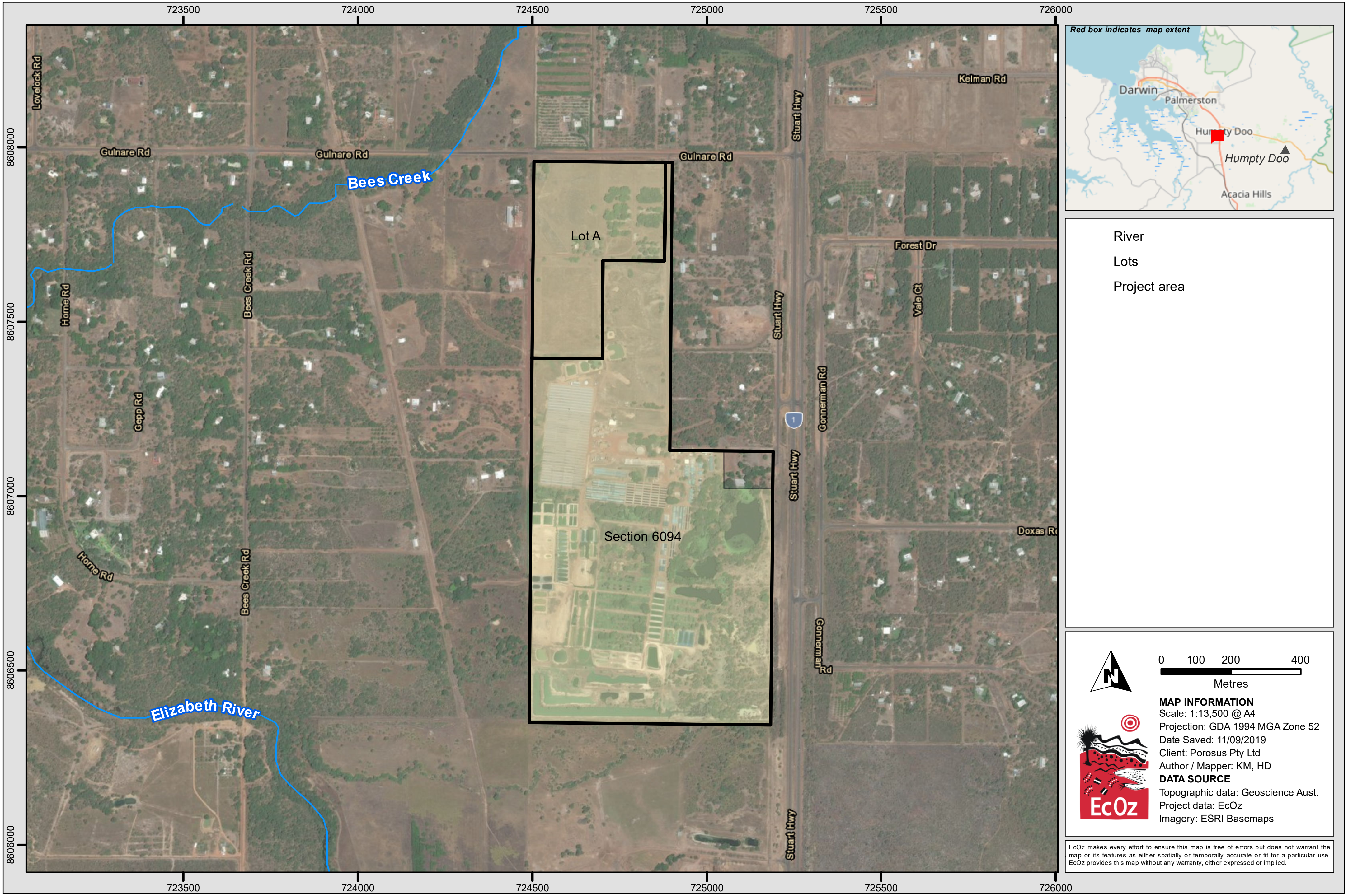
DCF experiences a tropical monsoonal climate with distinct wet and dry seasons and little variation in temperature. The wet season is characterised by higher humidity and rainfall, and occurs between October and April. The dry season extends from May to September and is characterised by lower humidity and very little rainfall.

Climate observations are made by the Bureau of Meteorology (BoM). The closest BoM weather monitoring station to the site is Middle Point (station number 014041). Average annual rainfall recorded at this station is 1394 mm with the highest rainfall occurring in January and the lowest in June and July. Over 84% of annual average rainfall falls between November and March. The average annual regional evaporation is 2,000 mm and exceeds the average annual rainfall. Evaporation is highest in October and lowest in January to March.

Table 2-1. Average rainfall and evaporation (BoM)

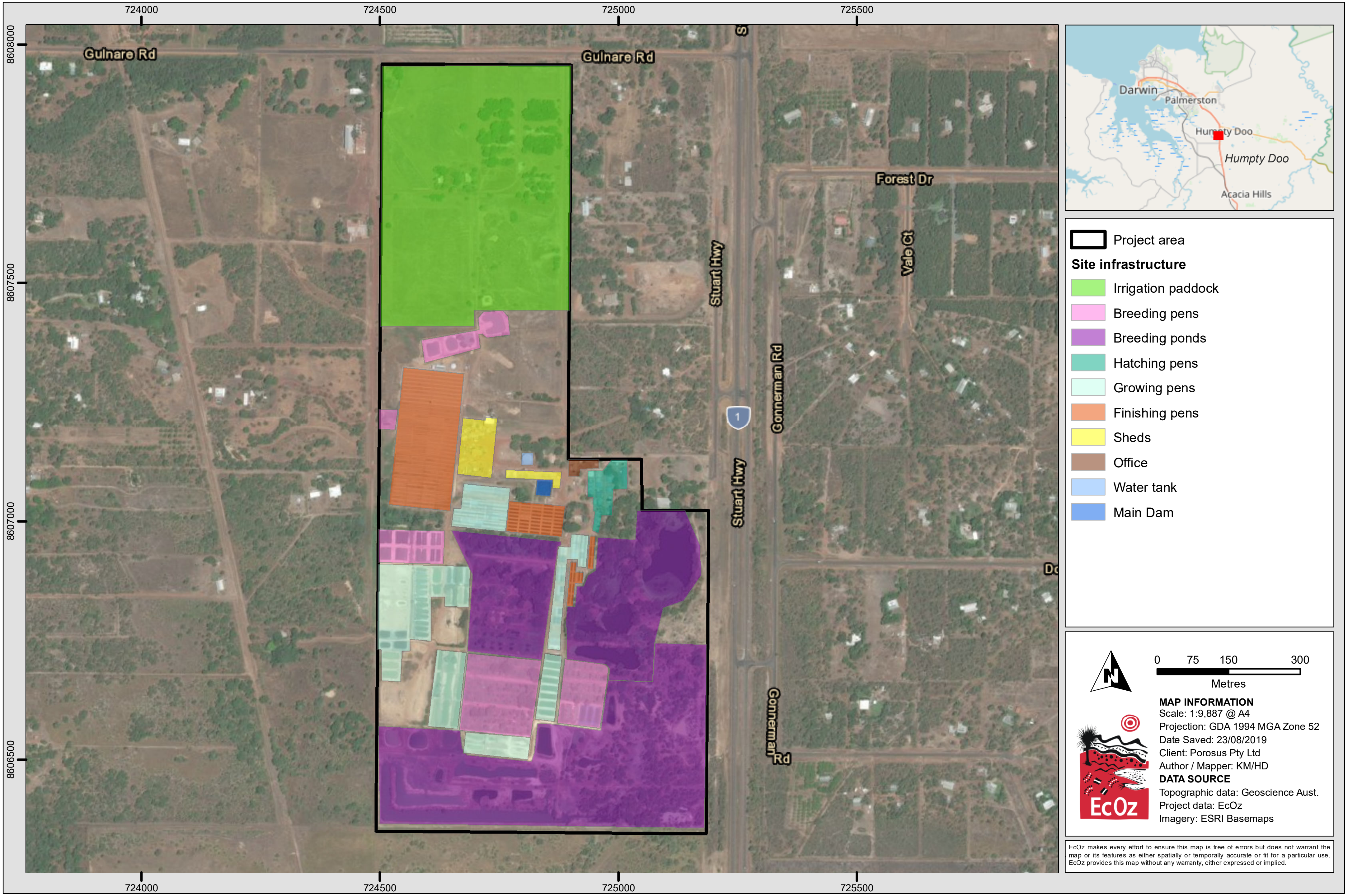
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	347	283	256	89	24	1	1	2	13	57	130	228
Evaporation (mm)	146	126	146	156	161	156	171	189	204	220	189	161
Temperature (°c)	33.4	33.5	33.8	34.2	33.4	32.3	32.8	34.2	36.5	37.4	36.4	35.0

Wind rose data is available for the Middle Point (9am) and the Darwin Airport station (no. 041015, 9 am and 3 pm) shows that the dry season is dominated by south-easterly and easterly wind directions. During the wet season, wind direction is more varied, particularly in the morning, while afternoons are dominated by westerly and north-westerly breezes. This has implications for irrigation management, as wind speed and direction will impact the potential spray drift and odour, and impacts on sensitive receptors (i.e. neighbouring properties.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19094 - Darwin Croc Farm EPL\01 Project Files\Figure 2-1. Map showing site location.mxd

Figure 2-1. Map showing site location



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19094 - Darwin Croc Farm EPL\01 Project Files\Figure 2-3 Map showing site layout and infrastructure.mxd

Figure 2-2. Map showing site layout and infrastructure

2.3 Land units

A land unit is a reasonably homogenous part of a land surface, distinct from surrounding terrain with consistent properties in landform, soil and vegetation (Jessop & King 1997). As such, each land unit has a characteristic pattern on aerial imagery. This area is within the Greater Darwin Area land unit descriptions.

The site contains land units that are characterised by well drained soils (detailed in Table 2-2), this is beneficial when considering the site for irrigation purposes.

Table 2-2. Summary of land units relevant to irrigated site

Land unit	Landform	Soil
3c	• Flat to very gently undulating upland surface. • Gradient 1-3% • Extensive ferruginous gravels (40-80% surface cover) small areas of laterite outcrop.	• Brown Kandosol. Shallow to moderately deep gravelly yellow massive earths, minor lateritic lithosols. • Loamy sand to sandy loam surface grading into sandy clay loam subsoil. • 20-40% ferruginous gravel in surface, 30-50% in subsoil. • Well drained
6b	• Broad drainage floors and creek margins. • Gradient <1.5% • Debil debil surface is common.	• Tenosolic Oxyaquic Hydrosol. • Shallow to moderately deep siliceous and earthy sands, minor sandy massive earths. • Coarse textured sands to sandy loams. • 0-10% gravel in surface, 5-40% gravel in subsoil. • Well drained.

The majority of the site, including the proposed irrigation area, has been previously cleared. There is a small patch of remnant vegetation in the north east irrigation paddock, this patch will remain intact during the duration of the trial irrigation activities. A clearing permit is being sought for any trees that require approval for clearing. Suitable crops for irrigation will be planted in the irrigation areas as specified in Section 7.

2.4 Soil

According to the Greater Darwin Region Land units (mapped at 1:25000 scale), the property predominately has Hydrosol and Rudosol soils. Hydrosols are seasonally inundated and generally occur on coastal floodplains, swamps and drainage lines. Rudosols are very shallow soils or those with minimal development.

Soil sampling was conducted in the proposed irrigation area to determine the suitability of the land application on 13 June 2019. Six sample locations were selected on the irrigation site to be sampled. These were selected during the baseline study for irrigation stability (Figure 2-3). All sampling and handling of samples were undertaken in accordance with AS4482.1-2005 *Guide to sampling and investigation of potentially contaminated soil – Part 1: Non-volatile and semi-volatile compounds*. All samples were analysed by ALS Environmental which is a National Association of Testing Authorities (NATA) approved laboratory, with the exception of field parameters such as pH and Electrical Conductivity (EC).

The sampling results revealed that the majority of the area contains sandy to sandy loam soils with poor structure (high permeability) and dark brown in colour. A summary of the soil sampling results is provided in Table 2-3 and Table 2-4, whilst the full suite of results is provided in Appendix A.

Table 2-3. Summary of soil sampling results

Parameter	Units	Results	
		Depth: 0 - 0.4 m	*Depth: 0.4 – 1 m*
pH		6 – 8	6 – 8.1
EC	dS/m	7	11
Total P	mg/kg	46 – 794	52 – 462
P sorption capacity	mg/kg	<250 – 551	<250 – 433
Total N	mg/kg	250 – 1220	170 - 950
Nitrate + nitrite (NO_x)	mg/kg	0.5 – 8.9	1.6 – 10.4
Exchangeable sodium	%	2.6	-

* based on average B horizon results

Table 2-4. Summary of total metals in soil samples

Sample Site ID	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)	Mercury (mg/kg)
1	<5	<1	27	<5	<5	<2	<5	<0.1
2	<5	<1	44	<5	6	<2	<5	<0.1
3	9	<1	81	7	25	5	<5	<0.1
4	8	<1	48	<5	5	<2	<5	<0.1
5	18	<1	62	11	16	3	32	<0.1
6	13	<1	42	5	8	3	9	<0.1

Note: The total metal results are from soil depths of 0.4-1 m

2.5 Topography and surface water drainage

Surface water from the operational area of DCF sheet flows towards the southern boundary of the site. The sheet flow continues into the neighbouring property where any un-retained runoff would enter a minor creek which feeds into the Elizabeth River. The irrigation area sheet flows to the north western boundary of the site towards the drainage lines on Gulnare Road (approximately 170 m from site) which feeds into a separate arm of the Elizabeth River (Bees Creek). The upper reaches of the Elizabeth River (part of the Darwin Harbour Conservation Area) are located approximately 1.7 km west of the site.

Currently there is a large stormwater culvert located directly adjacent to the south eastern border of the site, under the Stuart Highway. This has been known to feed large volumes of stormwater into the site during rainfall events. Works are currently underway with relevant stakeholders to relocate this drainage line around the site boundary to reduce the run on impacts to the sites wastewater management.

2.6 Groundwater

DCF lies within the Darwin Rural Water Control District, on the South Alligator groundwater system. The farm and operational areas are situated on the Horns Creek sub-catchment whilst the irrigation area is situated on the Bees Creek sub-catchment. Any surface water infiltration on the irrigation area would flow in a north westerly direction towards Bees Creek.

The DCF holds a groundwater extraction licence (Licence No: WSF01) with a total maximum extraction entitlement of 700 ML/year from six bores with the source water coming from the Wildman Siltstone Formation. With the exception of RN038879, all other water extraction bores are located within the Horns Creek sub-catchment area. An existing bore RN025932 located at the northern end of the irrigation area is not currently used for extraction but can be used as a monitoring bore for irrigation.

All the water source bores are equipped and therefore their standing water level (SWL) is not recorded regularly. The SWL and yield in each bore was recorded at the time of construction and has been included in Table 2-5 for reference. Bore records for RN025932 from the 1980's and 1990's recorded the SWL between 8 to 13 m.

Table 2-5. Groundwater bore details used by DCF

Bore	DCF Bore Name	Depth (m)	SWL (m)	Yield (L/s)	Average annual extraction (ML)
RN008775	Lindsay's (GW1)	63	7	2	19.5
RN030548	West Wing (GW2)	112	5	3	173
RN026341	Main (GW3)	80	-	10	227.4
RN033646	Hatchery (GW4)	138	23	4	21.4
RN034341	Murwangi (GW5)	102	2.3	8	145
RN038879	Recirculation (GW6)	109	18	10	106.4
RN025932	GW7 (Monitoring)	50	8	9	0
				Total	**692.7**

Groundwater quality sampling has been conducted on site for the purpose of the EPL. The results of this sampling is summarised in Table 2-6 and compared with the ANZECC guidelines for reference. The full suite of monitoring results in included in Appendix B.

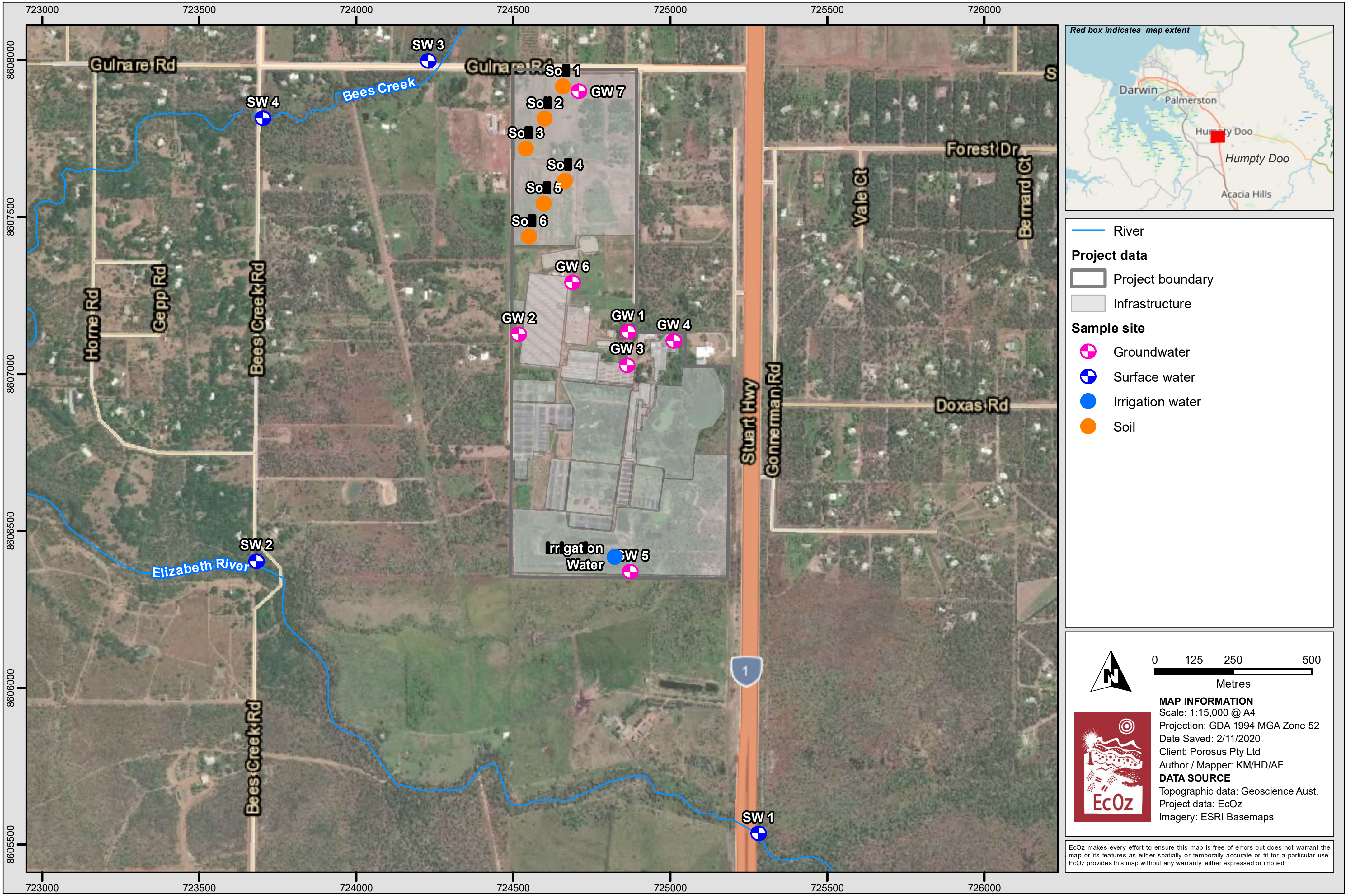
Table 2-6. Summary of groundwater quality sampling results

Sample Site ID	pH	EC (µS/cm)	Total P (mg / L)	Total N (mg / L)	NO_3 (mg / L)	Total Cations (meq / L)	Total anions (meq / L)
ANZECC Guidelines[1]	*6.0-8.0*	*250*	*0.01*	*0.2 - 0.3*	-	-	-
GW1	5.6	308.4	<0.01	7.8	6.68	3.04	2.78
GW2	7.1	530.0	<0.01	0.2	0.17	5.96	6.53
GW3	7.5	398.6	0.03	0.3	0.07	4.37	4.62
GW4	7.1	325.1	0.02	0.4	0.33	3.24	3.58
GW5	7.5	490.0	<0.01	<0.1	0.02	5.07	5.59
GW6	7.1	587.0	0.01	1.6	1.65	5.59	6.18
GW7	7.0	65.9	<0.01	4.1	1.2	0.3	0.4

Surrounding groundwater uses

The surrounding land uses are categorised by zoning plans developed under the NT Planning Scheme, in accordance with the NT *Planning Act, 1999*. The land immediately surrounding DCF is zoned Rural Living (RL) which is mostly comprised of rural residential properties with the majority relying on bore water as their primary supply. Directly adjacent to DCF east of the Stuart Highway is large areas of subdivision development.

[1] ANZECC Guidelines – Aquatic ecosystems 95% species protection level



Path: \\ecoz-vh01\dardata\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19094 - Darwin Croc Farm EPL\01 Project Files\Figure 7-1 Map showing monitoring locations.mxd

Figure 2-3. Map showing monitoring locations

3 DESCRIPTION OF OPERATIONS

3.1 Overview

The crocodile production process at DCF is summarised as follows:

1. Eggs are collected from breeding pens and lagoons (in addition to wild-collected eggs) and are assessed and cleaned in egg laboratory, with viable eggs transferred to the incubator room
2. Animals hatch in incubator then are immediately transferred to hatchling pens
3. When animals are about one-year-old, they are transferred to grow-out pens
4. When animals approach a size suitable for market, they are transferred to finishing pens for 6 - 12 months to ensure best possible skin and meat condition
5. Animals are harvested from the finishing pens, prepared for transport and then sent to separate facility for further processing.

Currently the DCF harvests 200 - 250 animals per week for processing to product raw crocodile skins, meat products and other saleable by-products. The processing is undertaken at a neighbouring processing facility (within the same lot). It operates as a separate business and manages its own wastewater through a septic system, therefore this water will not be taken into consideration in the irrigation management plan.

The operations at DCF are permitted under a Parks and Wildlife Commission *Permit to Keep Protected Wildlife in the Northern Territory, to Bring Protected Wildlife into (Import) and Take Protected Wildlife out of (Export) the Northern Territory* (Permit no. 20234), pursuant to section 56 of the *Territory Parks and Wildlife Conservation Act 1976 (NT)*.

It is also a requirement for DCF to hold an export permit under the Conservation of International Trade in Endangered Species (CITES) of Wild Fauna and Flora (Permit no. PWS2019-AU-000282), pursuant to s303CG of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

3.1.1 Water supply

The DCF currently holds a groundwater extraction licence (Licence no. WSF01) which allows a maximum extraction entitlement of 700 ML/year from the six bore holes located within the site boundary (see Table 2-5). The source of the water is from the Wildman Siltstone Formation. Each of the bores either specifically supplies a particular section(s) of the farm or supplies water directly to water storage facilities which is then distributed as required to different farm areas for general crocodile husbandry.

The primary use of water is through regular flushing of the different pens for maintenance of hygiene and health of individuals. Due to the high quantities of water required during the cleaning of the pens, there are two water storage facilities: a 2.5 ML water tank and a 1.5 ML storage dam. These storage facilities allow for the pens to be cleaned and refilled experientially as crocodiles require access to clean water. On average the water usage at DCF is estimated at 1,700 KL/day.

For the onsite office and administration facilities potable water is supplied (average 770 KL/month).

A map outlining water supply bore locations and wastewater drainage through the different farm areas is included in Figure 3-1.

3.1.2 Farming routine

The animals move through different growth stages, therefore the farming routine changes accordingly. Table 3-1 outlines the water, food and cleaning schedule requirements for the three different growth type pens and the breeding lagoons.

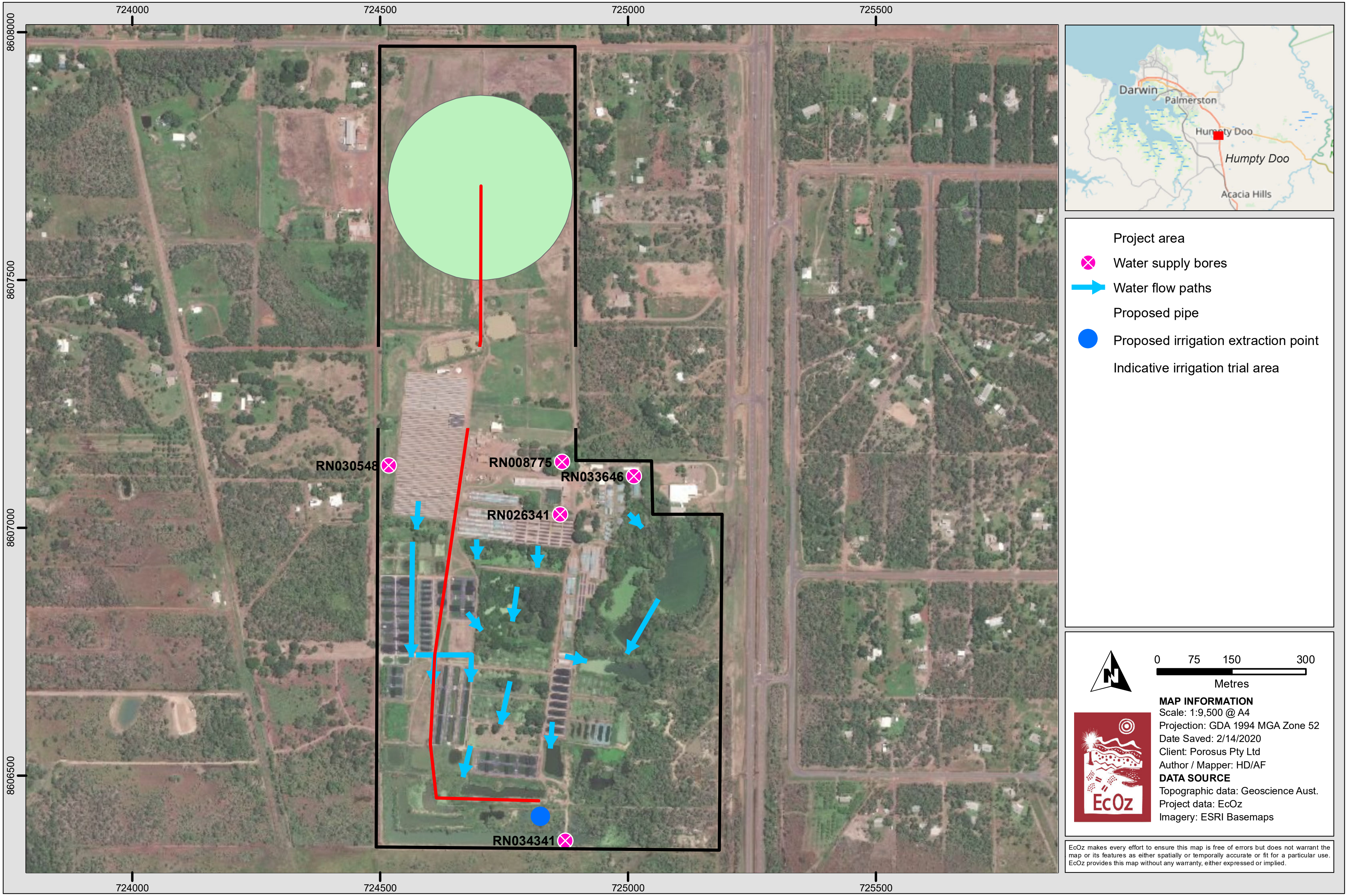
Table 3-1. DCF farming routine

	Hatching Pens	Grower Pens	Finishing Pens	Breeders
Water input	Bore water			Pen effluent & stormwater
Chlorine	Chlorine dosing on bore inlets			N/A
Food	5 times / week	3-4 times / week	2 times / week	Once / 3-4 weeks
Cleaning	5 times / week	Weekly (excess food collection 2-3 times / week)	Monthly (excess food collection 2 times / week)	N/A
Potassium Permanganate	N/A	N/A	Monthly	N/A

The feed type is determined by the growth type for each crocodile, therefore hatchlings feed consists of red meat, juvenile crocodiles (1-2 years) feed is a combination of red meat and chicken heads, then only chicken heads for mature crocodiles. Food additives are included in the feeds to ensure optimal growth of the individuals (Unical 20 [calcite], Protexin, and Monsoon Crocodile CH Premium).

Potassium permanganate (disinfectant), is added to the finishing pens on a monthly basis to prevent bacteriological skin conditions that may impact on the quality of the skin as a product.

Antibiotics are only administered in the hatchery to specified individuals if identified as necessary, as opposed to a blanket inoculation of the whole cohort. It is very rare that antibiotics are administered to individuals in the grower or finishing pens as illness is not common and the antibiotics impact the ability to process individuals for meat products.



Path: \\ecoz-vh01\dardata\01 EcOz_Documents\04 EcOz Vantage GIS\EZ19094 - Darwin Croc Farm EPL\01 Project Files\Figure XX. Map showing bores and water flow paths.mxd

Figure 3.1 Map showing bores, water flow paths and proposed irrigation infrastructure

4 WASTEWATER GENERATION AND QUALITY

4.1 Current wastewater flows

Water obtained from the bores is pumped through the hatchery, grower and finishing pens. The effluent from each stage discharges into numerous breeding lagoons and constructed earthen ponds on the property. The water flows through the breeding areas in a southerly direction before being detained in a series of large storage ponds on the southern boundary (see Figure 3-1). This flow of wastewater through the lagoons facilitates a bio-remediation process to reducing the nutrient and microbial levels in the wastewater.

The crocodile farming pens have been constructed to prevent ingress of stormwater runoff, however the breeding areas are not constructed to prevent stormwater inundation. Therefore, as the farm effluent moves through the breeding lagoons and the earthen ponds the wastewater is subject to dilution from stormwater, this assists with the bioremediation process.

During the wet season periods, stormwater inundation increases, resulting in the storage ponds adjacent to the southern boundary potentially exceeding capacity and subsequently wastewater being discharged off-site.

4.2 Current wastewater quality

Results of the wastewater quality sampling indicated that the nutrient levels in the wastewater from the farming routine are reduced after passing through numerous lagoons and reaching the storage basins at the southern end of the site. The water for irrigation will be sourced from one of these storage ponds and the quality of this water (based on recent monitoring) is summarised in Table 4-1. The full suite of monitoring results is included in Appendix B.

Table 4-1. Summary of wastewater quality for irrigation

pH	EC	TDS	BOD	O&G	NH3	TN	TP	*E.Coli*	Total Coliforms
-	*µS/cm*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*mg/L*	*CFU/100ml*	*CFU/100ml*
7.9	396.7	202	3.0	<5	0.1	2.1	0.2	96	96

When assessed against Table 3.1 of the *Environmental Guidelines – use of effluent by irrigation (DEC 2004)*, the current wastewater concentration is classified as "low" strength (Table 4-2).

Table 4-2. Classification of effluent based on DEC 2004 criteria

	Current irrigation water quality	Strength (average concentration mg/L)		
		Low	Medium	High
Total Nitrogen	2.1	<50	50-100	>100
Total Phosphorus	0.2	<10	40-1500	>1500
BOD	3.0	<40	40-1500	>1500
TDS	202	<600	600-1000	>1000

4.3 Irrigation suitability

This section assesses all the factors that need to be taken into consideration under the New South Wales *Environmental Guidelines – use of effluent by irrigation (DEC 2004)* ('NSW Guideline'). Currently there is 11 ha of available space on the property for irrigation to be conducted, with potential for further areas in neighbouring blocks owned by the company. There will be a 50 m buffer around the irrigation area to prevent sensitive receptors, such as neighbouring properties being impacted by the activities (as recommended by the NSW Guideline.

4.3.1 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 rate is 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 current median BOD content of the wastewater for irrigation is 3 mg/L. 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 BOD5 (mg/L)

Q = average effluent flow rate (kL/month)

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

For DCF:

A = 3 mg/L x 60,000 kL / month / (1,000 x 1,500 kg/ha/month)

A = 0.12 hectares

The above calculation indicates that a minimum area of 0.12 ha is required to manage the organic content of the DCF wastewater, therefore the current nominated irrigation area of 11 ha is sufficient to manage the organic content.

4.3.2 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. Sampling of the irrigation water pH at DCF was between 7.9 – 8.2.

4.3.3 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 4-3) along with the long-term trigger value (LTV) and short-term trigger value (STV) guidelines adapted from the Guidelines. The current metal levels in the wastewater are mostly below the detectable limit and are therefore well below the LTV.

Table 4-3. 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)	DCF wastewater quality
As	0.1	2.0	0.002
Cd	0.01	0.05	<0.0001
Cr(VI)	0.1	1	<0.001
Cu	0.2	5	<0.001
Pb	2	5	<0.001
Hg	0.002	0.002	<0.0001
Ni	0.2	2	<0.001
Zn	2	5	<0.005

4.3.4 Mineral salts and specific ions

The Electrical Conductivity (EC) and concentration of salts and specific ions (sodium, chloride, alkalinity etc) in the wastewater are relatively low (see Table 4-4). The aim is to protect soil structure and downstream surface and groundwater, and to not exceed the salt tolerance of pasture grasses.

Table 4-4. 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*
24	27	15	5	3	24	171

4.3.5 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.

4.3.6 Pathogens

The concentration of *E.coli* and other pathogens in the wastewater for irrigation is significantly lower than the wastewater coming directly out of the crocodile pens. This is likely due to the pathway of water through the breeding lagoons. 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 also off-limits to the public, therefore any pathogens in the wastewater are not expected to cause any harm to human receptors.

5 MODELING OF EFFLUENT REUSE SYSTEM

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 DCF effluent to assess the viability of irrigation as a method of wastewater management.

5.1 Model input data

The quantity of effluent and current quality outlined in the sections above was used in the MEDLI assessment. A 100-year climate file for the Bees Creek 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. Whilst 100 years of data is available, the model was run from 1950, to account for recent impacts of climate change that may affect the model outputs.

The MEDLI program operates on the assumption that effluent is managed through tanks or ponds prior to disposal or reuse. Whilst the DCF have a series of ponds, they are not solely storage ponds as they also inhabit breeding crocodiles. For the purpose of modelling, the irrigation supply pond dimensions (estimated) were used for the storage pond component.

The default MEDLI soil type, *red earth* was used in the model, as the default parameters are representative of Kandosols as defined by the Australian Soil Classification and identified at DCF. Site soil samples also contained concentrations of organic nitrogen in the organic layer, similar to the default values for *red earth* in MEDLI.

The default planting parameters for Forage Sorghum Crop were used in the model as they are representative of the crop selection for DCF. 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.

The irrigation method modelled was a centre pivot system over an irrigation area of 11 ha, with irrigation triggered when the soil water deficit reaches the drained upper limit. The irrigation was applied at a fixed depth of 5 mm (per day), with an irrigation override (i.e. no irrigation) on days where rainfall exceeds 1 mm.

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

5.2 Modelling results

The results of the water and nutrient balance modelled by MEDLI are outlined in Table 5-1and Table 5-2 respectively. The full MEDLI report is included in Appendix C.

Table 5-1. Water balance

	Unit	Irrigation	Dry-run
Rain	mm/year	1670.06	1670.06
Irrigation	mm/year	1265.29	0
Soil evaporation	mm/year	1143.67	462.17
Transpiration	mm/year	785.95	386.07
Rain runoff	mm/year	71.95	70.38
Irrigation runoff	mm/year	0	0
Deep drainage	mm/year	934.54	752.50

Table 5-2. Nutrient balance

	Unit	N	P
Irrigation (effluent load added)	kg/ha/year	24.20	2.54
Denitrification	kg/ha/year	0.01	-
Irrigation runoff	kg/ha/year	0	0
Plant uptake	kg/ha/year	58.28	2.03
Leached	kg/ha/year	1.74	0.05

Based on the average quality of the irrigation water, irrigation over an 11-hectare area at a rate of 5 mm is acceptable. The irrigation will not generate any run-off and whilst the activity increases the natural deep drainage rate of the soils, the increase is less than 200 mm/year. The deep drainage rates are considered naturally high due to the sandy nature of the soils. The nutrient uptake by the plants is higher than the nutrient load added during irrigation, and can therefore manage the effluent quality. The leaching of nutrients is due to the high deep drainage rates, however the low levels are deemed negligible.

Whilst the area can handle the irrigated wastewater at a rate of 5 mm, the volume of wastewater generated annually by DCF is extremely higher than what the current irrigation area can manage. Based on the assumptions included in the model, a total 690 ML of wastewater is generated annually, whilst only 140 ML can be irrigated.

5.3 Limitations

Whilst MEDLI is recognised as a useful tool for modelling irrigation of effluent, it still has many limitations and it is difficult to model the actual scenario at DCF. Whilst it is understood that 690 ML of wastewater is generated annually, this wastewater is pumped into a series of breeding lagoons and ponds prior to reaching the final storage ponds for irrigation. During this process it is subject to evaporation outputs and rainfall inputs that are difficult to simulate in the model.

The model was set to prevent irrigation on days where rainfall exceeds 1 mm which results in prevention of irrigation approximately 30% of the year. In reality however, with high evaporation rates, irrigation may still occur on days that experience minor rainfall events provided the conditions in this IMP are adhered too.

DCF recognise that additional land is required for irrigation in order to make this a viable option for wastewater disposal. However as highlighted in their application for an Environmental Protection Licence

(EPL), DCF wish to irrigate over the current nominated area as a trial to determine the viability of the activity prior to purchasing additional land and expanding the system.

6 SALINITY AND SODICITY ASSESSMENT

6.1 Effect on salinity of soils

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. It is a water-use issues when the potential water to be used is limited by its salt content.

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 waste are shown in Table 6-1. The current average ECi of the DCF wastewater to be used for irrigation is 0.4 dS/m, which is considered low for irrigation according to ANZECC (2000).

Table 6-1. 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

6.2 Effect on sodicity of soils

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 2.6%.

Soils with an ESP between 6 and 15% are considered sodic, and an ESP greater than 16% is considered strongly sodic. While soil with an ESP less than 6% are considered non-sodic.

Irrigation water that has a high concentration of sodium 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 the projected potential of sodium accumulation in soil, which is the end product of continual use of sodic water.

The SAR in the DCF wastewater for irrigation was identified to be 0.5 which is not considered an issue, as outlined in Table 6-2.

Table 6-2. 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

6.3 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. In comparison to the EC/SAR relationship graph detailed in the ANZECC 2000 guidelines, the levels fall within the "stable soil structure category (Figure 6-1).

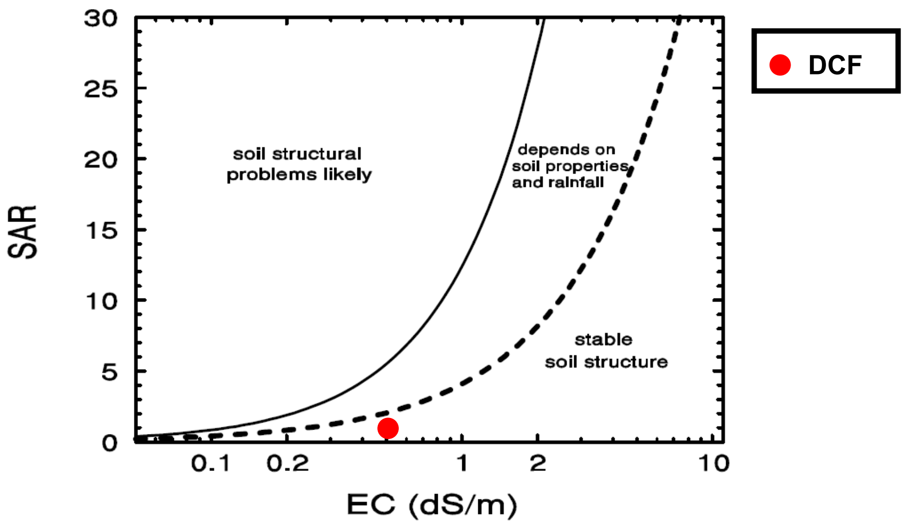


Figure 6-1. Relationship between SAR and EC for irrigation water for prediction of soil structure stability

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 has not been undertaken.

7 IRRIGATION AND CROP MANAGEMENT

7.1 Irrigation infrastructure

7.1.1 Pierce centre pivot system and Zenner flow meter

The Pierce C600 centre pivot system has been selected to be used as the irrigation mechanism for wastewater disposal. The system is self-propelled, rotating around a fixed central point and has a remote irrigation management product that uses global system for mobile communication (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.

The system is comprised of one 50 m and three 44.2 m long spans with end nozzles, reaching 190 m radius spray. The full reach of the system can cover an area of 11.3 ha.

Initially, the irrigator will only complete a ¾ turn (over a previously cleared area) and cover approximately 8.5 ha (Figure 3-1). The existing infrastructure shown in the irrigation area is currently being demolished and a clearing permit is being sought for any trees that require approval for clearing. Irrigation will commence at a rate of 5 mm/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.

7.2 Irrigation management

DCF recognise the importance of finding a solution to wastewater management and preventing discharge of untreated wastewater offsite and negatively impacting the surrounding 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 treated effluent via land irrigation has been developed to ensure the activities are managed appropriately (further information in Appendix D).

7.2.1 Runoff control

DCF 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)
- wastewater storage facility present on site, with capacity to hold wastewater during increased rainfall in the 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. This can lead to runoff.

7.3 Crop management

The crops will be managed by a third party local crop farmer, who will be responsible for the harvesting. The crops proposed to be planted include Sudan Grass (*Sorghum x drummondii*) and NuCal Guinea Grass. The crops will be inspected regularly to monitor their growth as well as plant health to determine any visual impacts of nutrient supply.

Sudan grass is a type of forage sorghum with a fine stem and commonly used for haymaking. They are tall, leafy, erect tussock grasses. In the Top End of the Northern Territory, forage sorghums are suited to deep, well-drained soils in areas receiving 900 to 1300 mm annual rainfall (Cameron, 2006).

Guinea Grass is a tall perennial grass that forms dense tussocks and is suited to areas with annual rainfall over 1100 mm. Guinea grass adapts to a wide range of soils but grows best on deep, well-drained soils of medium to high fertility (Cameron & Lemcke, 2008).

8 MONITORING AND REPORTING

8.1 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.

8.2 Compliance water and soil monitoring

The EPL application for this project has been submitted to the NT EPA, therefore monitoring and reporting for irrigation activities will be conducted in accordance with the EPL application. 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).

8.3 Monitoring procedure

All sampling and handling of samples are to be undertaken in accordance with the relevant standards and guidelines as outlined below:

- Australian Standard on Water Quality Sampling - *Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples* (AS/NZS 5667.1:1998);
- Australian Standard on Water Quality Sampling – *Part 6: Guidance on sampling of rivers and streams* (AS/NZS 5667.6:1998);
- Australian Standard on Water Quality Sampling – *Part 10: Guidance on sampling of wastewaters* (AN/NZS 5667.10:1998)
- Australian Standard on Contaminated Soil Sampling – *Guide to the sampling and investigation of potentially contaminated soil – Part 1: Non-volatile and semi-volatile compounds* (AS4482.1-2005)
- ANZECC & ARMCANZ 2000, *Australian Guidelines for Water Quality Monitoring and Reporting*, National Water Quality Management Strategy Paper No 7, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.
- ANZECC & ARMCANZ 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, National Water Quality Management Strategy Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

All samples are to be analysed at a National Association of Testing Authorities (NATA) approved laboratory, with the exception of field parameters such as pH and EC.

8.3.1 Monitoring parameters and frequencies

Figure 2-3 outlines the locations of the where water and soil monitoring is be conducted. The monitoring parameters, frequencies, location and trigger values of sampling the irrigation water are outlined in Table 8-1. The NSW Guidelines recommend that Total N and Total P be sampled biannually, however this has been increased to quarterly based on it being one of the main contaminants of concern.

Table 8-1. Monitoring program and trigger values for irrigation water

<table>
<tr><th>Monitoring sites</th><th colspan="2">Parameter</th><th>Sampling frequency</th><th>Trigger values</th></tr>
<tr><td rowspan="18">Irrigation Extraction Point

(724818 m E
8606409 m S)</td><td colspan="2">pH</td><td>Quarterly</td><td>6-9[1]</td></tr>
<tr><td colspan="2">EC</td><td>Quarterly</td><td>400 – 500 µs/cm [2]</td></tr>
<tr><td colspan="2">TDS</td><td>Quarterly</td><td>200 – 300 mg/L[2]</td></tr>
<tr><td colspan="2">Total P</td><td>Quarterly</td><td>0.9 mg/L[3]</td></tr>
<tr><td colspan="2">Total N</td><td>Quarterly</td><td>6 mg/L[3]</td></tr>
<tr><td colspan="2">NH_3</td><td>Quarterly</td><td>1 mg/L[1]</td></tr>
<tr><td colspan="2">BOD</td><td>Quarterly</td><td>40 mg/L [4]</td></tr>
<tr><td colspan="2">Cations & anions

(Ca, Mg, Na, K, SO4, Cl, CaCO3)</td><td>Quarterly</td><td>30 mg/L

(CaCO3 - 220 mg/L) [2]</td></tr>
<tr><td colspan="2">E.coli, Enterococci, Total coliforms</td><td>Quarterly</td><td>> 1,000 cfu/100mL (fodder) [1]</td></tr>
<tr><td colspan="2">Oil and grease</td><td>Biannually</td><td>> 5 mg/L (presence/absence) [5]</td></tr>
<tr><td rowspan="8">Total Metals</td><td>Arsenic</td><td>Quarterly</td><td>2.0 mg/L [6]</td></tr>
<tr><td>Cadmium</td><td>Quarterly</td><td>0.05 mg/L [6]</td></tr>
<tr><td>Chromium (VI)</td><td>Quarterly</td><td>1 mg/L [6]</td></tr>
<tr><td>Copper</td><td>Quarterly</td><td>5 mg/L [6]</td></tr>
<tr><td>Mercury</td><td>Quarterly</td><td>0.002 mg/L [6]</td></tr>
<tr><td>Nickel</td><td>Quarterly</td><td>2 mg/L [6]</td></tr>
<tr><td>Lead</td><td>Quarterly</td><td>5 mg/L [6]</td></tr>
<tr><td>Zinc</td><td>Quarterly</td><td>5 mg/L [6]</td></tr>
<tr><td colspan="2">Herbicides (Glyphosate)</td><td>Annually</td><td>1 mg/L [7]</td></tr>
</table>

Note: [1] Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 – Chapter 9 – Primary Industries (ANZECC, 2000) irrigation water quality Short Term Trigger Values.
[2]Baseline levels
[3] Interim site-specific short-term trigger value
[4] Environmental Guidelines – Use of Effluent by Irrigation (DEC, 2004)
[5] Laboratory limit of reporting (LOR)
[6] ANZECC, 2000 Short-term trigger values
[7] Australian Drinking Water Guidelines 6, 2011 Version 3.5 (Updated August 2018)

Soil

The monitoring parameters and frequencies of sampling for soil in the irrigation area are outlined in Table 8-2. Soil sampling locations are based on the initial sampling undertaken to establish baseline conditions.

Table 8-2. Monitoring program, frequencies and trigger levels for soil

Monitoring sites	Parameter	Sampling frequency	Trigger values
Soil 1, Soil 2, Soil 3, Soil 4, Soil 5 & Soil 6	pH	Annually	6-8
	EC	Annually	10 µS/cm
	Total P	Annually	80 mg/kg
	P sorption capacity	After 3 years	376 mg/kg
	Total N	After 3 years	347 mg/kg
	Nitrate + nitrite (NOx)	Annually	5 mg/kg
	ESP	Annually	2 %
	Total Metals (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn)	After 10 years	Baselines laboratory samples to be undertaken for comparison

* based on average B horizon results

Surface water

Surface water sampling is to be undertaken through the wet season when site runoff is generated. Sampling shall be undertaken at upstream and downstream locations each sampling event, when the sites are flowing (not stagnant). The monitoring program, frequencies and trigger levels of sampling for surface waters are outlined in Table 8-3.

Table 8-3. Monitoring program and trigger values for surface water sites

Monitoring sites	Parameter	Sampling frequency	Trigger values
SW1*, SW2, SW3 and SW4	pH	3 times during the wet season (start, during, end)	6.0-7.5 *
	EC		<200 µS/cm *
	DO		< 10% variation from baseline*
	Total P		<0.01 mg/L*
	Total N		<0.23 mg/L*
	NOx		<0.008 mg/L*
	NH_3		< 10% variation from baseline*
	BOD		< 10% variation from baseline*
	E.coli, Enterococci, Total coliforms	If increases are evident in irrigation waters	< 10% variation from baseline*

*SW1 Trigger Value not applicable. Tier 1 Assessment: Upstream reference site (SW1) data to be used in conjunction with baseline data to ascertain environmental impact. Tier 2 Assessment: where the results indicate a difference of 10% or greater, the Darwin Harbour Water Quality Objectives for freshwater rivers and streams are to be used.

Groundwater

Groundwater quality will be compared against baseline conditions (historical and current data). The Hazen percentile calculator was used to calculate 80th percentile parameters across the bores from the current data available, in order to develop trigger values for comparison. Where there are significant increases in the parameters measured, further assessment will be undertaken to determine potential sources of contamination. The monitoring program, frequencies and trigger levels of sampling for groundwater are outlined in Table 8-4.

Table 8-4. Monitoring program and trigger values groundwater sites

Monitoring sites	Parameter	Sampling frequency	Trigger values*
GW1, GW2, GW3, GW4, GW5, GW6 and GW7	pH	Quarterly	7.47
	EC	Quarterly	526 µs/cm
	Total P	Annually	0.02 mg/L
	Total N	Annually	3.85 mg/L
	Nitrate	Annually	3.37 mg/L
	Cations & anions (Ca, Mg, Na, K, SO4, Cl, $CaCO_3$)	Annually	30 mg/L ($CaCO_3$ - 260 mg/L)

*based on 80th percentile derived from available baseline data

8.4 Assessment of performance indicators

Annual nutrient balance calculations should be undertaken and compared with the soil monitoring results to assess the sustainability of the effluent 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.

8.5 Reporting

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

8.5.1 Internal reporting

Details of environmental incidents, non-conformances or other relevant information are included in daily reports which are issued to the Managing Director. 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.

8.5.2 External reporting

All non-compliances of the EPL will be reported by DCF 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)*.

An Annual report will be submitted to the NT EPA on the anniversary data of the EPL to 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. It will include a trend analysis of the water quality monitoring data and an assessment of any environmental impacts from the DCF operations.

9 SUMMARY AND RECOMMENDATIONS

The nutrient loading of the wastewater generated at DCF is considered low level and suitable for irrigation over the nominated irrigation area. The main issue impacting irrigation as a wastewater management method, is the large volumes of wastewater generated annually. It is acknowledged that the current 11 ha irrigation area is insufficient for the complete management of current wastewater volumes. However, provided the scheduled irrigation activity is successful, it can be expanded into neighbouring areas.

It is recommended that the wastewater overflows from the southern storage ponds be monitored in order to calculate the estimated volumes of wastewater to be managed. This will allow for the appropriate irrigation area to be determined and modelled prior to expansion of the current system and this IMP will be updated accordingly.

10 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.

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Department of Health (DOH) (2014). *Guidelines for Land Capability Assessment for On-site Wastewater Management.* DOH, Northern Territory Government, Casuarina.

Jessop P.J. and King, D. (1997). *The Land Resources of New Crown Station*, NTG Technical Report No. TM96/18.

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

Site ID	Date	Field Notes									Laboratory Results						
		Horizon	Depth Range(m)	Texture	Structure	Colour	Course Fragments size and %	Moisture Condition	Surface Gravel Cover	Rock Cover					Emerson Aggregate Test		
											pH	Sodium Absorption	Conductivity	Moisture Content	Colour	Texture	Class Number
														%			EC/TC
											0.1	0.01	1	0.1			
Objectives																	
Soil Sample 1 - surface	12/06/2019	1	0 - 0.1m	Loamy Sand	W2	Grey Brown	15% @ 5 - 25mm	Dry	30 - 70%	-	----	0.22	----	----	----	----	----
Soil Sample 1 - 0 - 0.4m	12/06/2019	2	0.4 - 0.6m	Sand	G	Pale Grey	5% @ 5 - 30mm	Dry	30 - 70%	-	6	0.29	11	1	Dark Brown (7.5YR 3/3)	Loamy Sand	4
Soil Sample 1 - 0.4 - 1m	12/06/2019	3	0.6 - 1m	Sand	G	Grey	35% @ 5 - 35mm	Dry	30 - 70%	-	6	0.35	11	2.9	----	----	----
Soil Sample 2 - surface	13/06/2019	1	0 - 0.2m	Sand	W1	Brown Grey	30% @ 5 - 25mm	Dry	70%	-	----	0.16	----	----	----	----	----
Soil Sample 2 - 0 - 0.4m	13/06/2019	2	0.4 - 0.6m	Sand	G	Yellow Grey	45% @ 5 - 100mm	Dry	50%	-	7.4	0.26	6	0.9	Dark Brown (7.5YR 3/3)	Loamy Sand	4
Soil Sample 2 - 0.4 - 1m	13/06/2019	2	0.7 - 0.9m	Sand	G	Yellow Grey	45% @ 5 - 100mm	Dry	70%	-	7.4	0.26	8	1.8	----	----	----
Soil Sample 3 - surface	13/06/2019	1	0 - 0.2m	Silty Loam	W2	Brown Grey	35% @ 5 - 35mm	Dry	10%	-	----	0.13	----	----	----	----	----
Soil Sample 3 - 0 - 0.4m	13/06/2019	2	0.4 - 0.6m	Sandy Loam	W2	Yellow Grey	40% @ 5 - 40mm	Dry	10%	-	7.3	0.18	8	3.1	Dark Reddish Brown (5YR	Sand	8
Soil Sample 3 - 0.4 - 1m	13/06/2019	3	0.8 - 1m	Sandy Loam	W2	Brown	60% @ 5 - 50mm	Dry	10%	-	7.7	0.28	6	5	----	----	----
Soil Sample 4 - surface	13/06/2019	1	0 - 0.2m	ZL	W2	Grey	35% @ 5 - 35mm	Dry	40%	-	----	0.17	----	----	----	----	----
Soil Sample 4 - 0 - 0.4m	13/06/2019	2	0.4 - 0.6m	SL	W2	Yellow Grey	45% @ 5 - 20mm	Dry	40%	-	7.8	0.26	9	1.9	Very Dark Brown (7.5YR	Sand	8
Soil Sample 4 - 0.4 - 1m	13/06/2019	3	0.8 - 1m	Loamy sand	W2	Yellow Orange Grey	50% @ 5 - 80mm	Dry	40%	-	7.5	0.3	6	2.7	----	----	----
Soil Sample 5 - surface	13/06/2019	1	0 - 0.2m	Loamy Sand	W2	Grey	80% @ 5 -100mm	Dry	90%	-	----	0.11	----	----	----	----	----
Soil Sample 5 - 0 - 0.4m	13/06/2019	2	0.4 - 0.6m	Loamy Sand	W2	Red Grey Brown	80% @ 5 -75mm	Dry	90%	-	8	0.12	6	5	Dark Reddish Brown (5YR	Sand	8
Soil Sample 5 - 0.4 - 1m	13/06/2019	2	0.6 - 0.9m	Loamy Sand	W2	Red Grey Brown	80-90% @ 5 - 90mm	Dry	90%	-	8.1	0.13	15	3.8	----	----	----
Soil Sample 6 - surface	13/06/2019	1	0 - 0.2m	Sandy Loam	W3	Brown Grey	40% @ 5 -30mm	Dry	60%	-	----	0.13	----	----	----	----	----
Soil Sample 6 - 0 - 0.4m	13/06/2019	2	0.4 - 0.6m	ZL	W6	Grey	5% @ 2 -8mm	Dry	60%	-	7.7	0.11	7	3.5	Very Dark Grayish Brown	Sandy Loam	4
Soil Sample 6 - 0.4 - 1m	13/06/2019	2	0.6 - 0.7m	ZL	W4	Brown Grey	20% @ 5 - 50mm	Dry	60%	-	7.8	0.16	9	4.5	----	----	----

Site ID	Laboratory Results															
	Particle Sizing												Soil Classification based on Particle Size			
	+75Âµm	+150Âµm	+300Âµm	+425Âµm	+600Âµm	+1180Âµm	+2.36mm	+4.75mm	+9.5mm	+19.0mm	+37.5mm	+75.0mm	Clay(<2 Âµm)	Silt (2-60 Âµm)	Sand (0.06 - 2.00 mm)	Gravel (>2mm)
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Objectives																
Soil Sample 1 - surface	79	67	50	45	42	39	34	25	5	<1	<1	<1	10	10	44	36
Soil Sample 1 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 1 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 2 - surface	87	77	61	54	51	50	48	41	<1	<1	<1	<1	7	5	40	48
Soil Sample 2 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 2 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 3 - surface	80	75	67	64	62	59	54	43	17	<1	<1	<1	9	10	26	55
Soil Sample 3 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 3 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 4 - surface	87	78	62	56	53	51	48	35	5	<1	<1	<1	6	6	40	48
Soil Sample 4 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 4 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 5 - surface	68	62	58	56	56	53	45	24	7	<1	<1	<1	16	15	21	48
Soil Sample 5 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 5 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 6 - surface	54	42	29	26	24	22	20	15	3	<1	<1	<1	21	23	36	20
Soil Sample 6 - 0 - 0.4m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 6 - 0.4 - 1m	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Site ID	Date		Exchangable Cations on Alkaline Soils						Exchangable Cations						Nitrate plus Nitrite as N(Nox) by discrete Analyser	Total Kjeldahl Nitrogen by Discrete Analyser	Total Nitrogen asN (TKN + Nox)	Total Phosphurous as P by Discrete Analyser	Phosphate Sorption Capacity		Organic Matter	Total Metals								
																						Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc	Moisture Content (Dried @ 105 - 110° C)	Mercury
		Cobbles (>6cm)	Exchangable Calcium	Exchangable Magnesium	Exchangable Potassium	Exchangable Sodium	Cation Exchange	Exchangable Sodium	Exchangable Calcium	Exchangable Magnesium	Exchangable Potassium	Exchangable Sodium	Cation Exchange	Exchangable Sodium	Nitrate plus Nitrite as N	Total Kjeldahl Nitrogen as N	Total Nitrogen as N	Total Phosphurous	Phosphate Sorption	Phosphate Sorption Index	Organic Matter									
		%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	%	mg/kg	mg/kg	mg/g	mg/kg	mg P sorbed/kg	mgkg-1/log10ugL-1	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg
		1	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	20	20	2	250	1	0.5	5	1	2	5	5	2	5	1	0.1
Objectives																														
Soil Sample 1 - surface	12/06/2019	<1	3	1	0.6	<0.2	4.5	<0.2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 1 - 0 - 0.4m	12/06/2019	----	----	----	----	----	----	----	0.5	0.2	<0.1	<0.1	0.7	1.8	0.5	340	340	86	<250	14	0.7	----	----	----	----	----	----	----	----	----
Soil Sample 1 - 0.4 - 1m	12/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	3.3	170	170	52	<250	23	----	<5	<1	27	<5	<5	<2	<5	3.4	<0.1
Soil Sample 2 - surface	13/06/2019	<1	----	----	----	----	----	----	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 2 - 0 - 0.4m	13/06/2019	----	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	----	----	----	----	----	----	1.5	250	250	46	<250	22	<0.5	----	----	----	----	----	----	----	----	----
Soil Sample 2 - 0.4 - 1m	13/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	2	220	220	57	288	25	----	<5	<1	44	<5	6	<2	<5	1.4	<0.1
Soil Sample 3 - surface	13/06/2019	<1	----	----	----	----	----	----	0.2	<0.1	<0.1	<0.1	0.4	2.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 3 - 0 - 0.4m	13/06/2019	----	----	----	----	----	----	----	0.2	0.1	<0.1	<0.1	0.4	<0.1	2.3	280	280	79	551	39	0.9	----	----	----	----	----	----	----	----	----
Soil Sample 3 - 0.4 - 1m	13/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	1.6	200	200	80	433	41	----	9	<1	81	7	25	5	<5	7.1	<0.1
Soil Sample 4 - surface	13/06/2019	<1	----	----	----	----	----	----	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 4 - 0 - 0.4m	13/06/2019	----	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	----	----	----	----	----	----	2.1	400	400	78	354	26	0.7	----	----	----	----	----	----	----	----	----
Soil Sample 4 - 0.4 - 1m	13/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	2.5	420	420	78	432	38	----	8	<1	48	<5	5	<2	<5	2.3	<0.1
Soil Sample 5 - surface	13/06/2019	<1	3.3	1.2	<0.2	<0.2	4.6	<0.2	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 5 - 0 - 0.4m	13/06/2019	----	2.2	0.9	<0.2	<0.2	3	<0.2	----	----	----	----	----	----	6.2	1210	1220	794	317	15	1.2	----	----	----	----	----	----	----	----	----
Soil Sample 5 - 0.4 - 1m	13/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	3.6	950	950	462	<250	9	----	18	<1	62	11	16	3	32	4.1	<0.1
Soil Sample 6 - surface	13/06/2019	<1	----	----	----	----	----	----	3.4	3.1	0.1	<0.1	6.6	0.4	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Soil Sample 6 - 0 - 0.4m	13/06/2019	----	0.7	0.6	<0.2	<0.2	1.3	<0.2	----	----	----	----	----	----	8.9	470	480	96	<250	15	0.9	----	----	----	----	----	----	----	----	----
Soil Sample 6 - 0.4 - 1m	13/06/2019	----	----	----	----	----	----	----	----	----	----	----	----	----	10.4	450	460	134	351	23	----	13	<1	42	5	8	3	9	4.2	<0.1

APPENDIX B WATER QUALITY DATA

Site ID	Date	Analyte	Field Parameters															
		Analyte	**pH**	**Temp**	**ORP**	**EC**	**TDS**	**Salinity**	**Dissolved Oxygen**	**Turbidity**	**Total dissolved solids**	**Biological Oxygen Demand**	**Ammonia**	**Nitrite**	**Nitrate**	**Nitrogen Oxides**	**Total Nitrogen**	**Reactive Phosphorus**
											TDS	**BOD**	**NH3**	**NO2-N**	**NO3-N**	**NOX-N**	**TN**	**RP**
		Units		**°C**	**mV**	**µS/cm**	**mg/L**	**ppt**	**%**	**NTU**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**
		Limit of Reporting	-	-	-	-	-	-	-	-	**10**	**1**	**0.3**	**0.1**	**0.1**	**0.1**	**0.4**	**0.1**
Darwin Harbour Water Quality Objectives - Freshwater Rivers and Steams			**6.0-8.5**	**-**	**-**	**200**	**-**	**-**	**50-100**	**20**	**-**	**-**	**0.02**	**-**	**-**	**-**	**0.23**	**0.005**
Darwin Harbour Water Quality Objectives - Lagoons			**5.0-6.0**	**-**	**-**	**25**	**-**	**-**	**35-100**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**0.55**	**0.005**
ANZECC Guidelines - Freshwater lakes and reservoirs			**6.0-8.0**	**-**	**-**	**90-900**	**-**	**-**	**90-120**	**2-200**	**-**	**-**	**0.01**	**-**	**-**	**-**	**0.35**	**0.005**
ANZECC Guidelines - Aquatic Ecosystem 95% Species Protection Level			**6.0-8.0**	**-**	**-**	**250**	**-**	**-**	**80-110**	**15**	**-**	**-**	**0.01**	**-**	**-**	**-**	**0.2-0.3**	**0.004**
Bore 1	12/Jun/19		5.6	30.0	200.1	**308.4**	200.2	0.1	4.2	3.4	175	<2	**0.05**	<0.01	6.68	6.68	**7.8**	<0.01
Bore 2	16/Jul/19		7.1	30.2	141.3	**530.0**	344.5	0.25	62.9	16.1	322	<2	<0.01	<0.01	0.17	0.17	0.2	<0.01
Bore 3	16/Jul/19		7.5	29.8	82.7	**398.6**	259.3	0.19	51.8	25.5	228	<2	0.01	<0.01	0.07	0.07	**0.3**	<0.01
Bore 4	16/Jul/19		7.1	30.1	82.6	**325.1**	211.3	0.15	65.4	29.8	188	<2	0.02	<0.01	0.33	0.33	**0.4**	**0.01**
Bore 5	16/Jul/19		7.5	28.7	141.3	**490.0**	318.5	0.23	62.9	8.4	272	<2	0.02	<0.01	0.02	0.02	<0.1	<0.01
Bore 6	16/Jul/19		7.1	31.0	109.7	**587.0**	370.5	0.27	34.8	11.7	307	<2	<0.01	<0.01	1.65	1.65	**1.6**	<0.01
HP1	12/Jun/19		7.9	30.6	323.2	**582.0**	377.0	0.3	49.9	23.8	260	22.0	**1.0**	0.0	1.0	1.0	**5.6**	**0.3**
GP2	12/Jun/19		7.2	26.4	234.9	**521.0**	338.0	0.3	19.6	93.9	254	<2	**7.0**	0.5	0.1	0.6	**13.3**	**0.3**
GP1	12/Jun/19		7.8	30.8	150.4	**582.0**	377.0	0.3	79.5	7.0	288	<2	**3.6**	0.1	0.2	0.3	**4.6**	**0.9**
BP2	12/Jun/19		8.8	29.3	169.6	**425.6**	276.9	0.2	165.2	56.3	242	23.0	**0.7**	0.0	0.0	0.1	**22.0**	**0.1**
BP4	12/Jun/19		8.1	26.6	146.3	**383.0**	248.9	0.2	103.0	20.3	188	2.0	**0.1**	<0.01	<0.01	<0.01	**1.3**	<0.01
BP3	12/Jun/19		7.9	27.2	144.1	**396.7**	258.0	0.2	72.1	46.4	202	3.0	**0.1**	<0.01	0.1	0.1	**2.1**	<0.01
FP1	12/Jun/19		7.8	30.3	137.6	**579.0**	377.0	0.3	43.0	6.8	286	4.0	**5.8**	0.1	0.1	0.3	**7.2**	**1.1**
BP1	12/Jun/19		8.1	32.5	131.0	**2093.0**	1358.0	1.1	67.5	16.3	1100	2.0	**0.3**	0.3	18.1	18.4	**22.5**	**2.5**
MD1	12/Jun/19		7.7	30.3	142.1	**413.0**	268.4	0.2	110.1	18.9	224	5.0	**0.0**	<0.01	<0.01	<0.01	0.2	<0.01
GW7	10/Sep/19		7.0	30.5	200.0	65.9	43.0	0.03	63.0	127.0	60.0	3.0	**0.03**	<0.01	3.6	3.6	**4.1**	<0.01
House Bore	10/Sep/19		7.9	29.9	202.1	**337.0**	219.0	0.2	50.3	1.3	257.0	<2	<0.01	<0.01	1.2	1.2	**1.2**	<0.01
Jakobi Pond	10/Sep/19		8.2	26.1	204.0	**356.3**	232.0	0.2	87.0	62.7	266.0	2.0	**0.04**	<0.01	0.0	0.0	**2.0**	<0.01

Site ID	Date	Total Phosphorus	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations	Sodium Adsorption Ratio	Total Alkalinity	Total Hardness	Sulfate	Chloride	Chlorphyll a	Oil & Grease	Faecal Coliforms	*E.coli*	*Enterococci*
		TP	**Ca**	**Mg**	**Na**	**K**	**-**	**-**	**SAR**	**CaCO3**		**SO4**						
		mg/L	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**meq/L**	**meq/L**		**mg/L**	**mg CaO3/L**	**mg/L**	**mg/L**	**mg/m3**	**mg/L**	**CFU/100mL**	**CFU/100mL**	**CFU/100mL**
		0.1	**0.03**	**0.02**	**1**	**1**	**0.01**	**0.01**	**0.01**	**1**	**1**	**1**	**1**	**1**	**5**	**1**	**1**	**1**
Darwin Harbour Water Quality Objectives - Freshwater Rivers and Steams		**0.01**	-	-							-			**2**			**200**	**50**
Darwin Harbour Water Quality Objectives - Lagoons		**0.02**	-	-							-			**10**				
ANZECC Guidelines - Freshwater lakes and reservoirs		**0.01**	-	-							-			**3**			**1000**	**230**
ANZECC Guidelines - Aquatic Ecosystem 95% Species Protection Level		**0.01**	-	-							-			-			-	-
Bore 1	12/Jun/19	<0.01	27	10	14	<1	3.04	2.78	0.58	114	-	3	25	<1	<5	12	12	12
Bore 2	16/Jul/19	<0.01	73	30	9	1	5.96	6.53	0.22	277	-	4	12	<1	<5	~<1	~<1	~2
Bore 3	16/Jul/19	**0.03**	54	22	2	1	4.37	4.62	0.06	210	-	3	4	<1	<5	~<1	~<1	<1
Bore 4	16/Jul/19	**0.02**	41	17	3	<1	3.24	3.58	0.1	152	-	3	5	<1	<5	<1	<1	<1
Bore 5	16/Jul/19	<0.01	53	31	9	<1	5.07	5.59	0.24	225	-	2	19	<1	<5	~<1	~<1	<1
Bore 6	16/Jul/19	0.01	74	27	6	<1	5.59	6.18	0.15	263	-	2	6	<1	<5	~<1	~<1	<1
HP1	12/Jun/19	**0.4**	48.0	26.0	16.0	2.0	5.3	5.3	0.5	227.0	-	3.0	26.0	<1	<5	220000.0	220000.0	8800.0
GP2	12/Jun/19	**1.8**	43.0	23.0	16.0	5.0	5.4	4.9	0.5	227.0	-	4.0	26.0	**57.0**	<5	3100.0	3100.0	1100.0
GP1	12/Jun/19	**0.9**	59.0	26.0	15.0	4.0	6.2	5.8	0.4	268.0	-	4.0	26.0	**6.0**	<5	600.0	600.0	800.0
BP2	12/Jun/19	**4.9**	34.0	25.0	16.0	8.0	4.8	4.7	0.5	188.0	-	13.0	26.0	**116.0**	<5	45000.0	45000.0	30000.0
BP4	12/Jun/19	**0.1**	27.0	25.0	14.0	4.0	4.1	4.1	0.5	173.0	-	4.0	21.0	**22.0**	<5	580.0	580.0	34.0
BP3	12/Jun/19	**0.2**	24.0	27.0	15.0	5.0	4.2	4.2	0.5	171.0	-	3.0	24.0	**40.0**	<5	96.0	96.0	2.0
FP1	12/Jun/19	**1.5**	61.0	25.0	12.0	3.0	6.2	5.7	0.3	276.0	-	6.0	18.0	0.0	<5	17000.0	17000.0	1800.0
BP1	12/Jun/19	**2.5**	80.0	36.0	277.0	11.0	20.4	19.3	6.5	249.0	-	56.0	504.0	2.0	<5	3500.0	1400.0	60.0
MD1	12/Jun/19	**0.0**	50.0	21.0	2.0	<1	4.4	4.3	0.1	213.0	-	3.0	4.0	**3.0**	<5	12.0	7.0	<2
GW7	10/Sep/19	<0.01	4.0	2.0	1.0	<1	0.3	0.4	0.1	7.0	-	<1	6.0	<1	<5	~<1	~<1	<1
House Bore	10/Sep/19	<0.01	54.0	30.0	6.0	<1	5.1	5.4	0.2	242.0	-	4.0	6.0	<1	<5	~<1	~<1	~5
Jakobi Pond	10/Sep/19	**0.2**	30.0	31.0	18.0	10.0	5.4	5.1	0.6	219.0	-	5.0	33.0	12.0	<5	~160	~160	130.0

APPENDIX C MEDLI OUTPUT FILES

Enterprise: **Darwin Crocodile Farm**

Description:
No subject entered

Client: **Porosus**

MEDLI User: Emma Lewis

Scenario Details:

DESCRIPTION

Climate Data: Darwin Crocodile Farm_-12.60_131.05, -12.6°, 131.05°

Run Period: 01/01/1950 to 31/12/2019 70 years, 0 days

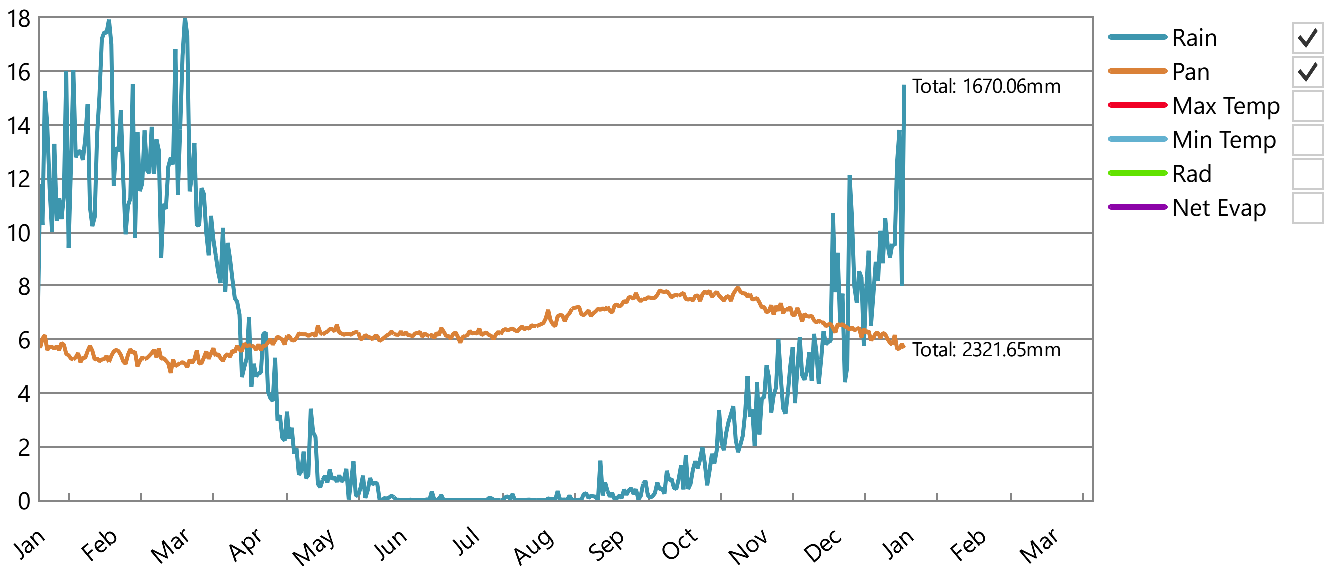
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	1082	1678	2231
Pan Evaporation (mm/year)	2142	2334	2473

Climate Data:

■ Chart ☐ Table
☐ Monthly ■ Daily

Daily Average Across Run Period



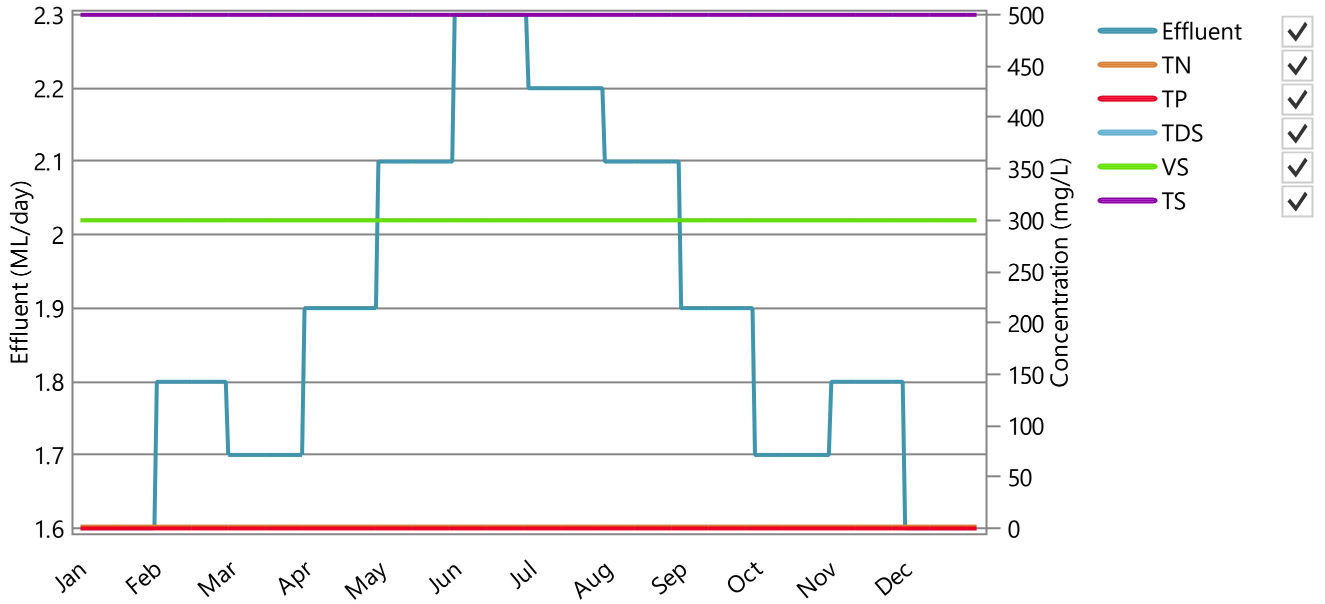
DESCRIPTION

Effluent type: Darwin Croc Farm

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

■ Chart ☐ Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **690.99 ML/year** or 1.89 ML/day (Min-Max: 1.60 - 2.30)

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

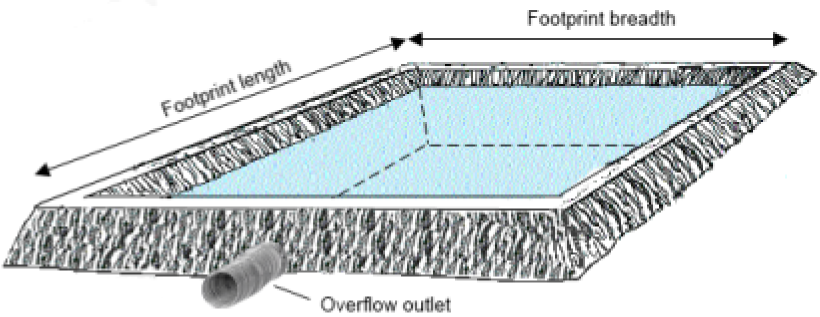
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	2.00 (2.00 - 2.00)	1381.98 (1381.20 - 1384.40)
Total Phosphorus	0.20 (0.20 - 0.20)	138.20 (138.12 - 138.44)
Total Dissolved Salts	300.00 (300.00 - 300.00)	207296.57 (207180.00 - 207660.00)
Volatile Solids	300.00 (300.00 - 300.00)	207296.57 (207180.00 - 207660.00)
Total Solids	500.00 (500.00 - 500.00)	345494.29 (345300.00 - 346100.00)

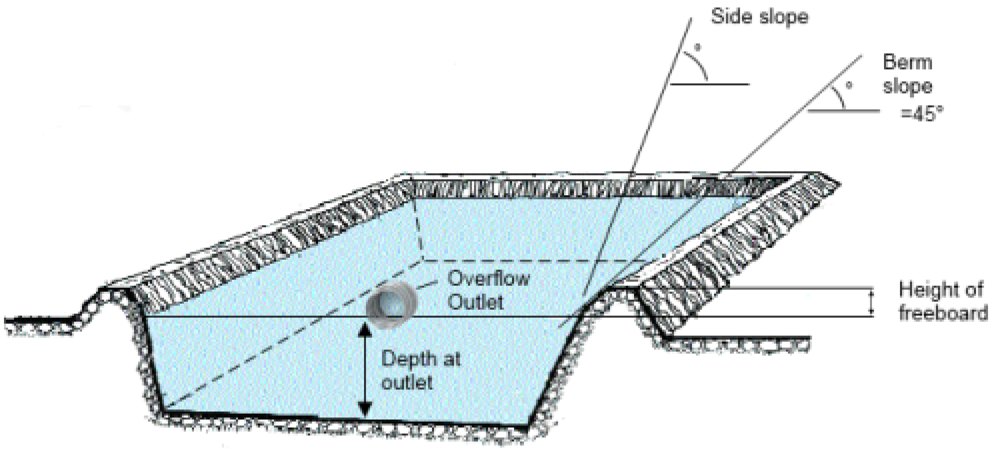
DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond

Pond system details:

	Pond 1
Maximum pond volume (ML)	7.00
Minimum allowable pond volume (ML)	0.27
Pond depth at overflow outlet (m)	2.40
Maximum water surface area (m2)	3196.66
Pond footprint length (m)	81.96
Pond footprint width (m)	41.98
Pond catchment area (m2)	3440.54
Average active volume (ML)	6.62





Irrigation pump limits:

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

Shandying water:

Annual allocation of fresh water available for shandying (ML/year)	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

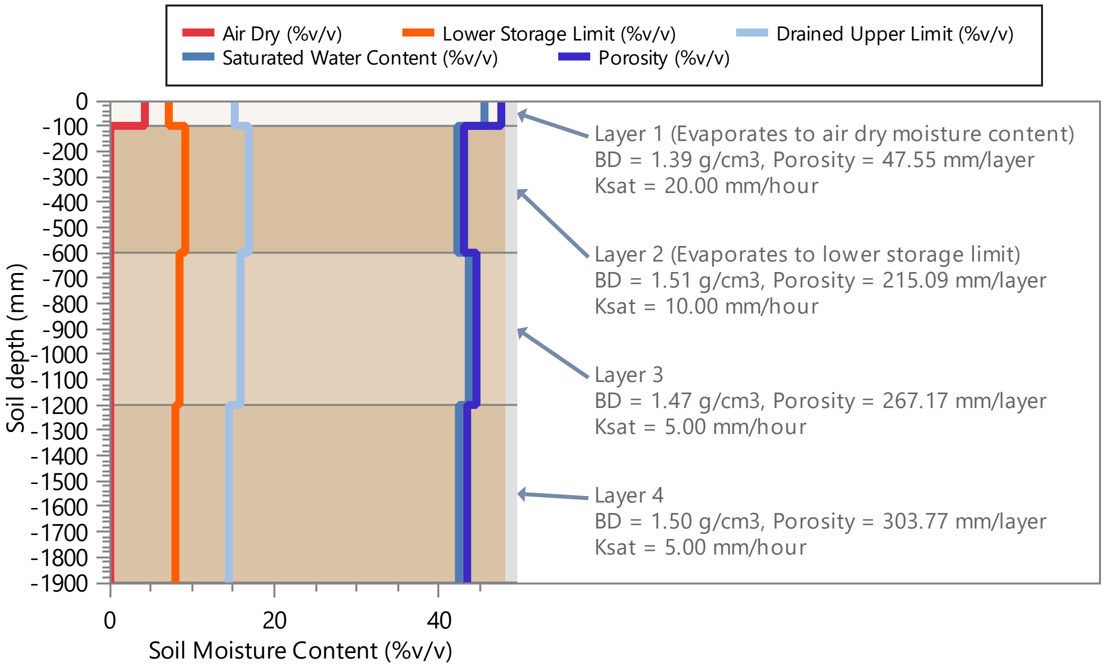
DESCRIPTION

Land: New Paddock

Area (ha): 11.00

Soil Type: Red Earth, 1900.00 mm defined profile depth

Profile Porosity (mm)	833.58
Profile saturation water content (mm)	814.90
Profile drained upper limit (or field capacity) (mm)	296.60
Profile lower storage limit (or permanent wilting point) (mm)	160.20
Profile available water capacity (mm)	136.40
Profile limiting saturated hydraulic conductivity (mm/hour)	5.00
Surface saturated hydraulic conductivity (mm/hour)	20.00
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

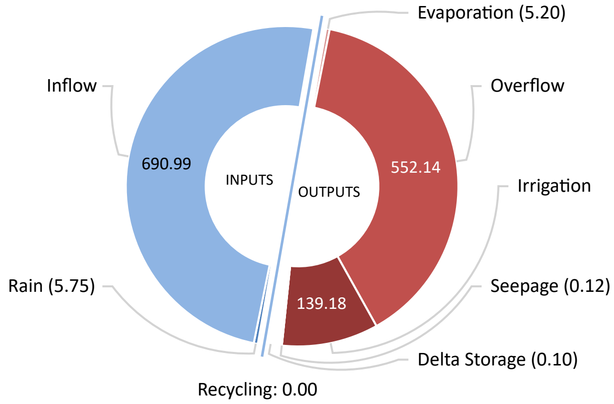
Average monthly cover (fraction) (minimum - maximum)	0.45 (0.25 - 0.58)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 1)	0.80
Total plant cover (both green and dead) left after harvest (fraction)	0.00
Maximum potential root depth in defined soil profile (mm)	1900.00
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: **7 ML**

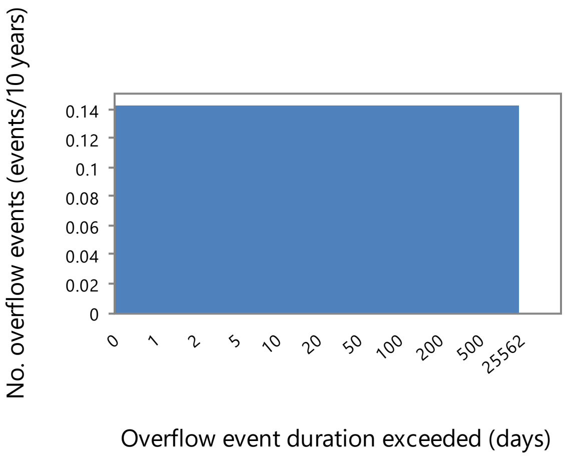
Pond System Water Balance (ML/year)



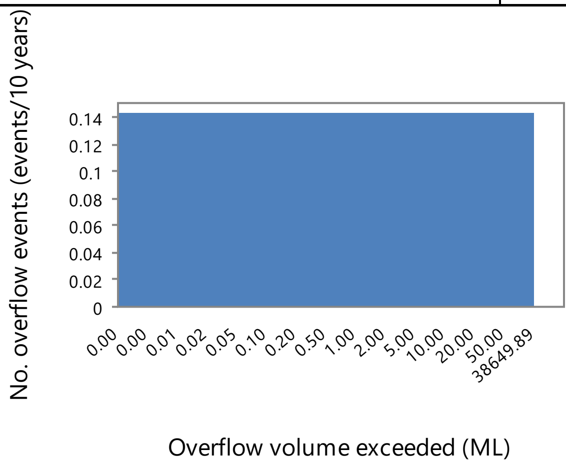
Name	Value
Rain	5.75
Inflow	690.99
Recycling	0.00
Evaporation	5.20
Overflow	552.14
Irrigation	139.18
Seepage	0.12
Delta Storage	0.10

Overflow Diagnostics

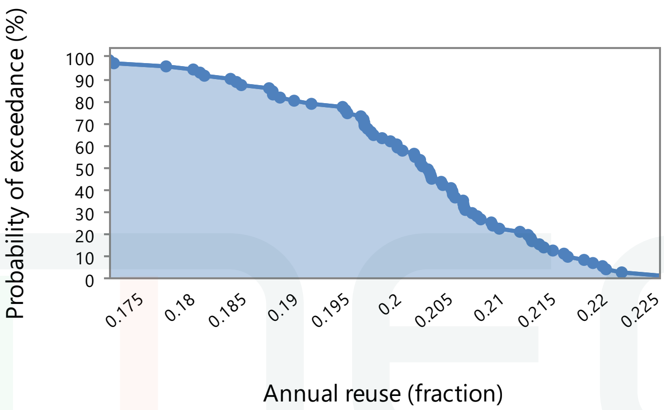
Volume of overflow (ML/year)	552.14
No. days pond overflows (days/year)	365.17
Average duration of overflow (days)	25562.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.20
Probability of at least 90% reuse (fraction)	0.00



Export plot



Export plot



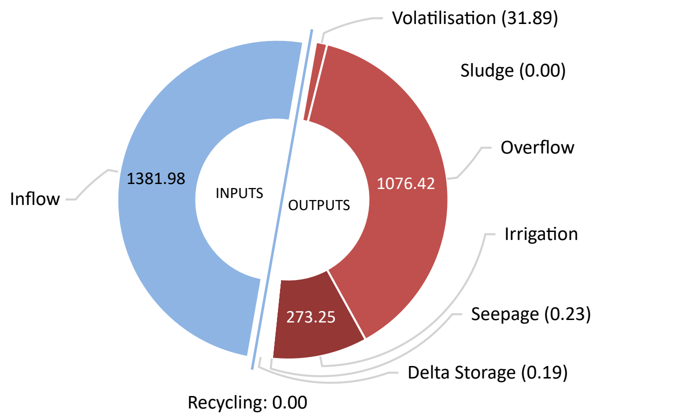
Export plot

PERFORMANCE

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

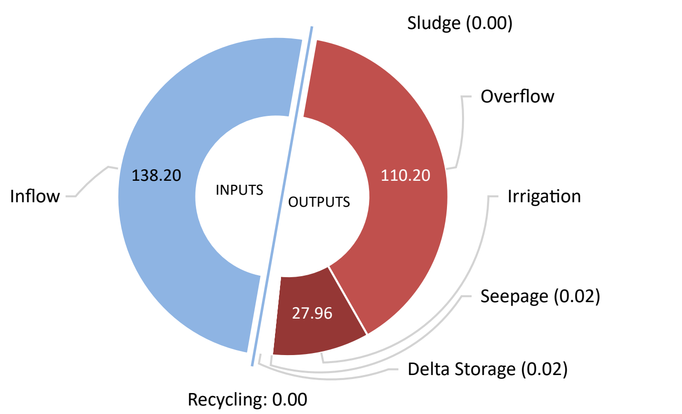
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



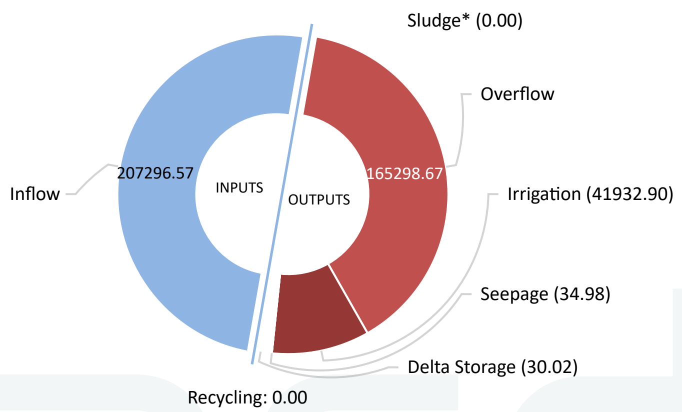
Name	Value
Inflow	1381.98
Recycling	0.00
Volatilisation	31.89
Sludge	0.00
Overflow	1076.42
Irrigation	273.25
Seepage	0.23
Delta Storage	0.19

Phosphorus Balance (kg/year)



Name	Value
Inflow	138.20
Recycling	0.00
Sludge	0.00
Overflow	110.20
Irrigation	27.96
Seepage	0.02
Delta Storage	0.02

Salt Balance (kg/year)



Name	Value
Inflow	207296.57
Recycling	0.00
Sludge*	0.00
Overflow	165298.67
Irrigation	41932.90
Seepage	34.98
Delta Storage	30.02

* 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)	1.94
Average phosphorus concentration of pond liquid (mg/L)	0.20
Average salinity of pond liquid (dS/m)	0.47

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	1.93
Final phosphorus concentration of pond liquid (mg/L)	0.20
Final salinity of pond liquid (dS/m)	0.47

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (ML/year)	139.18
Average Shandy water irrigation (ML/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (ML/year)	139.18
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 ML/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	1.96
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	1.91
Average phosphorus concentration of irrigation water (mg/L)	0.20
Average salinity of irrigation water (dS/m)	0.47

Irrigation Diagnostics:

Proportion of Days rain prevents irrigation (fraction)	0.31
Proportion of Days irrigation occurs (fraction)	0.69

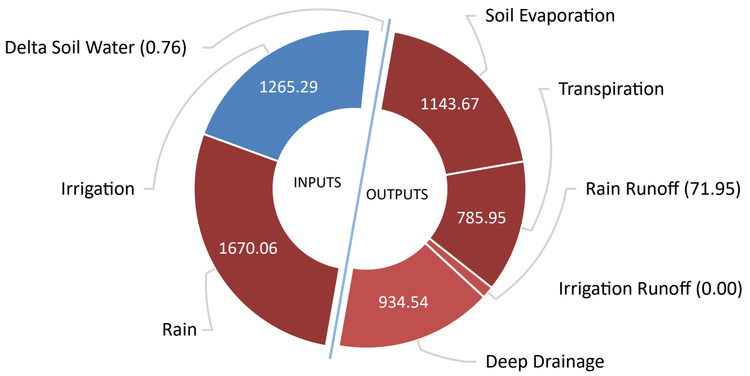
PERFORMANCE

Land Performance - Soil Water

Paddock: New Paddock, 11 ha
Soil Type: Red Earth, 136.40 mm PAWC at maximum root depth

Land Water Balance (mm/year):

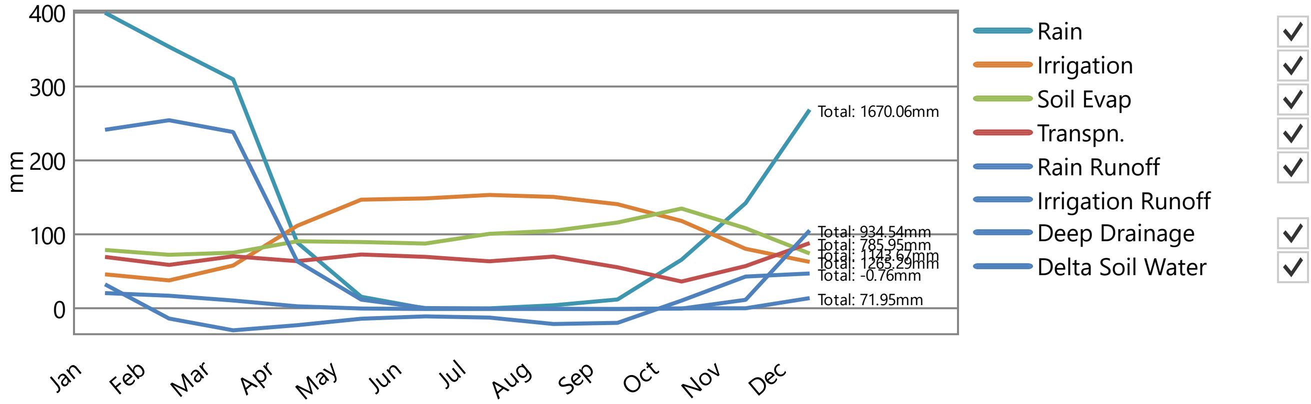
mm/year % Total inputs



Name	Value
Rain	1670.06
Irrigation	1265.29
Soil Evaporation	1143.67
Transpiration	785.95
Rain Runoff	71.95
Irrigation Runoff	0.00
Deep Drainage	934.54
Delta Soil Water	-0.76

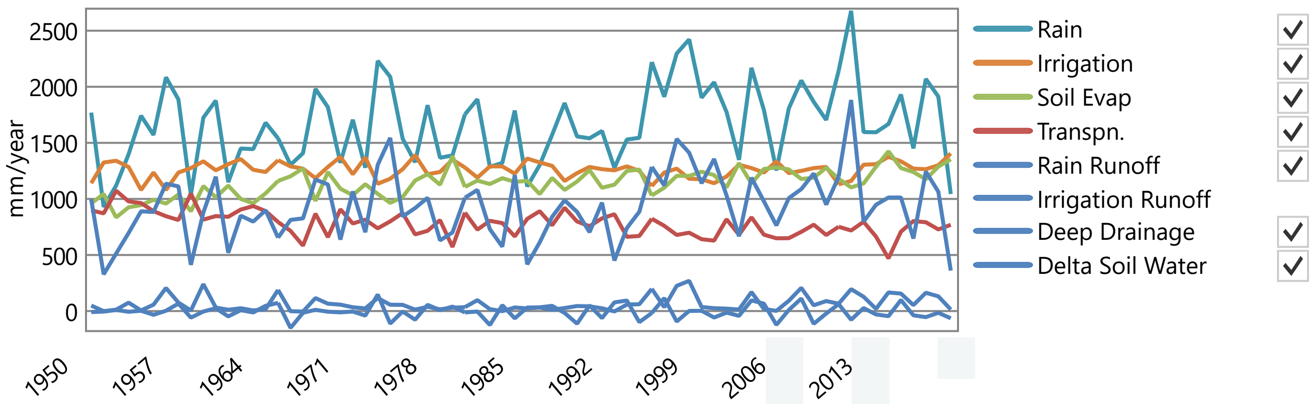
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



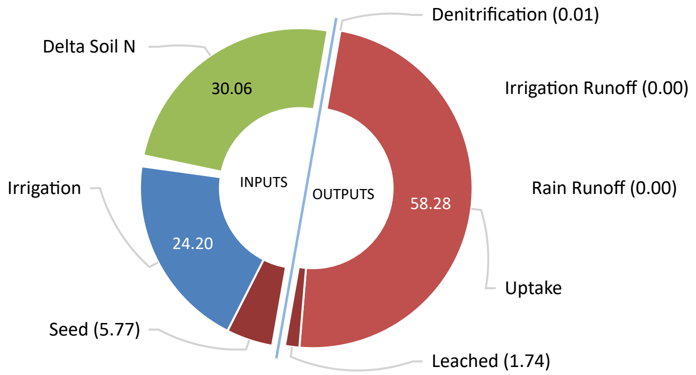
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: New Paddock, 11 ha **Soil Type: Red Earth**

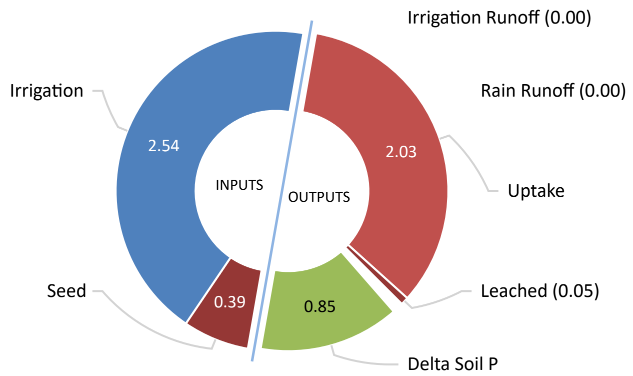
Irrigation ammonium volatilisation losses (kg/ha/year): 0.65
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.10

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	5.77
Irrigation	24.20
Denitrification	0.01
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	58.28
Leached	1.74
Delta Soil N	-30.06

Land Phosphorus Balance (kg/ha/year)



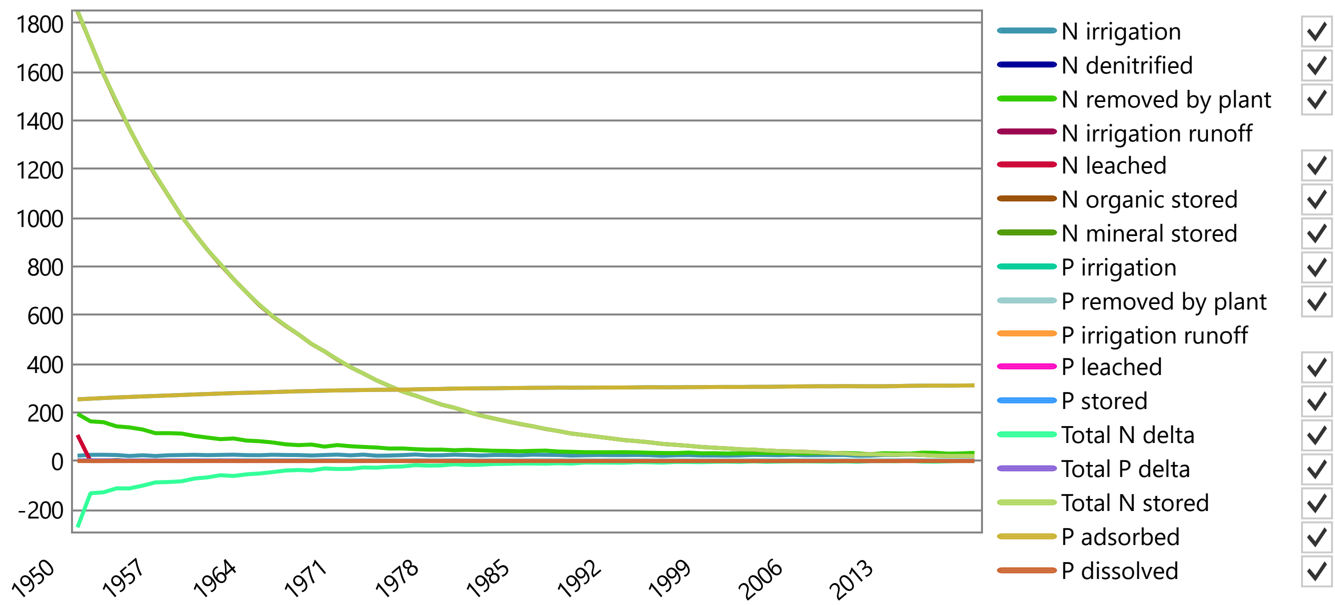
Name	Value
Seed	0.39
Irrigation	2.54
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	2.03
Leached	0.05
Delta Soil P	0.85

PERFORMANCE

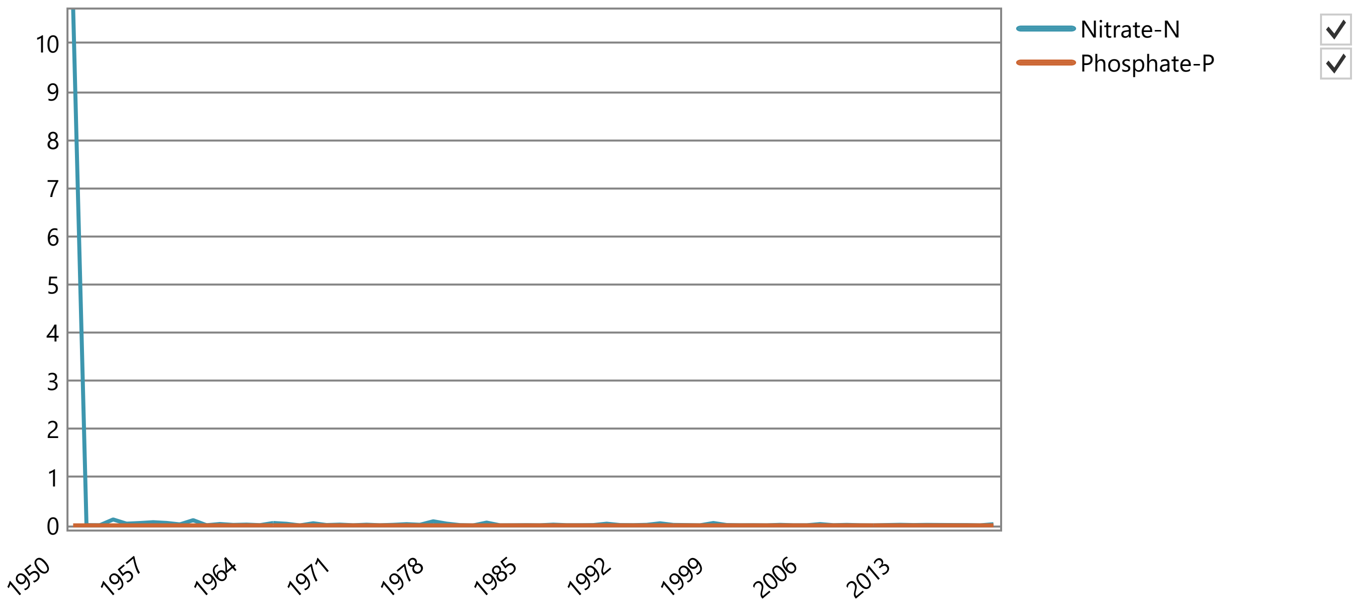
Land Performance - Soil Nutrient

Paddock: New Paddock, 11 ha **Soil Type**: Red Earth

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: New Paddock, 11 ha **Soil Type**: Red Earth

Plant: Continuous Forage Sorghum Crop

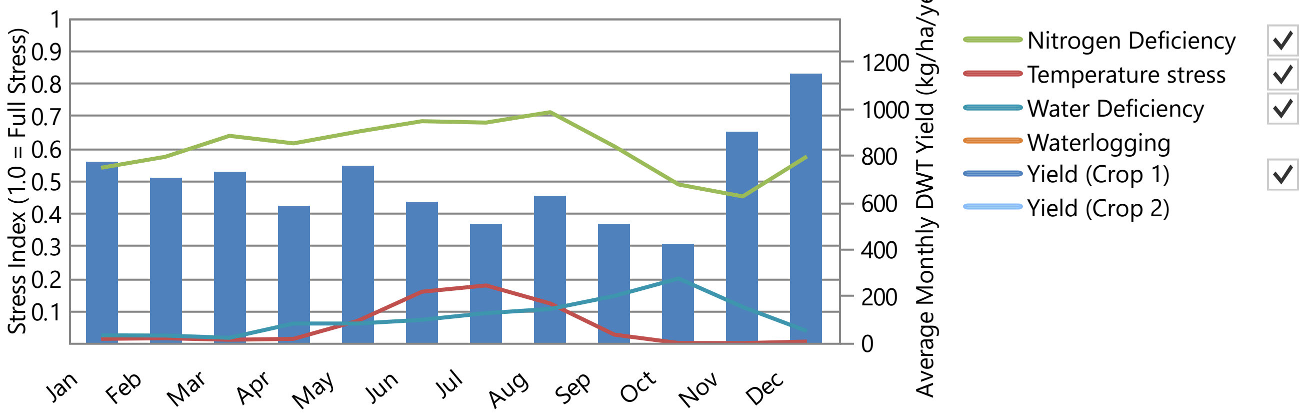
Average annual shoot dry matter yield (kg/ha/year)	8437.33 (3282.37 - 25814.08)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.45 (0.25 - 0.58)
Average monthly root depth (mm) (minimum - maximum)	1248.48 (889.87 - 1428.52)

Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	58.28 (27.77 - 193.93)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	2.03 (0.36 - 3.00)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.000 (0.000 - 0.001)

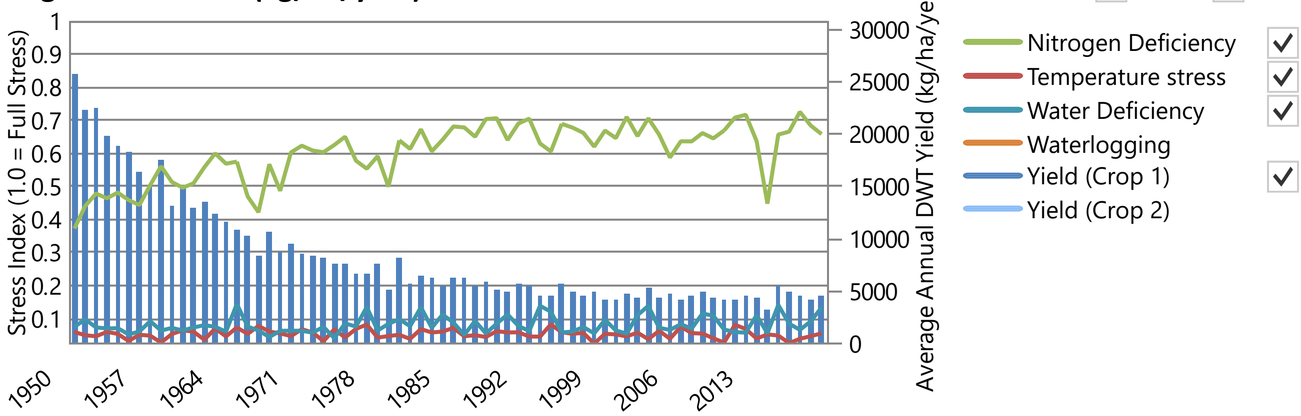
Average Monthly Yield (kg/ha/year) and Plant Stresses

Chart Table



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

Chart Table



No. of harvests/year: 3.57 (normal), 0.79 (forced by crop death due to nitrogen stress (0.77), water stress (0.01))

No. days without crop/year (days/year): 12.67 due to water stress (12.67)

PERFORMANCE

Land Performance

Paddock: New Paddock, 11 ha **Soil Type**: Red Earth

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

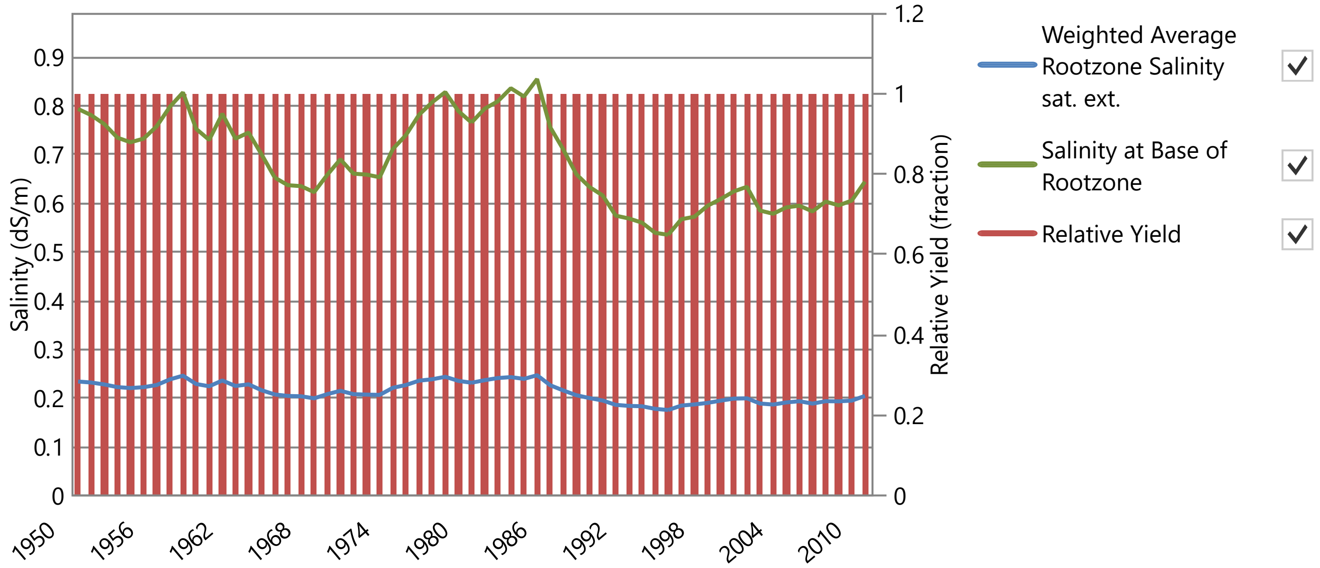
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.22
Salt added by rainfall (kg/ha/year)	306.84
Average annual effluent salt added & leached at steady state (kg/ha/year)	4118.92
Average leaching fraction based on 10 year running averages (fraction)	0.48
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.21
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.69
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



PERFORMANCE

Groundwater

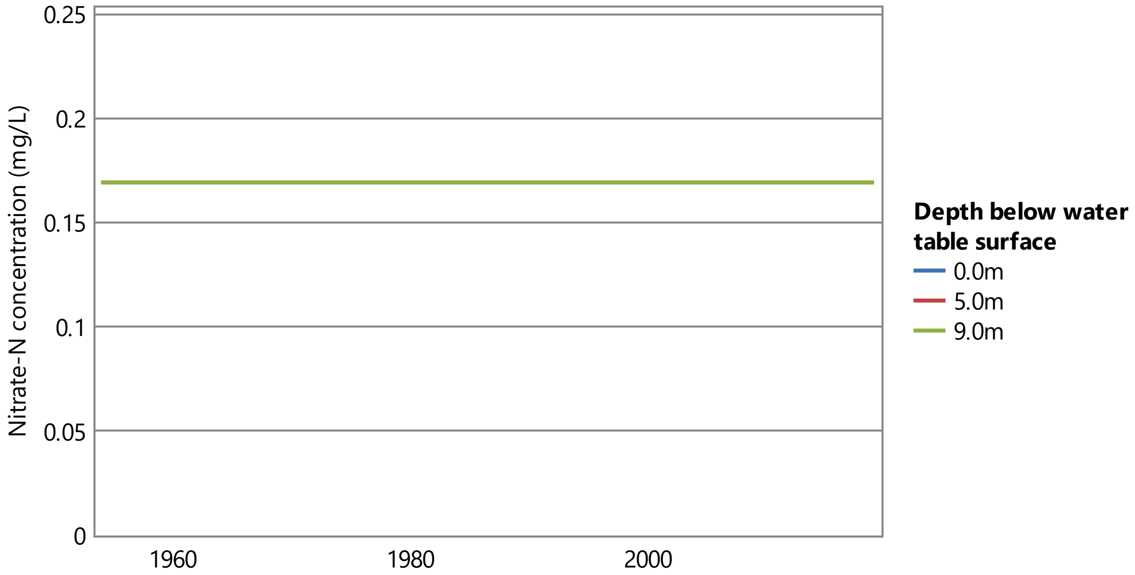
Recharge:
Average groundwater recharge (ML/day): 0.28
Average nitrate-N concentration of recharge (mg/L): 0.19

Aquifer characteristics:

Thickness (m)	10.0
Porosity (fraction)	0.1
Specific flux (mm/hour)	0.4
Vertical dispersion coefficient (m2/day)	1.0
Longitudinal dispersion coefficient (m2/day)	100.0
Retardation factor due to adsorption (multiplier)	1.0

Groundwater Nitrate-N concentration (mg/L) at property boundary, 10 m from effluent irrigation area:

■ Chart ☐ Table



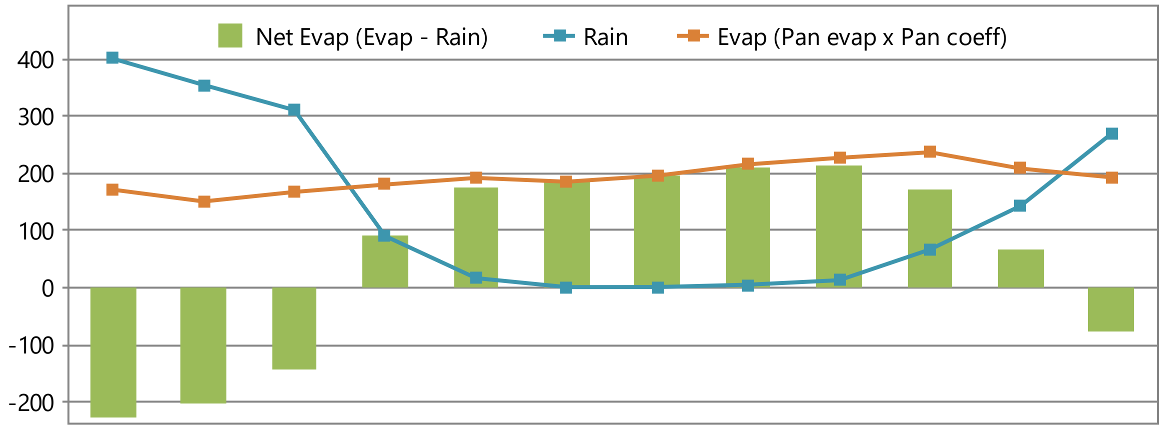
DIAGNOSTICS

Sustainability Diagnostics: Darwin Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Darwin Crocodile Farm_-12.60_131.05, -12.6°, 131.05°

Run Period: 01/01/1950 to 31/12/2019 70 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	400.4	354.4	310.4	89.9	16.5	0.8	0.9	5.0	12.8	66.6	143.1	269.4	1670.1
Evap	171.2	150.6	167.2	180.1	191.8	185.1	195.8	215.5	226.9	236.6	208.1	192.7	2321.7
Net Evap	-229.1	-203.8	-143.1	90.2	175.3	184.4	194.9	210.5	214.0	170.0	65.0	-76.6	651.6
Net Evap/day	-7.4	-7.2	-4.6	3.0	5.7	6.1	6.3	6.8	7.1	5.5	2.2	-2.5	1.8

DIAGNOSTICS

Sustainability Diagnostics: Darwin Crocodile Farm

Pond System: 1 facultative, aerobic or storage pond

Darwin Croc Farm - 690.99 ML/year or 1.89 ML/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	2.00 (2.00 - 2.00)	1381.98 (1381.20 - 1384.40)
Total Phosphorus	0.20 (0.20 - 0.20)	138.20 (138.12 - 138.44)
Total Dissolved Salts	300.00 (300.00 - 300.00)	207296.57 (207180.00 - 207660.00)
Volatile Solids	300.00 (300.00 - 300.00)	207296.57 (207180.00 - 207660.00)
Total Solids	500.00 (500.00 - 500.00)	345494.29 (345300.00 - 346100.00)

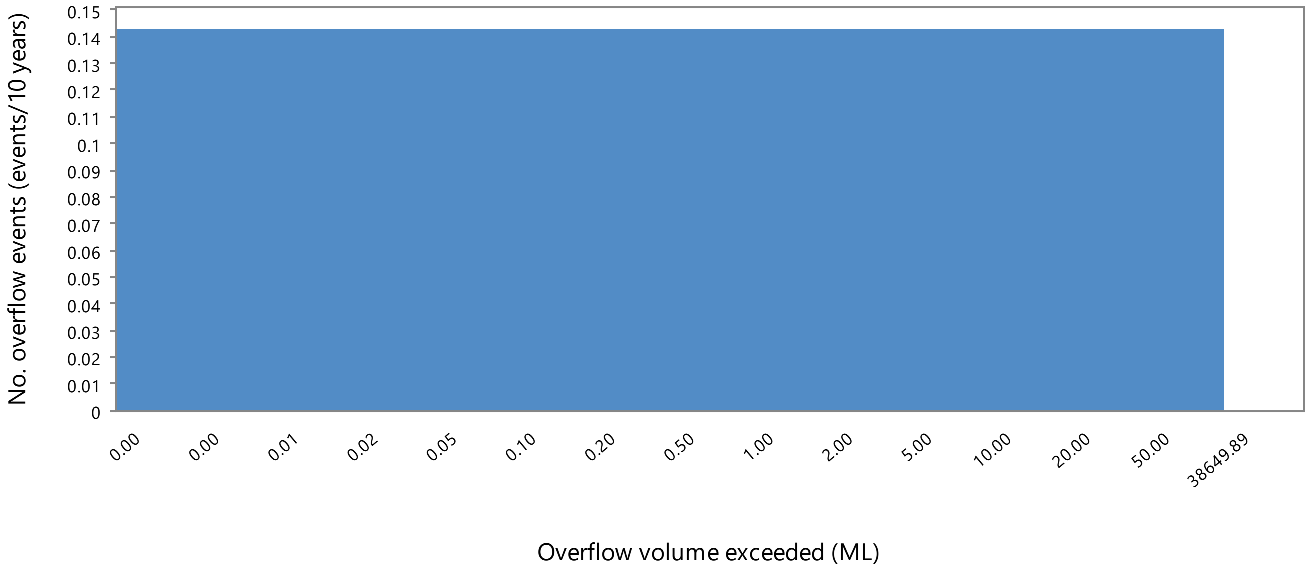
Last pond (Wet weather store): 7.00 ML

Theoretical hydraulic retention time (days)	3.70
Average volume of overflow (ML/year)	552.14
No. overflow events per year exceeding threshold* of 0.00 ML (no./year)	0.01
Average duration of overflow (days)	25562.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.20
Probability of at least 90% effluent reuse (fraction)	0.00
Average salinity of last pond (dS/m)	0.47
Salinity of last pond on final day of simulation (dS/m)	0.47
Ammonia loss from pond system water area (kg/m2/year)	0.70

* 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: Darwin Crocodile Farm

Irrigation Information

Irrigation: 11 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (ML)	139.18	12.65
Total nitrogen applied (kg)	266.15	24.20
Total phosphorus applied (kg)	27.96	2.54
Total salts applied (kg)	41932.90	3812.08

Shandying

Annual allocation of fresh water for shandying (ML/year)	0.00
Average Shandy water irrigation (ML/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)	0.31
Proportion of Days irrigation occurs (fraction)	0.69

DIAGNOSTICS

Sustainability Diagnostics: Darwin Crocodile Farm

Paddock Land: New Paddock: 11 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 0.00 mm and rainfall is less than or equal to 1.00 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): Red Earth, 136.40 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	400.4	354.4	310.4	89.9	16.5	0.8	0.9	5.0	12.8	66.6	143.1	269.4	1670.1
Irrigation	46.9	38.6	58.8	112.4	147.8	149.5	154.1	151.5	141.6	119.0	81.4	63.6	1265.3
Soil Evap	79.8	73.3	76.1	91.5	90.5	88.5	101.6	105.7	116.8	135.8	109.2	75.0	1143.7
Transpn.	70.4	59.6	71.2	64.7	73.7	70.5	64.5	70.8	56.4	37.1	58.0	89.1	785.9
Runoff	21.5	17.9	11.5	3.6	0.6	0.0	0.0	0.2	0.0	0.9	1.0	14.7	71.9
Drainage	242.2	255.1	239.2	64.4	12.6	1.3	0.5	0.0	0.0	0.5	12.4	106.2	934.5
Delta	33.3	-12.9	-28.8	-21.9	-13.1	-10.0	-11.6	-20.3	-18.7	11.3	43.8	48.0	-0.8

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	24.20
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	58.28
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.01
Average annual soil nitrogen leached (kg/ha/year)	1.74
Average annual nitrate-N loading to groundwater (kg/ha/year)	1.74
Soil organic-N kg/ha (Initial - Final)	1984.50 - 21.31
	141.30 - 0.02
Average nitrate-N concentration of deep drainage (mg/L)	0.19
Max. annual nitrate-N concentration of deep drainage (mg/L)	10.72

Soil Phosphorus Balance

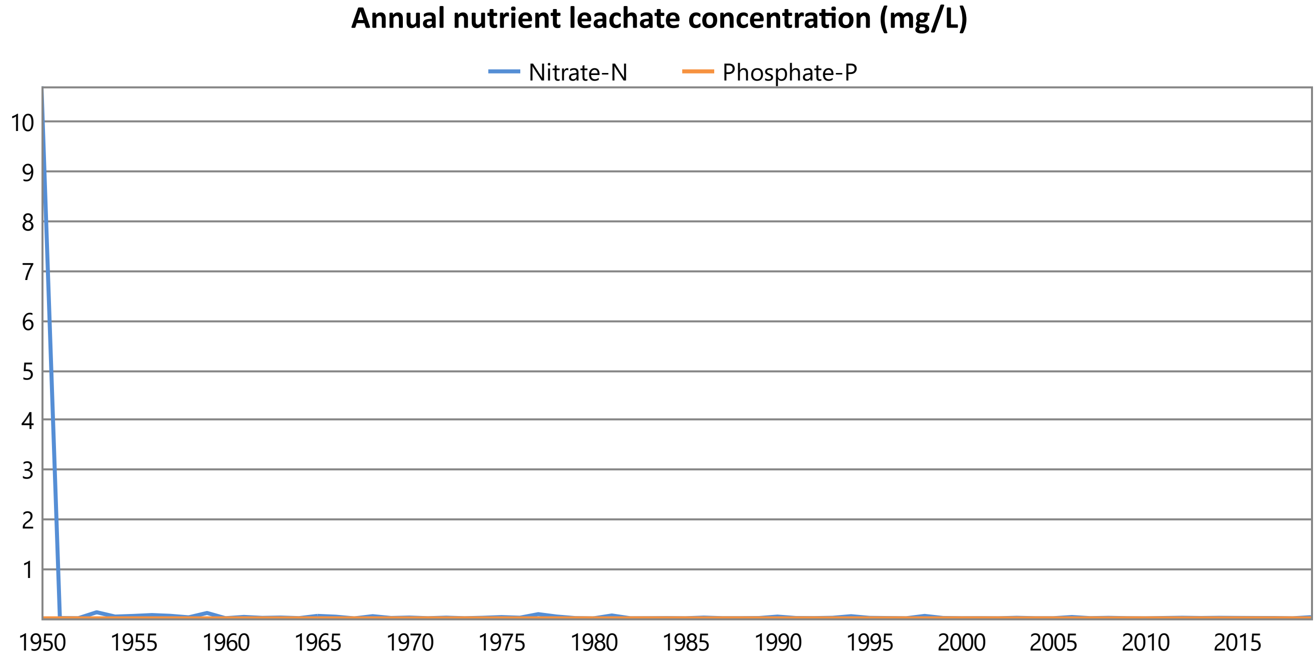
Average annual effluent phosphorus added (kg/ha/year)	2.54
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	2.03
Average annual soil phosphorus leached (kg/ha/year)	0.05
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	251.51 - 311.24
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	0.01
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 0.09 mg/L (years)	341.81

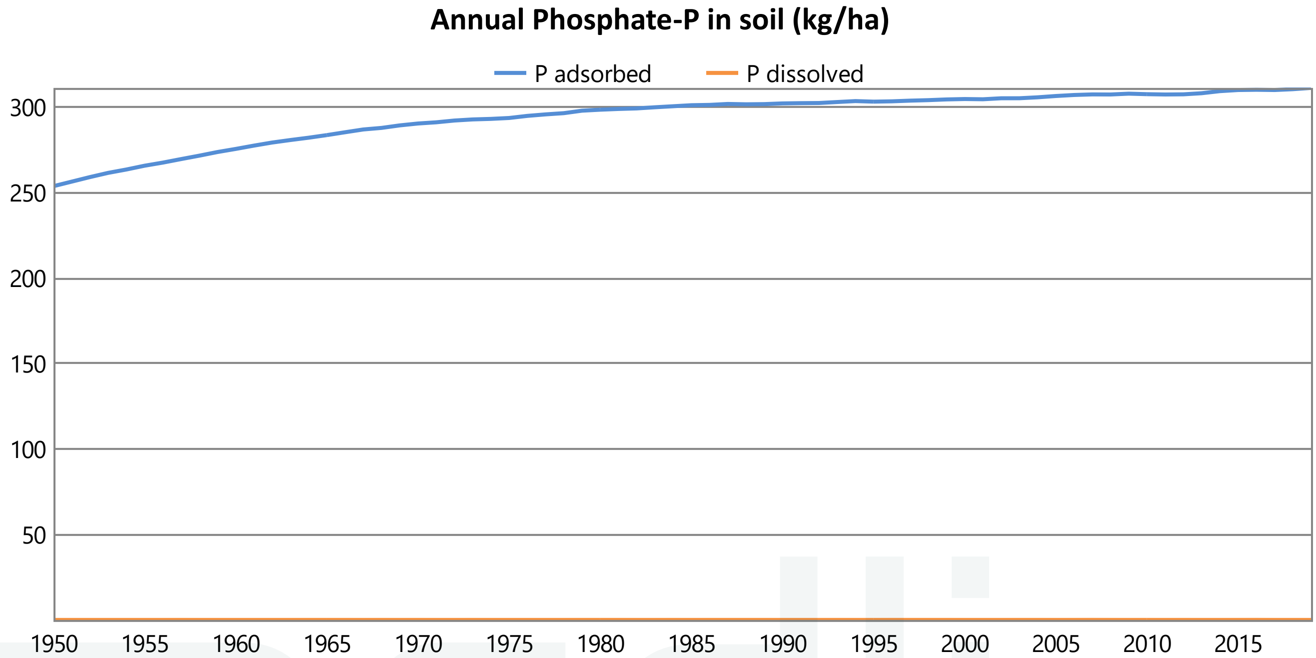
DIAGNOSTICS

Sustainability Diagnostics: Darwin Crocodile Farm

Paddock Land: New Paddock: 11 ha

Irrigation: Centre Pivot with 0.26% ammonium loss during irrigation





DIAGNOSTICS

Sustainability Diagnostics: Darwin Crocodile Farm

Paddock Plant Performance: New Paddock: 11 ha

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

Average annual shoot dry matter yield (kg/ha/year)	8437.33 (3282.37 - 25814.08)
Average monthly plant (green) cover (fraction)	0.45 (0.25 - 0.58)
Average monthly crop factor (fraction)	0.36 (0.20 - 0.46)
Total plant cover (both green and dead) left after harvest (fraction)	0.00
Average monthly root depth (mm)	1248.48 (889.87 - 1428.52)
Average number of normal harvests per year (no./year)	3.57 (2.00 - 5.00)
Average number of normal harvests for last five years only (no./year)	3.40
Average number of crop deaths per year (no./year)	0.79 (0.00 - 2.00)
Average number of crop deaths for last five years only (no./year)	1.40
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.60 (0.37 - 0.72)
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)	0.18 (0.05 - 0.32)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.08 (0.02 - 0.20)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	12.67

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)	0.22
Salt added by rainfall (kg/ha/year)	306.84
Average annual effluent salt added & leached at steady state (kg/ha/year)	4118.92
Average leaching fraction based on 10 year running averages (fraction)	0.48
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.21
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.69
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 Darwin Crocodile Farm

Porosus Pty Ltd

DOCUMENT CONTROL RECORD

Job	EZ19094
Document ID	185871-9
Author(s)	Britanny Crescentino

DOCUMENT HISTORY

Rev	Reviewed by	Approved by	Issued to	Date
1	Emma Lewis	Ray Hall	Porosus Pty Ltd	14/02/2020

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

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APPROVED COMPANY AS/NZS 4801 Occupational Health & Safety Management Systems — QMS Certification Services
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Appendices

1 INTRODUCTION

This document lists procedures to be followed by Porosus Pty Ltd (Porosus) management, staff and contractors to ensure that the reuse of wastewater via terrestrial irrigation is managed appropriately at the Darwin Crocodile Farm (DCF). This document has been developed in association with the Environmental Protection Licence (EPL) 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 one the EPL is issued, to reflect any conditions identified.

DCF recognise the importance of finding a solution to wastewater management and preventing uncontrolled discharge of untreated wastewater offsite and negatively impacting the surrounding 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 unstainable 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 can drift towards surrounding neighbours and sensitive receptors.
2) Ensure daily visual inspection 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 area 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 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 use 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 boundaries.
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 identify if soil saturation is the likely cause.
9) Commence 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 areas too saturated for irrigation application?								
2.	Is there water pooling? (if yes, where)								
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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