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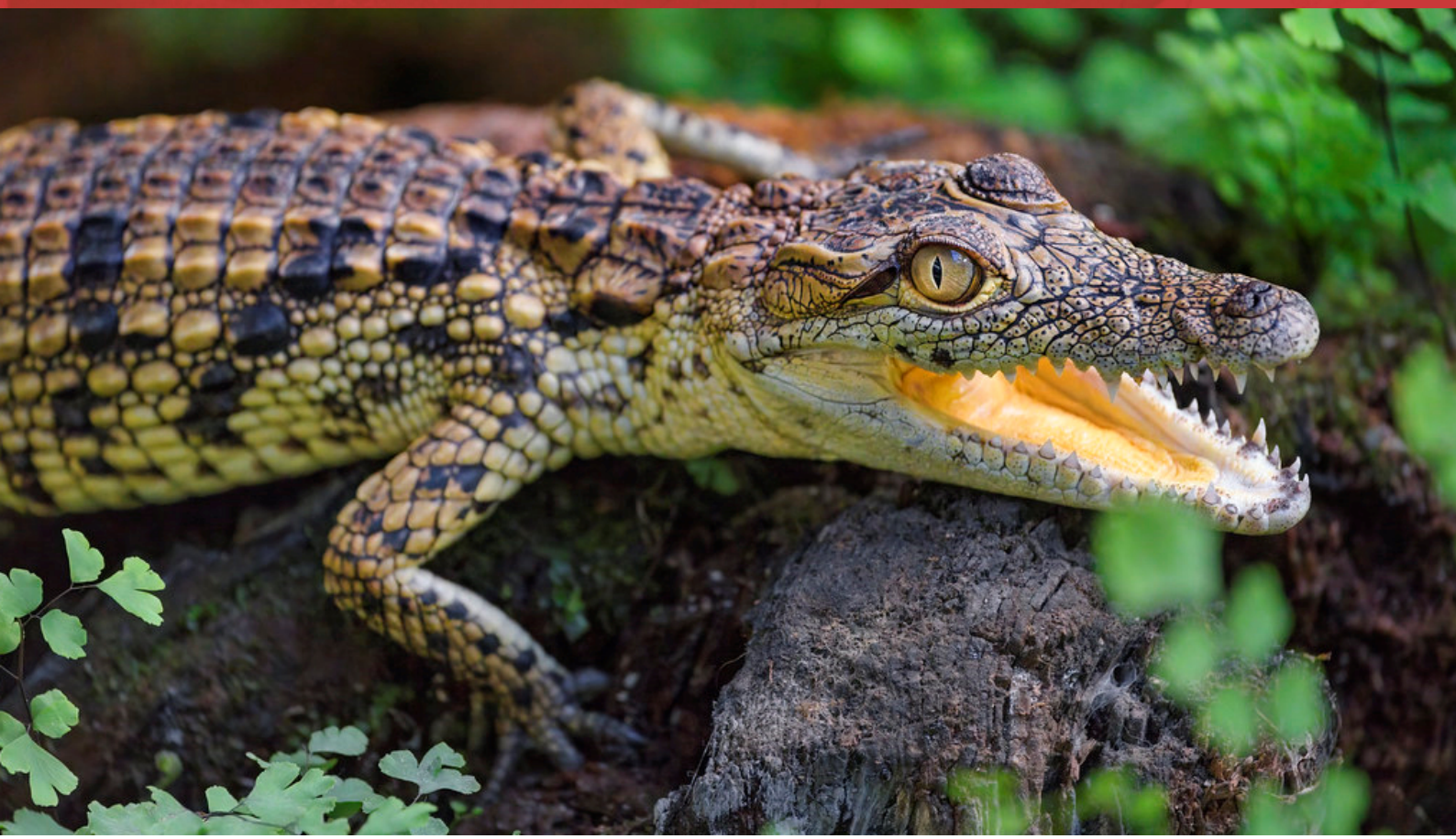
Supporting Information for the Ramingining Crocodile Rearing Facility EPL application

Arafura Swamp Rangers Aboriginal Corporation



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ACRONYMS

ADWG	Australian Drinking Water Guidelines
ALPA	Arnhem Land Progress Authority
ANZECC	Australian and New Zealand Environment and Conservation Council
ASS	acid sulfate soils
ASRAC	Arafura Swamp Rangers Aboriginal Corporation
BOM	Bureau of Meteorology
BTEXN	Benzene, Toluene, Ethylbenzene, Xylene and Naphthalene
CSM	Conceptual Site Model
DCF	Darwin Crocodile Farm
DIW	Directory of Important Wetlands
EC	Electrical Conductivity
EPA	Environmental Protection Approval
EPL	Environmental Protection Licence
ESC	Erosion and Sediment Control
ESP	Exchangeable Sodium Percentage
LOR	Limit of Reporting
LTV	Long term Trigger Values
MEDLI	Model for Effluent Disposal via Land Irrigation
NEPM	National Environment Protection Measures
NT	Northern Territory
NT EPA	Northern Territory Environmental Protection Agency
NTG	Northern Territory Government
RCRF	Ramingining Crocodile Rearing Facility
TPH	Total Petroleum Hydrocarbons
TRH	Total Recoverable Hydrocarbons
TPWC Act	*Territory Parks and Wildlife Conservation Act (Northern Territory)*
WQO	Water quality objectives

1 INTRODUCTION

The Arafura Swamp Rangers Aboriginal Corporation (ASRAC) propose to operate the Ramingining Crocodile Rearing Facility (RCRF), for the commercial production of saltwater crocodiles (*Crocodylus porosus*) for meat and skin products (to be completed at another facility by an external company to ASRAC). The proposal involves the incubation and hatching of harvested crocodile eggs, and the grow out of hatchlings up to 90cm. Hatchlings will be sold to crocodile farms in Darwin, and transported via truck, for the grow-out and processing phases. The site is located on 14 Ganinydja Road, Ramingining, Part NT Portion 1646 (NT Portion 1646 being the entirety of Arnhem Land).

RCRF is currently being constructed in two stages, with operations combining both stages so the facility operates as a whole. Stage one encompasses the incubation building, four crocodile pens, auxiliary infrastructure and irrigation infrastructure. Stage two encompasses the remaining eleven crocodile pens, future caretakers residence, future ancillary buildings and future irrigation areas (if required).

This document presents information to support the Environmental Protection Licence (EPL) application for stage one of this project; operation of the incubation and hatchery, and will be included within the online EPL application process.

The document structure addresses the information requirements specified in the NTEPA's *Guide to Environment Protection Approvals and Licences Under the Waste Management and Pollution Control Act* (NTEPA, 2013).

1.1 Purpose and scope

The nature of the crocodile rearing 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 (WMPC) Act*, ASRAC is applying for an Environment Protection Licence (EPL) to address the storage, recycling and disposal of animal effluent. An amendment to the EPL will be sought for the subsequent stage two of operations during 2022.

This supporting document has been developed to establish a framework for identification, management, monitoring and reporting of potential environmental impacts associated with the stage one project operations.

The objectives of this plan are:

- To prevent or minimise pollution or environmental harm from the stage one operational activities.
- Ensure that the premise is operated in a manner that provides for suitable storage, recycling and treatment of the wastewater from animal effluent and residues (a listed waste), so that the future operational activities can be licensed under the NT *WMPC Act.*
- To adhere to conditions of applicable licence approvals and permits.

1.2 Approvals

Development Permit

A Development Application (DA) was prepared and submitted to the NT Development Consent Authority, a division of the Department of Infrastructure, Planning and Logistics (DIPL). An Exceptional Development Permit (EDP) was granted as EDP17/0001.

Environmental Protection Approval and Licence

Construction and operation of the RCRF will be regulated under the *WMPC Act* because the water discharged from the crocodile pens will contain crocodile effluent, faeces, residual feed and other 'crocodile wastes', which are classified as 'animal effluent and residues' and therefore are a **listed waste** under the Act. An Environment Protection Approval (EPA) for works associated with construction of the premises has been sought and, at the time of writing this report, was undergoing assessment. An Environment Protection Licence (EPL) is required for the crocodile rearing operations. This document provides supporting information for Stage one operations only. Prior to operation of Stage two – an EPL amendment will be sought to cover the facility expansion, and information in the amendment will include updated site details (e.g. site specific water quality data and revised wastewater irrigation modelling).

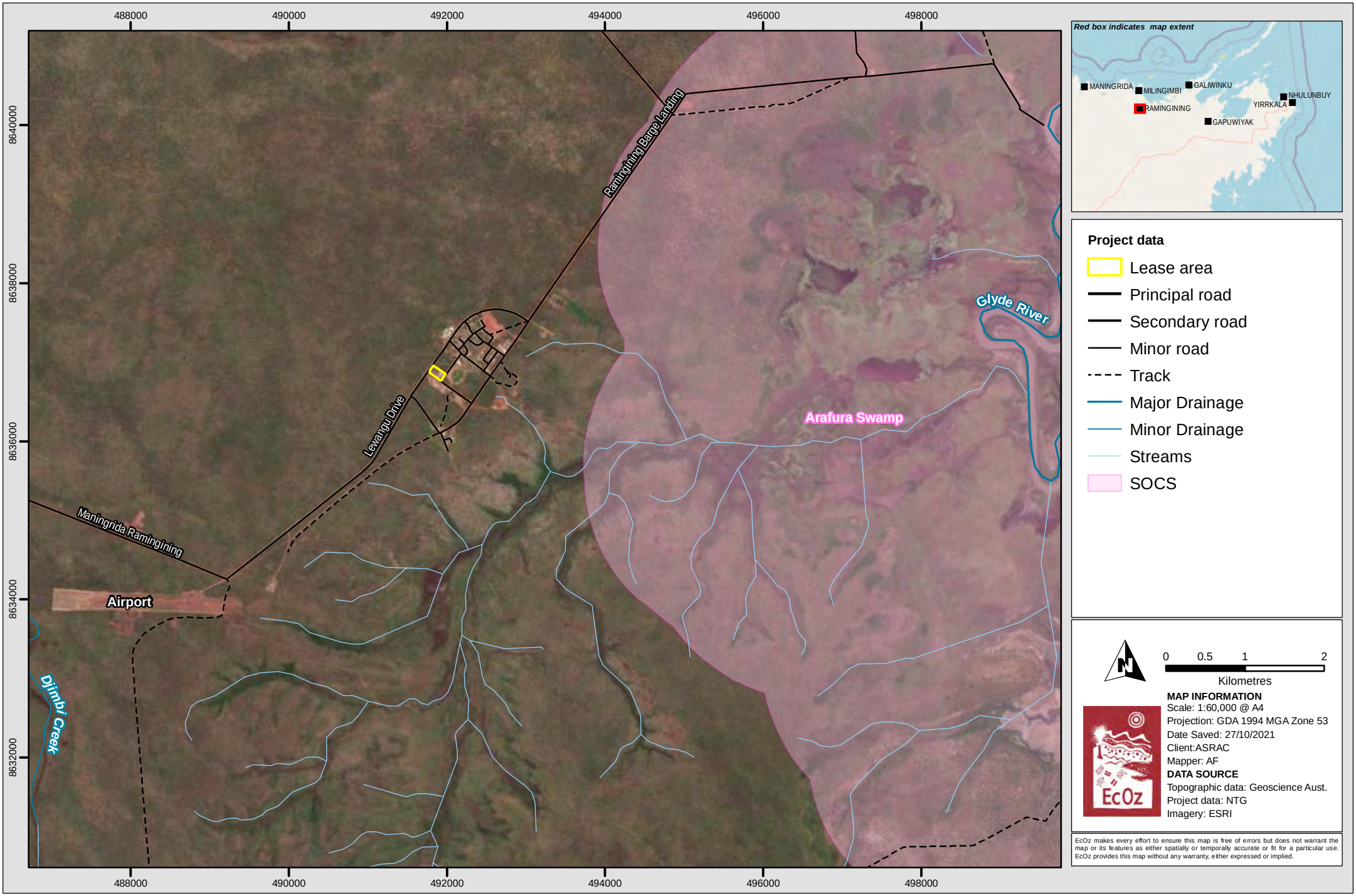

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Figure 1-1. Map location of RCRF

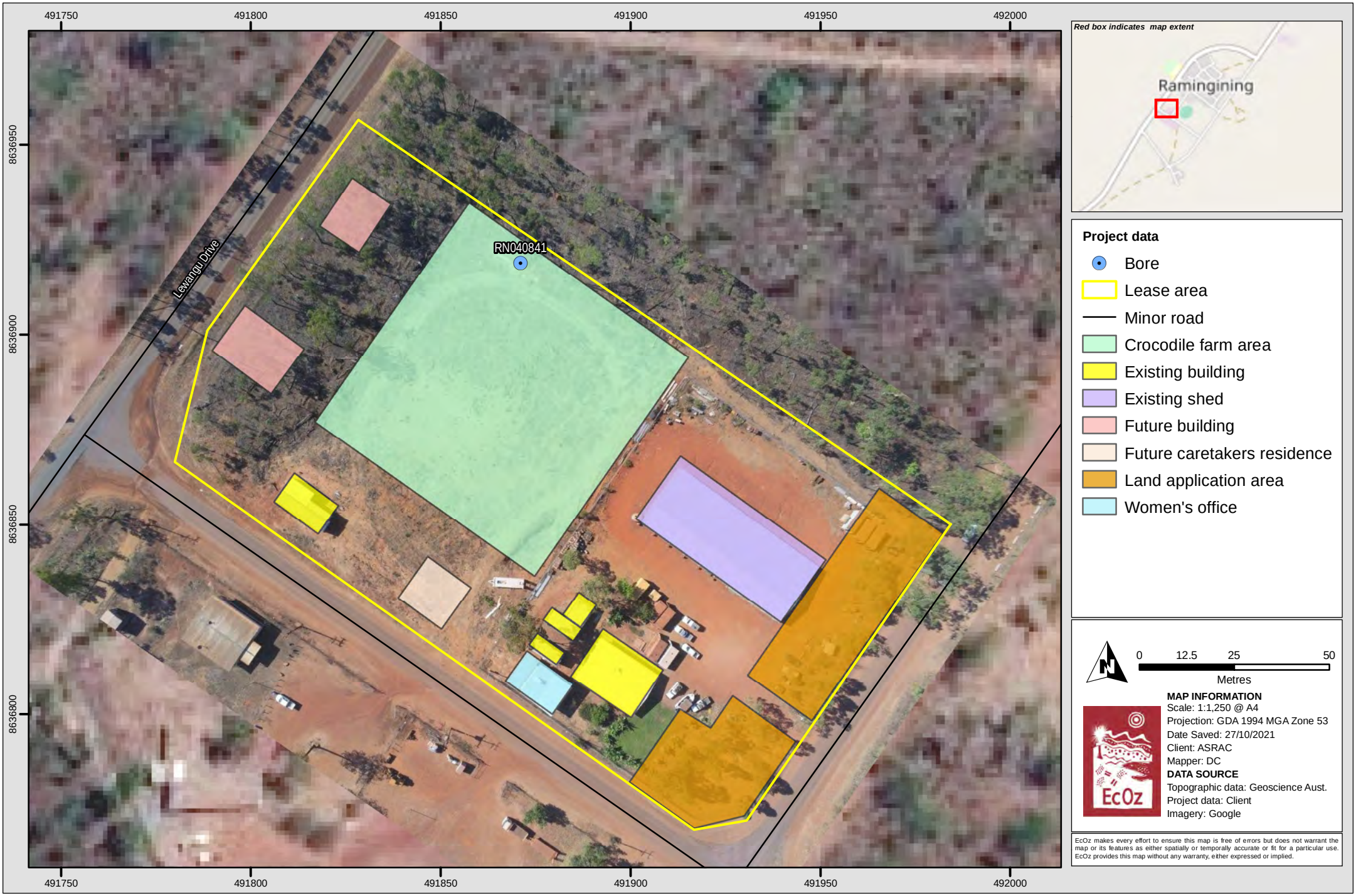

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Figure 1-2. Map of RCRF layout

2 SITE DESCRIPTION AND EXISTING ENVIRONMENT

2.1 Location

Ramingining is in Arnhem Land, approximately 580 km east of Darwin and 435 km west of Nhulunbuy. The land proposed for the RCRF is located on Part NT Portion 1646 in Ramingining, bounded by Lewangu Drive to the north, Ganinydja Rd to the west and Warrk Road to the south and is currently leased by ASRAC. The lease area of Part NT Portion 1646 is approximately 1.6 ha in size, and land consists of predominantly remnant native vegetation cover, with existing buildings and infrastructure used by the ASRAC Rangers located in the southern corner of the lot. The RCRF is proposed to be located adjacent to the existing infrastructure, in an already cleared area in the western portion of the lot. The RCRF will require approximately 0.5 ha of land, in addition to the land already developed for ranger infrastructure, as well as an additional 0.3 ha of land for irrigation of wastewater.

2.2 Site history

All of Arnhem Land was proclaimed as an Aboriginal reserve in 1931, and the Yolngu people have been recognised as native title holders to parts of eastern Arnhem Land, including Ramingining and surrounds (East Arnhem Regional Council, 2020). In addition, Arnhem Land is detailed as Schedule 1 land of the *Aboriginal Land Rights (Northern Territory) Act 1976 (Cth)* (ALRA). Ramingining township was established in late 1971 as a result of the conversion of Ngangalala (the original landing point site on the Glyde River fir the Arafura cattle venture) from an outstation to a community. Today, Ramingining is now the major community and Ngangalala is a homeland community, 8 km north-east of Ramingining (RAHC, 2014).

The location of the RCRF is the base of the ASRAC Rangers, and the land contains infrastructure to support the rangers, such as an office and sheds. The RCRF is located adjacent to the existing ranger station.

2.3 Surrounding land and sensitive receptors

Across Ganinydja Road to the south are commercial properties including an Alpa Express Petrol Station. To the north-east of the property there is an arts centre, as well as a council office and church. To the east across Warrk Road is parkland and an oval, as well as a number of residential and commercial properties, approximately 500 m to the north-east. Land to the north-west, across Lewangu Drive, is vacant bushland. The Arafura Swamp is located approximately 4.5 kilometres to the east.

Arafura swamp

The RCRF site is located 4.5km to the west of the Arafura Swamp. The Arafura Swamp is characterised by grass and sedgeland plains, paperbark forests, lagoons and sandstone hills in the upper catchment area. Woodlands and patches of rainforest fringe the swamp. The swamp is the largest freshwater ecosystem in Arnhem Land and the largest paperbark swamp in Australia, and holds significant ecological and cultural value, including habitat for 27 threatened species listed under the EPBC Act. Under a new proposal the Arafura Swamp will become an Indigenous Protected Area (IPA), where Traditional Owners work on country to protect biodiversity and conserve cultural resources. Given the distance of the Arafura Swamp to the RCRF, the project works are unlikely to impact on the values of the Arafura Swamp.

The Arafura Swamp is listed on the Directory of Important Wetlands (DIW). The DIW identifies nationally important wetlands, as well as providing knowledge on wetland definitions and the flora and fauna species that depend on them. The wetland spans 71,400 ha providing a variety of ecological features and cultural features, whilst also hosting a plethora of flora and fauna species.

The facility development is unlikely to have any significant impact on the conservation values of the Arafura Swamp. The footprint of the RCRF is small and is ~2km from the outer boundary of the SOCS area.

2.4 Land suitability

2.4.1 Climate

Rainfall and evaporation

The site is located in a tropical climate area, with distinct wet (November to April) and dry (May to October) seasons. Typically, for this region, humidity, maximum and minimum temperatures are highest in the wet season and annual evaporation far exceeds annual rainfall.

Climate data is sourced from the Bureau of Meteorology (BoM) Milingimbi Airport weather monitoring station (station ID 014404), located 26.5 km north-west of the site. Given the scarcity of readings, data from 1923 to 2021 has been used. Average annual rainfall at Milingimbi is 1,113.9mm with an average annual temperate of 31.4º Celsius. Rainfall is highest in January, while temperature is highest in November.

Average evaporation data, (point data collected for Ramingining from the Queensland Government SILO database) was analysed in the MEDLI modelling (refer to Appendix A), which was obtained for the region.

Table 2-1. Average rainfall (mm) and temperature max (°C)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	253.2	237.5	251.4	115.2	21.7	6.7	1.8	0.8	1.1	10.9	49.1	176.4	1113.9
Temperature Max (°C)	32.1	31.6	31.5	31.8	31.0	29.4	28.9	29.9	31.3	32.6	33.6	33.2	31.4

Wind

Wind roses were not available at Milingimbi Airport, therefore representative wind direction and wind speed were retrieved from Gove and are presented in Table 2-2. Maximum monthly wind speed gusts were available for the site and are presented in Table 2-3.

Table 2-2. Annual wind Roses for Gove Airport (BoM, 2021)

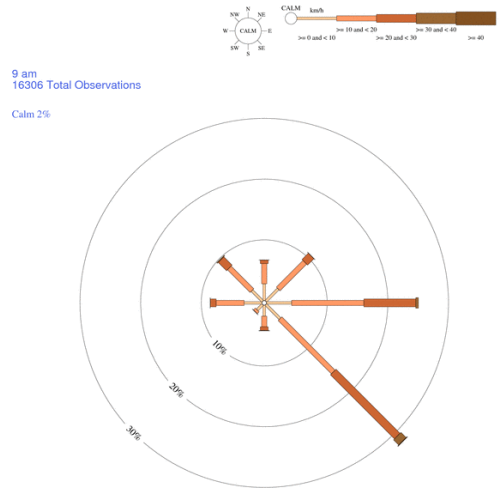
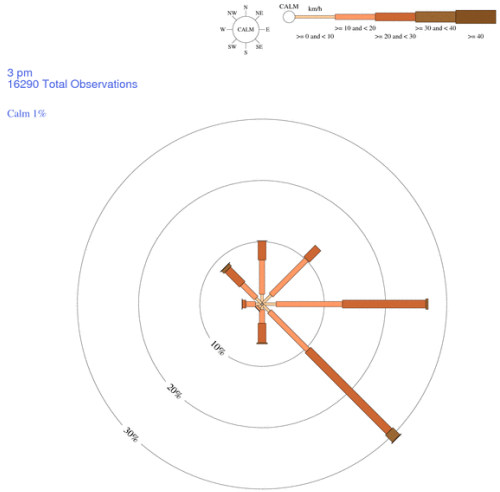
Annual – 9am	Annual – 3pm
	

Table 2-3. Maximum monthly wind gust speeds (Milingimbi Airport, BoM 2021)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max wind gust speed (km/hr)	80	80	104	68	54	57	57	55	57	68	61	91	104

2.4.2 Flooding

The risk of flooding is minimal, with a series of well-established drains throughout the project area. The closest major waterway is the Glyde River, located over 7 km from the site.

2.4.3 Topography and drainage

The project area is relatively flat with a gradient of <2%. The project area is moderately well drained allowing soil infiltration with minimal surface water runoff. Surface water drainage will flow east to ephemeral streams which flow on into the Glyde River, within the Arafura Swamp, before discharging into Castlereagh Bay 10 kms to the north.

2.4.4 Soil and vegetation

Baseline soil sampling was undertaken in September 2021, at five locations at three depths (surface, 0.5 m and 1.0 m). The results of the sampling identified the following:

- Soil colour was predominantly classed as brown, with variations including strong brown, yellowish brown and reddish brown. Soil texture is Sandy Loam.
- The soils are non-saline, with a low Electrical Conductivity (EC) (<45 µS/cm) and average pH of 6.27.
- Most soils are classified as non-sodic (<6) with an average exchangeable sodium percentage (ESP) of 3.6%. One out of the fifteen samples collected recorded an ESP of 8.6%.

- Soils are mostly dispersive. Soils are mostly classed with an Emerson class of 3 (class 1 being complete dispersion). Three out of the fifteen samples collected have am Emerson class number of 2. This may pose a potential problem with soil loss through dispersion and runoff.
- Total Nitrogen (TN) levels ranged from 150 mg/kg to 660 mg/kg, averaging an TN concentration of 350 mg/kg. Total Phosphorous (TP) levels ranged from 51 mg/kg to 91 mg/kg, with an average TP concentration of 74 mg/kg
- Soils recorded low concentrations of *E.coli* and Faecal Coliforms, at or below the limit of reporting (LOR). Enterococci concentrations between 65 MPN/g to 240MPN/g.
- Total metal results were compared to the National Environmental Protection Measure (NEPM) guidelines for soil (2013) and the preferred levels for crop/plant growth (NSW DPI, 2004). All metals were within acceptable guideline limits.

See Appendix A for soil quality results within the Irrigation Management Plan (IMP).

A large percentage of the project area has previously been cleared and is under use by the Ramingining Rangers with buildings placed in the southern part of the lot. Overall, the results and site observation determined that the soil and land is suitable for crop growth.

2.4.5 Pests and weeds

A review of the NT Weeds Record Database, available from DEPWS, identified that there are no weed or pest records from the RCRF. Communications with ASRAC confirmed that there are no existing weeds in the project area.

2.4.6 Surface water

There are no water bodies or defined drainage lines in the RCRF, or immediate surrounds. It is assumed that any surface water from the RCRF would flow, via overland flow, toward the east to the surrounding areas (i.e. Ramingining) and into any potential stormwater drains that may be present. Given the distance to the Arafura Swamp, it is unlikely that any runoff from the RCRF would reach the Arafura Swamp or its tributaries.

Approximately 500 m to the east of the RCRF, minor ephemeral drainage lines form, directing surface runoff to the south-east before flowing east in a tributary of the Glyde River. The Glyde River, which is the main outflow of the Arafura Swamp, flows north for approximately 10 km before discharging into the sea at Castlereagh Bay

The RCRF is not within a water control district, nor are there any declared beneficial uses.

2.4.7 Groundwater

The RCRF is underlain by the Arafura Basin, which is located on the northern margin of Australia in the Arafura Sea and extends from onshore Northern Territory to beyond the Australian-Indonesian border. The aquifer is a fractured and weathered sandstone, with yields ranging from 0.5 L/s to 5.0 L/s.

A registered bore is located on site, Arafura Swamp Rangers Bore (RN040841). The bore was drilled and constructed in 2018, with a completed depth of 36mbgl and a yield of 3L/s (NR Maps, 2021). The standing water level after construction of the bore was 17mgbl. The bore will be utilised to provide water for construction and operation of the crocodile rearing facility. The aquifer is of sufficient yield for local small-scale use.

There are very few groundwater bores located in the direct vicinity of the RCRF. The closest neighbouring bore is located at the oval, approximately 200 m south-east of the RCRF. The next closest bores are located over 500 m to the south and east of the site. Groundwater in these bores is deep (>30 m) based on bore

reports (NR Maps, 2021). The Ramingining water supply is sourced from groundwater; with water supply bores (RN025813 and RN025816) located 800 m south of the RCRF.

Based on topography, it is assumed that groundwater flows toward the east/south-east, toward the Arafura Swamp.

Groundwater quality

The bore within the RCRF, RN040841 and the potable water (from facility taps) were sampled on 1 September 2021, with water quality results indicating it is suitable for crocodile rearing purposes and for potable use, respectively, with the exception of arsenic (as discussed below).

The results were compared against the *Primary Industries Long-term Trigger Values (LTV) for Irrigation* (ANZECC [2000]), *Environmental Guidelines – Use of Effluent by Irrigation* (DEC, 2004) and the *Australian Drinking Water Guideline* (ADWG, 2011) as a conservative assessment for potable water use.

Overall, the water quality from both sources is below the ANZECC (2000) guidelines for Primary Industries LTV for Irrigation and the ADWG with pH's of 6.63 and 6.19 for the bore and potable water respectively. The water is classed as freshwater with an average EC of 35 µS/cm. Both samples were below the DEC 2004 guidelines for all parameters analysed. It is noted however, as the facility is currently not operational, the samples collected are not representative of the effluent that is to be irrigated, but is rather representative of the facility's source water, prior to any animal effluent inputs. All results for dissolved metals and nutrients were within the guideline limits, with the exception of one parameter; arsenic. The arsenic concentration was 0.031 mg/L within the potable water sample (connected to the Ramingining town water supply bore), which exceeds the ADWG (0.01 mg/L). An additional water sample was collected in October 2021, in which the arsenic concentration was below the LOR. The remainder of the dissolved metals and nutrient concentrations were within guideline limits.

See Appendix A for groundwater and potable water quality results, within the IMP.

Riparian areas, sinkholes and groundwater dependant ecosystems

No riparian vegetation or sinkholes are located within or immediately proximate to the RCRF. Groundwater Dependant Ecosystems (GDE's) are mapped downstream of the RCRF within the Arafura Swamp, approximately 4 km away (BoM GDE Atlas, 2021).

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Figure 2-1. Map of topography and surface water direction

3 PROJECT DESCRIPTION

3.1 Overview

ASRAC plan to operate a crocodile rearing facility in Ramingining, which will include the incubation of harvested eggs, and the grow out of hatchlings to 90 cm. Hatchlings will be transported to Darwin crocodile farms for further grow-out.

The RCRF will be developed in stages, with stage one comprising 4 hatchling pens, and Stage two consisting of another 11 pens, totalling 15 pens at full capacity. Stage one is to be constructed first, with expansion to occur over the next 2 years. The general rearing process is as follows:

- Crocodile eggs harvested in January
- Eggs incubated at the RCRF until April
- Hatchlings grown out in pens until October/November, then trucked to Darwin
- Pens decommissioned until the following season.

The pens will only be operational during the dry season months, and egg harvesting and incubating will be the only wet season activities.

Pens will have a capacity of approximately 90 crocodiles each. Water will flow through the pens, with each pen using approximately 260-270L per day. It is envisaged that, when the RCRF is fully operational, approximately 4,000L of water will be used per day across all 15 pens. All wastewater will be collected and treated prior to disposal via irrigation onsite. The crocodiles will be fed buffalo meat; meat will be brought to site butchered and de-boned, and then the meat will be minced onsite. Feed will be stored in the freezer and fed to the hatchlings each day. There will be no waste associated with the mincing of meat onsite. No other inputs (e.g. antibiotics, additives) will be in the feed. Wastewater will therefore contain some waste feed (minced meat) and crocodile excrement.

3.2 Site layout and design

RCRF is located on a portion of parcel 1646, adjacent to Lewangu Drive with an area of approximately 1.6 ha. All stage one activities will be conducted on the existing parcel. Further detail regarding water treatment, water collection, source water and infrastructure at the site is detailed in the IMP in Appendix A.

3.2.1 Physical components

Stormwater management

The land disturbance that will occur during construction has potential to increase sediment loads in stormwater runoff from the area. The potential for erosion and off-site movement of sediments is limited because the land is relatively flat (<2%) and rainfall during the time of construction is minimal as it will be during the dry season, however, erosion and sediment control (ESC) structures will be applied for the construction area if construction works were to occur in the wet season.

Incubator, service slab and freezer

The crocodile eggs will be collected by rangers and incubated onsite, in a room located adjacent to the service slab and freezer. The service slab will be used for food preparation and other operational activities, and the freezer will store minced buffalo meat which will be fed to the hatchlings.

Pens

Once eggs hatch, hatchlings will be moved into the pens. Four pens will be installed at the site initially, with another 11 (totalling 15) added when the RCRF is running at full capacity. The pens will be in three rows of 5, all on a concrete slab. The plastic pens are prefabricated offsite and installed onsite, with plumbing and water heating infrastructure installed at site. The pens have an opening hatch in the roof, used to access the pens, feed the crocodiles and monitor health etc. Each pen is approximately 3 m by 3 m, with a capacity of 90 crocodile hatchlings per pen. A drain will run along the centre of the base of the pen, where wastewater will be collected and drained from the pen, reporting to the wastewater treatment area.

3.3 Key operational activities

3.3.1 Schedule

The operations will commence on a small scale for the first 12 months, with up to 360 grower crocodiles (4 pens). At full capacity (i.e. all 15 pens online), in approximately 2 years time, the RCRF is expected to produce up to 1,350 crocodiles.

3.3.1 Operations overview

The development footprint for the RCRF infrastructure, including the accommodation and wastewater irrigation area is approximately 1.6 ha. This includes the existing ranger building and infrastructure, which cover approximately 1 ha of land. The key components of the RCRF are:

- Internal roads/driveways
- Fencing – security and internal separation fencing
- Concrete pad for RCRF infrastructure
- Incubation room, service slab (for workers to prepare feed etc) and freezer
- Crocodile pens
- Water management infrastructure:
  - Bore and water storage tanks; bore water will supply the RCRF, and town water will supply potable water to service area
  - Pumps and plumbing pipework
  - Wastewater storage tanks
  - Wastewater treatment system; collection tank, parabolic screen, holding tank, and irrigation system for wastewater disposal.)
  - Bore storage tanks, plumbing
- Irrigation area (approx. 2,000m^2 for Stage one)
- Gas hot water system, to heat water for hatchling pens
- Future construction
  - Caretakers residence
  - Ranger accommodation
  - Women's office (constructed in 2019)
  - Additional office buildings
  - Additional land application area

The location and positioning of the RCRF infrastructure has been designed with consideration of local topography for stormwater management and proximity to neighbouring properties, to minimise impacts from potential noise, and air (dust and odour) emissions. Positioning and design of the pens is also critical for the animal's health, preventing stress and disease. The primary wastewater treatment area is located to the north of the incubation building, for greater separation distances to neighbouring properties, minimising potential noise and dust issues during construction and odour issues during operations.

3.3.2 Water demand

When in full operation, the RCRF is anticipated to use 4,000L of water from the onsite bore and/or potable water per day. Daily water usage per pen is expected to be approximately 270 L per day.

3.3.3 Wastewater irrigation

Treated wastewater will be used to irrigate crops (currently, bananas are proposed) planted in the irrigation areas. There is a total of 2,000 m^2 of land available for irrigation at the RCRF. To ensure that the wastewater does not impact offsite environmental values or neighbouring land uses, the irrigation regime will be designed and operated to minimise runoff and seepage to groundwater.

Details of the irrigation systems, crop types, irrigation regimes and monitoring requirements are detailed in the IMP provided in Appendix A. To demonstrate the capacity of the proposed system to manage nutrients onsite, a MEDLI assessment has been prepared, based on estimated wastewater volumes and quality (Appendix A). The model addresses factors impacting on effluent irrigation, such as the quality and quantity of effluent, climate, soil type, storage, irrigation frequency and amount, nitrogen, phosphorus and salt components and plant type and growth. The model is set to prevent irrigation when soils become saturated (i.e. during or following rain events that may occur in the dry season).

The MEDLI modelling indicates that wastewater generated from stage one operations can be accommodated in the available irrigation area provided onsite (2,000 m^2), without runoff or impacts to the surrounding areas. However, the nutrient loading in the wastewater may need to be managed with additional dilution, however as wastewater data from another crocodile farm in the Northern Territory was used as effluent input data in MEDLI, the requirements for dilution will be confirmed once site specific data is available. Sampling of wastewater from the RCRF will be undertaken once the RCRF is operational, and the MEDLI modelling refined to ensure the irrigation area is adequate for the wastewater loads, and to confirm whether dilution is required. If dilution is required, it can be achieved with existing water sources at the site.

Irrigation of wastewater has potential to either risk runoff or pool where there is not enough slope (i.e. site is too flat, too high of slope and/or the application rates are too high and result in runoff. The irrigation rate will be set at 5 mm per day as recommended by the Australian Standard for *On-site domestic wastewater management* (AS/NZS 1547:2012) for drip or spray irrigation.

3.3.4 Finished product

The RCRF is for the commercial production of saltwater crocodiles hatchlings, which will be sold to farms in Darwin for grow-out and ultimately for skin and meat products. The operation will be scaled, commencing at up to 450 crocodiles per year in stage one, to up to 1,350 crocodiles per year at full capacity. Expansion will occur over 2 years.

3.3.5 Pollutants and wastes

Pollutants and wastes produced during operations are listed below, with details of treatment and disposal methods.

Table 3-1. Pollutant and waste summary

Pollutant/waste	Treatment / Mitigation	Disposal
Odour emissions	Appropriate separation distances to sensitive receptors.	NA
Crocodile mortalities	Maintain good water quality and avoid overcrowding pens	Buried on site or taken to landfill
Primary water treatment screenings - solid waste (animal effluent and feed	On-site storage	Buried on site or taken to landfill

Pollutant/waste	Treatment / Mitigation	Disposal
waste)		
Wastewater from crocodile pens	Primary and secondary treatment on site	Discharged to land for irrigation of crops
Domestic waste	NA	Taken to landfill by ASRAC staff
Waste oils from light maintenance activities	NA	Taken to landfill by ASRAC staff
Sewage	On-site septic tank	Pump out by licenced contractor
Stormwater discharges	Stormwater drains	Discharge to Ramingining stormwater infrastructure.

4 DISCHARGE SPECIFICATIONS

4.1 Discharges to air

Odours may be produced from the hatchery pens and irrigation areas. Aerosols may also be dispersed through irrigation of wastewater.

The key measures that will minimise odour emissions are listed below:

- Primary treatment of wastewater to remove solids
- Regular removal of solids off-site
- Monitoring of treatment system performance to ensure wastewater entering the treated wastewater storage tank meets water quality criteria for irrigation
- Buffers to neighbours
- Frequent cycling of water through the pens to avoid stagnation
- Management of irrigation so that irrigation does not occur when conditions are windy.

4.2 Discharges to land

Treated wastewater will be discharged by land irrigation. Further details and specific information regarding the discharging of wastewater to the irrigation area can be found in the IMP in Appendix A.

4.2.1 Effluent quality and volume

It is estimated that when the RCRF is operating at full capacity, 4,000L/day of wastewater will be generated throughout the dry season. For stage one, it is assumed that only 1,080L/day (i.e. 260-270L/pen) is generated. Effluent quality is currently based on hatchling water quality data from Lagoon Crocodile Farm in Darwin, which is considered to be classed as a “low strength” effluent as per the DEC, 2004. Once the RCRF is operational, site-specific data will be available to update MEDLI modelling. Refer to the IMP in Appendix A for details of the effluent quality data (quality and volume).

4.2.2 Irrigation areas

Stage one wastewater will be irrigated of 2,000 m^2 of land at the RCRF.

Soil and land characteristics

Five sample sites were chosen and sampled at three depths (surface, 0.5 m and 1.0 m). The results of the sampling classified the soils and predominately sandy loam with various variations of brown, yellowish brown and reddish brown. Most of the soils were described as non-saline and baseline soil quality analysis indicates that the soils on site have sufficient capacity to uptake wastewater volumes and nutrient loads. Refer to Section 2.4.4 for further details.

Topography

The topography is relatively flat allowing water to saturate the soil with limited runoff (refer to Figure 2-1).

Climate

Irrigation will only occur in the dry season months, when rainfall is very low and evaporation and evapotranspiration are high. The irrigation method modelled was a fixed sprinkler system to mimic surface spray via irrigation, with irrigation triggered when the soil water deficit (SWD) reaches 5mm. The irrigation was applied at a depth of 5mm at each irrigation event, until the SWD is reached. To prevent over saturation

of the soil, and runoff, irrigation cannot occur when a rainfall event exceeding 10mm occurs (which will be frequent during the wet season).

A “dry-run” was also modelled for the irrigation area, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the area without any irrigation inputs. The model was set to turn-off irrigation when rainfall reaches a total of 10mm (likely during most of the wet season) to prevent over saturation of the soil.

In reality with high evaporation rates, it is possible that irrigation may still occur on days that experience minor rainfall events (occasional dry season rainfall event and early wet season rainfall) provided conditions in a site-specific IMP are adhered to (refer to Appendix A).

4.2.3 Irrigation system

The irrigation regime will be designed and operated to minimise runoff and seepage, and irrigation will only occur in the dry season.

The irrigation rate will be set at 5 mm per day, per spray irrigation system, as recommended by the Australian Standard for *On-site domestic wastewater management* (AS/NZS 1547:2012) for drip or spray irrigation. There is potential to increase/decrease the irrigation rate based on actual project area conditions; modelling will be further refined when the site is operational and actual wastewater quality is known.

If required, nutrient loading in the wastewater will be managed by including a level of dilution to minimise excessive nutrient build up. Note the requirement for this will be subject to testing and obtaining onsite wastewater quality data, and assessing water quality data against irrigation criteria (i.e. ANZECC 2000 and DEC 2004).

The results of the MEDLI modelling indicated that an area of 2,000 m^2 is sufficient for disposal of wastewater from stage one operations.

Refer to the IMP in Appendix A for further details.

4.3 Discharges to water

There will be no direct discharges to water, as surface water bodies are a significant distance (over 500m) from the RCRF. There may be some discharges to stormwater from overland flow across the site. The risk of discharging to stormwater/surface water will be minimised by:

- Irrigating during the dry season, when there is low risk of rainfall transporting irrigation water into stormwater.
- Managing irrigation area to minimise runoff (irrigation volumes and quality as per trigger values and capacity of soils to take up wastewater).
- Visually monitoring irrigation area for any runoff, and amending irrigation rates/volumes as appropriate.

No surface water monitoring will be undertaken, as no surface water bodies are proximate to the project area.

Groundwater

Impacts to groundwater will be minimised by:

- Primary treatment of the wastewater to reduce contaminant loads
- Selection of suitable irrigation infrastructure to match the water and nutrient requirements of the crops
- Use of sufficient sized irrigation areas which can support the wastewater volumes

- Only irrigating during the dry season; irrigation during the wet season could result in greater transport of wastewater in soils and into groundwater as soils will be saturated from rainfall and groundwater will be shallow
- Controlling irrigation rates and volumes to prevent oversaturation that results in seepage
- Monitoring of effluent quality and irrigation volumes to ensure nutrient loading is within acceptable limits (based on modelling)
- Monitoring of existing bore at the RCRF for early detection of contamination.

5 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) has been developed for the operational phase to identify key sources, pathways and receptors of potential contaminants and include the following considerations:

- Potential contaminants
- Inferred sources
- Pathways and mechanisms for transport
- Potential sensitive receptors.

5.1 Potential contaminants

The contaminants of concern that could result from the operations of the RCRF include:

- Nitrates, phosphates, ammonia, bacteria and pathogens (i.e. *E. coli*, enterococci or faecal coliforms) in wastewater, from the rearing of animals.
- The use of cleaning products in the pens include multipurpose cleaners and disinfectant sanitisers which contain chlorine-based compounds. The volumes of which will be less than 1 L and will be stored at the ASRAC facility.
- The generation of airborne contaminants and nuisance odour.
- Wastewater from staff ablutions
- Waste from crocodile carcasses
- Contamination of fruit if inappropriate irrigation is undertaken (i.e. wastewater is sprayed on fruit)

The release of these contaminants could result in contamination of soil and surface water runoff, due to increased biochemical oxygen demand, increased nutrient and bacterial loads, reduced dissolved oxygen, changes in pH, increased electrical conductivity, turbidity or total suspended solids and an increase in chlorophyll-a. Additionally, airborne contaminants or nuisance odours could result in an impact to neighbours and surrounding properties.

5.2 Sources

Sources of potential contaminants include feed inputs and waste feed, crocodile faecal matter and cleaning products used in pens (however only minor volumes - less than 1 L). Pens will be cleaned and flushed at the start of each season, and no cleaning will be undertaken for the rest of the season, so chemical inputs from cleaning products are minimal.

5.3 Pathways and transport

Controlled and uncontrolled discharges to land and discharges to land and stormwater (although unlikely given distance to nearest surface water bodies). Infiltration through soil to groundwater. Nuisance odours carried by wind and potential irrigation activities generating molecules with the potential to become wind-borne.

5.4 Receptors and fate

Those receptors affected by migration of potential contaminants to groundwater, nuisance odours and land and stormwater, include neighbouring properties that utilise groundwater (football ground and industrial

properties to the south), ASRAC staff/personnel and those eating bananas from the irrigated area, if irrigation is not applied correctly.

6 ENVIRONMENTAL RISK ASSESSMENT

The CSM outlined in Section 5 above has been used to inform environmental risk assessment of stage one operations and derive corresponding mitigation measures for identified risks. An Operational Aspects and Impact Register is presented in Table 6-4.

6.1 Operational risks

The likelihood and consequence categories adopted are provided in Table 6-1 and Table 6-2, and were combined to derive an overall risk rating using the matrix in Table 6-3 below. The environmental aspects and impacts register is provided in Table 6-4.

Table 6-1. Likelihood categories

Level	Descriptor	Likelihood Description
1	Rare	The impact is very unlikely to occur. The impact has not occurred on similar projects and/or in similar environments.
2	Unlikely	The impact is not expected to occur. The impact occurs very infrequently on similar projects and/or in similar environments.
3	Possible	The impact could occur in some circumstances. The impact has occurred infrequently on similar projects and/or in similar environments.
4	Likely	The impact will probably occur in most circumstance but there is some uncertainty about the likelihood. The impact has association with similar projects and/or in similar environments.
5	Almost Certain	The event/impact will occur or is expected to occur. The impact occurs regularly in association with similar projects and/or in similar environments.

Table 6-2. Consequence categories

Level	Descriptor	Description
1	Insignificant	No noticeable or measurable impact.
2	Minor	Low intensity short-term impact that is very limited in extent i.e. confined to the direct disturbance footprint.
3	Moderate	Localised impact that alters environmental quality without compromising ecological integrity. Impact occurs periodically or is experienced over short periods of time i.e. months.
4	Major	Impact/damage that occurs at a regional scale. Impact compromises the integrity of environmental values and is felt for many years (i.e. is long-term)
5	Severe	Widespread and permanent/irreversible damage to receiving environment will occur - unlikely to ever be fixed (e.g. extinctions).

Table 6-3. Risk matrix

			CONSEQUENCE				
			1	2	3	4	5
			Insignificant	Minor	Moderate	Major	Severe
LIKELIHOOD	5	Almost Certain	Medium	Medium	High	Very High	Very High
	4	Likely	Medium	Medium	High	Very High	Very High
	3	Possible	Low	Medium	Medium	High	Very High
	2	Unlikely	Low	Low	Medium	Medium	High
	1	Rare	Low	Low	Low	Medium	High

Table 6-4. Stage one operational aspects and impacts register

Aspect	Potential impact	Assumptions	Initial risk			Management and mitigation controls	Residual risk		
			L/hood	Cons	Risk		L/hood	Cons	Risk
Treatment of wastewater	Inadequate treatment of water quality Generation of by-products	All wastewater from pens will be captured and treated through a parabolic screen prior to irrigation. Screened solids will be stored separate to treated wastewater for offsite removal. Water will flow through pens, reducing risk of stagnation.	3	3	**Med**	• Store water in tanks and test prior to discharge and retreat if required. • Waste by-products to be removed by a licensed waste handler • Ensure wastewater treatment system is operating effectively • Review and amend wastewater treatment system if treated water quality does not meet irrigation criteria	2	3	**Med**
Irrigation of wastewater	Runoff of irrigated wastewater, impacting neighbouring land uses and downstream water quality (i.e. stormwater).	No watercourses downstream of irrigation area. Irrigation will occur in the dry season. Irrigation will be to a suitably sized area, based on MEDLI modelling.	3	2	**Med**	• Treat wastewater prior to irrigation. • Irrigate in allocated irrigation area, away from neighbours and watercourses. • Manage vegetated irrigation area to encourage uptake of wastewater. Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff. • Adhere to Irrigation Management Plan and Procedures.	1	2	**Low**
	Reduction in groundwater quality of underlying aquifers.	Irrigation will occur in the dry season. Groundwater in surrounding bores is deep (>30 m). Irrigation will be to a suitably sized area, based on MEDLI modelling. Irrigation area is not located close to major groundwater users.	2	3	**Low**	• Treat wastewater prior to irrigation. • Irrigate in allocated irrigation area, away from neighbours and watercourses. • Manage vegetated irrigation area to encourage uptake of wastewater. Irrigation design to incorporate appropriate irrigation rates to prevent surface water ponding and generation of runoff. • Adhere to Irrigation Management Plan and Procedures. • Maintain buffers to groundwater bores (>50m)	1	2	**Low**
	Overspray/mist generation impacting on comfort of neighbouring properties. Windborne particles spreading impacting health of workers	Irrigation will occur in the dry season. Irrigation will be spray or drip irrigation close to the ground (as per design drawings, provided in EPA documentation).	3	2	**Med**	• Irrigation design to include provision for large droplet size to prevent mist generation. • Irrigation activities confined to approved irrigation areas and appropriate buffers maintained. • Adhere to Irrigation Management Plan and Procedures; avoid irrigating in high winds.	2	2	**Low (4)**

Aspect	Potential impact	Assumptions	Initial risk			Management and mitigation controls	Residual risk		
			L/hood	Cons	Risk		L/hood	Cons	Risk
Groundwater use	Reduction in groundwater levels around bore due to extraction.	No other major groundwater users are located proximate to the RCRF. RCRF will use modest volumes of water, for a portion of the year.	2	2	**Low**	• Limit groundwater extraction to that required for farm operations. • If groundwater extraction volumes exceed 15 ML/year, apply for a water extraction licence, and adhere to licence conditions.	2	2	**Low**
Storage of general waste	Contamination of land/soils Attraction of pests and animals.	Minimal waste will be generated and will mostly be domestic waste. No waste from feed processing will be generated at site.	3	2	**Med**	• Separate waste and store appropriately in sealed containers. • Ensure waste is disposed of in appropriate containers for waste type prior to disposal. • Removal of waste products by ASRAC staff and taken to a local landfill. • Monitoring of waste storage areas.	2	1	**Low**
Collection and disposal of waste from water treatment system	Soil and surface water contamination.	Solids separated from wastewater will be stored in a sealed container.	3	1	**Low**	• Collect all solids from wastewater treatment system and store adequately in a sealed container. • Monitor volumes of solids stored, to avoid overflow. • Routine removal of solid waste by ASRAC staff and buried on-site or disposed of at landfill. • Onsite disposal must be adequately covered and away from groundwater bores or stormwater. • Monitor disposal area for erosion.	2	1	**Low**
Dust emissions from facility during the dry season	Degradation of air quality, impacting staff and neighbours.	RCRF is relatively small and most of farm area will be hardstand or sealed surface.	3	1	**Low**	• Visual monitoring of airborne dust. • Implement dust mitigation measures (e.g. dust suppression with water) if required.	2	1	**Low (2)**

Aspect	Potential impact	Assumptions	Initial risk			Management and mitigation controls	Residual risk		
			L/hood	Cons	Risk		L/hood	Cons	Risk
Generation of odours	Disturbance to neighbouring properties	Pens will be relatively small and covered, with a hatch that will be opened as needed. Total farm capacity is relatively low; 90 crocodiles per pen, 15 pens at full capacity. Irrigation of treated wastewater will occur.	3	2	**Med**	• Adherence to pen cleaning schedule. • Continuous flow of water through pens, or routine changing of water to avoid stagnation. • All putrescible waste to be stored appropriately prior to being buried on site by ASRAC staff. • Ensure wastewater treatment system is operating effectively and not generating excessive odour. • Achievement of adequate treatment prior to irrigation, to reduce odour. • Irrigation design to include provision for large droplet size to minimise mist and odour generation. • Irrigation activities confined to approved irrigation areas and appropriate buffers maintained. • Irrigation to be managed to avoid ponding or runoff, which can increase odour	2	1	**Low (2)**
Movement of vehicles and equipment	Spread of weeds	No existing weeds within RCRF boundaries.	2	2	**Low**	• Regular inspections of RCRF for weed occurrence. • Control of weeds as required by herbicide spraying. • Regular slashing.	1	1	**Low**
Creation of mosquito breeding habitat	Impacts on comfort of employees/neighbours and increased disease risk	Crocodile pens will be covered and water will flow through continuously. Wastewater irrigation will occur which could create ponding.	3	1	**Low**	• Minimise any stagnant water by ensuring containers are kept out of rain. • Manage irrigation to avoid ponding in land application area. • Adherence to pen cleaning schedule. • Regular inspections of site to identify areas of ponding water and subsequent rectification. • Water is changed daily pens so that water does not stagnate • Design of wastewater treatment systems to minimise biting insect breeding habitat (i.e. constant flow in pens) in accordance with the *Guidelines for preventing mosquito breeding associated with wastewater treatment and disposal in the Northern Territory* • Store water and wastewater in covered tanks, to avoid creating mosquito breeding habitat in tanks.	2	1	**Low (2)**

Aspect	Potential impact	Assumptions	Initial risk			Management and mitigation controls	Residual risk		
			L/hood	Cons	Risk		L/hood	Cons	Risk
Mortality	Quarantine issues or spread of diseases.	Some crocodile deaths may occur. Locally sourced crocodile eggs will be hatched, and local crocodiles will be reared, so risk of importing disease is low.	3	1	**Low (3)**	• Monitor pens for crocodile health and deaths; remove any deceased crocodiles promptly. • Establish monitoring and surveillance program to identify any potential disease outbreak. • Dispose of any crocodile carcasses promptly and at a suitable facility. Bury any carcass.	1	1	**Low (1)**

7 ENVIRONMENTAL MANAGEMENT AND COMPLIANCE

The risk assessment process detailed in Section 6 identified controls that will be implemented to minimise the risks to the environment during Stage one operational activities. This Environmental Management Plan (EMP) provides a consolidated plan for environmental management to mitigate the environmental risks. Section 7.1 identifies the potential impacts of Stage one operations on the environment and includes environmental objectives, management and mitigation measures, performance criteria and target indicators, corrective actions and contingencies, monitoring and reporting and record-keeping mechanisms for each aspect.

7.1 Table of provisions

Table 7-1. Environmental management summary

ASPECT	POTENTIAL IMPACT	OBJECTIVE / OUTCOME	MANAGEMENT ACTION	TARGET / PERFORMANCE INDICATOR	MONITORING	CORRECTIVE ACTIONS AND CONTINGENCIES	REPORTING AND RECORD-KEEPING
Groundwater use to fill and replenish pens	• Reduction in groundwater availability	• No reduction in groundwater availability for surrounding land users due to extraction.	• Monitor groundwater levels for drawdown impacts • Use only volume of water required for adequate facility operation (i.e. not excess) • Investigate and remedy excess water use (i.e. leaks) • If volumes extracted exceed 15L/s, apply for a water extraction licence.	• No drawdown of groundwater levels at neighbouring bores.	• Monitor standing water levels in supply bore.	• Revise groundwater level monitoring procedure and install meter if required. • Review options for water reuse.	• Water usage is recorded. • Groundwater usage detailed in Annual Return.
Treatment of wastewater	• Impacts to soil and stormwater quality due to inadequate treatment of wastewater.	• No discharge or reuse of water above the irrigation criteria (section 8.3.1).	• Investigate treatment improvements if irrigation criteria not met. • Install returns (in this case a 25,000L storage tank) to enable re-treatment of water that does not meet the approved criteria for reuse or discharge	• No exceedance of irrigation criteria.	• Establish a monitoring program, which incorporates monitoring quality of treated wastewater prior to irrigation	• Review treatment methods • Review water quality and implement additional treatment if required	• Reporting undertaken through Monitoring Report and Annual Return
	• Generation of excessive odours	• No impacts on neighbouring properties from odour during treatment process	• Ensure wastewater treatment system is operating effectively and not generating excessive odour. • Manage irrigation to avoid spraying and producing odour.	• No complaints received in relation to odour	• Establish a monitoring plan which incorporates odour monitoring by site staff • Establish a monitoring program, which incorporates monitoring quality of treated wastewater prior to irrigation.	• Review water quality and implement additional treatment if required.	• Record and respond to any complaints received • Reporting undertaken through Monitoring Report and Annual Return
Irrigation of treated wastewater	• Overspray/mist	• No impacts on neighbouring properties from irrigation	• Develop and implement Irrigation Management Plan • Irrigation design to include provision for large droplet size to prevent mist generation. • Irrigation activities confined to approved irrigation areas and appropriate buffers maintained (>50m from neighbouring properties). • Irrigation restrictions pending weather conditions	• No complaints received in regards to mist generation	• Establish a monitoring plan which incorporates visual inspections of irrigation areas	• Review Irrigation Management Plan, including irrigation rates, areas and timing	• Record and respond to any complaints received • Reporting undertaken through Monitoring Report and Annual Return
	• Soil and water contamination	• Avoid impacts to soil, surface water or groundwater quality	• Adherence to irrigation management plan and procedures. • Undertake monitoring regularly, adhering to environmental monitoring plan in this document	• Adherence to assessment criteria in Section 8.3.	• Monitoring in accordance with Section 8.2.	• Review irrigation management plan • Review environmental monitoring plan	• Record all water and soil quality results in a database and compare to assessment criteria. • Reporting undertaken through Monitoring Report and Annual Return
	• Odour generation	• No impacts on neighbouring properties from odour during irrigation	• Adherence to irrigation management plan and procedures. • Irrigation design to include provision for large droplet size to prevent odour generation. • Irrigation activities confined to approved irrigation areas and appropriate buffers maintained (>50m from neighbouring properties). • Irrigation restrictions pending weather conditions (wind)	• No complaints received in relation to odour	• Establish a monitoring plan which incorporates odour monitoring by site staff • Monitoring of wastewater quality in accordance with Section 8.2.	• Review Irrigation Management Plan, including irrigation rates, areas and timing • Review water quality and implement additional treatment if required (e.g. to reduce odour from BOD, oil and grease, bacteria)	• Record and respond to any complaints received • Reporting undertaken through Monitoring Report and Annual Return
Waste generation	• Poorly managed site attracting native fauna and pests • Contamination to land/soils	• No introduction of pest species at site. • No contamination of soils due to poor waste management	• Ensure waste is stored/disposed of in appropriate containers for waste type prior to disposal.	• No recorded incidents of pests or native fauna accessing waste • No indication of land/soil	• Monitoring of waste disposal areas.	• Review waste handling and disposal practices	• Inspection records • Incident reporting records

ASPECT	POTENTIAL IMPACT	OBJECTIVE / OUTCOME	MANAGEMENT ACTION	TARGET / PERFORMANCE INDICATOR	MONITORING	CORRECTIVE ACTIONS AND CONTINGENCIES	REPORTING AND RECORD-KEEPING
		practices	• Removal of waste products by ASRAC staff to landfill.	contamination			
Solids disposal from wastewater treatment	• Soil and surface water contamination.	• No release of separated solids to soils or environment.	• Adherence to pen cleaning schedule. • Solids separated from wastewater to be stored in sealed container, collected and disposed of to landfill.	• No signs of solids overflow/contamination to soils surrounding treatment area.	• Daily pen inspections • Undertake visual inspections of wastewater treatment area and solids storage.	• Review sludge handling and removal procedures	• Record all water and soil quality results in a database and compare to guideline values. • Records of solids removal and disposal, reported in Annual Return.
Rearing of live animals	• Quarantine issues or spread of diseases.	• No introduction or spread of disease across the facility or into the receiving environment.	• Monitor pens for crocodile health and deaths; remove any deceased crocodiles promptly. • Dispose of any crocodile carcasses promptly and at a suitable facility. Bury any carcass.	• No recorded incidents of disease spread/outbreak	• Established monitoring and surveillance program to identify any potential disease outbreak.	• Review quarantine practices • Review monitoring program	• Inspection records • Incident reporting records
General facility operations	• Degradation of air quality, including dust	• No impacts from dust on neighbouring properties	• Implement dust mitigation measures (e.g. suppression) as required.	• No complaints in relation to air quality	• Visual monitoring during periods of dry weather and high winds.	• Review dust control measures and implementation	• Record and respond to any complaints received
	• Disturbance to neighbouring properties associated with excessive odours	• No impacts from odour on neighbouring properties	• Adherence to pen cleaning schedule. • General housekeeping around facility to reduce odour sources. • All putrescible waste to be stored appropriately prior to disposal by ASRAC staff to local landfill.	• No complaints in relation to odour.	• Daily pen inspections. • Inspections of waste management areas.	• Review of cleaning schedule • Review of waste management practices	• Record and respond to any complaints received
	• Spread of weeds	• To prevent introduction of new weed species to the site and surrounds.	• Control of weeds by herbicide spraying or slashing if required.	• No introduction of new weed species.	• Undertake regular weed inspections.	• Review weed control activities and frequency	• Inspection records • Incident reporting records
	• Creation of mosquito breeding habitat impacting on comfort of employees/neighbours and increased disease risk	• Avoid creation of stagnant water which could become mosquito breeding habitat. • Design of wastewater treatment and storage systems to minimise biting insect breeding habitat.	• Minimise any stagnant water by ensuring containers are kept out of rain. • Adherence to pen cleaning schedule, and continuous flow/change of water in pens. • Adherence to Irrigation Management Plan, to avoid creating ponding water.	• No prolonged areas of ponding water on-site • No reported increase in mosquitos onsite.	• Regular inspections of site to identify areas of ponding water and subsequent rectification.	• Amend pen water flow through or replacement procedure, to avoid stagnation. • Review irrigation management procedures, to avoid pooling water. • Housekeeping.	• Inspection records • Record and respond to any complaints received

8 ENVIRONMENTAL MONITORING PLAN

8.1 Objectives

The following environmental protection objectives (EPOs) under the *WMPC Act* and *Water Act* are applied to the Project:

- environmental quality is to be maintained, enhanced, managed or protected
- pollution, or environmental harm resulting from pollution, is to be assessed, prevented, reduced, controlled, rectified or cleaned up
- effective waste management is to be implemented or evaluated

The monitoring program will provide early-warning of surface and groundwater quality and soil quality issues and inform adaptive management of the operational water management including the wastewater treatment system and to achieve water quality criteria.

8.2 Operational monitoring program

During operations of stage one, environmental sampling will be conducted on irrigation water, the groundwater bore and soil. There are no on or off-site surface water monitoring locations, as there are no well-defined watercourses flowing onto the site (representing background/reference) or receiving water from the site that would be representative of off-site impacts.

Program details are outlined below and in Figure 8-1.

8.2.1 Irrigation water

Treated effluent quality will be monitored from the wastewater storage tank, where irrigation water is sourced. Monitoring parameters and frequency is as per Table 8-1. Volumes of wastewater irrigated will also be recorded.

Table 8-1. Monitoring parameters and frequencies for irrigation water

Monitoring sites	Parameter	Sampling frequency
Irrigation Extraction Point	pH	Monthly
	EC	
	Total P	
	Total N	
	Cations & anions (Ca, Mg, Na, K, SO4, Cl, CaCO3)	
	E.coli, enterococci, Total coliforms	
	Nitrate, Ammonia and organic N	Quarterly (required to calculate nutrient loading)

8.2.2 Groundwater

Groundwater will be sampled from the bore onsite, which is the closest groundwater bore to the proposed irrigation area; see Table 8-2.

Table 8-2. Monitoring parameters and frequencies for groundwater

Monitoring sites	Parameter	Sampling frequency
Bore (RN040841)	Standing water level	Quarterly
	pH	
	EC	
	Total P	
	Total N	
	Cations & anions (Ca, Mg, Na, K, SO4, Cl, CaCO3)	
	E.coli, enterococci, Total coliforms	

8.2.3 Soil

Soil samples will be taken from the land application area; the B horizon will be sampled (i.e. subsurface samples). The number of soil sampling sites will increase when the irrigation area is increased for the full-scale system (refer to Table 8-3).

Table 8-3. Soil monitoring program

Monitoring sites	Easting (53L)	Northing (53L)	Description	Parameters	Frequency
SS01	491930	8636788	Stage one irrigation area	• pH • Electrical conductivity (EC) • Total nitrogen & phosphorous • *E.coli, Enterococci,* Total coliforms	Annual
SS02	491911	86367823			
SS03	491956	8636819			

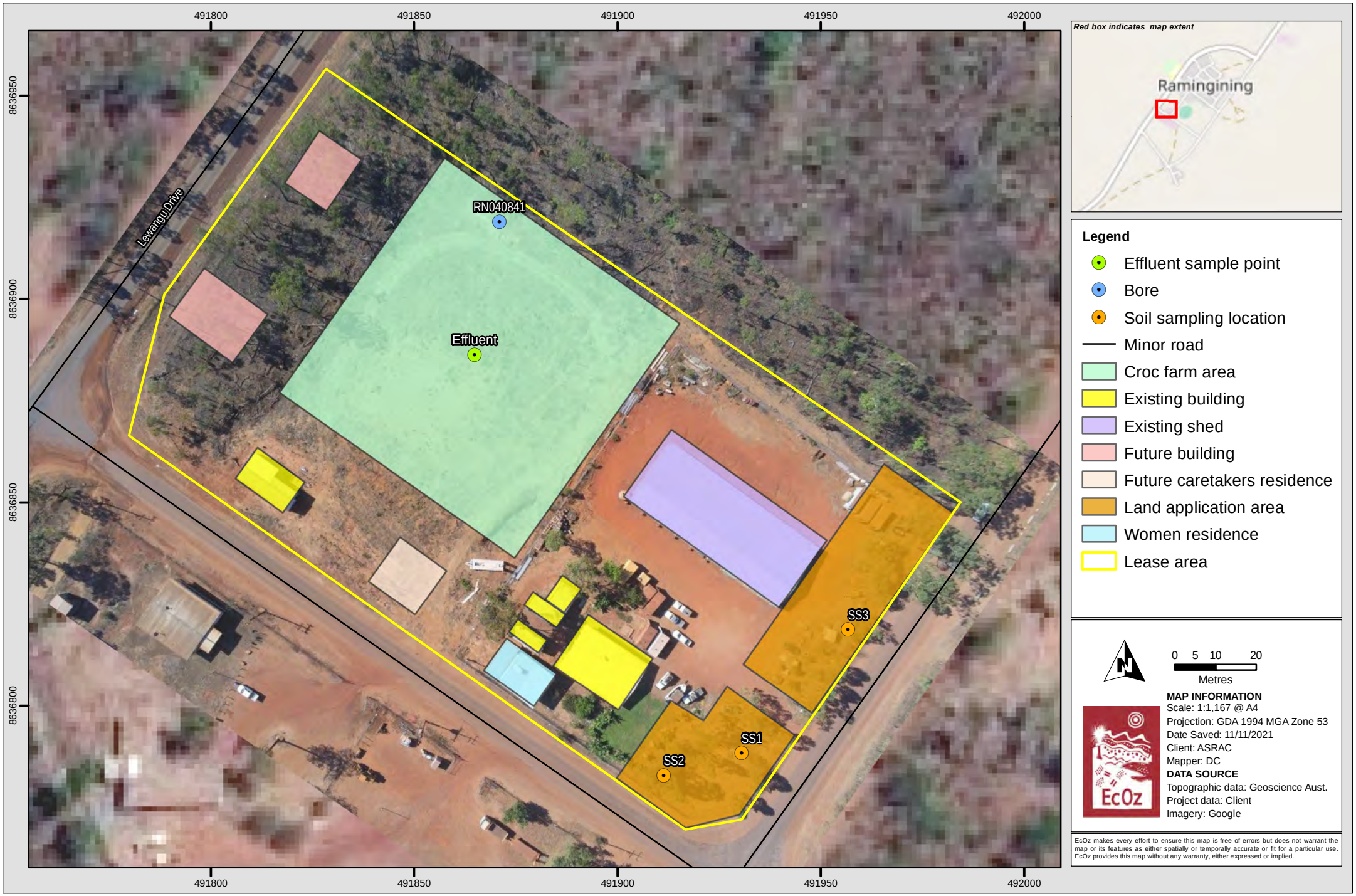

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Figure 8-1. Map showing monitoring locations

8.3 Assessment criteria

8.3.1 Irrigation water

Ongoing monitoring will be undertaken to ensure that the quality remains within the acceptable limits for irrigation in the nominated area.

Trigger values were derived from the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 – Chapter 9 – Primary Industries* (ANZECC, 2000) guidelines and the *Environmental Guidelines – Use of Effluent by Irrigation* for low strength effluent (DEC, 2004). Where there are significant increases in the parameters measured, further assessment will be undertaken to determine the impact on irrigation.

Table 8-4. Monitoring program and trigger values for irrigation water

Monitoring sites	Parameter	Indicative Trigger values
Irrigation Extraction Point	pH	6-8.5
	EC	<1,300 µS/cm
	Total P	10 mg/L
	Total N	50 mg/L
	Cations & anions (Ca, Mg, Na, K, SO4, Cl, CaCO3)	N/A
	E.coli, Enterococci, Total coliforms	< 1,000 cfu/100mL

8.3.2 Groundwater

Groundwater will be compared against the trigger values identified in Table 8-5, which have been adopted from the *Primary Industries Long-term Trigger Values (LTV) for Irrigation* (ANZECC (2000)) and the *Environmental Guidelines – Use of Effluent by Irrigation* (DEC, 2004). Where there are significant increases in the parameters measured, further assessment will be undertaken to determine the potential sources of contamination.

Groundwater quality will also be compared against baseline conditions to assess the impacts (if any) of the irrigated water to groundwater.

Table 8-5. Monitoring program and trigger values for groundwater

Monitoring sites	Parameter	Indicative Trigger values
Groundwater bore	pH	6-8.5
	EC	<400 µS/cm
	Total P	An increase of >10% from previous monitoring round
	Total N	
	Cations & anions (Ca, Mg, Na, K, SO4, Cl, CaCO3)	N/A
	E.coli, Enterococci, Total coliforms	< 1,000 cfu/100mL

8.3.3 Soil

Soil quality will be compared against existing baseline conditions. Where there are significant increases in the parameters measured, further assessment will be undertaken to determine the impact of irrigation.

Table 8-6. Monitoring program and trigger values for soil

Parameter	Trigger value*
pH	6 – 8
EC	An increase of >10% from baseline soil data
Total Phosphorus	
Total Nitrogen	
E.coli, Enterococci, Total coliforms	

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 (TN and TP) should be graphed and compared annually, to identify any nutrient application issues or irrigation practices that may need to be altered.

8.4 Quality assurance and quality control

All sampling and handling of samples is 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 waste waters (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.

Monitoring equipment will be calibrated prior to use and calibration checks performed to be within an acceptable range. Sampling will be collected, preserved, stored and transported in accordance with above standards and sampled by a suitably qualified sampler. All samples will be tracked with a chain of custody and sample receipt/record of delivery. Adequate sampling frequency, duplicates, triplicates, blanks and inter-laboratory checks will be undertaken as per sampling methodology.

All samples will be analysed in accordance with National standards, and an accredited National Association of Testing Authority (NATA).

8.5 Audits and inspections

Internal audits will be undertaken on an annual basis. These audits include compliance with the EMP and occupational health & safety and environmental aspects of the operation. The auditor will report findings to the RCRF Manager and the Managing Director.

Crocodile pen areas are inspected daily and any issues are recorded in a daily report. Inspections include the following environmental aspects:

- Water levels in pens and input requirements
- Wastewater outbreaks or leaks
- Animal health and potential disease outbreaks

Visual inspections of the irrigation areas for mist/overspray, odour, ponding and runoff will be undertaken daily during irrigation activities.

Response to environmental incidents and complaints is details in Section 9 and Section 10 respectively.

8.6 Reporting and records

8.6.1 Internal

Reporting requirements are in accordance with Table 7-1. This document will be reviewed annually to reflect any changes in operations.

Details of environmental incidents, non-conformances or other relevant information will be 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 and will be available upon request to the NT EPA.

8.6.2 External

External reporting to the NT EPA, including an Annual Return and/or Monitoring Report, will be in accordance with the EPL conditions. This document will be revised to include specific EPL reporting requirements once the EPL is issued

Any non-compliances of the EPL will be reported by ASRAC by completing a Non-Conformance Notification via the NT EPA website as soon as practicable after becoming aware of the non-conformance, in accordance with the EPL conditions. The non-compliance notification will include:

- Date and time on non-compliance
- When the non-compliance was detected and by whom
- Nature of non-compliance
- The actual and potential causes and contributing factors to the non-compliance
- The risk of environmental harm as a result of the non-compliance
- Actions taken to mitigate environmental harm as a result of the non-compliance
- Corrective actions to prevent re-occurrence
- If no action was taken, explanation why; and
- Date when investigation report will be submitted to the NT EPA.

9 EMERGENCY RESPONSE PLAN

Emergency response planning includes responses to environmental emergencies, and operational actions that cause an environmental incident. The Emergency Response Plan (ERP) provides detailed information regarding the types of environmental emergencies that could be experienced at the RCRF, as well as specific procedures for flood events, cyclone and severe weather. The ERP also outlines the roles and responsibilities of the ASRAC Emergency Response Team in responding to environmental emergencies.

The ASRAC CEO is the contact person for all emergencies and environmental incidents. All incidents which cause or have the potential to cause material or serious environmental harm will be reported to the NT EPA as soon as possible after the event, and in any case within 24 hours, as required under Section 14 of the NT WMPC Act.

Table 9-1. Emergency events and responses

Emergency event	Response
Medical	Preparation • Site-based staff trained in first aid • First aid equipment maintained on site In the event of a medical emergency: • First aid to be administered by trained first aid personnel. If required call emergency services (000) for assistance.
Bushfire	Preparation • Ensure firebreaks surrounding perimeter of the facility are adequately cleared all year round in accordance with the *Bushfires Management Act* 2016. • Ensure no remnant materials, that could cause a fire hazard, are built up on the site. • If smoke is visible in the vicinity of the RCRF, utilise the North Australian Fire Information (NAFI) website as a first response capacity to track the bushfire. In the event of a fire
Fire onsite	• ASRAC will control any fires that may begin on site. • If required call emergency services (000) for assistance. • Arrange for safe removal of personnel and contractors from any dangerous situation. • If able to be conducted safely, apply appropriate firefighting equipment to fire source (ensure that water or water-based suppression is not applied to Class E (electrical) fires until de-energised). • Secure the area and do not allow any disturbance to the Project area • Ensure all hazards identified and managed / isolated prior to entry. • Allow only designated personnel into the Project area.
Cyclone	Preparation • All rubbish and other materials that could be projectiles in the event of tropical cyclone conditions to be removed, stored or tied down as appropriate. Cyclone watch • Secure or remove all unfixed items • Check to ensure all fuel tanks are full (for vehicles, equipment and generators) (if applicable). • Check to ensure equipment/ machinery stored in the open are secured. Cyclone warning Ensure all portable equipment/ machinery and related items are tied down, and when advised, vacate the Project area and move off site as advised by the Site Manager or Northern Territory Emergency Services.
Flood	Preparation • Secure / store any loose materials or equipment that has the potential to cause harm or damage in a safe location. • Park any vehicles/ equipment to be left at the facilities, under solid shelter. • Secure all external doors and windows (if applicable). • Disconnect all electrical items, external radio aerials and computer equipment (if
Severe weather	

	applicable). • Listen to announcements on ABC Local Radio 107.3 FM for weather updates. Unexpected / during • Personnel on site to move to any fastened structure or vehicle on site. • Move all people away from windows and shut windows. • Shut doors and shelter in the strongest part of the structure. • Stay inside. • Monitor all directions from staff/ emergency services. After • Listen to your portable radio for Warning updates. • Check for damaged windows, walls, or roof. Temporarily repair if appropriate and safe to do so. • For emergency assistance, contact your local emergency services call **000.** If you don't need help, check, and if necessary, help your neighbours. Don't go sightseeing.
Fuel or chemical spill	As per Section 9.1.

General emergency response preparedness is ensured by the following:

- Inductions and training for rangers and ASRAC staff
- Drills
- In the event of an emergency or incident
  - Incident investigation and reporting
  - Debrief/learning from the incident communicated to all rangers and staff

9.1 Spill response plan

In the event of any spill the following procedure is to be implemented:

- locate the source of the spill, identify the volume and type of spill
- assess the risk to workers and the environment from the spill to ensure appropriate PPE and containment measures are implemented
- control and contain the spill by isolating and/or removing the source
- clean the spill using spill kit absorbent material if practical, or installing bunds
- collect all contaminated material and dispose of at an appropriately licenced waste facility
- report significant spills, or spills that entered a waterway to the NT EPA Pollution Hotline (1800 064 567).

Appropriately stocked spill containment equipment kits will be available in all works areas. All personnel on site will be trained in the use of spill kits.

9.2 Emergency contact details

Emergency contact details are provided below. They will be displayed around RCRF.

Table 9-2. Emergency contact details

Contact	Contact details
ASRAC CEO	Ian Brown Headquarters – 8 Warrk Road, Ramingining, NT 0822 Darwin Office – Unit 4/98 Woods Street Darwin, NT 0800 T: 08 8979 7988 M: 0487 021 431

Contact	Contact details
	ceo@asrac.org.au
NT EPA Pollution Hotline / Pollution Reporting	Level 1 Arnhemica House, 16 Parap Road, Parap NT 0820 Pollution Hotline: 1800 064 567 pollution@nt.gov.au
DEPWS Parks and Wildlife Commission, permits etc.	Level 1, Goyder Centre, 25 Chung Wah Terrace, Palmerston NT 0830 08 8924 4218 (general services) 08 8999 4455 (water resources general enquiries)
EcOz Environmental Consultants	Level 1 70 Cavanagh Street, Darwin NT 0800 08 8981 1100 ecoz@ecoz.com.au
Northern Land Council	Endeavour Square Nhulunbuy NT 0880 08 8986 8500 reception@nlc.org.au
NT Police/Fire	000
Ramingining Police Station	305 Dingbulu Road Ramingining NT 0822
Ramingining Community Health Centre	Lot 19, 17 Milbrim Road Ramingining NT 0822 08 8979 7923 ramingining.clinicmgr@nt.gov.au

10 CONSULTATION AND COMMUNICATION PLAN

Effective consultation and communications are essential to ASRAC, as it manages a number of different ranger groups and is designed to facilitate traditional land management of the Arafura Swamp and surrounding regions. Various management plans have been developed to communicate the goals of ASRAC and inform ongoing management of country. Effective communication with a wide range of stakeholders and interested parties is essential for the ongoing operation of ASRAC. Specific communication and consultation strategies are discussed below.

10.1 Methods of consultation and communication

ASRAC communicate to stakeholders and interested parties via the following methods:

- Direct communications with relevant parties (email, phone calls etc.)
- Workshops and networking days
- The ASRAC website, including the news section
- Social media platforms
- Media releases, and interactions with media as appropriate.

The ASRAC website provides detail on the history and structure of ASRAC, the work that ASRAC and the ranger groups do, and information on how country is managed, including the Healthy Country Plan which is a strategic plan for management of country in order to achieve targets and address current identified threats. The ASRAC website will be updated as required to include detail on the RCRF.

10.2 Relevant stakeholders

ASRAC comprises of a number of ranger groups which manage the Arafura Swamp and surrounding regions of eastern Arnhem Land. The site is located within the township of Ramingining, at the existing ranger station. Neighbouring land includes residential and commercial land uses, as well as town facilities such as the sporting oval. ASRAC will liaise with relevant stakeholders throughout the operations phase to ensure they remain aware of proposed activities, and maintain open lines of communication. Stakeholders relevant to the RCRF are shown in Table 10-1. This table will be updated as required to maintain a current list of stakeholders.

Table 10-1. Stakeholders

Stakeholders
Government
Parks and Wildlife Commission of the Northern Territory
Councils/Land Councils
East Arnhem Regional Council
Northern Land Council
ASRAC
Ranger groups
Employees
Partners and contractors
Neighbours

Ramingining School
Dinybulu Lodge
ALPA Stores
Bula Bula Arts
Industry Bodies
Crocodile Farmers Associated of the Northern Territory
Territory Natural Resource Management (TNRM)

10.3 Employee training and awareness

Training is provided to all employees and contractors to outline the environmental responsibilities of individuals and ASRAC. The aim of these interactions is to provide forums for communication to ensure that all employees and contractors have training delivered through site inductions and ongoing staff meetings, such as daily pre-start meetings and environmental toolbox talks to discuss changes and updates to operational aspects of the facility. Employee inductions cover the following content relevant to this EMP and ASRAC's environmental responsibilities:

- Roles and responsibilities
- Management plans including this EMP
- Complaint management and recording
- Standard Operating Procedures (SOPs)
- Policy instructions.

Staff training completed and required is managed and recorded in the Training Spreadsheet.

10.4 Complaint management

ASRAC will maintain a compliant register for any complaints received regarding their operations, which will record:

- Date and time of complaint
- Method by which complaint was made (i.e. telephone, letter, meeting, etc.)
- Name, address, contact telephone number of complainant
- Details of complaint
- Action taken in response to the complaint, including follow up contract with the complainant
- Any monitoring to confirm the complaint has been satisfactorily resolved
- If no action was taken, the reason for no action being taken.

11 REFERENCES

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APPENDIX A IRRIGATION MANAGEMENT PLAN AND MEDLI MODELLING REPORT

Irrigation Management Plan Ramingining Crocodile Rearing Facility

Arafura Swamp Rangers Aboriginal Corporation

www.ecoz.com.au

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1 INTRODUCTION

1.1 Background

The Arafura Swamp Rangers Aboriginal Corporation (ASRAC) propose to operate the Ramingining Crocodile Rearing Facility (RCRF) for commercial production of saltwater crocodiles (*Crocodylus porosus*) for meat and skin products. The site is located on 14 Ganinydja Road, Ramingining, Part NT Portion 1646 (NT Portion 1646 being the entirety of Arnhem Land).

RCRF is currently being constructed in two stages, with operations combining both stages so the facility operates as a whole. Stage one encompasses the incubation building, four crocodile pens, ancillary infrastructure and irrigation infrastructure. Stage two encompasses the remaining eleven crocodile pens, future caretakers residences, future ancillary buildings and future irrigation areas (if required).

1.2 Purpose and scope

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

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

2 WASTEWATER QUALITY

The RCRF is not yet operational and so there is no site-specific operational water quality data for wastewater at the time of reporting. For the purposes of MEDLI modelling and designing the irrigation area, anticipated effluent quality has been derived from monitoring undertaken at Lagoon Crocodile Farm, based in Darwin. The stage one effluent will be generated directly from the pens and will undergo a solids screening process prior to irrigation, similarly to that at Lagoon Crocodile Farm (see Table 2-1).

The anticipated effluent quality for irrigation and the effluent strength when assessed against the *Environmental Guidelines – use of effluent by irrigation (DEC 2004)* is detailed in Table 2-1. The anticipated wastewater concentration for stage one is classified as "low" strength for all parameters except for BOD, which is considered "medium" strength.

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

Analyte	**Irrigation water quality – stage one**	**Strength (average concentration mg/L)**		
		Low	**Medium**	**High**
Total Nitrogen	38.1	<50	50-100	>100
Total Phosphorus	4.88	<10	10-20	>20
Biological oxygen demand (BOD)	313*	<40	40-1500	>1500
Total dissolved solids (TDS)	323	<600	600-1000	>1000
Effluent strength	Low strength			

*BOD is considered "medium" strength

3 IRRIGATION SUITABILITY ASSESSMENT

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

3.1 Organic content

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

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

The BOD content of the wastewater for irrigation is estimated at 313 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 BOD^5 (mg/L)

Q = average effluent flow rate (kL/month)

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

For RCRF Stage one:

A = 313 mg/L x 33.48 kL / month / (1,000 x 1,500 kg/ha/month)

A = 0.007 hectares

The above calculation indicates that a minimum area of 0.007 ha is required to manage the organic content of RCRF wastewater in stage one.

3.2 Suspended solids

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

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

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

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

3.3 pH

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

3.4 Metals

ANZECC (2000) Guidelines, Volume 3, Section 9.2.5 identify the maximum concentrations of metals in irrigation waters considered acceptable for continuous use. The concentration of the long-term trigger value (LTV) and short-term trigger value (STV) guidelines adapted from the Guidelines are show in Table 3-1. The majority of metal levels in the groundwater (water to be used within the pens) are all below the detectable limit and are therefore well below the LTV, except for arsenic which further sampling has been conducted to confirm the arsenic exceedances.

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

Metal	Bore water (mg/L)	Potable water (mg/L)	LTV in irrigation water (mg/L)	STV in irrigation water (mg/L)
As	<0.001	0.031	0.1	2.0
Cd	<0.0001	<0.0001	0.01	0.05
Cr(VI)	<0.001	<0.001	0.1	1
Cu	0.023	0.02	0.2	5
Pb	<0.001	<0.001	2	5
Hg	<0.0001	<0.0001	0.002	0.002
Ni	<0.001	<0.001	0.2	2
Zn	0.033	0.014	2	5

3.5 Oil and grease

The levels of oil and grease in the wastewater are expected to be below detection limits based on data collected from other crocodile farms around Darwin. These low levels will not present problems in regards to clogging irrigation systems or coating leaf surfaces of irrigated crops.

3.6 Pathogens

The concentration of *E.coli* and other pathogens in the wastewater for irrigation is expected to be high. Bacterial movement through soils is extremely limited and the harsh sunlight and climatic conditions typical of Australia rapidly diminish viable populations of bacteria. The irrigation area is off-limits to the public, therefore any pathogens in the wastewater are not expected to cause any harm to human receptors. Banana's have been chosen as the crop of choice by ASRAC , but as the banana skin is peeled off and irrigation to the banana plant will occur at the bases of the plan, the risk to human health is low. Irrigation

application is to be managed appropriately to avoid potentially harmful runoff. Chlorination of the wastewater to assist in pathogen removal can be introduced if required.

3.7 Salinity & sodicity

3.7.1 Salinity

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

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

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

EC is a measure of the total soluble salts in water. Some general irrigation electrical conductivity (ECi) ratings for wastewater are shown in Table 3-2. The anticipated average ECi of RCRF wastewater to be used for irrigation is < 0.5 dS/m (based on baseline groundwater and potable water collected from site as well as other crocodile farms around Darwin), which is considered low for irrigation according to ANZECC (2000). This will be confirmed with site-specific data.

Table 3-2. Salinity ratings for water (ANZECC 2000)

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

3.7.2 Sodicity

Sodicity is a term for the high concentrations of sodium ions relative to other cations in the exchangeable and / or soluble form in soil or water. Sodic soils have a range of adverse properties including poor soil structure and stability; surface crusting; poor aggregation; increased runoff and erosion; poor seedling emergence and slow water infiltration. Soil sampling was undertaken in the proposed irrigation area and the results of sampling identified that the exchange sodium percentage (ESP) had an average of 3.6%, with one of the fifteen samples recording an ESP of 8.6%. Soils with an ESP less than 6% are considered non-sodic, an ESP between 6 and 15% are considered sodic, and an ESP greater than 16% is considered strongly sodic.

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

The SAR in RCRF wastewater for irrigation (using representative wastewater data from Lagoon Crocodile Farm) is expected to be 1.4 which is not considered an issue, as outlined in Table 3-3.

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

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

3.7.3 Relationship between salinity and sodicity

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

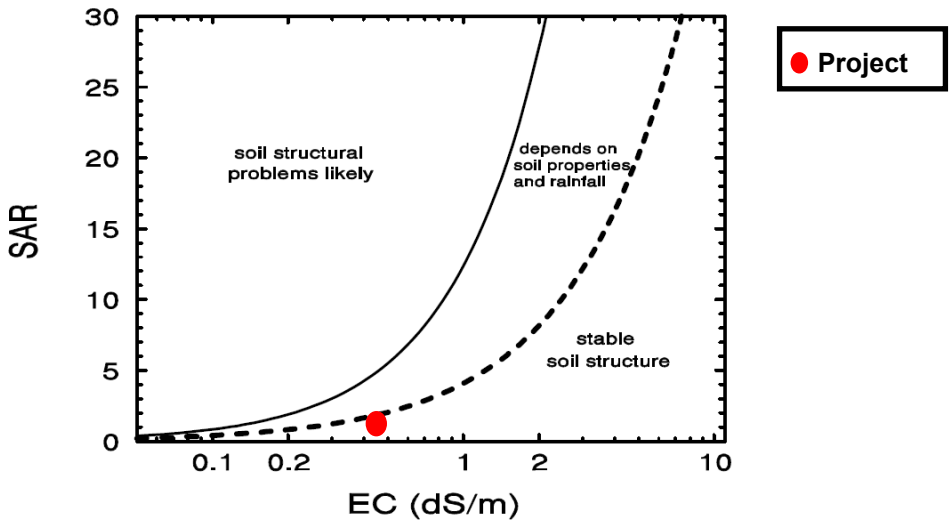


Figure 3-1. Relationship between SAR and EC for irrigation water for prediction of soil structure stability

Based on the above, salinity is not expected to be an issue for irrigation and salinity modelling is not required in this case.

4 MODELLING OF EFFLUENT REUSE

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

The MEDLI program was used to inform design requirements for the effluent land irrigation scheme for stage one of the RCRF (i.e. initial four pens). Note that MEDLI modelling was undertaken based on hatchery water quality data from Lagoon Crocodile Farm, which is considered likely to be similar to the outputs from the RCRF crocodile pens. However, RCRF water quality is likely to be better than that from the Lagoon Crocodile Farm due to the pens being new (i.e. no nutrient build up) and the pens being managed differently; therefore the MEDLI modelling is conservative. Once the RCRF is operational, site specific wastewater quality data will be used to update the modelling and refine irrigation area calculations.

4.1.1 Input data

Climate

A 70-year climate file for the Project area (Ramingining) was obtained from the SILO database (a climate database managed by the Queensland Department of Environment and Science) to input rainfall and evaporation data. The model was run using climate data from 01/01/1957 to 31/12/2020, to account for recent impacts of climate change that may affect the model outputs.

Inflow

The effluent inflow was set at 1,080 L a day based on predicted water use for stage one. Inflow volumes were only set for March to November (dry season) to coincide with the current programmed stage one operational period. A summary of the anticipated wastewater characteristics can be found below in Table 4-1.

Table 4-1. MEDLI waste estimation data inputs (Stage one)

Average daily quality	
Daily Effluent Production (m^3) i.e inflow volume	1.08
Total Nitrogen (mg/L)	38.1
Total Phosphorous (mg/L)	4.8
Total Dissolved Salts (mg/L)	153
Total Solids (mg/L)	323
Electrical Conductivity (dS/m)	0.239

Storage

The operation of the RCRF does not include wet weather storage as it will only be operational and generating wastewater during the dry season. However, the facility does has a series of holding storage tanks, which equate to a total volume of 34,500 L. These tanks are completely enclosed and consists of

- x1 Primary Tank (6,500 L)
- x1 Holding Tank (3,000 L)
- x1 Wastewater tank (25,000 L)

Soil

Soil samples were collected from the RCRF irrigation area in August 2021 and sent for laboratory analysis to assist in inputs for the MEDLI model. The results of the soil analysis input into MEDLI are described below in Table 4-2. Note that the term 'layers' is used throughout the MEDLI modelling and refers to soil horizons.

Table 4-2. MEDLI soil properties

Soil properties	Layer 1 (surface)	Layer 2 (surface to 0.5 m)	Layer 3 (0.5 m to 1.0 m)
Soil layer thickness (mm)	100	500	1000
Air dry (%v/v)	3.22	0.1	0.1
*Lower storage limit (%v/v)**	7.2	9.2	8
*Drained upper limit (%v/v)**	15.2	16.9	14.5
Available water capacity (mm)	8	38.5	65
*Saturated water content (%v/v)**	45.5	42.2	43.6
*Bulk density (g/cm^3)**	1.39	1.51	1.47
*Porosity**	47.55	43.02	44.53
Saturated Hydraulic Conductivity	50	50	20

**MEDLI standard 'Red Earth' paddock soil library used in this instance*

Crop selection

The default planting parameters for 'Banana Pasture' were used in the model as they are representative of the crop selection for the irrigation area. The default crop also has a maximum crop coefficient of 0.7. According to the NT *Guidelines for Land Capability Assessment for On-site Wastewater Management* (DOH, 2014), a crop factor of 0.8-1.0 would be appropriate for irrigation design purposes, based on the generally high year-round daytime temperatures in the NT.

Irrigation method

A total of 2,000 m^2 of land has been made available at the RCRF to irrigate banana crops for stage one. The irrigation system will consist of a surface irrigation with sprinklers spaced out across the proposed irrigation areas.

As rates and timing of irrigation operations are currently unknown, a general assumption was made as to when irrigation is triggered and applied.

A Soil Water Deficit (SWD) rate of 5 mm was adopted based on general conditions of the tropics in the absence of SWD data from the site.

Irrigation was adopted to be at a rate of 5 mm per irrigation event.

10mm of rainfall was adopted as a conservative measure to ensure the impact of rainfall on soil saturation is reflective of site conditions in the wet season when irrigation may occur. This is reflected in Appendix C.

The irrigation method was defined as MEDLI's default parameters for a Fixed Sprinkler system to mimic surface irrigation with sprinklers.

4.1.2 Modelling results

The results of the water and nutrient balances modelled by MEDLI are outlined in Table 4-3 to Table 4-6, respectively.

Table 4-3. WWS balance

	Unit	Scenario 1a (dryland)	Scenario 2 (Stage one condition)
Rain	m3/year	0.00	0.00
Inflow	m3/year	264.60	264.60
Evaporation	m3/year	0.00	0.00
Overflow	m3/year	264.06	**0.84**
Irrigation	m3/year	0.00	263.66
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	0.00	**1.00**
Probability of at least 90% reuse	Fraction	0.00	**1.00**

Table 4-4. Storage tank performance

	Unit	Scenario 2 (Stage one condition)
Number of overflow events	events/year	0.14
Overflow	m3/year	0.84
No. of overflow days	days/year	6.00
Effluent reuse through irrigation	Fraction	1.00

Table 4-5. Land water balance

	Unit	Scenario 1a (dryland)	Scenario 2 (Stage one condition)
Rain	mm/year	1280.76	1280.76
Irrigation	mm/year	0.00	131.83
Soil evaporation	mm/year	492.65	589.28
Transpiration	mm/year	67.52	92.43
Rain runoff	mm/year	123.84	120.74
Irrigation runoff	mm/year	0.00	0.00
Deep drainage	mm/year	596.18	**609.57**

Table 4-6. Land nutrient balance

	Unit	N balance	P balance
		Scenario 2	
Irrigation (effluent load added)	kg/ha/year	35.01	6.33
Denitrification	kg/ha/year	0.13	-
Irrigation runoff	kg/ha/year	0.00	0.00
Plant uptake	kg/ha/year	**23.08**	**3.58**
Leached	kg/ha/year	**46.43**	**0.03**
Average nitrate-N concentration of deep drainage	mg/L	**7.62**	-

The results for Scenario 2 show that under the stage one effluent system, overtopping from the tank storage system estimated to be at 0.84 m^3/year or about 0.3 % of the annual effluent inflow. A general rule of thumb is that effluent overflow should not exceed more than 5% of the annual effluent inflow. The overtopping detailed in Appendix B shows 0.14 overflow events per year (1.4 events every 10 years). Effluent reuse fraction is 1.00, which is above the Queensland MEDLI guidelines of an effluent reuse fraction of at least 0.95. The probability fraction of at least 90% reuse was 1.00.

The effluent irrigation volume applied in Scenario 2 is approximately 263.66 m^3/year. The predicted deep drainage is 609.57 mm/year, less than 200mm /year more than the dryland scenario (596.18 mm/year).

The nitrogen loading rate is estimated at 35.01 kg/ha/year, average annual soil nitrogen leached is approximately 23.08 kg/ha/year and average nitrate-N concentration of deep drainage is 7.62 mg/L (below 10 mg/L). The predicted phosphorus loading rate is 6.33 kg/ha/yr, with approximately 3.58 kg/ha/yr removed by plant uptake. Average annual phosphorous leaching is predicted to be 0.03 kg/ha/year.

4.1.3 Summary

In summary, the irrigation area required for stage one, to adequately dispose of the wastewater from the RCRF is 2,000 m^2. It is recommended that once the RCRF is operational, water samples are collected of the site-specific wastewater to be applied to the irrigation area to provide a more accurate indication of the uptake of nutrients. The models run indicate that due to the higher TN and TP loading in the soils naturally, would require an extremely large irrigation areas (greater than 2 hectares for a fully operational rearing facility) to be able to irrigate the wastewater to the assessment criteria specified in the MEDLI modelling report.

However, the average nitrate and phosphorous concentrations in the predicted wastewater do not exceed the assessment criteria. Dilution of wastewater with bore water may be an option to reduce the volume of nutrients that may leach into the soils, however for this to be assessed properly, site water samples will be required to confirm the nutrient concentrations.

It is recommended that, once operational, wastewater samples are collected to confirm the nutrient loads, and the MEDLI modelling be repeated to give a more accurate model for the site conditions. Additionally, ongoing soil sampling should be undertaken in the irrigation area to assess the level of nutrient uptake by the soil, and amend the wastewater volumes, dilution ratios, or size of the irrigation area for the remainder of the RCRF, as appropriate.

5 IRRIGATION AND CROP MANAGEMENT

5.1 Irrigation infrastructure

After treatment through a parabolic screen, wastewater will be irrigated onto crops adjacent to the RCRF, within the site boundary. Wastewater will be irrigated onto banana crops within the irrigation area, as banana's take up significant water and nutrient loads. Note that wastewater will only be irrigated during the dry season as pens will be decommissioned, and therefore not generating wastewater, during the wet season

Surface spray irrigation will be undertaken via lateral surface irrigation lines, which are buried to protect the infrastructure from damage and sprinklers. The irrigation area will be surrounded by a vegetated buffer, and stormwater drainage will be installed to divert any stormwater away from the irrigation area (noting that irrigation will not be undertaken during the wet season). In addition, the location of the irrigation area at the RCRF maintains more than a 100 m buffer distance from any sensitive receptors, such as the site bore, waterways, waterbodies and neighbouring properties as per the NT Code of Practice for Wastewater Management.

5.2 Irrigation management

Sustainable wastewater management involves the selection of suitable irrigation infrastructure to the water and nutrient requirements of the crops, while also preventing oversaturation resulting in uncontrolled run off, damaging of the soil and unsustainable crops.

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

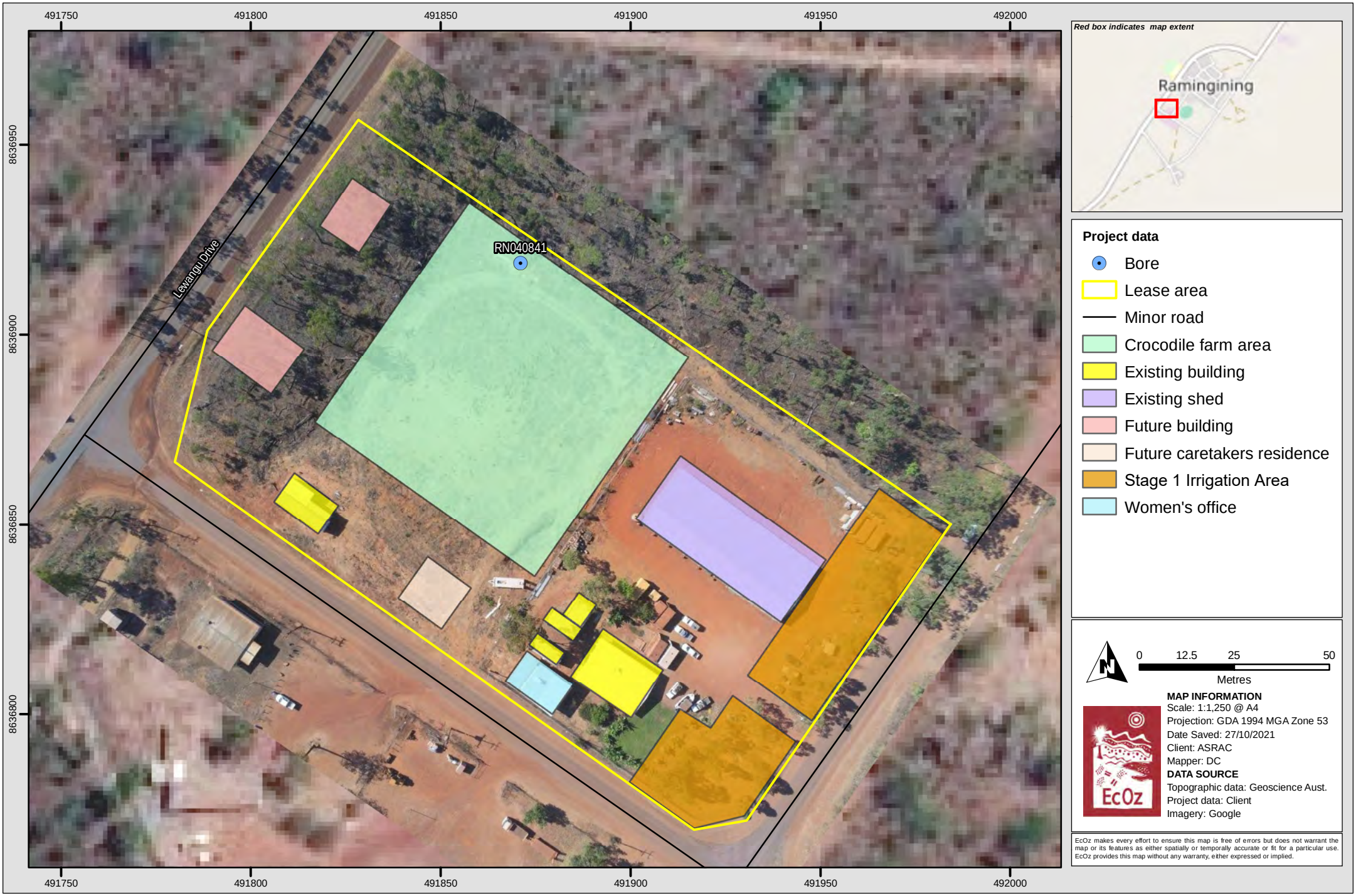
5.2.1 Runoff control

RCRF 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, based on MEDLI modelling outputs.
- Daily visual inspections of irrigation area for evidence of potential runoff (also mist/overspray and odour).
- Avoid irrigating during and after heavy rainfall
- Buffer zone of 50 m around the irrigation area, to prevent impact on sensitive receptors and neighbouring properties.

5.3 Crop management

The irrigation area is to be managed by ASRAC, who will be responsible for the harvesting when required. The crops proposed are bananas and will be inspected regularly to monitor their growth as well as plant health to determine any visual impacts of nutrient supply. Crops will be managed to encourage growth and nutrient uptake. The banana's will be edible and therefore irrigated water will be at the base of the plant, whereby no irrigation water will be sprayed onto the fruit.



Path: Z:\01 EcOz_Documents\04 EcOz Vantage GIS\EZ21134 - Ramingining Crocodile Farm Approvals\01 Project Files\Infrastructure map.mxd

Figure 5-1. Stage 1 Irrigation Areas

6 MONITORING AND REPORTING

6.1 Daily monitoring

Daily visual inspections of the irrigation area will be undertaken as per the procedures included in Appendix C.

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

6.2 Compliance water and soil monitoring

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

6.3 Assessment of performance indicators

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

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

Key parameters:

- Soil nitrogen
- Available phosphorus
- Salinity

6.4 Reporting

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

6.4.1 Internal reporting

Details of environmental incidents, non-conformances or other relevant information are included in daily reports which are issued to the RCRF Manager and ASRAC CEO. 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 and will be available upon request to the NT EPA.

6.4.2 External reporting

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

Reporting will be undertaken in accordance with the EPL. An annual report will be submitted to the NT EPA on the anniversary data of the EPL which summaries the activities and outcomes of the previous 12 months

of operation. Additionally, a monitoring report will be prepared and submitted in conjunction with the Annual Report, which will include a trend analysis of the water quality monitoring data and an assessment of any environmental impacts from RCRF operations.

7 REFERENCES

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

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

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

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

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

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

APPENDIX A SOIL AND WATER SAMPLING RESULTS

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2130425**	Page	: 1 of 9
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: SUZANNE BARBER	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 08 8981 1100	Telephone	: +61-2-8784 8555
Project	: EZ21134 Ramingining Crocodile Farm	Date Samples Received	: 20-Aug-2021 13:56
Order number	: EZ21134	Date Analysis Commenced	: 23-Aug-2021
C-O-C number	: ----	Issue Date	: 31-Aug-2021 15:29
Sampler	: AF		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 17		
No. of samples analysed	: 16		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Aleksandar Vujkovic	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Dian Dao	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Evie Sidarta	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA150H: Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1 2006 was not requested by the client. Typical sediment SPD values used for calculations and consequently NATA endorsement does not apply to hydrometer results.
- MF = membrane filtration
- CFU = colony forming unit
- Microbiological Comment: In accordance with ALS work instruction QWI-MIC/04, membrane filtration result is reported an approximate (~) when the count of colonies on the filtered membrane is outside the range of 10 - 100cfu.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- MW023 is ALS's internal code and is equivalent to AS4276.9.
- MW006 is ALS's internal code and is equivalent to AS4276.7.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 1 - surface	Soil sample 1 - 0-0.5m	Soil sample 1 - 0.5m-1.0m	Soil sample 2 - surface	Soil sample 2 - 0-0.5m
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	ES2130425-003	ES2130425-004	ES2130425-005	ES2130425-006	ES2130425-007
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	7.8	6.7	6.5	5.9	6.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	39	9	8	19	6
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	2.8	5.7	6.1	3.9	5.8
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Strong Brown (7.5YR 4/6)	Strong Brown (7.5YR 4/6)	Red (2.5YR 4/6)	Very Dark Grayish Brown (10YR 3/2)	Dark Yellowish Brown (10YR 4/4)
Texture	----	-	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Emerson Class Number	EC/TC	-	-	3	3	3	2	3
EA150: Particle Sizing								
+75µm	----	1	%	71	68	65	76	74
+150µm	----	1	%	43	41	43	46	47
+300µm	----	1	%	26	21	28	26	32
+425µm	----	1	%	21	15	22	19	27
+600µm	----	1	%	18	12	19	16	25
+1180µm	----	1	%	15	9	17	12	22
+2.36mm	----	1	%	8	4	9	7	14
+4.75mm	----	1	%	2	1	3	3	5
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	17	21	23	9	13
Silt (2-60 µm)	----	1	%	11	9	10	11	12
Sand (0.06-2.00 mm)	----	1	%	62	64	56	72	59
Gravel (>2mm)	----	1	%	10	6	11	8	16
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
ED006: Exchangeable Cations on Alkaline Soils								
Exchangeable Calcium	----	0.2	meq/100g	0.4	----	----	----	----
Exchangeable Magnesium	----	0.2	meq/100g	<0.2	----	----	----	----
Exchangeable Potassium	----	0.2	meq/100g	<0.2	----	----	----	----
Exchangeable Sodium	----	0.2	meq/100g	<0.2	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 1 - surface	Soil sample 1 - 0-0.5m	Soil sample 1 - 0.5m-1.0m	Soil sample 2 - surface	Soil sample 2 - 0-0.5m
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	ES2130425-003	ES2130425-004	ES2130425-005	ES2130425-006	ES2130425-007
				Result	Result	Result	Result	Result
ED006: Exchangeable Cations on Alkaline Soils - Continued								
Cation Exchange Capacity	----	0.2	meq/100g	**0.4**	----	----	----	----
Exchangeable Sodium Percent	----	0.2	%	<0.2	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	----	**0.3**	**0.2**	**1.4**	**0.7**
Exchangeable Magnesium	----	0.1	meq/100g	----	**0.6**	**0.7**	**0.6**	**0.3**
Exchangeable Potassium	----	0.1	meq/100g	----	<0.1	<0.1	**0.1**	<0.1
Exchangeable Sodium	----	0.1	meq/100g	----	<0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	----	**1.0**	**1.0**	**2.1**	**1.0**
Exchangeable Sodium Percent	----	0.1	%	----	**5.6**	**1.7**	**2.4**	**3.1**
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	<100	<100	<100	<100	<100
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	**8.1**	**1.6**	**1.6**	**0.2**	**0.3**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	**340**	**160**	**150**	**660**	**270**
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	**350**	**160**	**150**	**660**	**270**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	**72**	**51**	**57**	**91**	**80**
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	**998**	**1330**	**1390**	**1380**	**1330**
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	**29**	**38**	**44**	**31**	**40**
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5
EP004: Organic Matter								
Organic Matter	----	0.5	%	**1.2**	**0.7**	<0.5	**3.3**	**1.0**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 2 - 0.5m-1.0m	Soil sample 3 - surface	Soil sample 3 - 0-0.5m	Soil sample 3 - 0.5m-1.0m	Soil sample 4 - surface
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	ES2130425-008	ES2130425-009	ES2130425-010	ES2130425-011	ES2130425-012
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.9	6.1	6.2	6.2	5.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	8	33	7	6	14
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	8.2	2.3	4.7	5.2	2.8
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Brown (7.5YR 4/3)	Brown (7.5YR 4/3)	Brown (7.5YR 4/4)	Brown (7.5YR 4/4)	Brown (7.5YR 4/3)
Texture	----	-	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam
Emerson Class Number	EC/TC	-	-	3	3	3	3	3
EA150: Particle Sizing								
+75µm	----	1	%	64	71	71	66	70
+150µm	----	1	%	46	44	47	46	43
+300µm	----	1	%	33	28	30	31	23
+425µm	----	1	%	28	21	23	25	16
+600µm	----	1	%	26	18	20	21	12
+1180µm	----	1	%	23	14	16	17	8
+2.36mm	----	1	%	15	9	10	10	4
+4.75mm	----	1	%	7	3	4	4	1
+9.5mm	----	1	%	<1	<1	<1	<1	<1
+19.0mm	----	1	%	<1	<1	<1	<1	<1
+37.5mm	----	1	%	<1	<1	<1	<1	<1
+75.0mm	----	1	%	<1	<1	<1	<1	<1
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	21	12	13	19	11
Silt (2-60 µm)	----	1	%	13	14	15	14	17
Sand (0.06-2.00 mm)	----	1	%	48	64	60	55	67
Gravel (>2mm)	----	1	%	18	10	12	12	5
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	<1
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.8	0.6	0.2	0.3	0.4
Exchangeable Magnesium	----	0.1	meq/100g	0.5	0.5	0.4	0.6	0.3
Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	<0.1
Exchangeable Sodium	----	0.1	meq/100g	<0.1	0.1	<0.1	<0.1	<0.1
Cation Exchange Capacity	----	0.1	meq/100g	1.3	1.4	0.7	1.0	0.8

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 2 - 0.5m-1.0m	Soil sample 3 - surface	Soil sample 3 - 0-0.5m	Soil sample 3 - 0.5m-1.0m	Soil sample 4 - surface
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00
Compound	CAS Number	LOR	Unit	ES2130425-008	ES2130425-009	ES2130425-010	ES2130425-011	ES2130425-012
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Sodium Percent	----	0.1	%	3.2	8.6	5.5	4.8	1.3
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	<100	<100	<100	<100	<100
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	0.2	1.8	0.7	0.4	5.5
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	320	520	210	330	400
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	320	520	210	330	400
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	73	84	66	79	75
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	1740	910	1090	1140	1340
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	45	22	37	39	46
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	<5
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.4	1.4	0.6	0.8	1.4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 4 - 0-0.5m	Soil sample 5 - surface	Soil sample 5 - 0-0.5m	Soil sample 5 - 0.5m-1.0m	----
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	----
Compound	CAS Number	LOR	Unit	ES2130425-013	ES2130425-015	ES2130425-016	ES2130425-017	--------
				Result	Result	Result	Result	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	6.4	6.5	6.5	6.2	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	10	8	5	6	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	7.3	4.3	5.8	6.5	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Yellowish Red (5YR 4/6)	Dark Brown (10YR 3/3)	Brown (7.5YR 4/4)	Reddish Brown (5YR 4/4)	----
Texture	----	-	-	Sandy Loam	Sandy Loam	Sandy Loam	Sandy Loam	----
Emerson Class Number	EC/TC	-	-	3	2	3	3	----
EA150: Particle Sizing								
+75µm	----	1	%	62	74	81	80	----
+150µm	----	1	%	43	47	57	60	----
+300µm	----	1	%	29	27	43	46	----
+425µm	----	1	%	23	20	40	42	----
+600µm	----	1	%	19	17	37	39	----
+1180µm	----	1	%	16	13	33	35	----
+2.36mm	----	1	%	8	7	25	27	----
+4.75mm	----	1	%	2	3	14	17	----
+9.5mm	----	1	%	<1	<1	5	7	----
+19.0mm	----	1	%	<1	<1	<1	<1	----
+37.5mm	----	1	%	<1	<1	<1	<1	----
+75.0mm	----	1	%	<1	<1	<1	<1	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	22	8	8	9	----
Silt (2-60 µm)	----	1	%	13	18	10	10	----
Sand (0.06-2.00 mm)	----	1	%	54	65	54	52	----
Gravel (>2mm)	----	1	%	11	9	28	29	----
Cobbles (>6cm)	----	1	%	<1	<1	<1	<1	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.3	0.7	0.2	0.1	----
Exchangeable Magnesium	----	0.1	meq/100g	0.4	0.5	0.6	0.7	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----
Exchangeable Sodium	----	0.1	meq/100g	<0.1	<0.1	<0.1	<0.1	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 4 - 0-0.5m	Soil sample 5 - surface	Soil sample 5 - 0-0.5m	Soil sample 5 - 0.5m-1.0m	----
			Sampling date / time	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	12-Aug-2021 00:00	----
Compound	CAS Number	LOR	Unit	ES2130425-013	ES2130425-015	ES2130425-016	ES2130425-017	--------
				Result	Result	Result	Result	----
ED007: Exchangeable Cations - Continued								
Cation Exchange Capacity	----	0.1	meq/100g	0.7	1.3	0.8	0.9	----
Exchangeable Sodium Percent	----	0.1	%	3.8	2.7	2.6	2.8	----
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	100	mg/kg	<100	<100	<100	<100	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	4.3	0.6	0.3	0.5	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	320	670	320	250	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	320	670	320	250	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	69	97	65	65	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	1270	1350	1110	978	----
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	47	41	39	48	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	<5	<5	<5	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	0.8	1.8	0.8	0.6	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	Bore	Potable water	----	----	----
			Sampling date / time	13-Aug-2021 00:00	13-Aug-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2130425-001	ES2130425-002	--------	--------	--------
				Result	Result	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	<0.001	**0.031**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.023**	**0.020**	----	----	----
Nickel	7440-02-0	0.001	mg/L	<0.001	<0.001	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	<0.001	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.033**	**0.014**	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) EA058: Emerson Aggregate Test

(SOIL) ED021: Bicarbonate Extractable Potassium (Colwell)

(SOIL) EK080: Bicarbonate Extractable Phosphorus (Colwell)

Analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no. 1656 (Chemistry) 9854 (Biology).

(SOIL) EA150: Soil Classification based on Particle Size

(SOIL) EA150: Particle Sizing

Department of Industry, Tourism and Trade

Certificate of Analysis

Project No: **D212156 Final Report**

Report Number: **77400** *Date Issued:* **03/09/2021**

Water Microbiology Darwin
BVL Building, Berrimah Farm
29 Makagon Road, BERRIMAH, NT 0828
p: +61 8 8999 2347
f: +61 8 8923 9566
e: WaterLabsDarwin.ITT@nt.gov.au
w: https://industry.nt.gov.au/

Customer **EcOz Environmental Services**

Address: **75 Wood St Darwin**
GPO Box 381
Darwin 0801 NT 0800

Project Title: **Ramingining Croc Farm EZ21134**

Attention: **Adele Faraone**

Date Received: **31/08/2021**

Date Completed: **02/09/2021**

Number of Samples Received: **2**

Number of Samples Tested: **2**

The sample(s) referred to in this report were analysed by the following method(s):

Analyte	*Method Reference*	*Accreditation Status*	*Analyte*	*Method Reference*	*Accreditation Status*
Enterococci (MPN)	ASTM D6503	NATA Accredited	E. coli (Membrane Filtration)	AS 4276.7	NATA Accredited
Thermotolerant Coliforms (Membrane Filtration)	AS 4276.7	NATA Accredited			

Lab Number	Sampling Point*	Customer Reference*	Free Cl (mg/L)*	Total Cl (mg/L)*	Sample Collection Temp (°C)*	Temp on Arrival (°C) #	Type of Sample
D212156-01	Bore	EZ21134	Not supplied	Not supplied	Not supplied	26	Water
D212156-02	Potable Water	EZ21134	Not supplied	Not supplied	Not supplied	26	Water

***Based on information supplied by customer ; # Reported arrival temperature reflects the approximate temperature of the group of samples when received by the laboratory. This measurement does not fall within the scope of the Laboratory's NATA Accreditation.

Holding Time

Max Holding Time is the maximum time permitted between sample collection and commencement of analysis. Reference: AS 2031.

^ indicates the sample has exceeded the maximum holding time permitted for the analysis. Affected results must be considered indicative only.

****Sample collection dates and times are reported as supplied by the customer and reported holding times are calculated from this information. While all due care is taken during transcription, the accuracy of this information is not guaranteed by the laboratory.

		Enterococci Max Holding Time: 24 hrs		E. coli (MF) Max Holding Time: 24 hrs		Thermotolerant Coliforms (MF) Max Holding Time: 24 hrs	
Lab Number	Sample Collected**	Date of Analysis	Analysed within**	Date of Analysis	Analysed within**	Date of Analysis	Analysed within**
D212156-01	31/08/2021 11:10am	31/08/2021 3:10pm	4 hrs	31/08/2021 3:10pm	4 hrs	31/08/2021 3:10pm	4 hrs
D212156-02	31/08/2021 1:20pm	31/08/2021 3:10pm	1h 50m	31/08/2021 3:10pm	1h 50m	31/08/2021 3:10pm	1h 50m

Results of Analysis

	Enterococci MPN/100mL	E. coli (MF) cfu/100mL	Thermotolerant Coliforms (MF) cfu/100mL
D212156-01 Bore	<1	<1	<1
D212156-02 Potable Water	<1	<1	<1

The results in this report were authorised by:

Stephen Poole - Laboratory Manager

Measurement Uncertainty (MU) should be considered when assessing quantitative results. Contact the laboratory for current MU values.

Dates are reported in the format dd/mm/yyyy.

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2131710**	Page	: 1 of 7
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: SUZANNE BARBER	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: 08 8981 1100	Telephone	: +61-2-8784 8555
Project	: EZ21134 Ramingining Crocodile Farm	Date Samples Received	: 02-Sep-2021 06:30
Order number	: EZ21134	Date Analysis Commenced	: 02-Sep-2021
C-O-C number	: ----	Issue Date	: 14-Sep-2021 14:54
Sampler	: AF		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 8		
No. of samples analysed	: 8		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics, Smithfield, NSW
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Dian Dao	Senior Chemist - Inorganics	Sydney Inorganics, Smithfield, NSW
Franco Lentini	LCMS Coordinator	Sydney Inorganics, Smithfield, NSW
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD
Somlok Chai	Microbiologist	Sydney Microbiology, Smithfield, NSW
Uma Nagendiram	Subcontracting Coordinator	WRG Subcontracting, Smithfield, NSW
Vincent Emerton-Bell	Laboratory Technician	Newcastle - Inorganics, Mayfield West, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EA150H: Soil Particle Density required for Hydrometer analysis according to AS 1289.3.5.1 2006 was not requested by the client. Typical sediment SPD values used for calculations and consequently NATA endorsement does not apply to hydrometer results.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the Chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.
- TDS by method EA-015 may bias high for various samples due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- ED021 (Bicarbonate Extractable K (Colwell) by ICP-AES): The limit of reporting for Sample Soil sample 4 (ES2131710_001) has been raised due to matrix interference.
- EA058 Emerson: V. = Very, D. = Dark, L. = Light, VD. = Very Dark
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 4 0.5m-1.0m	SS1	SS2	SS3	SS4
			Sampling date / time	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00
Compound	CAS Number	LOR	Unit	ES2131710-001	ES2131710-002	ES2131710-003	ES2131710-004	ES2131710-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.3	----	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	12	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	----	4.0	4.7	3.4	2.6
Moisture Content	----	1.0	%	6.8	----	----	----	----
EA058: Emerson Aggregate Test								
Color (Munsell)	----	-	-	Yellowish Red (5YR 4/6)	----	----	----	----
Texture	----	-	-	Clayey Sand	----	----	----	----
Emerson Class Number	EC/TC	-	-	2	----	----	----	----
EA150: Particle Sizing								
+75µm	----	1	%	66	----	----	----	----
+150µm	----	1	%	47	----	----	----	----
+300µm	----	1	%	34	----	----	----	----
+425µm	----	1	%	28	----	----	----	----
+600µm	----	1	%	25	----	----	----	----
+1180µm	----	1	%	22	----	----	----	----
+2.36mm	----	1	%	14	----	----	----	----
+4.75mm	----	1	%	4	----	----	----	----
+9.5mm	----	1	%	<1	----	----	----	----
+19.0mm	----	1	%	<1	----	----	----	----
+37.5mm	----	1	%	<1	----	----	----	----
+75.0mm	----	1	%	<1	----	----	----	----
EA150: Soil Classification based on Particle Size								
Clay (<2 µm)	----	1	%	18	----	----	----	----
Silt (2-60 µm)	----	1	%	15	----	----	----	----
Sand (0.06-2.00 mm)	----	1	%	51	----	----	----	----
Gravel (>2mm)	----	1	%	16	----	----	----	----
Cobbles (>6cm)	----	1	%	<1	----	----	----	----
ED007: Exchangeable Cations								
Exchangeable Calcium	----	0.1	meq/100g	0.3	----	----	----	----
Exchangeable Magnesium	----	0.1	meq/100g	0.6	----	----	----	----
Exchangeable Potassium	----	0.1	meq/100g	<0.1	----	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Sample ID	Soil sample 4 0.5m-1.0m	SS1	SS2	SS3	SS4
			Sampling date / time	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00	01-Sep-2021 00:00
Compound	CAS Number	LOR	Unit	ES2131710-001	ES2131710-002	ES2131710-003	ES2131710-004	ES2131710-005
				Result	Result	Result	Result	Result
ED007: Exchangeable Cations - Continued								
Exchangeable Sodium	----	0.1	meq/100g	<0.1	----	----	----	----
Cation Exchange Capacity	----	0.1	meq/100g	1.0	----	----	----	----
Exchangeable Sodium Percent	----	0.1	%	2.6	----	----	----	----
ED021: Bicarbonate Extractable Potassium (Colwell)								
Bicarbonate Extractable K (Colwell)	----	10	mg/kg	<100	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N (Sol.)	----	0.1	mg/kg	4.9	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	20	mg/kg	330	----	----	----	----
EK062: Total Nitrogen as N (TKN + NOx)								
^ Total Nitrogen as N	----	20	mg/kg	330	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	2	mg/kg	90	----	----	----	----
EK072: Phosphate Sorption Capacity								
Phosphate Sorption Capacity	----	250	mg P sorbed/kg	963	----	----	----	----
Phosphate Sorption Index	----	1	mgkg-1/log10 ugL-1	51	----	----	----	----
EK080: Bicarbonate Extractable Phosphorus (Colwell)								
Bicarbonate Ext. P (Colwell)	----	5	mg/kg	<5	----	----	----	----
EP004: Organic Matter								
Organic Matter	----	0.5	%	1.3	----	----	----	----
MM804: Faecal Coliforms & E.coli by MPN								
Faecal Coliforms	----	2	MPN/g	----	2	<2	<2	<2
Escherichia coli	----	2	MPN/g	----	<2	<2	<2	<2
MM834: Enterococci by Enterolert								
Enterococci MPN Enterolert	----	10	MPN/g	----	<10	65	160	640

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)				Sample ID	SS5	----	----	----	----
				Sampling date / time	01-Sep-2021 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES2131710-006	--------	--------	--------	--------
					Result	----	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)									
Moisture Content	----	0.1	%		**3.2**	----	----	----	----
MM804: Faecal Coliforms & E.coli by MPN									
Faecal Coliforms	----	2	MPN/g		**2**	----	----	----	----
Escherichia coli	----	2	MPN/g		<2	----	----	----	----
MM834: Enterococci by Enterolert									
Enterococci MPN Enterolert	----	10	MPN/g		**95**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	Bore	Potable Water	----	----	----
			Sampling date / time	01-Sep-2021 00:00	01-Sep-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2131710-007	ES2131710-008	--------	--------	--------
				Result	Result	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**6.63**	**6.19**	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**32**	**38**	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**24**	**33**	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**8**	**6**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**8**	**6**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	<1	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**6**	**8**	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	<1	<1	----	----	----
Magnesium	7439-95-4	1	mg/L	<1	<1	----	----	----
Sodium	7440-23-5	1	mg/L	**5**	**6**	----	----	----
Potassium	7440-09-7	1	mg/L	<1	<1	----	----	----
ED093F: SAR and Hardness Calculations								
^ Sodium Adsorption Ratio	----	0.01	-	**1.20**	**1.44**	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.05**	**0.03**	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.04**	**0.05**	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.04**	**0.05**	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	<0.1	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	<0.1	<0.1	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	Bore	Potable Water	----	----	----
			Sampling date / time	01-Sep-2021 00:00	01-Sep-2021 00:00	----	----	----
Compound	CAS Number	LOR	Unit	ES2131710-007	ES2131710-008	--------	--------	--------
				Result	Result	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	<0.01	**0.10**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	<0.01	----	----	----
EN055: Ionic Balance								
ø **Total Anions**	----	0.01	meq/L	**0.33**	**0.34**	----	----	----
ø **Total Cations**	----	0.01	meq/L	**0.22**	**0.26**	----	----	----
EP030: Biochemical Oxygen Demand (BOD)								
Biochemical Oxygen Demand	----	2	mg/L	<2	<2	----	----	----

Inter-Laboratory Testing

Analysis conducted by ALS Brisbane, NATA accreditation no. 825, site no. 818 (Chemistry) 18958 (Biology).

(SOIL) ED021: Bicarbonate Extractable Potassium (Colwell)

(SOIL) EK080: Bicarbonate Extractable Phosphorus (Colwell)

(SOIL) EA058: Emerson Aggregate Test

Analysis conducted by ALS Newcastle, NATA accreditation no. 825, site no. 1656 (Chemistry) 9854 (Biology).

(SOIL) EA150: Soil Classification based on Particle Size

(SOIL) EA150: Particle Sizing

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **ES2139346**	Page	: 1 of 2
Client	: **ECOZ ENVIRONMENTAL SERVICES**	Laboratory	: Environmental Division Sydney
Contact	: MS HELEN DWYER	Contact	: Customer Services ES
Address	: PO BOX 381 DARWIN NT, AUSTRALIA 0801	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
Telephone	: +61 08 89811100	Telephone	: +61-2-8784 8555
Project	: EZ21137 Ramingining Crocodile Farm	Date Samples Received	: 02-Nov-2021 07:00
Order number	: ----	Date Analysis Commenced	: 08-Nov-2021
C-O-C number	: ----	Issue Date	: 09-Nov-2021 10:29
Sampler	: Adele Faraone		
Site	: ----		
Quote number	: EN/222		
No. of samples received	: 1		
No. of samples analysed	: 1		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ivan Taylor	Analyst	Sydney Inorganics, Smithfield, NSW

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)				Sample ID	**Potable Water**	----	----	----	----
				Sampling date / time	29-Oct-2021 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*		**ES2139346-001**	--------	--------	--------	--------
					Result	----	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		<0.001	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.136**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L		<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	----	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.128**	----	----	----	----
EG035F: Dissolved Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	----	----	----	----

APPENDIX B MEDLI MODELLING OUTPUTS

MEDLI Modelling Report for Ramingining Crocodile Rearing Facility

Arafura Swamp Rangers Aboriginal Corporation

www.ecoz.com.au

DOCUMENT CONTROL RECORD

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

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1 INTRODUCTION

1.1 MEDLI

MEDLI is a software tool developed by the CRC for Waste Management and Pollution Control, the then Queensland Department of Primary Industries, and Commonwealth Scientific and Industrial Research Organisation (CSIRO) in the mid-1990s. It is a model to assist in designing and analysing effluent systems for intensive rural industries, agri-industrial processors (e.g. abattoirs) and sewage treatment plants using land irrigation. The model integrates many factors impacting on effluent irrigation, such as the quality and quantity of effluent, climate, storage, irrigation frequency and amount, nitrogen and phosphorus loads, salt components and plant growth.

MEDLI was utilised to model the current conditions of Ramingining Crocodile Rearing Facility (RCRF) irrigation area, based on information provided by the Arafura Swamp Rangers Aboriginal Corporation (ASRAC), soil data from the RCRF and water quality data from Lagoon Crocodile Farm in Darwin.

1.2 Approach

Soil samples were collected from the RCRF in August 2021, whilst effluent data (post screen) was obtained from Lagoon Crocodile Farm in Darwin from March 2020. This data was used to inform the MEDLI model inputs. Where data was unavailable, assumptions were made and are listed in the below sections. Modelling will be refined when site specific data is available.

The approach taken for the model is listed below:

- Scenario 1a (dryland run) – A ‘dryland’ scenario (i.e natural condition) was run initially, where the irrigation inputs were removed, in order to determine the natural conditions and deep drainage rates for the irrigation area without any irrigation inputs.
- Scenario 2 (future Stage 1 situation) – The proposed site conditions were modelled as per the data provided and assumptions listed in Section 3.

2 SOIL SAMPLING

Soil samples were collected on 12 August 2021 at 5 sites within the proposed irrigation area. Samples were collected from three depths throughout the profile (surface, 0.5 m and 1.0 m). Results are summarised as follow:

- Soil colour was predominantly classed as Brown, with some variations including Strong Brown, Yellowish Brown and Reddish Brown. Soil texture is predominantly Sandy Loam.
- The soils are non-saline, with a low Electrical Conductivity (EC) (<45 µS/cm) and average pH of 6.27.
- Most soils are classified as non-sodic (<6) with an average exchangeable sodium percentage (ESP) of 3.6 %. One out of the fifteen samples collected recorded an ESP of 8.6 %.
- Soils are mostly classed with an Emerson class of 3 (class 1 being complete dispersion). Three out of the fifteen samples collected have am Emerson class number of 2. Standard erosion and sediment controls will prevent soil loss through dispersion and runoff.
- Total Nitrogen (TN) levels ranged from 150 mg/kg to 660 mg/kg, averaging an TN concentration of 350 mg/kg. Total Phosphorous (TP) levels ranged from 51 mg/kg to 91 mg/kg, with an average TP concentration of 74 mg/kg.
- Soils recorded low concentrations of *E.coli* and Faecal Coliforms, at or below the limit of reporting (LOR). Enterococci concentrations between 65 MPN/g to 240 MPN/g.

The samples collected were also analysed for particle sizing and soil classification, summarised below in Table 2-1.

Table 2-1. Summary of soil classification based on particle sizing

Soil sample	Clay (<2µm)	Silt (2-60µm)	Sand (0.06-2.00mm)	Gravel (>2mm)	Cobbles (>6cm)
Soil sample 1 - surface	17	11	62	10	<1
Soil sample 1 - 0-0.5m	21	9	64	6	<1
Soil sample 1 - 0.5m-1.0m	23	10	56	11	<1
Soil sample 2 - surface	9	11	72	8	<1
Soil sample 2 - 0-0.5m	13	12	59	16	<1
Soil sample 2 - 0.5m-1.0m	21	13	48	18	<1
Soil sample 3 - surface	12	14	64	10	<1
Soil sample 3 - 0-0.5m	13	15	60	12	<1
Soil sample 3 - 0.5m-1.0m	19	14	55	12	<1
Soil sample 4 - surface	11	17	67	5	<1
Soil sample 4 - 0-0.5m	22	13	54	11	<1
Soil sample 4 - 0.5m-1.0m	18	15	51	16	<1
Soil sample 5 - surface	8	18	65	9	<1
Soil sample 5 - 0-0.5m	8	10	54	28	<1
Soil sample 5 - 0.5m-1.0m	9	10	52	29	<1

From the samples collected, averages were calculated for each depth (horizon) to input into MEDLI, refer to Section 3.5 for more information.

3 INPUTS AND ASSUMPTIONS

3.1 Location and climate

A 70-year climate file for the Project area (Ramingining) was obtained from the SILO database (a climate database managed by the Queensland Department of Environment and Science) to input rainfall and evaporation data. The model was run using climate data from 01/01/1957 to 31/12/2020, to account for recent impacts of climate change that may affect the model outputs. Monthly data from the dataset is summarised below in Table 3-1.

Table 3-1. Climate data recorded at Ramingining (SILO coordinates -12.35, 134.95)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Average Max Temperature	32.5	32.1	32.0	32.2	31.5	30.0	29.7	30.6	32.1	33.3	34.1	33.6
Average Min Temperature	24.9	24.7	24.3	23.3	21.6	19.2	18.2	18.4	20.5	23.0	24.8	25.3
Average Total Rain	295.3	269.3	278.2	143.7	25.6	5.5	2.2	0.6	2.4	13.2	58.2	186.5
Average total Evaporation	171.1	144.5	156.9	164.5	169.7	158.7	169.9	190.8	208.5	226.9	208.1	195.9
Average Radiation	16.4	16.1	16.7	17.8	17.7	17.6	18.4	21.1	22.9	23.6	22.1	18.9

3.2 Wastewater estimation

The wastewater effluent used as inputs for the MEDLI model have been taken from the Lagoon Crocodile Farm in Darwin. It is considered a 'low strength' effluent by the NSW DEC for TN, TP and TDS, however, has medium strength BOD readings. A summary of the effluent quality is found below in Table 3-2.

Table 3-2. Wastewater quality (Lagoon Crocodile Farm, 2020)

Analyte	NSW Dec Guideline for low strength effluent (for environmental management – Table 3.1)	Result (post screening)
pH	-	7.5
Dissolved Oxygen (mg/L)	-	8.5
Total Dissolved Solids (mg/L)	<600	323
Total Suspended Solids (mg/L)	-	138
Total Nitrogen (mg/L)	<50	38.1
Total Phosphorous (mg/L)	<10	4.88
Total Kjeldhal Nitrogen (mg/L)	-	37.7
Chemical Oxygen Demand (mg/L)	-	674
Biochemical Oxygen Demand (mg/L)	<40	313
Faecal Coliforms (CFU/100ml)	-	340,000

Once construction is completed and the RCRF is fully operational (i.e Stage 2), it is anticipated that up to 4000L of wastewater could be generated per day. For the purposes of this assessment, Stage 1 and Stage 2

of the RCRF have been broken into separate models, to reflect the construction staging and subsequent water usage at the site. Stage 1 will use approximately 1,080L per day.

A summary of the estimated projected effluent and water quality inputs for MEDLI (taken from data from Lagoon Crocodile Farm, post screen as a conservative measure) are summarised in the below tables.

Table 3-3. MEDLI waste estimation data inputs (Stage 1)

Average daily quality	
Daily Effluent Production (m^3) i.e inflow volume	1.08
Total Nitrogen (mg/L)	38.1
Total Phosphorous (mg/L)	4.8
Total Dissolved Salts (mg/L)	153
Total Solids (mg/L)	323
Electrical Conductivity (dS/m)	0.239

3.3 Wet weather storage

The operation of the RCRF does not include wet weather storage as it will only be operational and generating wastewater during the dry season. However the farm does has a series of holding storage tanks, which equate to a total volume of 34,500 L. These tanks are completely enclosed and consists of

- x1 Primary Tank (6,500 L)
- x1 Holding Tank (3,000 L)
- x1 Wastewater tank (25,000 L)

The relevant dimensions for MEDLI inputs are described in the Table 3-4 below. For simplicity of the model, the tank volumes have been combined. Inputs highlighted in orange are derived from information provided by ASRAC in regard to the tank, whereby the remaining inputs are standard MEDLI derived guideline values.

Table 3-4. MEDLI pond system inputs

Pond properties	Combined Storage Tanks
Volume at outlet (m^3)	34.5
Depth at outlet (m)	2.5
Side slope (degrees from horizontal)	90
Rainfall catchment area (fraction of potential)	0
Evaporation area (fraction of potential)	0
Leakage (mm/day)	0
Evaporation coefficient (mm/mm)	0
Starting status	Empty
Nitrogen Transfer Coefficient	0.014
Nitrate-Nitrogen (fraction)	0
Ammonium-Nitrogen (fraction)	0.8
Organic-Nitrogen (fraction)	0.2

3.4 Irrigation

A total of 2,000 m^2 of land has been made available at the RCRF to irrigate banana crops for Stage 1. The irrigation system will consist of a surface irrigation with sprinklers spaced out across the proposed irrigation areas.

As rates and timing of irrigation operations are currently unknown, a general assumption was made as to when irrigation is triggered and applied.

A Soil Water Deficit (SWD) rate of 5 mm was adopted based on general conditions of the tropics in the absence of SWD data from the site.

Irrigation was adopted to be at a rate of 5 mm per irrigation event.

10mm of rainfall was adopted as a conservative measure to ensure the impact of rainfall on soil saturation is reflective of site conditions in the wet season when irrigation may occur.

The irrigation method was defined as MEDLI's default parameters for a Fixed Sprinkler system to mimic surface irrigation with sprinklers.

3.5 Soil

As discussed in Section 2, soil samples were collected from the project area in August 2021 and sent for laboratory analysis to assist in inputs for the MEDLI model. The results of the soil analysis input into MEDLI are described below in Table 3-5. Note that the term 'layers' is used throughout the MEDLI modelling and refers to soil horizons.

Table 3-5. MEDLI soil properties

Soil properties	Layer 1 (surface)	Layer 2 (surface to 0.5 m)	Layer 3 (0.5 m to 1.0 m)
Soil layer thickness (mm)	100	500	1000
Air dry (%v/v)	3.22	0.1	0.1
*Lower storage limit (%v/v)**	7.2	9.2	8
*Drained upper limit (%v/v)**	15.2	16.9	14.5
Available water capacity (mm)	8	38.5	65
*Saturated water content (%v/v)**	45.5	42.2	43.6
*Bulk density (g/cm^3)**	1.39	1.51	1.47
*Porosity**	47.55	43.02	44.53
Saturated Hydraulic Conductivity	50	50	20

**MEDLI standard 'Red Earth' paddock soil library used in this instance*

3.6 Crop type

The default planting parameters for 'Banana Pasture' were used in the model as they are representative of the crop selection for the irrigation area. The default crop also has a maximum crop coefficient of 0.7. 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.

3.7 Further assumptions and limitations

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

- Future weather will behave like past weather as supplied in the historical data (i.e from 1957 to 2020). This model does not account for the uncertainty regarding future climate conditions.
- Data obtained for the rainfall and evaporation at the site, is assumed to be as close as possible to the site as there is no on-site weather station (SILO data obtained for Ramingining).
- Wastewater production and irrigation is only to occur in the dry season (March to October has been assumed).
- Site specific water quality is currently unknown, therefore water quality data used for the purposes of modelling has been used from another NT based crocodile farm (Lagoon Crocodile Farm, March 2020). Site specific water quality data, when collected, may change the outputs of the MEDLI model in the future.
- Both a pathogen risk assessment and groundwater aquifer assessment were not included in this model, as the risk of irrigation to human health and groundwater were assessed as low. Refer to the CEMP for the RCRF for further information.
- Data provided by ASRAC is accurate and reflects project operating conditions.

4 RESULTS

4.1 Criteria for assessment

Key criteria that were used to assess the current MEDLI scenarios includes:

- Overflow less than 5% of inflow volume
- Effluent reuse fraction of 0.95
- Probability of at least 90% reuse fraction between 0.8 and 0.9
- Deep drainage within 200 mm/year of the dryland scenario
- Nutrient uptake is higher than irrigation value

4.2 Results

Several key results are tabulated below, while the full MEDLI summary outputs for all scenarios are presented in Appendices A and B of this report. Table 4-1 and Table 4-2 summarise the water balance and wet weather storage (WWS) component of the ponds, Table 4-3 shows the land water balance aspect of the modelling (i.e saturation), and Table 4-4 displays the land nutrient balance for the irrigation area.

Results highlighted in red indicate an exceedance of key indicators that MEDLI define as a well working system. Results highlighted in green show key indicators that meet the assessment criteria listed above.

The modelling results also demonstrate that an area of 1 ha will be sufficient for irrigation when the entire RCRF becomes operational.

Table 4-1. WWS balance

	Unit	Scenario 1a (dryland)	Scenario 2 (Stage 1 condition)
Rain	m3/year	0.00	0.00
Inflow	m3/year	264.60	264.60
Evaporation	m3/year	0.00	0.00
Overflow	m3/year	264.06	**0.84**
Irrigation	m3/year	0.00	263.66
Effluent reuse (proportion of inflow + net rain gain irrigated)	Fraction	0.00	**1.00**
Probability of at least 90% reuse	Fraction	0.00	**1.00**

Table 4-2. WWS pond performance

	Unit	Scenario 2 (Stage 1 condition)
Number of overflow events	events/year	0.14
Overflow	m3/year	0.84
No. of overflow days	days/year	6.00
Effluent reuse through irrigation	Fraction	1.00

Table 4-3. Land water balance

	Unit	Scenario 1a (dryland)	Scenario 2 (Stage 1 condition)
Rain	mm/year	1280.76	1280.76
Irrigation	mm/year	0.00	131.83
Soil evaporation	mm/year	492.65	589.28
Transpiration	mm/year	67.52	92.43
Rain runoff	mm/year	123.84	120.74
Irrigation runoff	mm/year	0.00	0.00
Deep drainage	mm/year	596.18	**609.57**

Table 4-4. Land nutrient balance

	Unit	N balance	P balance
		Scenario 2	
Irrigation (effluent load added)	kg/ha/year	35.01	6.33
Denitrification	kg/ha/year	0.13	-
Irrigation runoff	kg/ha/year	0.00	0.00
Plant uptake	kg/ha/year	**23.08**	**3.58**
Leached	kg/ha/year	**46.43**	**0.03**
Average nitrate-N concentration of deep drainage	mg/L	**7.62**	**-**

4.3 Discussion of results

4.3.1 Stage 1

The results for Scenario 2 show that under the Stage 1 effluent system, overtopping is estimated to be at 0.84 m^3/year or about 0.3 % of the annual effluent inflow. A general rule of thumb is that effluent overflow should not exceed more than 5% of the annual effluent inflow. The overtopping detailed in Appendix B shows 0.14 overflow events per year (1.4 events every 10 years). Effluent reuse fraction is 1.00, which is above the Queensland MEDLI guidelines of an effluent reuse fraction of at least 0.95. The probability fraction of at least 90% reuse was 1.00.

The effluent irrigation volume applied in Scenario 2 is approximately 263.66 m^3/year. The predicted deep drainage is 609.57 mm/year, less than 200mm /year more than the dryland scenario (596.18 mm/year).

The nitrogen loading rate is estimated at 35.01 kg/ha/year, average annual soil nitrogen leached is approximately 23.08 kg/ha/year and average nitrate-N concentration of deep drainage is 7.62 mg/L (below 10 mg/L). The predicted phosphorus loading rate is 6.33 kg/ha/yr, with approximately 3.58 kg/ha/yr removed by plant uptake. Average annual phosphorous leaching is predicted to be 0.03 kg/ha/year.

4.3.2 Overall summary

It is recommended that once the RCRF is operational, water samples are collected of the site-specific wastewater to be applied to the irrigation area to provide a more accurate indication of the uptake of nutrients.

The average nitrate and phosphorous concentrations do not exceed the assessment criteria. Dilution of wastewater with bore water may be an option to reduce the volume of nutrients that may leach into the soils, however for this to be assessed properly, site water samples will be required to confirm the nutrient concentrations.

It is recommended that, once operational, wastewater samples are collected to confirm the nutrient loads, and the MEDLI modelling be repeated to give a more accurate model for the site conditions. Additionally, ongoing soil sampling should be undertaken in the irrigation area to assess the level of nutrient uptake by the soil, and amend the wastewater volumes, dilution ratios, or size of the irrigation area as appropriate.

5 REFERENCES

Queensland Government (2021), *SILO Australian climate data from 1889 to yesterday* (Queensland Government 2021) [online]. Available at: https://www.longpaddock.qld.gov.au/silo/ [Accessed 23 August 2021]

Vieritz, Alison & Ramsay, Ian & Haworth, Lex & Gardner, Edward. (2011). Sustainable Effluent Irrigation over the Past Decade – The Role of MEDLI Modelling for wastewater discharge

APPENDIX A MEDLI MODEL OUTPUTS – DRYLAND SCENARIO STAGE 1

MEDLI REPORT - FULL RUN

Enterprise: Ramingining Crocodile Farm

Description:
Ramingining Crocodile Farm

Client: ASRAC

MEDLI User: adele.faraone

Scenario Details:
To determine the irrigaiton area required for irrigation of banana crops at the RCF for stage 1

DESCRIPTION

Climate Data: Ramingining_-12.35_134.95, -12.35°, 134.95°

Run Period: 01/01/1957 to 31/12/2020 64 years, 0 days

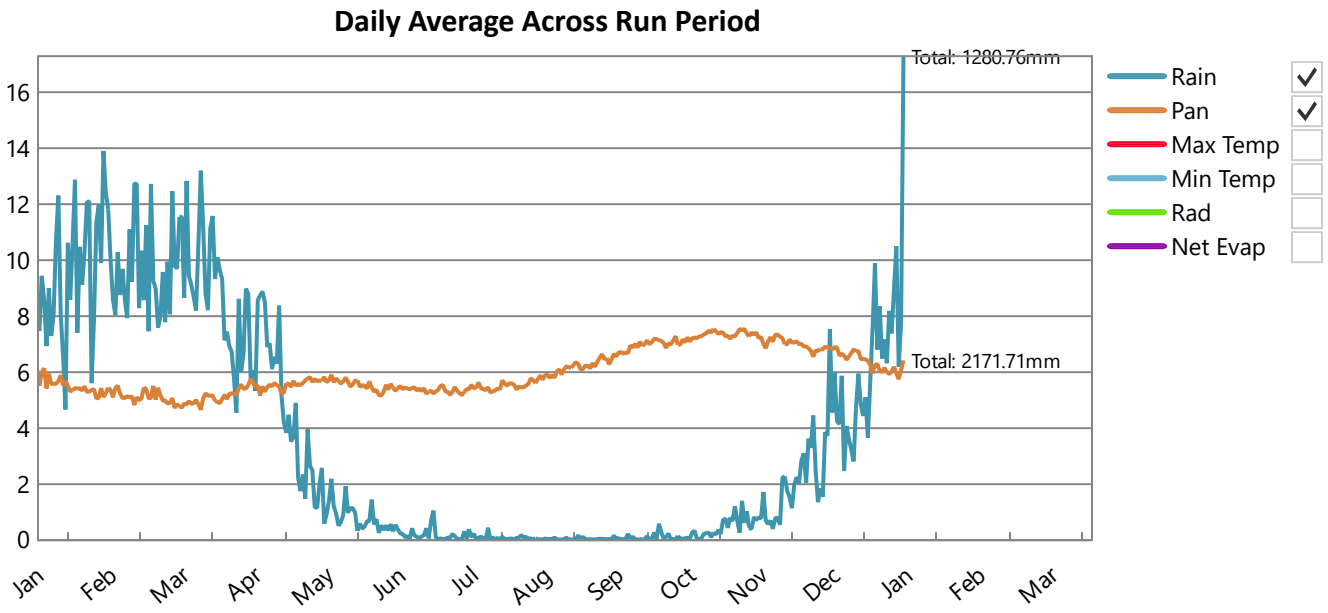
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	802	1277	1817
Pan Evaporation (mm/year)	1874	2132	2479

Climate Data:

Chart Table

Monthly Daily

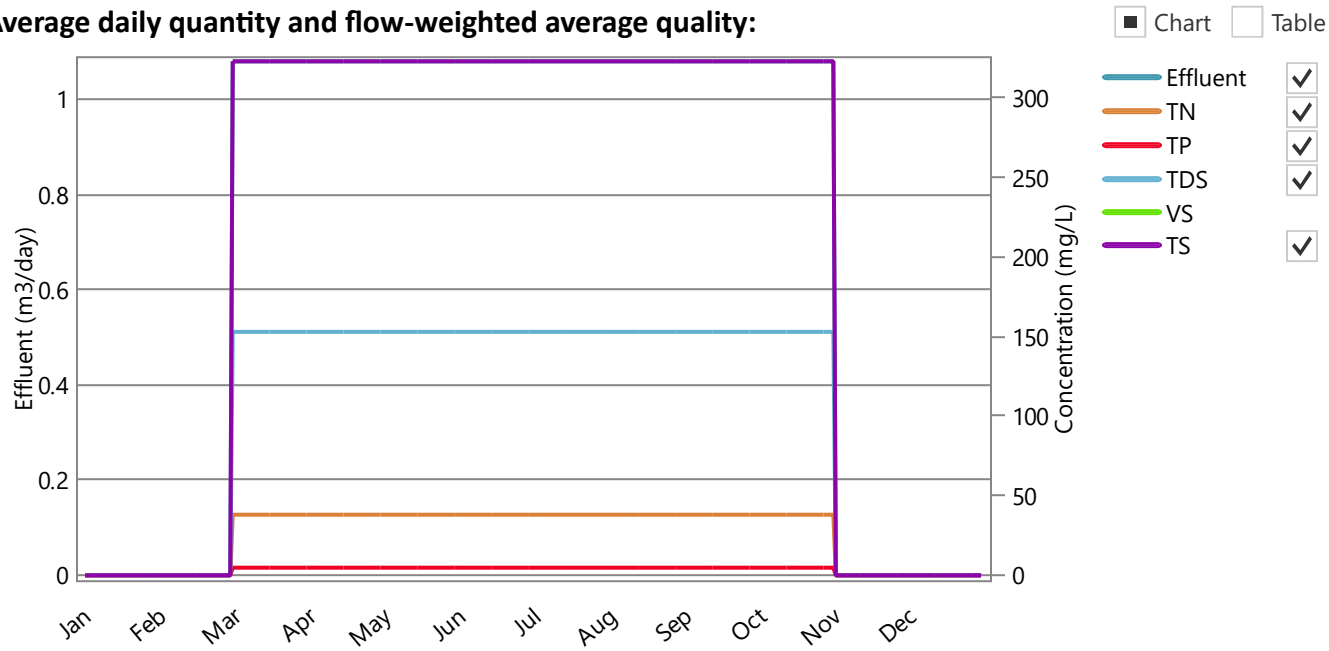


DESCRIPTION

Effluent type: Ramingining Crocodile Farm

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **264.60 m3/year** or 0.72 m3/day (Min-Max: 0.00 - 1.08)

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

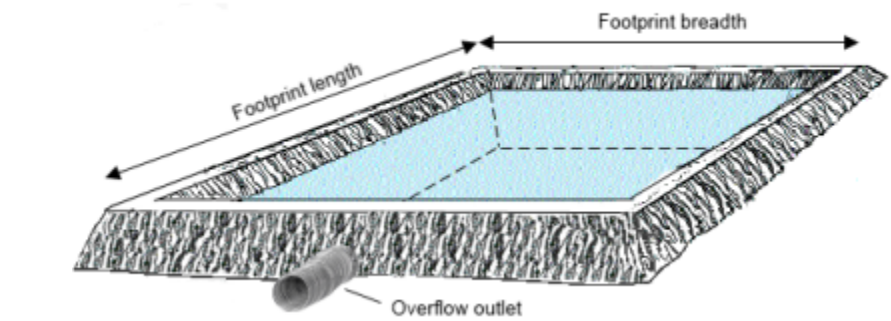
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	38.10 (0.00 - 38.10)	10.08 (10.08 - 10.08)
Total Phosphorus	4.80 (0.00 - 4.80)	1.27 (1.27 - 1.27)
Total Dissolved Salts	153.00 (0.00 - 153.00)	40.48 (40.48 - 40.48)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	323.00 (0.00 - 323.00)	85.47 (85.47 - 85.47)

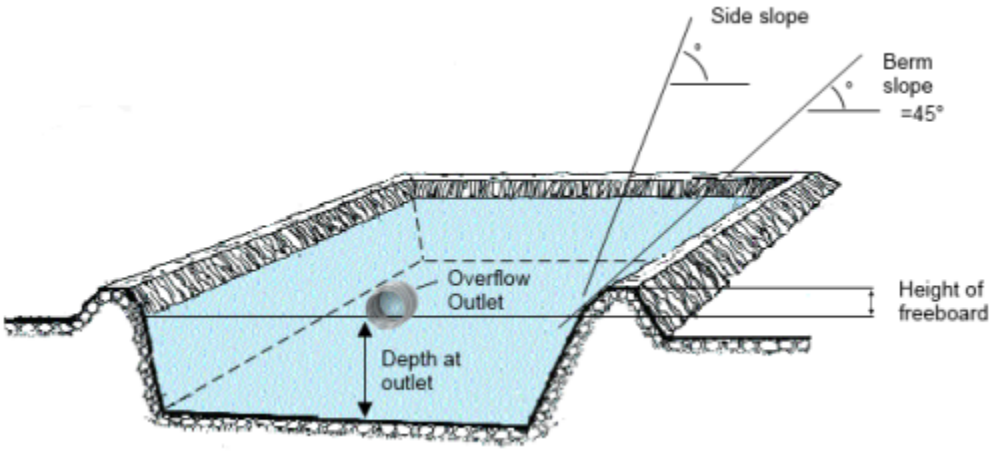
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	34.50
Minimum allowable pond volume (m3)	6.90
Pond depth at overflow outlet (m)	2.50
Maximum water surface area (m2)	13.80
Pond footprint length (m)	5.25
Pond footprint width (m)	2.63
Pond catchment area (m2)	13.80
Average active volume (m3)	34.39





Irrigation pump limits:

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

Shandying water:

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

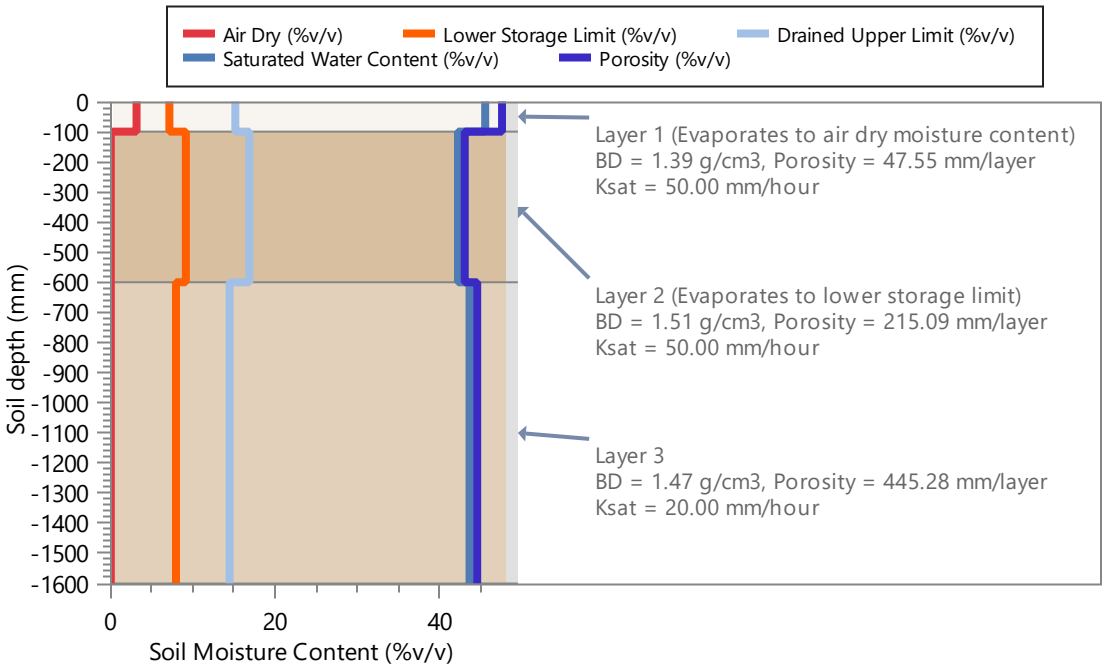
DESCRIPTION

Land: RCF

Area (ha): 0.20

Soil Type: Ramingining Crocodile Farm, 1600.00 mm defined profile depth

Profile Porosity (mm)	707.92
Profile saturation water content (mm)	692.50
Profile drained upper limit (or field capacity) (mm)	244.70
Profile lower storage limit (or permanent wilting point) (mm)	133.20
Profile available water capacity (mm)	111.50
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	86.00
Soil evaporation U (mm)	7.00
Soil evaporation Cona (mm/sqrt day)	3.50



Plant Data: Continuous Banana Pasture

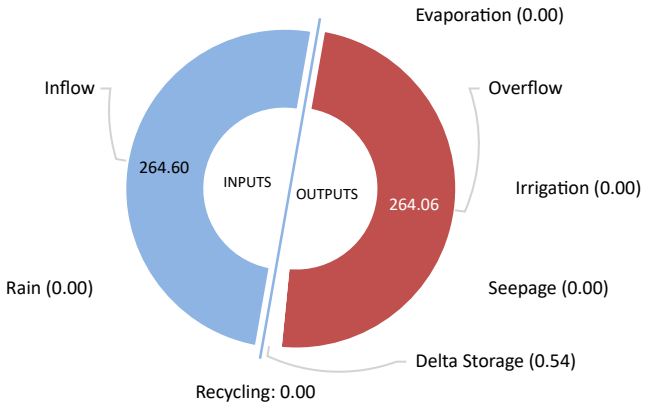
Average monthly cover (fraction) (minimum - maximum)	0.07 (0.00 - 0.24)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.7 x Pan coefficient 1)	0.70
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	303.29
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	10.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.01

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **34.5 m3**

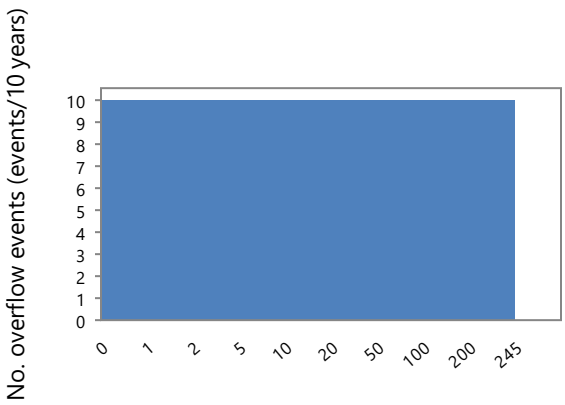
Pond System Water Balance (m3/year)



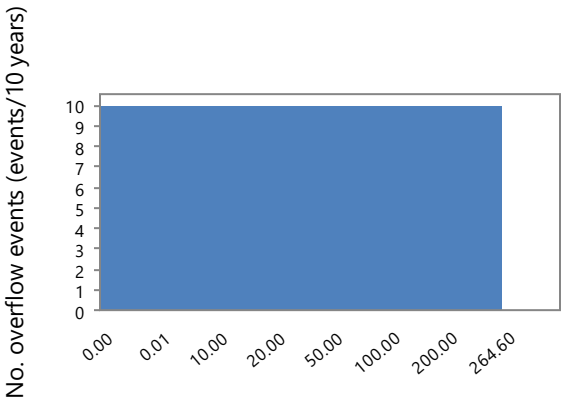
Name	Value
Rain	0.00
Inflow	264.60
Recycling	0.00
Evaporation	0.00
Overflow	264.06
Irrigation	0.00
Seepage	0.00
Delta Storage	0.54

Overflow Diagnostics

Volume of overflow (m3/year)	264.06
No. days pond overflows (days/year)	244.52
Average duration of overflow (days)	244.52
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% reuse (fraction)	0.00



Export plot



Export plot

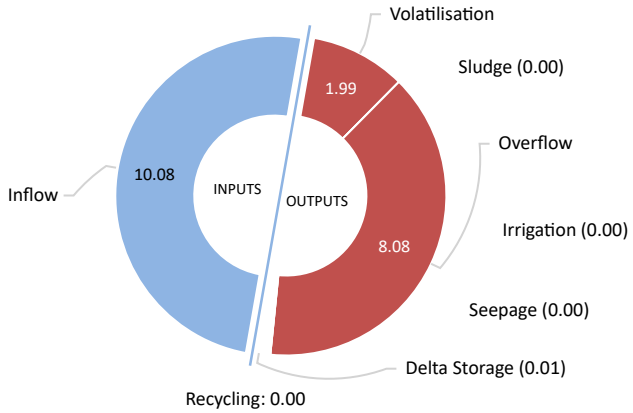
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

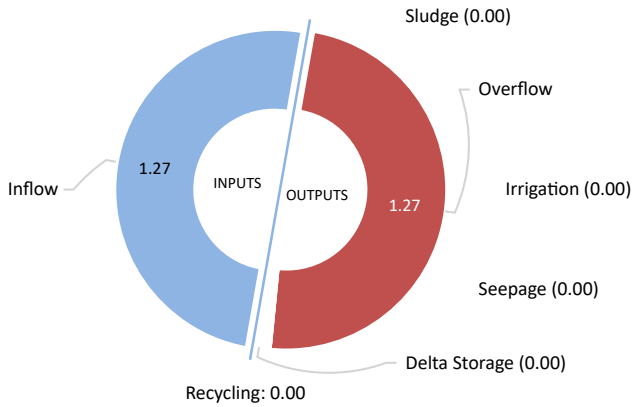
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



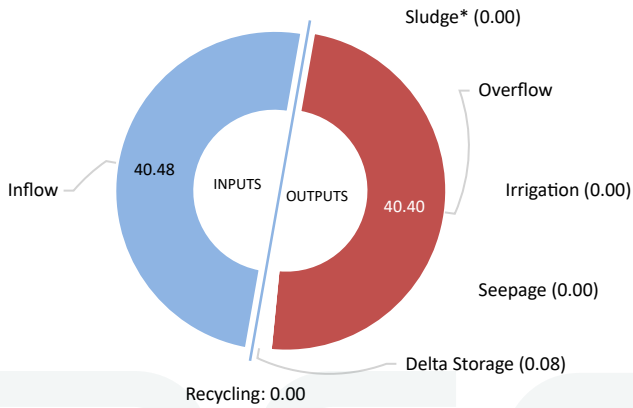
Name	Value
Inflow	10.08
Recycling	0.00
Volatilisation	1.99
Sludge	0.00
Overflow	8.08
Irrigation	0.00
Seepage	0.00
Delta Storage	0.01

Phosphorus Balance (kg/year)



Name	Value
Inflow	1.27
Recycling	0.00
Sludge	0.00
Overflow	1.27
Irrigation	0.00
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	40.48
Recycling	0.00
Sludge*	0.00
Overflow	40.40
Irrigation	0.00
Seepage	0.00
Delta Storage	0.08

* 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 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	28.10
Average phosphorus concentration of pond liquid (mg/L)	4.80
Average salinity of pond liquid (dS/m)	0.24

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	22.81
Final phosphorus concentration of pond liquid (mg/L)	4.80
Final salinity of pond liquid (dS/m)	0.24

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	0.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

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

Irrigation Diagnostics (No effluent irrigation occurred!):

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

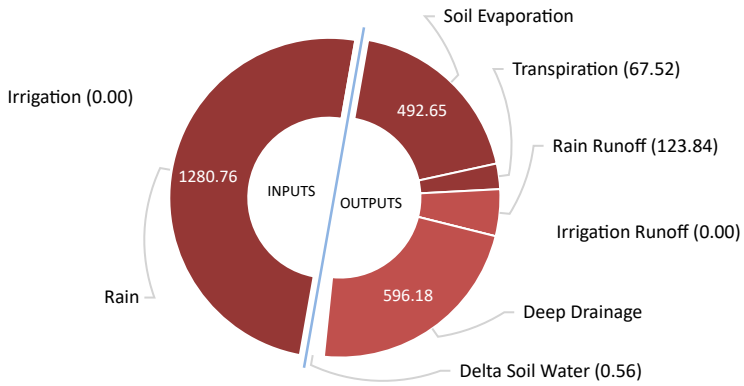
PERFORMANCE

Land Performance - Soil Water

Paddock: RCF, 0.2 ha
Soil Type: Ramingining Crocodile Farm, 23.65 mm PAWC at maximum root depth

Land Water Balance (mm/year):

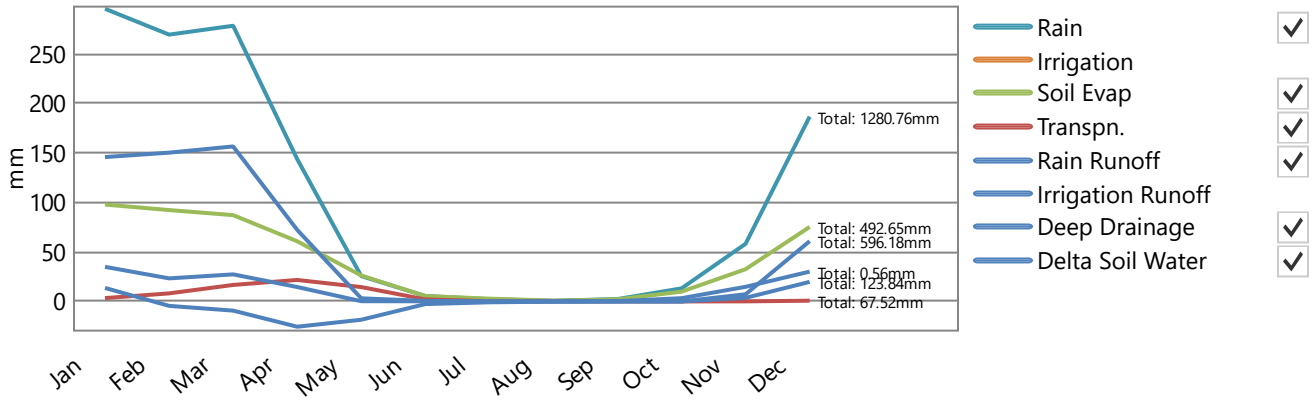
mm/year % Total inputs



Name	Value
Rain	1280.76
Irrigation	0.00
Soil Evaporation	492.65
Transpiration	67.52
Rain Runoff	123.84
Irrigation Runoff	0.00
Deep Drainage	596.18
Delta Soil Water	0.56

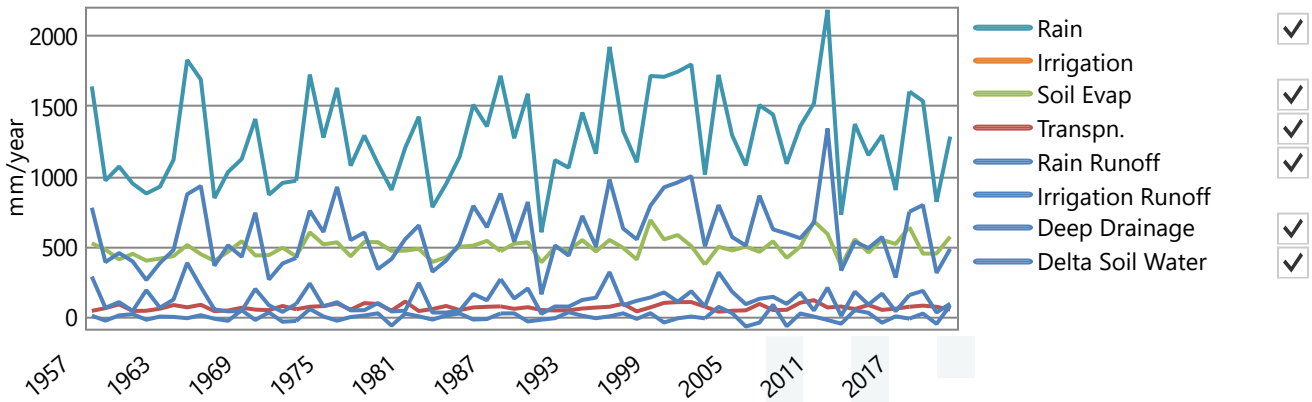
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



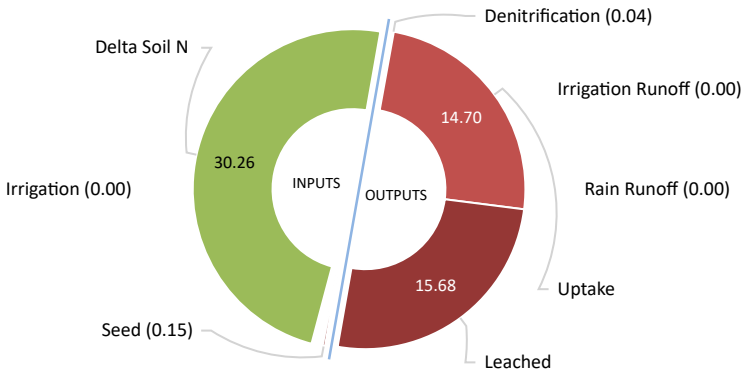
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

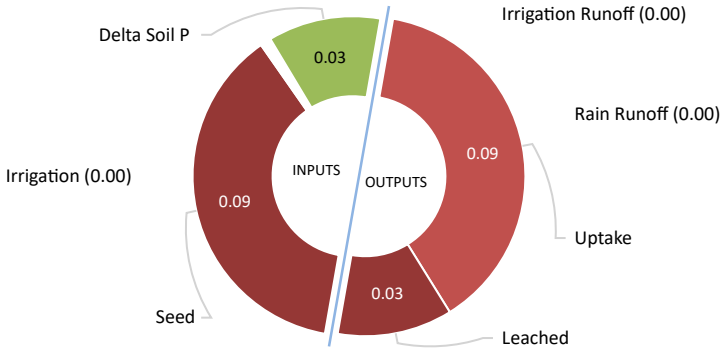
Irrigation ammonium volatilisation losses (kg/ha/year): 0.00
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.80

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.15
Irrigation	0.00
Denitrification	0.04
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	14.70
Leached	15.68
Delta Soil N	-30.26

Land Phosphorus Balance (kg/ha/year)



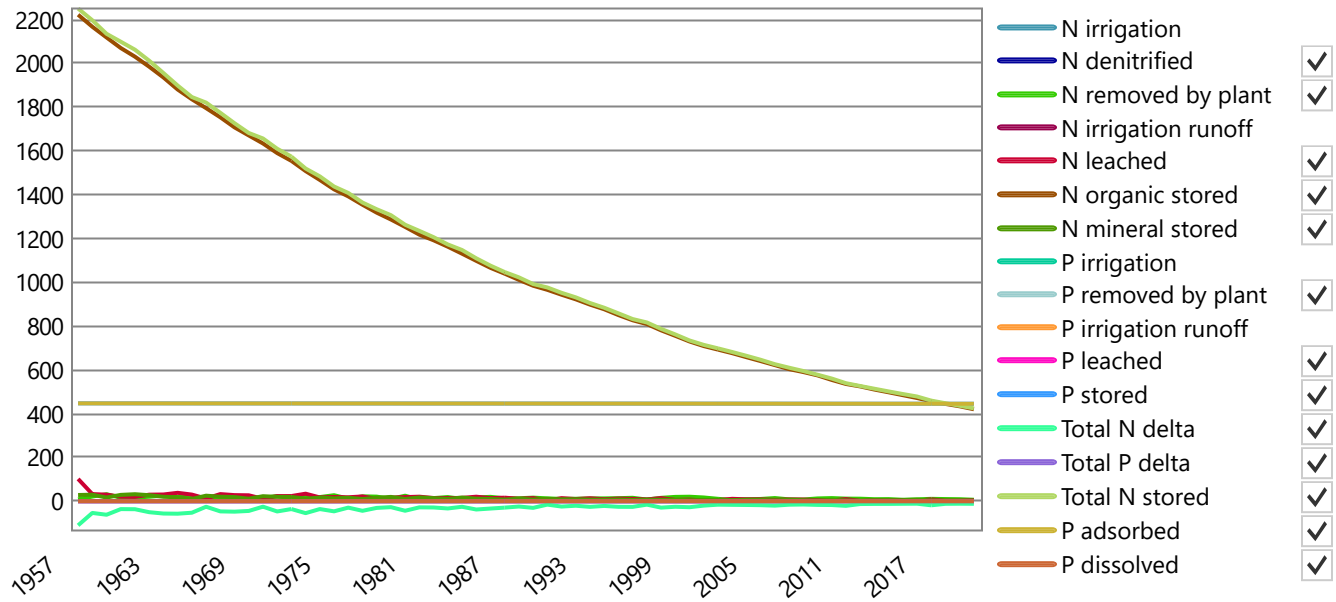
Name	Value
Seed	0.09
Irrigation	0.00
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	0.09
Leached	0.03
Delta Soil P	-0.03

PERFORMANCE

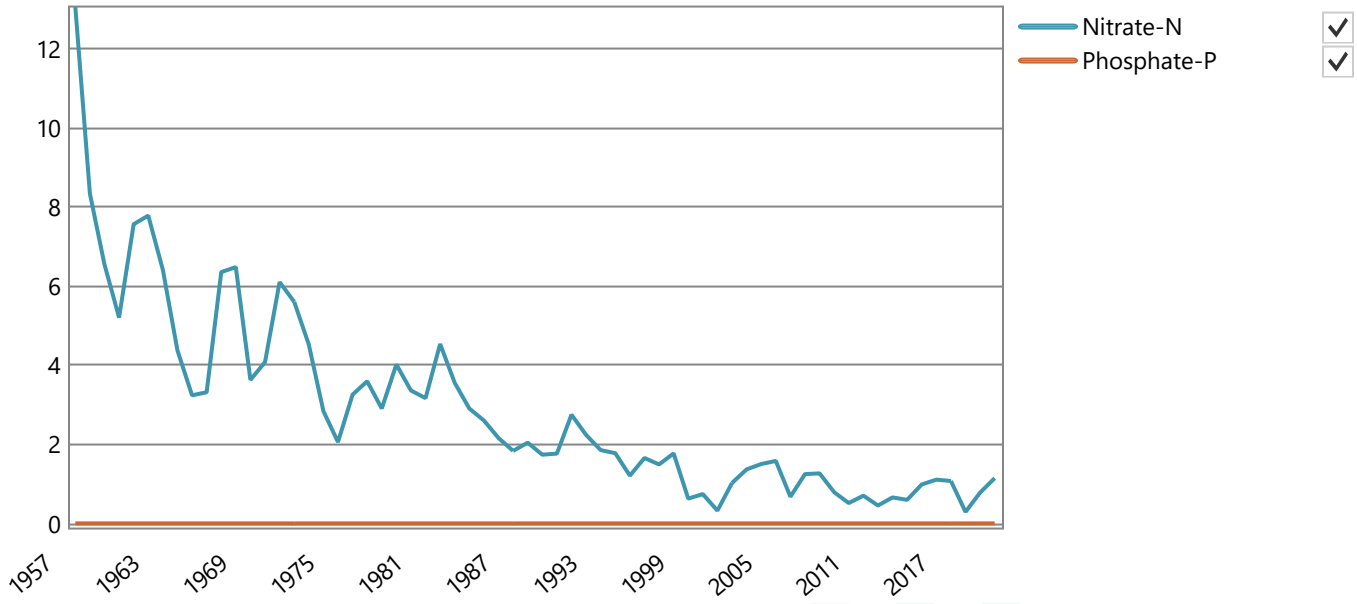
Land Performance - Soil Nutrient

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

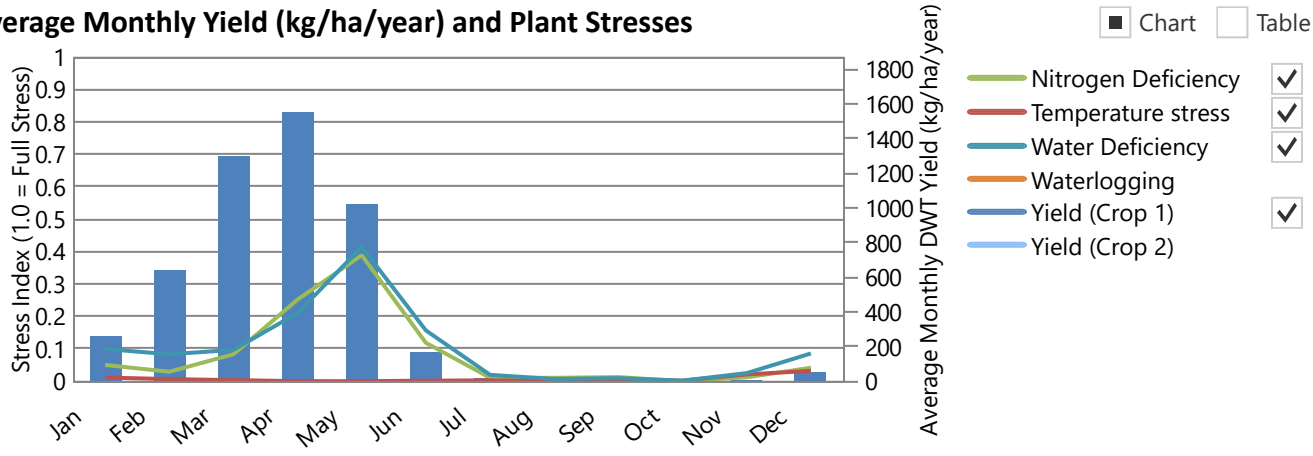
Plant: Continuous Banana Pasture

Average annual shoot dry matter yield (kg/ha/year)	5080.23 (2630.69 - 8098.86)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.07 (0.00 - 0.24)
Average monthly root depth (mm) (minimum - maximum)	84.76 (1.06 - 222.01)

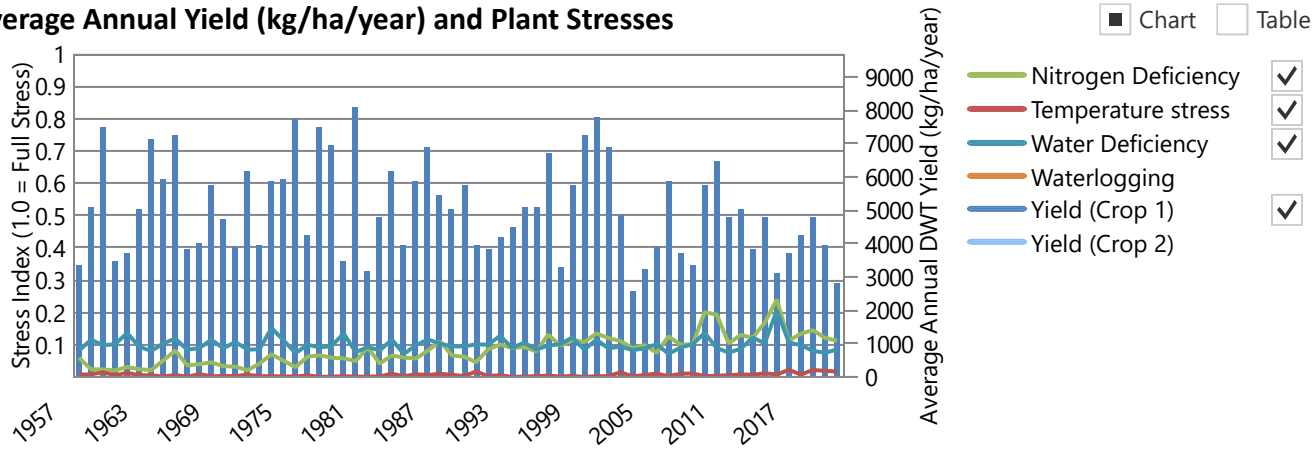
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	14.70 (5.81 - 32.06)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	0.09 (0.00 - 0.18)
Average annual shoot nitrogen concentration (fraction dwt)	0.00 (0.00 - 0.00)
Average annual shoot phosphorus concentration (fraction dwt)	0.000 (0.000 - 0.000)

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



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



No. of harvests/year: 1.02 (forced by crop death due to water stress (1.02))
No. days without crop/year (days/year): 188.20 due to water stress (188.20)

PERFORMANCE

Land Performance

Paddock: RCF, 0.2 ha **Soil Type**: **Ramingining Crocodile Farm**

Plant: Continuous Banana Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	10.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.01
No. years assumed for leaching to reach steady-state (years)	10.00

Soil Salinity:

Average Infiltrate Salinity (dS/m)	0.03

Insufficient deep drainage to run steady state salinity calculations.

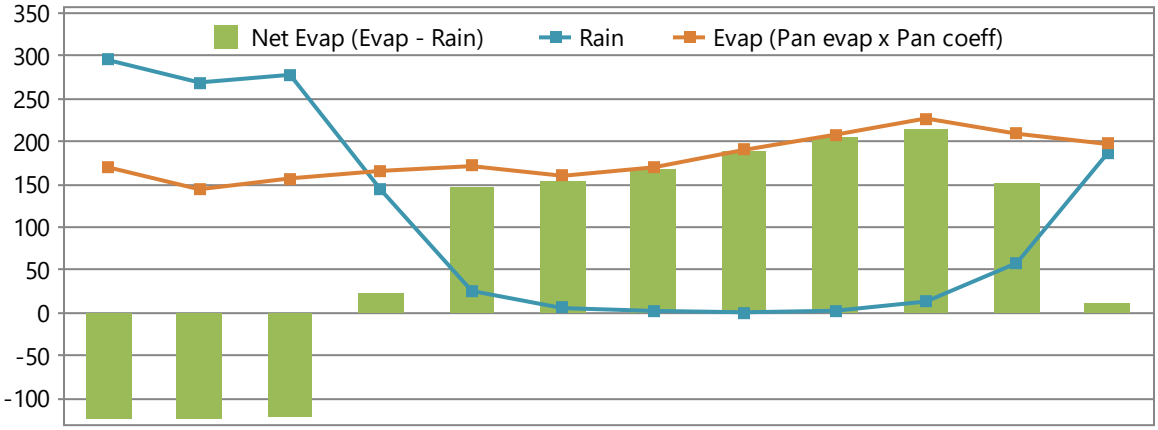
DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Ramingining_-12.35_134.95, -12.35°, 134.95°

Run Period: 01/01/1957 to 31/12/2020 64 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	295.3	269.3	278.2	143.7	25.6	5.5	2.2	0.6	2.4	13.2	58.2	186.5	1280.8
Evap	170.0	144.4	157.2	165.9	171.5	160.2	170.0	190.5	208.2	227.2	209.4	197.3	2171.7
Net Evap	-125.3	-124.9	-121.1	22.3	145.9	154.6	167.8	189.9	205.8	214.0	151.2	10.8	891.0
Net Evap/day	-4.0	-4.4	-3.9	0.7	4.7	5.2	5.4	6.1	6.9	6.9	5.0	0.3	2.4

DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Pond System: 1 closed storage tank

Ramingining Crocodile Farm - 264.60 m3/year or 0.72 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 245.00 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	38.10 (0.00 - 38.10)	10.08 (10.08 - 10.08)
Total Phosphorus	4.80 (0.00 - 4.80)	1.27 (1.27 - 1.27)
Total Dissolved Salts	153.00 (0.00 - 153.00)	40.48 (40.48 - 40.48)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	323.00 (0.00 - 323.00)	85.47 (85.47 - 85.47)

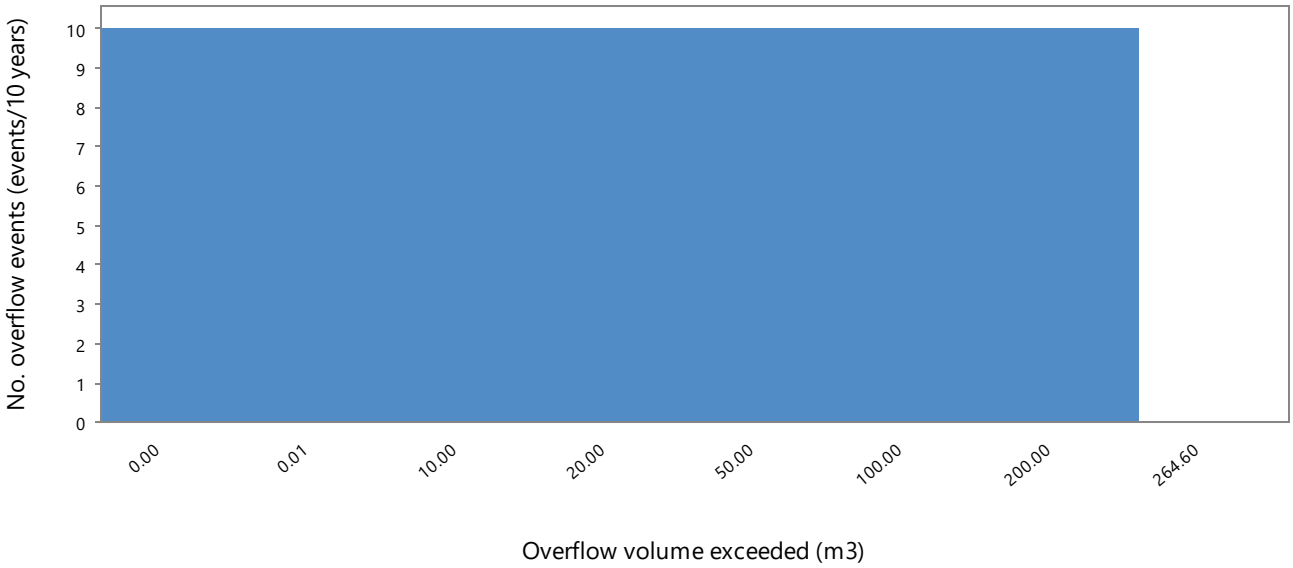
Last pond (Wet weather store): 34.50 m3

Theoretical hydraulic retention time (days)	47.62
Average volume of overflow (m3/year)	264.06
No. overflow events per year exceeding threshold* of 0.01 m3 (no./year)	1.00
Average duration of overflow (days)	244.52
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.00
Probability of at least 90% effluent reuse (fraction)	0.00
Average salinity of last pond (dS/m)	0.24
Salinity of last pond on final day of simulation (dS/m)	0.24
Ammonia loss from pond system water area (kg/m2/year)	9.23

* 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: Ramingining Crocodile Farm

Irrigation Information

Irrigation: 0.2 ha total area (assumed 100% irrigation efficiency)

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

Shandying

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

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	1.00

DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Paddock Land: RCF: 0.2 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 0.00 mm and rainfall is less than or equal to 10.00 mm
Irrigate a fixed amount of 0.00 mm each day
Irrigation window from 1/3 to 31/10 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Ramingining Crocodile Farm, 23.65 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	295.3	269.3	278.2	143.7	25.6	5.5	2.2	0.6	2.4	13.2	58.2	186.5	1280.8
Irrigation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil Evap	97.7	92.2	87.1	60.7	26.2	5.4	2.8	0.8	2.1	9.9	32.5	75.2	492.7
Transpn.	3.4	8.1	16.6	21.7	14.5	2.1	0.3	0.0	0.0	0.0	0.1	0.7	67.5
Runoff	34.9	23.3	27.3	14.6	0.2	0.2	0.0	0.0	0.0	0.0	3.6	19.7	123.8
Drainage	145.7	150.2	156.4	72.2	3.1	0.5	0.0	0.0	0.0	0.0	7.2	60.8	596.2
Delta	13.6	-4.5	-9.3	-25.5	-18.5	-2.7	-0.9	-0.2	0.3	3.3	14.7	30.1	0.6

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	0.00
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	14.70
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.04
Average annual soil nitrogen leached (kg/ha/year)	15.68
Average annual nitrate-N loading to groundwater (kg/ha/year)	15.68
Soil organic-N kg/ha (Initial - Final)	2284.38 - 419.96
	76.59 - 4.15
Average nitrate-N concentration of deep drainage (mg/L)	2.63
Max. annual nitrate-N concentration of deep drainage (mg/L)	13.06

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	0.00
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	0.09
Average annual soil phosphorus leached (kg/ha/year)	0.03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	446.98 - 445.17
Average phosphate-P concentration in rootzone (mg/L)	0.01
Average phosphate-P concentration of deep drainage (mg/L)	4.72E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	4.76E-03
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.00 mg/L (years)	0.00

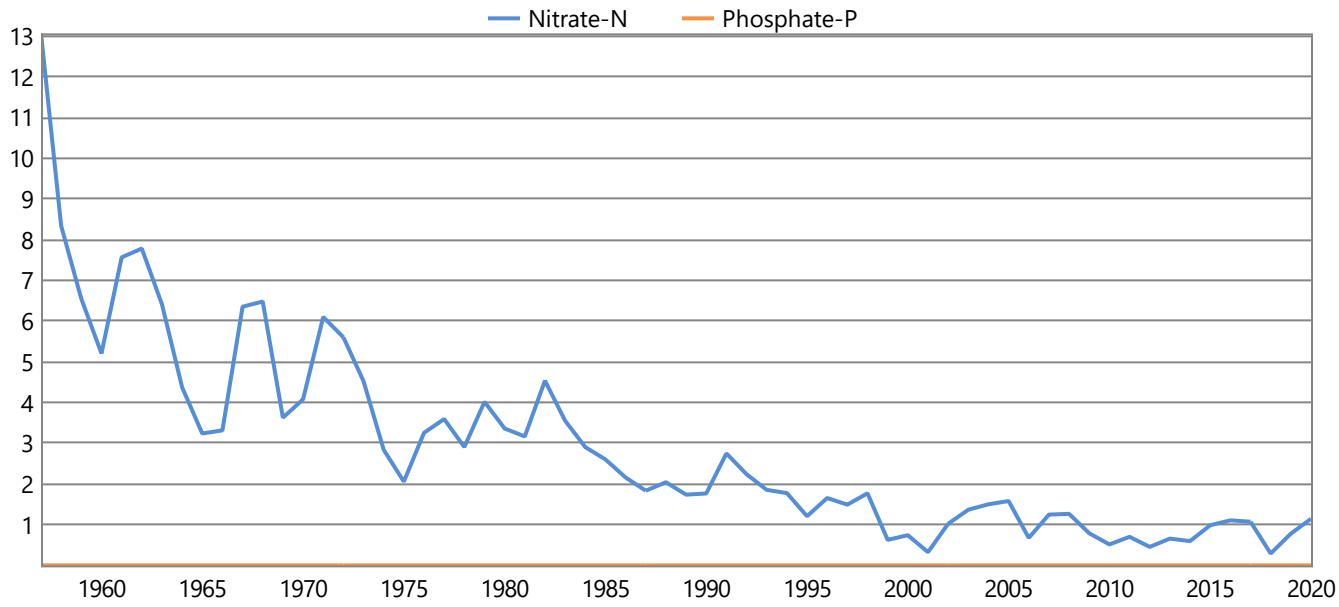
DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

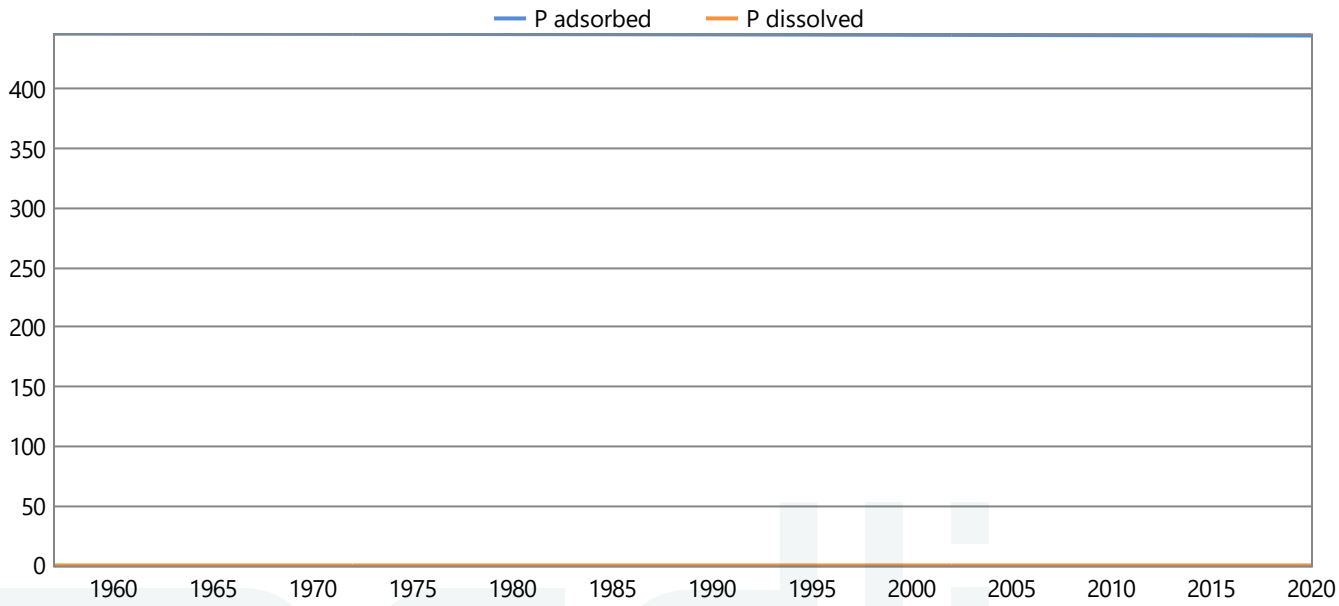
Paddock Land: RCF: 0.2 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Paddock Plant Performance: RCF: 0.2 ha

Average Plant Performance (Minimum - Maximum): Continuous Banana Pasture

Average annual shoot dry matter yield (kg/ha/year)	5080.23 (2630.69 - 8098.86)
Average monthly plant (green) cover (fraction)	0.07 (0.00 - 0.24)
Average monthly crop factor (fraction)	0.05 (0.00 - 0.17)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	84.76 (1.06 - 222.01)
Average number of normal harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of crop deaths per year (no./year)	1.02 (1.00 - 2.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.08 (0.02 - 0.24)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.09)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.07)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.10 (0.00 - 0.41)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	188.20

Soil Salinity - Plant salinity tolerance: Tolerant

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

Insufficient deep drainage to run steady state salinity calculations.

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

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

APPENDIX B MEDLI MODEL OUTPUTS – PROPOSED IRRIGAITON AREA STAGE 1

MEDLI REPORT - FULL RUN

Enterprise: Ramingining Crocodile Farm

Description:
Ramingining Crocodile Farm

Client: ASRAC

MEDLI User: adele.faraone

Scenario Details:
To determine the irrigaiton area required for irrigation of banana crops at the RCF for stage 1

DESCRIPTION

Climate Data: Ramingining_-12.35_134.95, -12.35°, 134.95°

Run Period: 01/01/1957 to 31/12/2020 64 years, 0 days

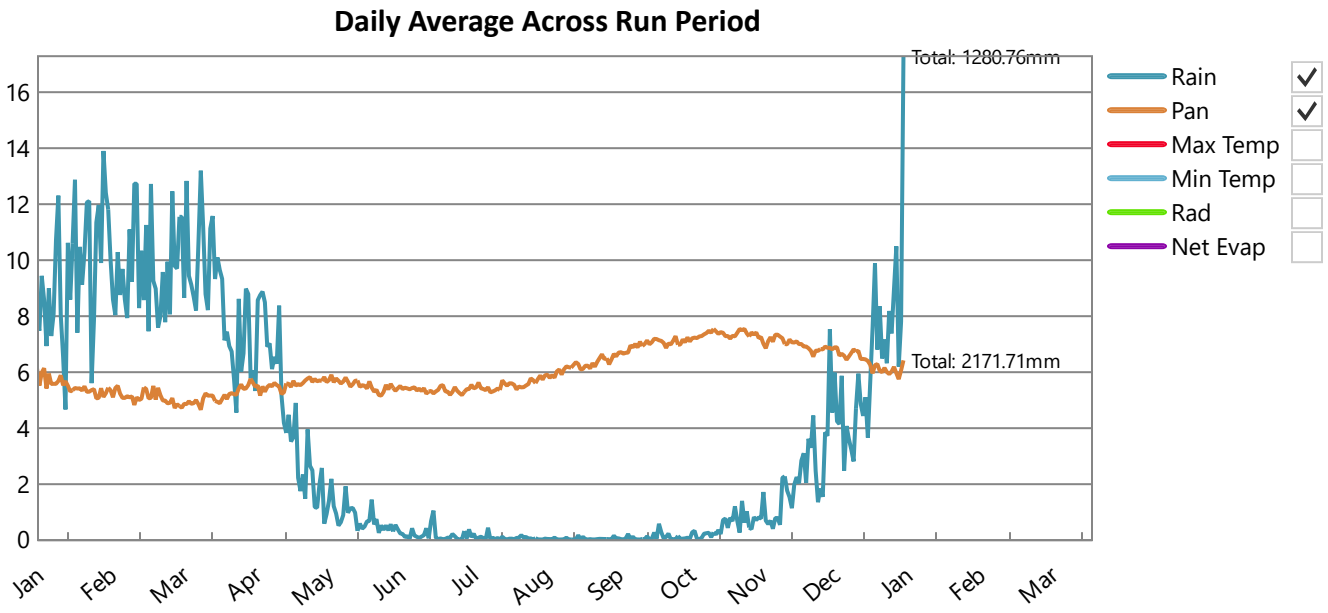
Climate Statistics:

	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	802	1277	1817
Pan Evaporation (mm/year)	1874	2132	2479

Climate Data:

Chart Table

Monthly Daily

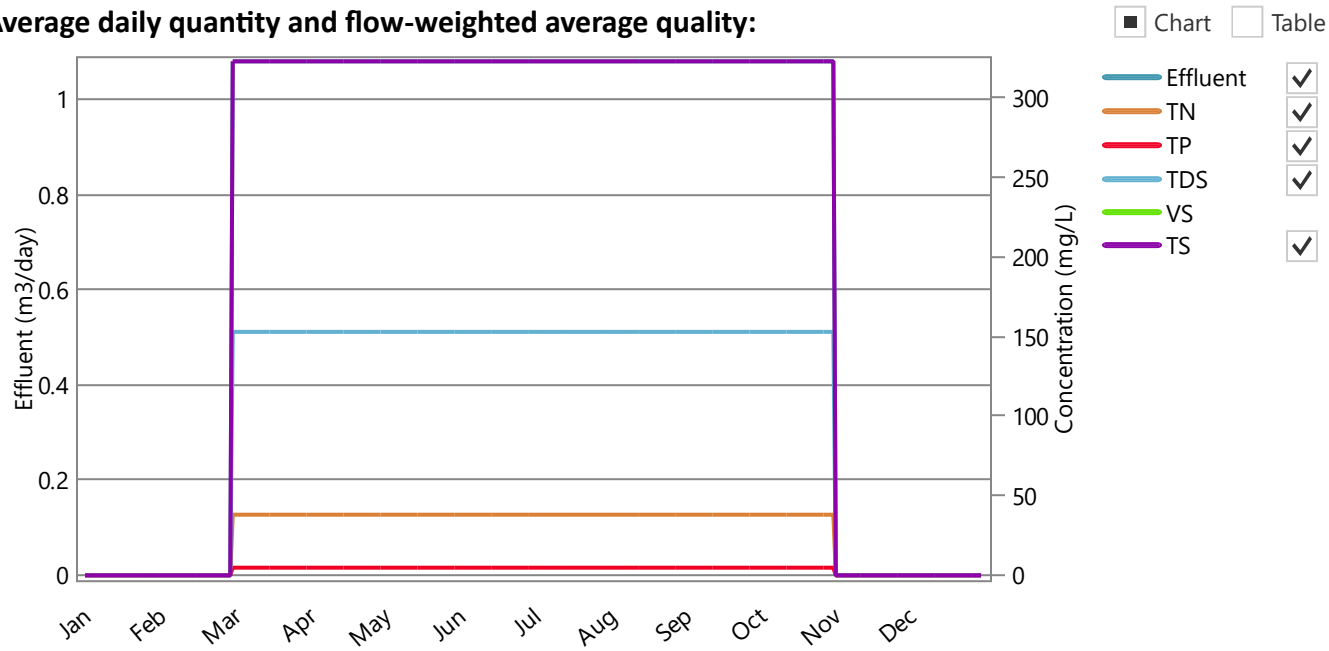


DESCRIPTION

Effluent type: Ramingining Crocodile Farm stage 1

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: **264.60 m3/year** or 0.72 m3/day (Min-Max: 0.00 - 1.08)

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

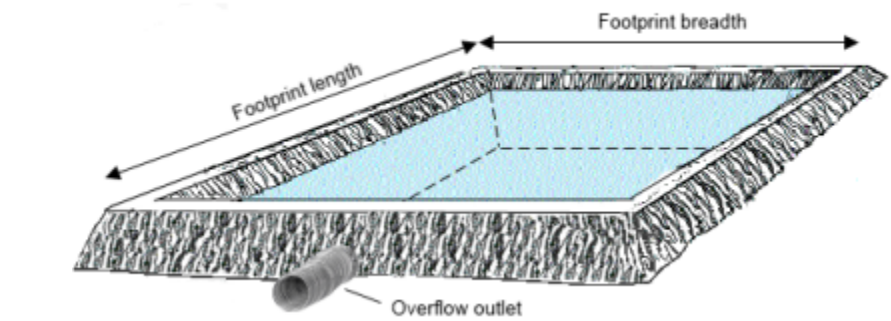
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	38.10 (0.00 - 38.10)	10.08 (10.08 - 10.08)
Total Phosphorus	4.80 (0.00 - 4.80)	1.27 (1.27 - 1.27)
Total Dissolved Salts	153.00 (0.00 - 153.00)	40.48 (40.48 - 40.48)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	323.00 (0.00 - 323.00)	85.47 (85.47 - 85.47)

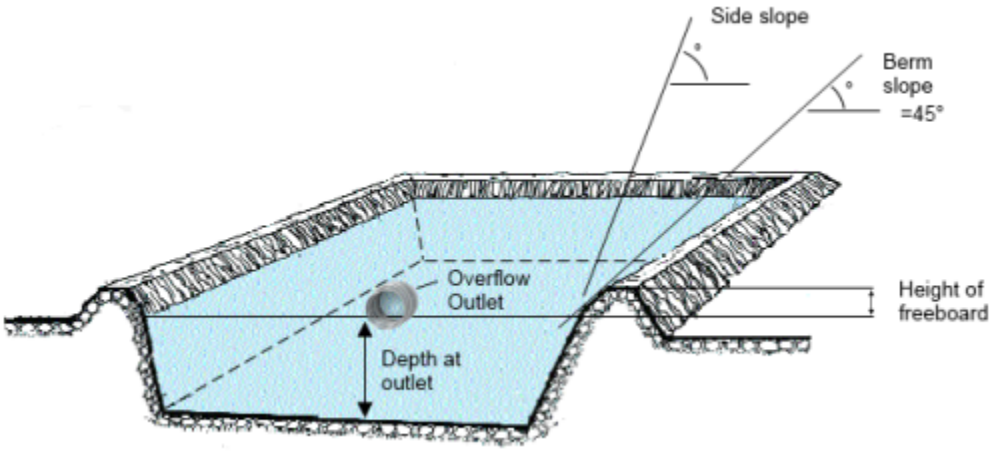
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	34.50
Minimum allowable pond volume (m3)	6.90
Pond depth at overflow outlet (m)	2.50
Maximum water surface area (m2)	13.80
Pond footprint length (m)	5.25
Pond footprint width (m)	2.63
Pond catchment area (m2)	13.80
Average active volume (m3)	7.81





Irrigation pump limits:

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

Shandying water:

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

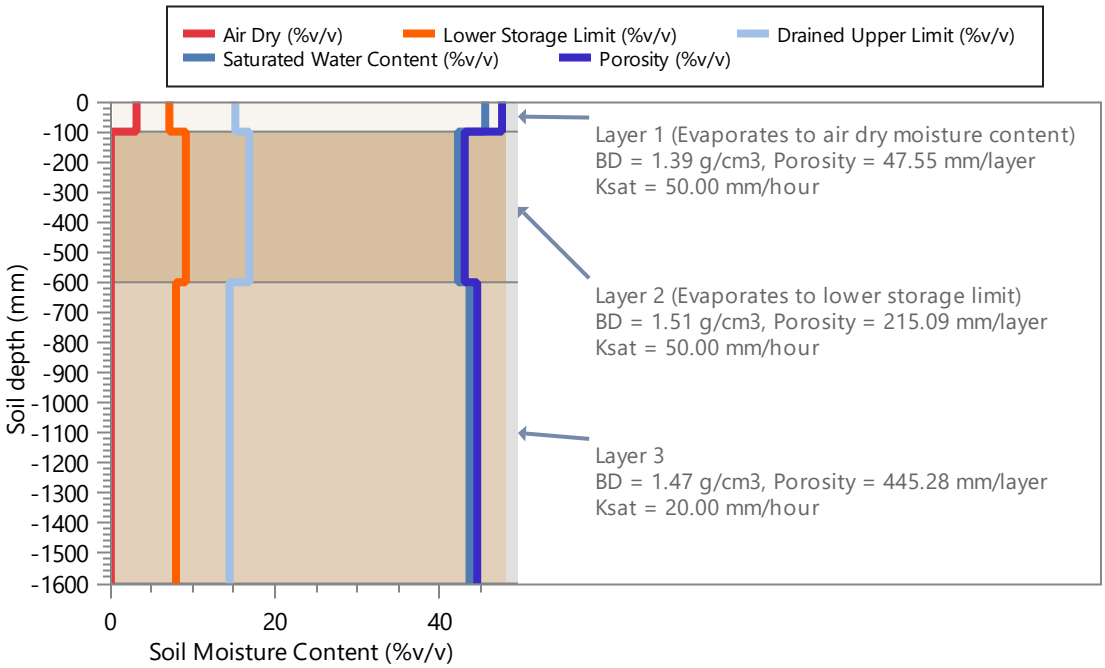
DESCRIPTION

Land: RCF

Area (ha): 0.20

Soil Type: Ramingining Crocodile Farm, 1600.00 mm defined profile depth

Profile Porosity (mm)	707.92
Profile saturation water content (mm)	692.50
Profile drained upper limit (or field capacity) (mm)	244.70
Profile lower storage limit (or permanent wilting point) (mm)	133.20
Profile available water capacity (mm)	111.50
Profile limiting saturated hydraulic conductivity (mm/hour)	20.00
Surface saturated hydraulic conductivity (mm/hour)	50.00
Runoff curve number II (coefficient)	86.00
Soil evaporation U (mm)	7.00
Soil evaporation Cona (mm/sqrt day)	3.50



Plant Data: Continuous Banana Pasture

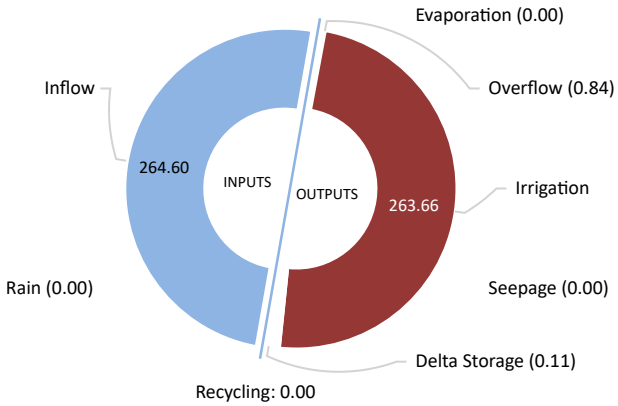
Average monthly cover (fraction) (minimum - maximum)	0.10 (0.00 - 0.31)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.7 x Pan coefficient 1)	0.70
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Maximum potential root depth in defined soil profile (mm)	346.08
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	10.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.01

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **34.5 m3**

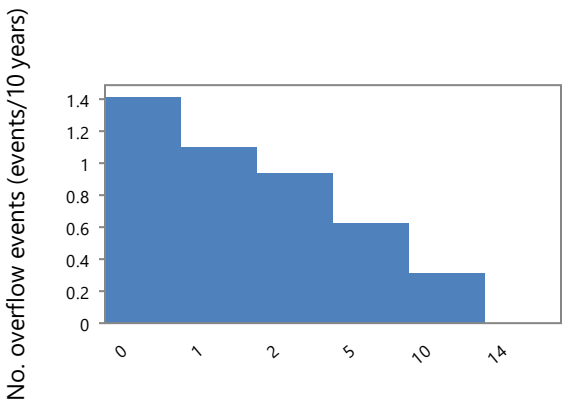
Pond System Water Balance (m3/year)



Name	Value
Rain	0.00
Inflow	264.60
Recycling	0.00
Evaporation	0.00
Overflow	0.84
Irrigation	263.66
Seepage	0.00
Delta Storage	0.11

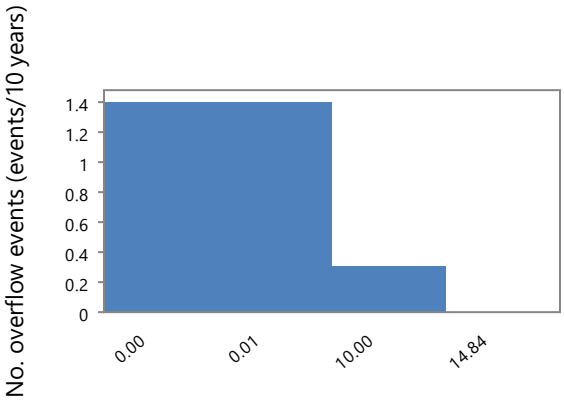
Overflow Diagnostics

Volume of overflow (m3/year)	0.84
No. days pond overflows (days/year)	0.84
Average duration of overflow (days)	6.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00



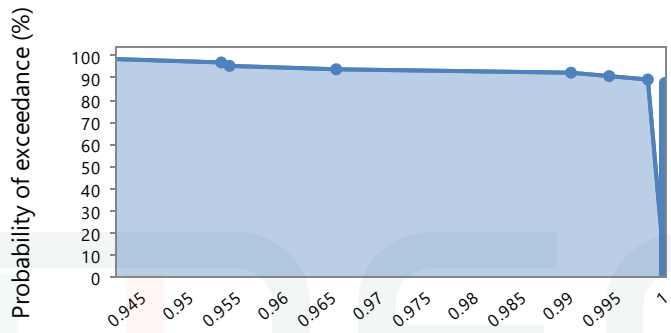
Overflow event duration exceeded (days)

Export plot



Overflow volume exceeded (m3)

Export plot



Annual reuse (fraction)

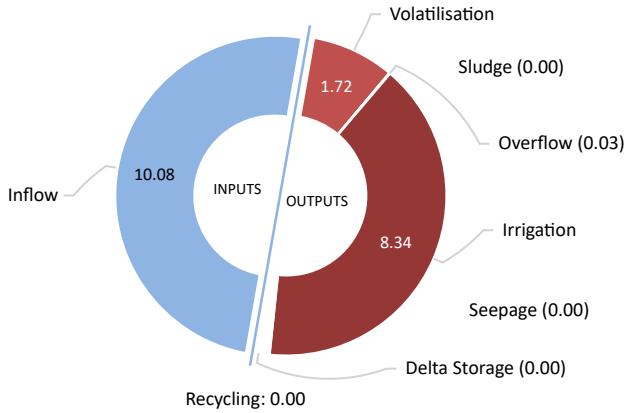
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

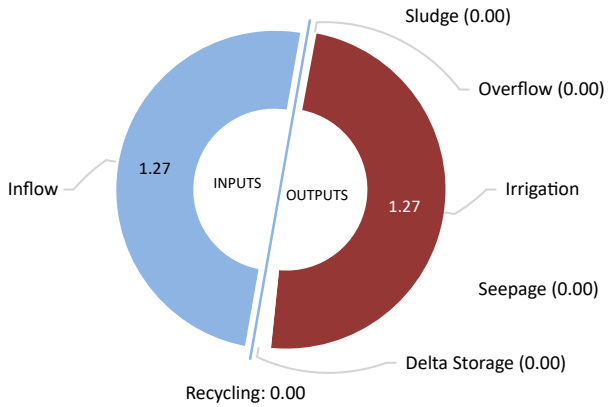
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



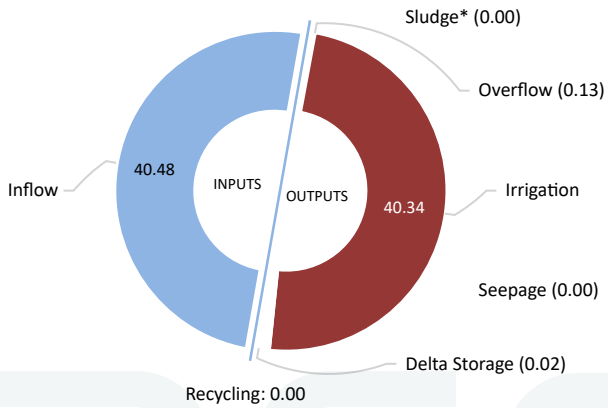
Name	Value
Inflow	10.08
Recycling	0.00
Volatilisation	1.72
Sludge	0.00
Overflow	0.03
Irrigation	8.34
Seepage	0.00
Delta Storage	0.00

Phosphorus Balance (kg/year)



Name	Value
Inflow	1.27
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	1.27
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	40.48
Recycling	0.00
Sludge*	0.00
Overflow	0.13
Irrigation	40.34
Seepage	0.00
Delta Storage	0.02

* 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 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	23.66
Average phosphorus concentration of pond liquid (mg/L)	4.80
Average salinity of pond liquid (dS/m)	0.24

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	5.56
Final phosphorus concentration of pond liquid (mg/L)	4.80
Final salinity of pond liquid (dS/m)	0.24

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	263.66
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	263.66
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	31.62
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	26.56
Average phosphorus concentration of irrigation water (mg/L)	4.80
Average salinity of irrigation water (dS/m)	0.24

Irrigation Diagnostics:

Proportion Days Irrigation Turned Off (fraction)	0.26
Proportion of Days rain prevents irrigation (fraction)	0.10
Proportion of Days water demand too small to trigger irrigation (fraction)	0.05
Proportion of Days irrigation occurs (fraction)	0.59

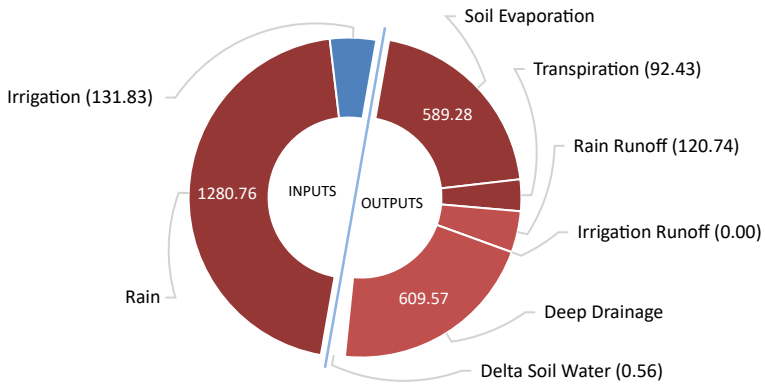
PERFORMANCE

Land Performance - Soil Water

Paddock: RCF, 0.2 ha
Soil Type: Ramingining Crocodile Farm, 26.95 mm PAWC at maximum root depth

Land Water Balance (mm/year):

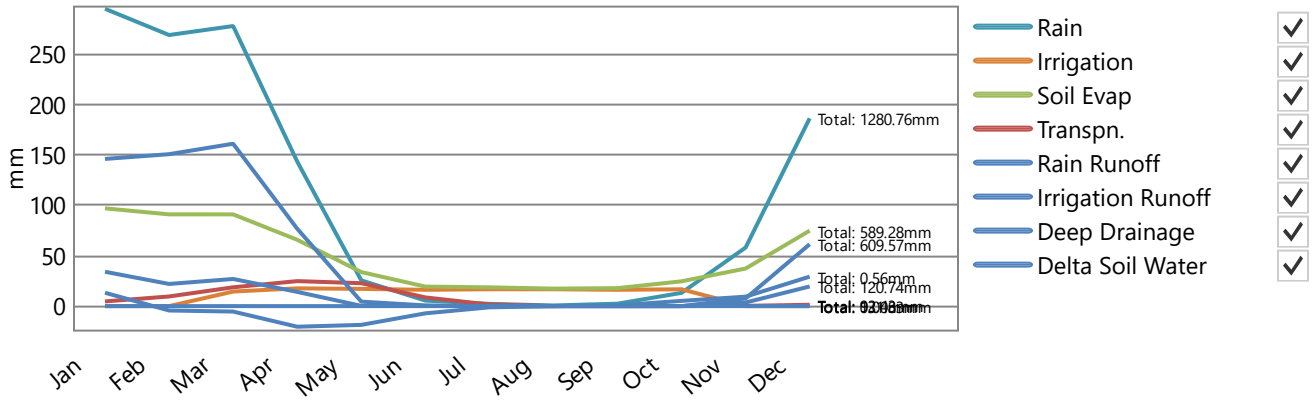
mm/year % Total inputs



Name	Value
Rain	1280.76
Irrigation	131.83
Soil Evaporation	589.28
Transpiration	92.43
Rain Runoff	120.74
Irrigation Runoff	0.00
Deep Drainage	609.57
Delta Soil Water	0.56

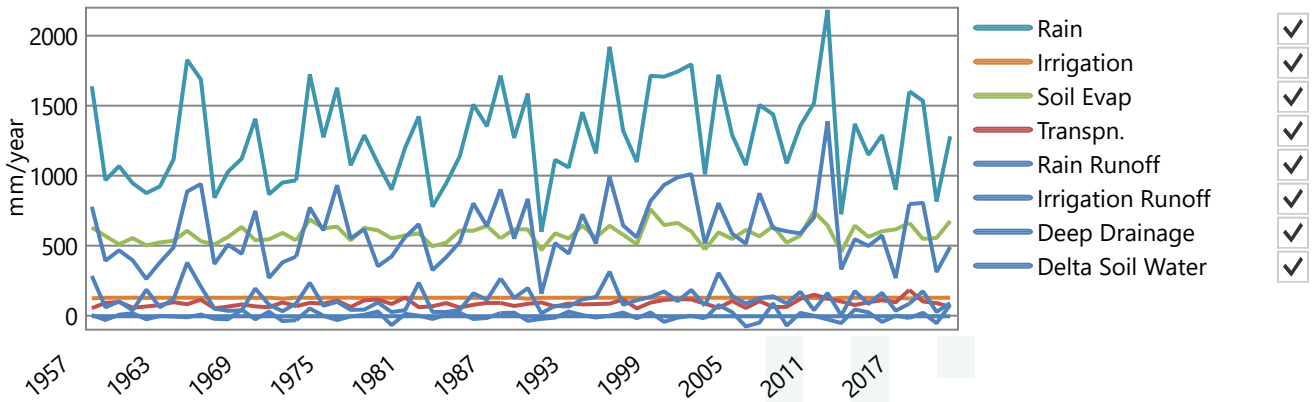
Average Monthly Totals (mm):

Chart Table



Average Annual Totals (mm/year):

Chart Table



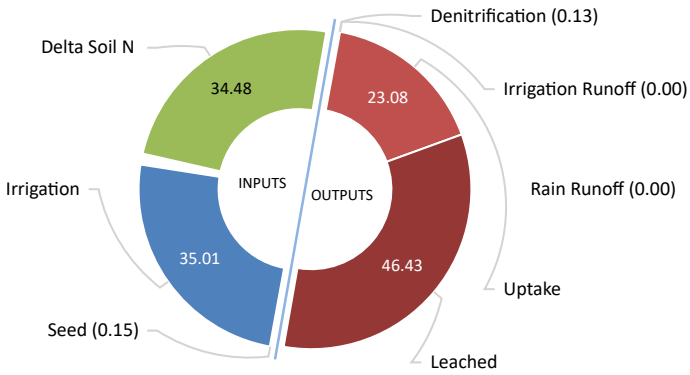
PERFORMANCE

Land Performance - Soil Nutrient

Paddock: RCF, 0.2 ha **Soil Type: Ramingining Crocodile Farm**

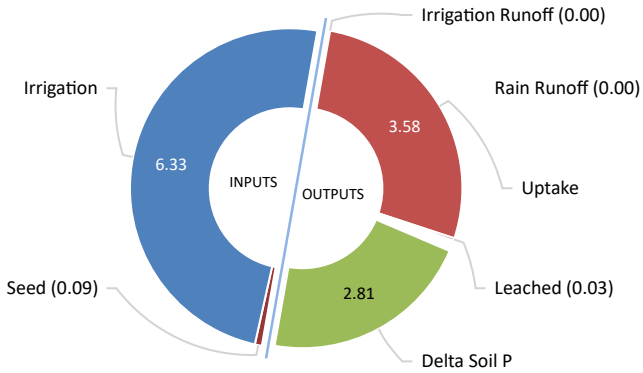
Irrigation ammonium volatilisation losses (kg/ha/year): 6.67
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.80

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.15
Irrigation	35.01
Denitrification	0.13
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	23.08
Leached	46.43
Delta Soil N	-34.48

Land Phosphorus Balance (kg/ha/year)



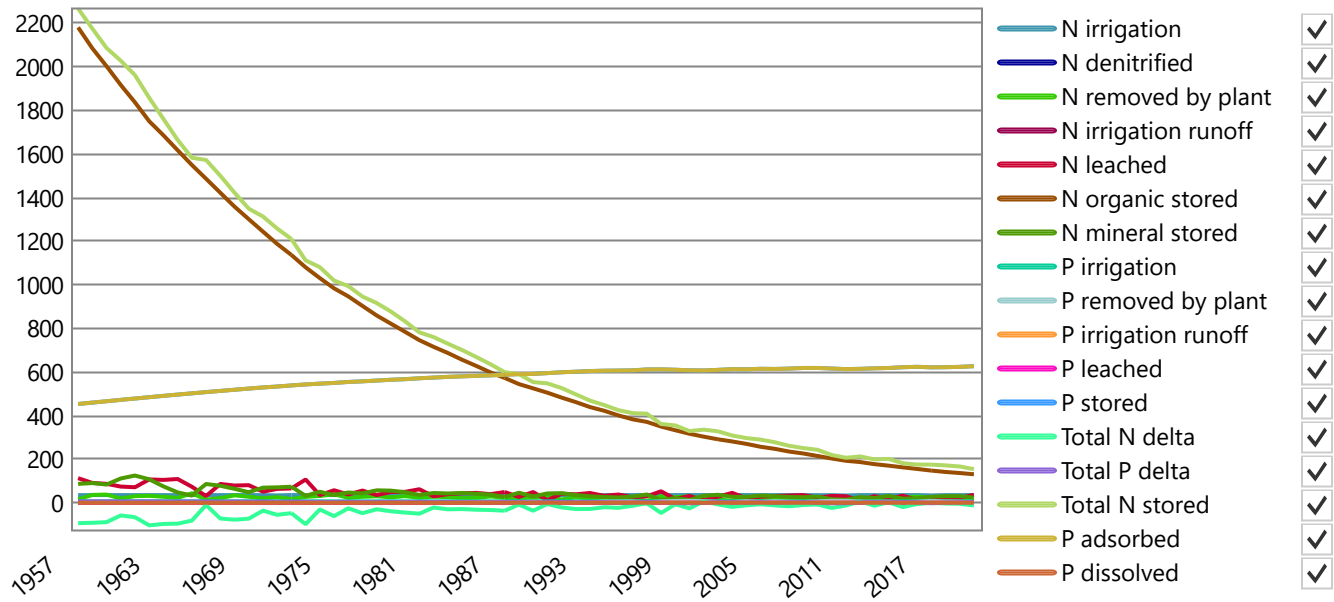
Name	Value
Seed	0.09
Irrigation	6.33
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	3.58
Leached	0.03
Delta Soil P	2.81

PERFORMANCE

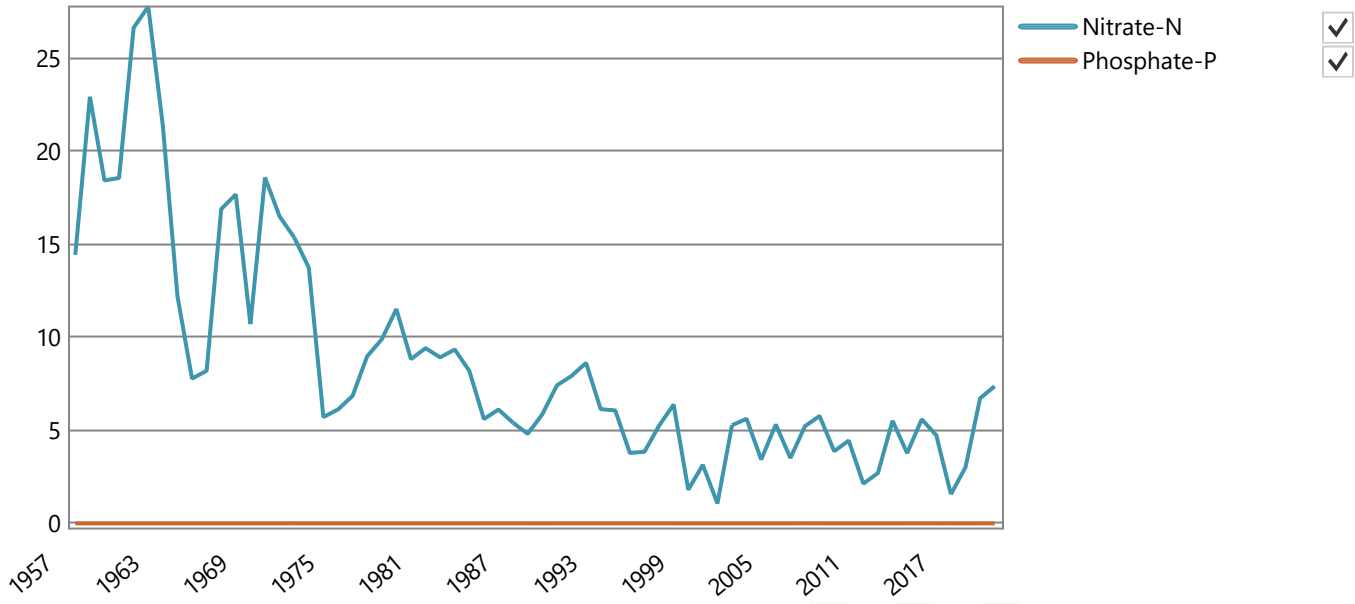
Land Performance - Soil Nutrient

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

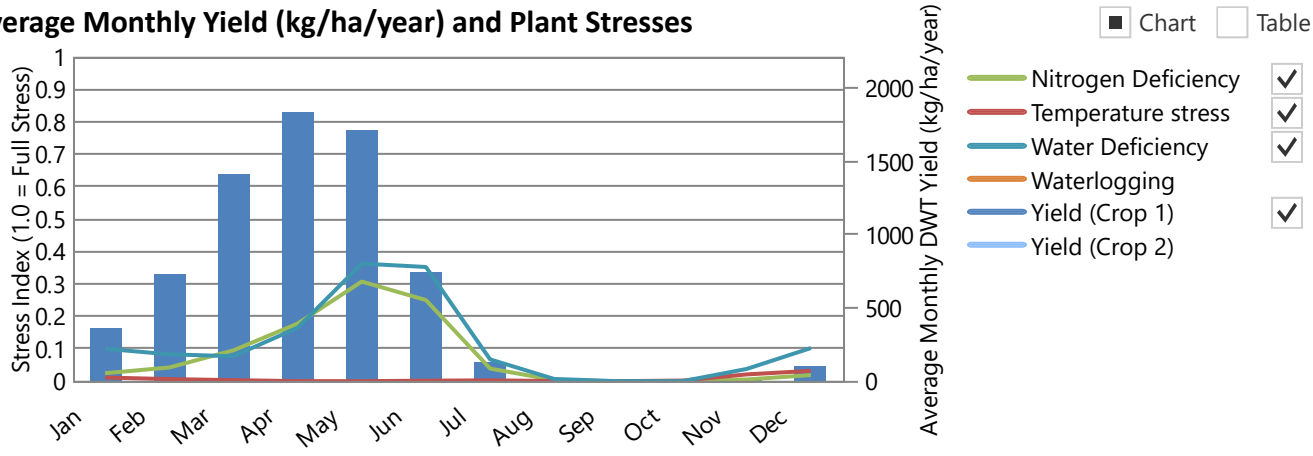
Plant: Continuous Banana Pasture

Average annual shoot dry matter yield (kg/ha/year)	7110.83 (3927.21 - 10160.68)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.10 (0.00 - 0.31)
Average monthly root depth (mm) (minimum - maximum)	103.12 (0.52 - 253.77)

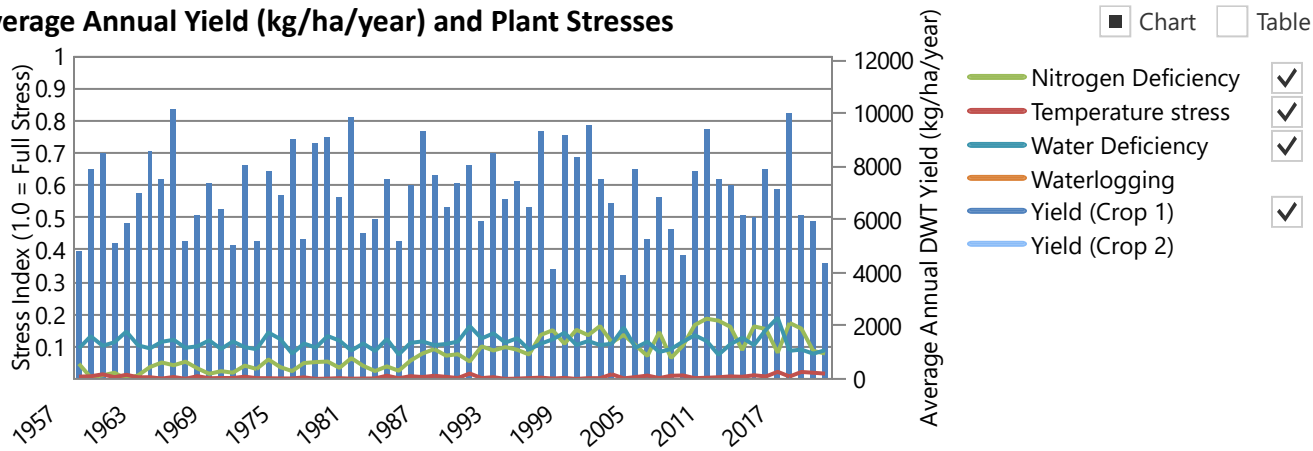
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	23.08 (8.02 - 43.62)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	3.58 (0.09 - 9.07)
Average annual shoot nitrogen concentration (fraction dwt)	0.00 (0.00 - 0.01)
Average annual shoot phosphorus concentration (fraction dwt)	0.001 (0.000 - 0.002)

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



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



No. of harvests/year: 1.00 (forced by crop death due to water stress (1.00))
No. days without crop/year (days/year): 167.86 due to water stress (167.86)

PERFORMANCE

Land Performance

Paddock: RCF, 0.2 ha **Soil Type**: Ramingining Crocodile Farm

Plant: Continuous Banana Pasture

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	10.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.01
No. years assumed for leaching to reach steady-state (years)	10.00

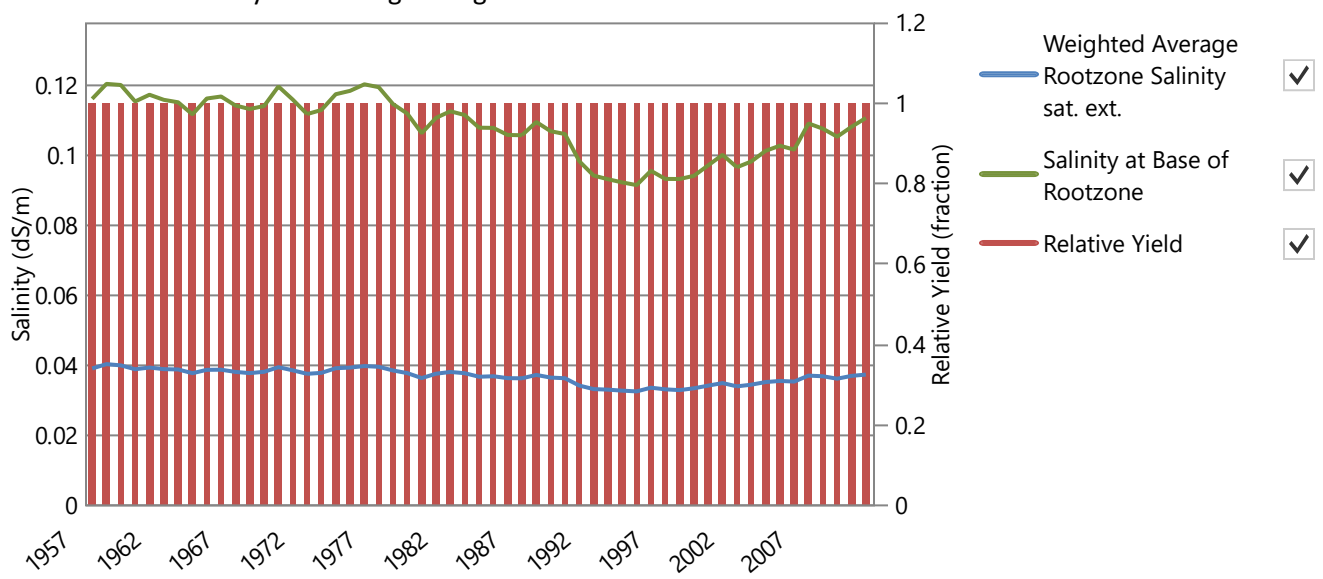
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.05
Salt added by rainfall (kg/ha/year)	222.72
Average annual effluent salt added & leached at steady state (kg/ha/year)	424.42
Average leaching fraction based on 10 year running averages (fraction)	0.63
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.04
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.11
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

■ Chart ☐ Table

All values based on 10 year running averages



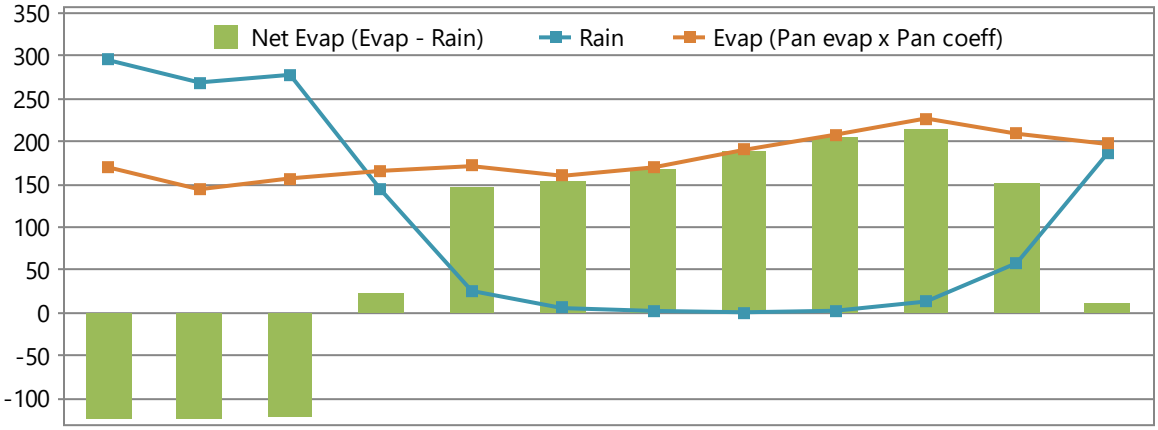
DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Averaged Historical Climate Data Used in Simulation (mm)

Location: Ramingining_-12.35_134.95, -12.35°, 134.95°

Run Period: 01/01/1957 to 31/12/2020 64 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	295.3	269.3	278.2	143.7	25.6	5.5	2.2	0.6	2.4	13.2	58.2	186.5	1280.8
Evap	170.0	144.4	157.2	165.9	171.5	160.2	170.0	190.5	208.2	227.2	209.4	197.3	2171.7
Net Evap	-125.3	-124.9	-121.1	22.3	145.9	154.6	167.8	189.9	205.8	214.0	151.2	10.8	891.0
Net Evap/day	-4.0	-4.4	-3.9	0.7	4.7	5.2	5.4	6.1	6.9	6.9	5.0	0.3	2.4

DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Pond System: 1 closed storage tank

Ramingining Crocodile Farm stage 1 - 264.60 m3/year or 0.72 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 245.00 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	38.10 (0.00 - 38.10)	10.08 (10.08 - 10.08)
Total Phosphorus	4.80 (0.00 - 4.80)	1.27 (1.27 - 1.27)
Total Dissolved Salts	153.00 (0.00 - 153.00)	40.48 (40.48 - 40.48)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	323.00 (0.00 - 323.00)	85.47 (85.47 - 85.47)

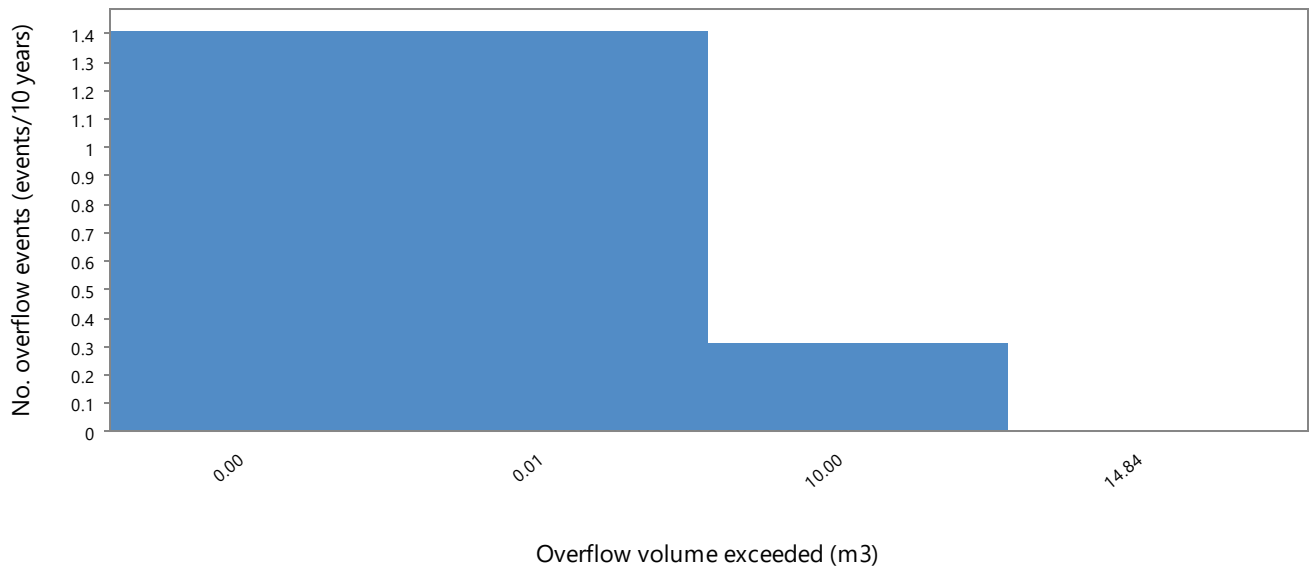
Last pond (Wet weather store): 34.50 m3

Theoretical hydraulic retention time (days)	47.62
Average volume of overflow (m3/year)	0.84
No. overflow events per year exceeding threshold* of 0.01 m3 (no./year)	0.14
Average duration of overflow (days)	6.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	0.24
Salinity of last pond on final day of simulation (dS/m)	0.24
Ammonia loss from pond system water area (kg/m2/year)	7.97

* 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: Ramingining Crocodile Farm

Irrigation Information

Irrigation: 0.2 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	263.66	1318.28
Total nitrogen applied (kg)	7.00	35.01
Total phosphorus applied (kg)	1.27	6.33
Total salts applied (kg)	40.34	201.70

Shandying

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

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	0.26
Proportion of Days irrigation is prevented when triggered (fraction)	0.10
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.05
Proportion of Days irrigation occurs (fraction)	0.59

DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Paddock Land: RCF: 0.2 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 5.00 mm and rainfall is less than or equal to 10.00 mm
Irrigate a fixed amount of 5.00 mm each day
Irrigation window from 1/3 to 31/10 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Ramingining Crocodile Farm, 26.95 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	295.3	269.3	278.2	143.7	25.6	5.5	2.2	0.6	2.4	13.2	58.2	186.5	1280.8
Irrigation	0.0	0.0	14.5	17.7	17.1	16.2	16.7	16.7	16.2	16.7	0.0	0.0	131.8
Soil Evap	97.1	91.1	91.1	65.9	33.8	19.4	18.7	17.4	17.9	24.6	37.3	74.9	589.3
Transpn.	4.7	9.6	18.7	24.8	22.8	8.6	1.6	0.1	0.0	0.1	0.3	1.3	92.4
Rain Runoff	34.1	22.0	27.0	14.1	0.3	0.2	0.0	0.0	0.0	0.0	3.6	19.5	120.7
Irr. Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	146.2	150.9	161.3	76.9	4.5	0.7	0.0	0.0	0.0	0.0	7.6	61.5	609.6
Delta	13.3	-4.3	-5.4	-20.5	-18.6	-7.2	-1.2	-0.1	0.7	5.2	9.4	29.3	0.6

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	35.01
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	23.08
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.13
Average annual soil nitrogen leached (kg/ha/year)	46.43
Average annual nitrate-N loading to groundwater (kg/ha/year)	46.43
Soil organic-N kg/ha (Initial - Final)	2284.38 - 130.59
	76.59 - 23.50
Average nitrate-N concentration of deep drainage (mg/L)	7.62
Max. annual nitrate-N concentration of deep drainage (mg/L)	27.75

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	6.33
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	3.58
Average annual soil phosphorus leached (kg/ha/year)	0.03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.12
Adsorbed phosphorus (kg/ha) (Initial - Final)	446.98 - 626.39
Average phosphate-P concentration in rootzone (mg/L)	0.10
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 0.49 mg/L (years)	354.48

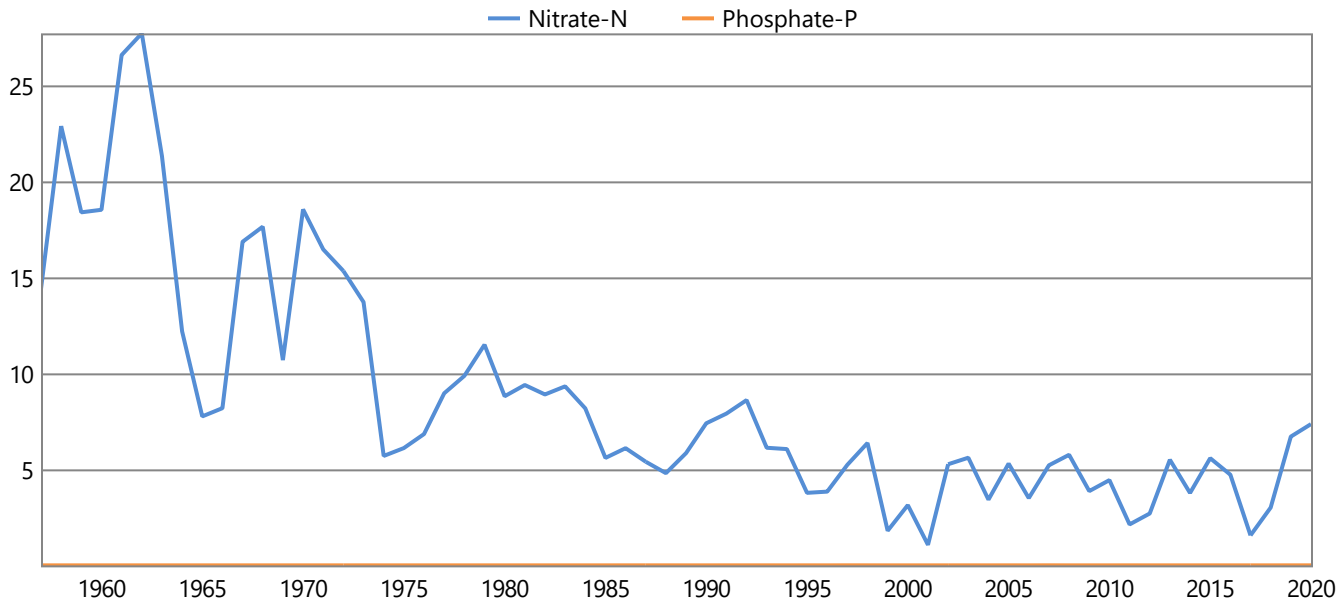
DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

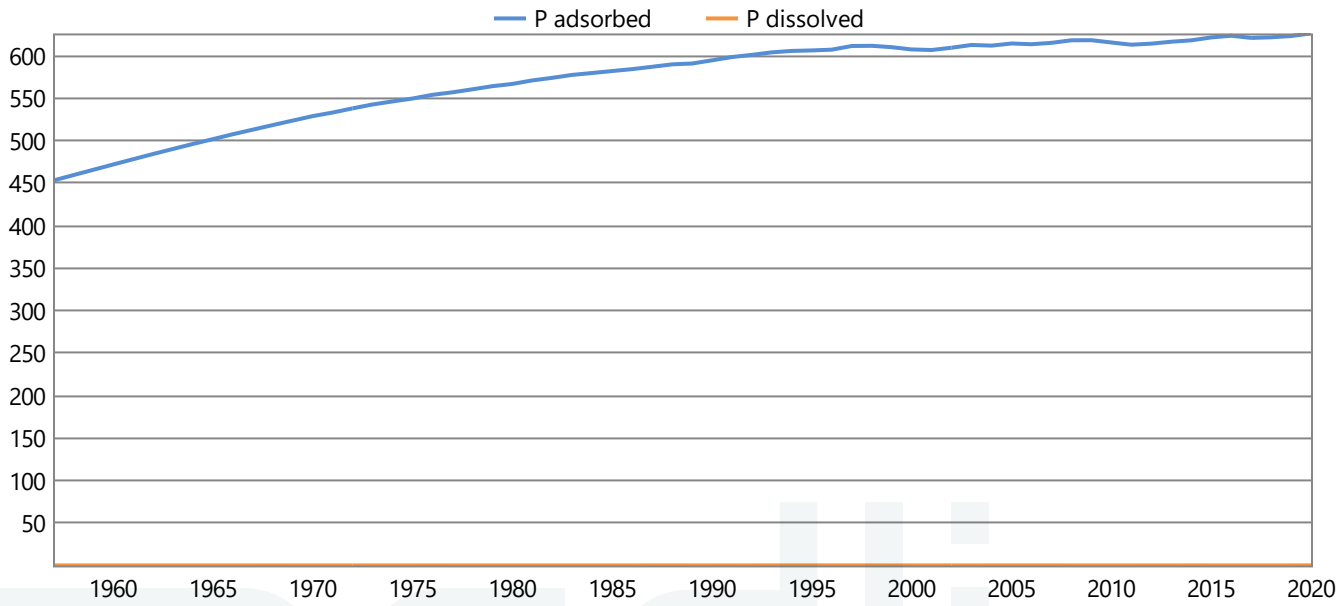
Paddock Land: RCF: 0.2 ha

Irrigation: Fixed Sprinkler with 0.2% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual Phosphate-P in soil (kg/ha)



DIAGNOSTICS

Sustainability Diagnostics: Ramingining Crocodile Farm

Paddock Plant Performance: RCF: 0.2 ha

Average Plant Performance (Minimum - Maximum): Continuous Banana Pasture

Average annual shoot dry matter yield (kg/ha/year)	7110.83 (3927.21 - 10160.68)
Average monthly plant (green) cover (fraction)	0.10 (0.00 - 0.31)
Average monthly crop factor (fraction)	0.07 (0.00 - 0.22)
Total plant cover (both green and dead) left after harvest (fraction)	0.70
Average monthly root depth (mm)	103.12 (0.52 - 253.77)
Average number of normal harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of crop deaths per year (no./year)	1.00 (1.00 - 1.00)
Average number of crop deaths for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.08 (0.00 - 0.19)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.09)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.07)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.11 (0.00 - 0.36)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop/year (days)	167.86

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

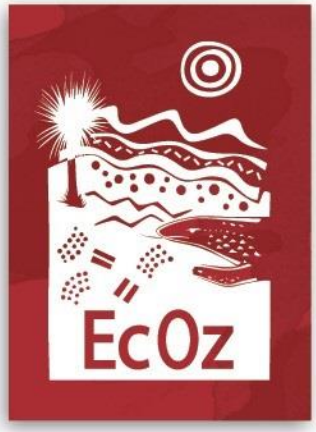
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.05
Salt added by rainfall (kg/ha/year)	222.72
Average annual effluent salt added & leached at steady state (kg/ha/year)	424.42
Average leaching fraction based on 10 year running averages (fraction)	0.63
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.04
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.11
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



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APPENDIX C IRRIGATION PROCEDURES

Irrigation Procedures Ramingining Crocodile Rearing Facility

Arafura Swamp Rangers Aboriginal Corporation

www.ecoz.com.au

DOCUMENT CONTROL RECORD

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Rev	Reviewed by	Approved by	Issued to	Date
1	Helen Dwyer	Helen Dwyer	ASRAC	25/11/2021
2	Helen Dwyer	Helen Dwyer	ASRAC NT EPA	14/12/2021

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

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Appendices

1 INTRODUCTION

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

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

The list of procedures includes:

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

2 TIMING OF IRRIGATION PROCEDURE

2.1 Aim

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

2.2 Procedure

This procedure is to be implemented in conjunction with the selection of area to be irrigated procedure. It is noted that irrigation at the RCRF will occur only in the dry season when rainfall is unlikely (although not impossible).

1) Check the daily weather forecast for potential rainfall. Irrigation activities are not to be conducted two hours prior to when heavy rainfall (>10mm) is forecasted, or at the time of rain events or high winds. Used as a preventative measure for surface water run-off.

1) Additionally, check the daily weather forecast for wind speed and direction; although irrigation is only planned for dry season months unseasonal rainfall or early wet season rainfall may occur which could impact irrigation. Avoid irrigation activities being conducted when prevailing wind direction will carry any odours or over-spray towards surrounding neighbours and sensitive receptors.

2) Ensure daily visual inspections of potential irrigation areas are conducted as per daily visual inspection checklist (refer to Appendix A). Ensure area can adequately absorb the volume being applied as per irrigation rate. This can be achieved through digging a small hole and checking the soil moisture content or through soil moisture monitoring equipment such as a tensiometer.

3) When heavy rain (>10mm) has been received within the previous 24 hours, a daily visual inspection and moisture test (tensiometer) is to be conducted to ensure the irrigation area is not saturated prior to the commencement of irrigation activities. If saturated, delay irrigation until sufficiently dried out, or apply the minimum irrigation flow rate of 1mm/day.

3 APPLICATION OF IRRIGATION

3.1 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.

3.2 Procedure

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

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APPENDIX A VISUAL INSPECTION CHECKLIST

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

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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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